BOOK OF ABSTRACTS

NN24

21st International Conference on Nanosciences & Nanotechnologies

2-5 July 2024

Porto Palace Conference Center & Hotel

Thessaloniki, Greece

2024

A Warm Welcome to the NN24!

The International Conference on Nanosciences and Nanotechnologies (NN24), is the internationally established world-class event in Nanosciences and Nanotechnologies (N&N) that focuses on the latest advances on N&N and promotes profound scientific discussions between scientists and researchers and innovators from different disciplines.

The Program of the 21st year of the International Conference on Nanosciences & Nanotechnologies at 2-5 July 2024 in Thessaloniki is a multidisciplinary collection of hot topics and a fine list of Invited Speakers related to the N&N fields, consisting of Invited, Oral presentations, poster presentations and running EU funded R&D Projects. These combined with the ISFOE International Symposium, the ISSON Summer Schools, the EXPO Exhibition and the B2B meetings that will take place in parallel within NANOTEXNOLOGY 2024, will provide to the participants access to a unique global network of innovators and specialists from the world academic, research and industrial communities.

Front-line experts from multidisciplinary research and application areas joined this conference, to discuss the benefits of N&N in their R&D efforts, to advance the networking and collaborating between different academia, research and industry players in the field and to stimulate the exchange of educational concepts.

NN24 targets the latest developments in the fields of Nanosciences & Nanotechnologies:

- **Plasmonics, Nanoelectronics & Clean Energy**
- **Nanomaterials, Nanofabrication, Nanoengineering & Nanocharacterization**
- **Nanomedicine**
- **Bioelectronics**

This year we are extremely proud to include in the NANOTEXNOLOGY 2023 and NN24, the

- **Workshop on Artificial Intelligence, Machine Learning, Intelligent Manufacturing and Automation,**
- **Workshop on Computational Modeling of Materials, Devices & Processes**

On behalf of the NN24 Organizing and International Scientific Committees, we would like to thank you for your participation and support and we ensure that the NN24 presentations, discussions and Round Tables will expand our knowledge and form an outstanding platform for dynamic networking in the N&N fields.

It is our great pleasure to welcome you again to Thessaloniki and we hope that you will enjoy not only the insightful and interesting Scientific Program, but also the exciting networking and social events of NANOTEXNOLOGY 2024!

Best Regards

Professor S. Logothetidis
NN24 Chairman

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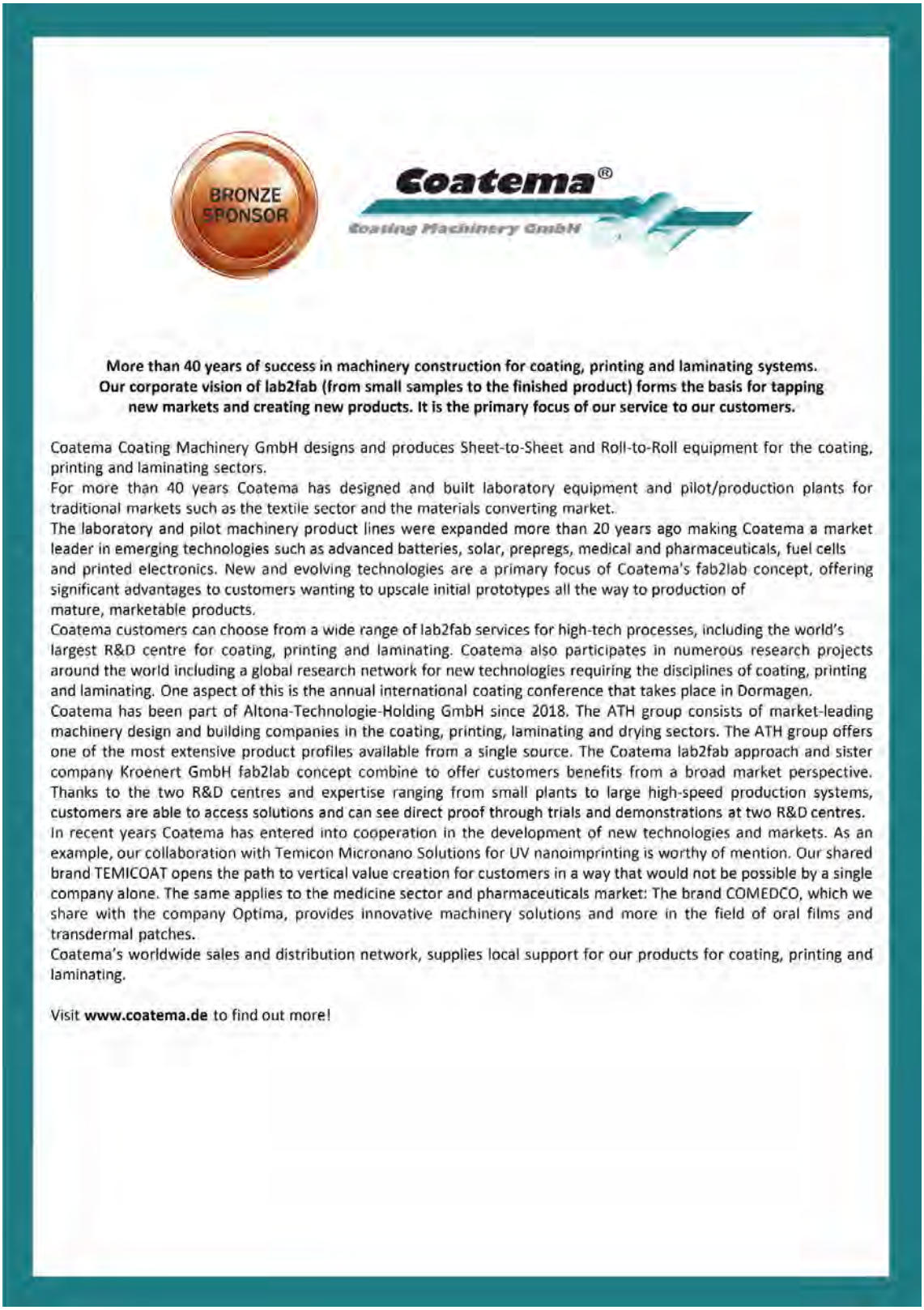

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Workshop on Artificial Intelligence, Machine Learning, Intelligent Manufacturing and Automation Tuesday 2 to Thursday 4 July: Poster Display & Presentations Tuesday 2 July (17:00-20:00): Poster Presentation	
I3D-1 **YRA CANDIDATE**	**Isocyanate-free urethanediol itaconates as biobased liquid monomers in photopolymerization-based 3D printing** R. Carmenini, C. Spanu, E. Locatelli, L. Sambri, M. Comes Franchini* and M. Maturi* *Dept. of Industrial Chemistry "Toso Montanari", Un. of Bologna, Viale Risorgimento 4, 40136 Bologna, Italy*
I3D-2	**Lightweight mineral particles/ABS composite filaments for Fused Filament Fabrication (FFF); physical and mechanical properties, and printability** P. Angelopoulos[1], N. Kountouris[1], Z. Viskadourakis[2], A. Skaropoulou[1], C. Panagiotopoulou[1], A. Peppas[1], G. Kenanakis[2]. M. Taxiarchou[1] *[1] Laboratory of Metallurgy, School of Mining and Metallurgical Engineering, National Technical Un. of Athens (NTUA), Greece* *[2] Institute of Electronic Structure and Laser, Foundation for Research & Technology-Hellas, N. Plastira 100, Heraklion, Crete, GR 70013, Greece*
I3D-3	**Tandem FFF Printing using High-Load Composite Polymeric Filaments for Rapid Manufacturing of Dielectric and Electrochemical Energy Storage Devices** A. Tiliakos[1,2], R.-Valentin Rabuga[1], G.-Rainer Gillich[2] *[1] National R&D Institute for Cryogenic and Isotopic Technologies (ICSI), ICSI Energy Dept., Rm. Vâlcea, 240050, Romania* *[2] Babeș-Bolyai Un., Dept. of Engineering Science, Centre for Vibrodiagnostics for Equipment Testing and Automation (CVDTEA), Cluj-Napoca, 400084, Romania*
I3D-4 **YRA CANDIDATE**	**Functionalized red emitting carbon dots as fluorescent additives for 3D printing photopolymerization** S. Maturi,[1] A. Baschieri,[2] E. Locatelli,[1] M. Comes Franchini[1] and L. Sambri[1] *[1] Dept. of Industrial Chemistry "Toso Montanari", Un. of Bologna, via P. Gobetti 85, Bologna, 40129, Italy* *[2] ISOF, CNR, via P. Gobetti 101, Bologna, 40129, Italy*
I3D-5	**Bipolar Plates for Hydrogen Fuel Cells Manufactured by Fused Filament Fabrication using High-Load Metal-Polymer Composites** A. Tiliakos[1,2], R.-V. Răbuga[1], G.-Rainer Gillich[2] *[1] National R&D Institute for Cryogenic and Isotopic Technologies (ICSI), ICSI Energy Dept., Rm. Vâlcea, 240050, Romania* *[2] Babeș-Bolyai Un., Dept. of Engineering Science, Centre for Vibrodiagnostics for Equipment Testing and Automation (CVDTEA), Cluj-Napoca, 400084, Romania*
I3D-6	**Extending the Aerodynamic Shape Optimization of a Solar Car to 3D Printing** An. Moissiadis[1], I. Tzionas[1] *[1]Dept. of Mechanical Engineering, International Hellenic Un., Serres, Greece*
I3D-7	**3D printed materials for healing of bone defects** J. Frankova[1], R. Novotna[1], R. Novotny[1], J. Janusz[2] and A. Jabłoński[2], I. Rajzer[2] *[1]Dept. of Medical Chemistry and Biochemistry, Hnevotinska 3, Palacky Un. Olomouc, 775 15, Czech Republic* *[2] Faculty of Mechanical Engineering and Computer Science, Un. of Bielsko-Biala, Willowa 2, 43-309 Poland*
I3D-8	**Advanced 3D collagen-based scaffolds enriched with vasculogenic compound for enhanced vascularization and wound healing** D. Izsak[1], V. Pavliňáková[1], Z. Fohlerová[1], T. Szotkowská[2], M. Buchtová[2], L. Vojtová[1] *[1]CEITEC BUT, Central European Institute of Technology, Brno Un. of Technoogy, Czech Republic* *[2]Institute of Animal Physiology and Genetics, The Czech Academie of Science, Czech Republic*
I3D-9	**Finite Element Analysis and Topology Optimization of Additive Manufactured Orthodontic Twin Brackets for Enhanced Performance and Mass Reduction** T. Profitiliotis[1], N. Kladovasilakis[1,2], E. M. Pechlivani[1], D. Tzetzis[1] *[1] Digital Manufacturing and Materials Characterization Laboratory, School of Science and Technology, International Hellenic Un., Thessaloniki, 57001, Greece* *[2] Center for Research and Technology Hellas, Information Technologies Institute, 57001 Thessaloniki, Greece*

I3D-10	**Development and Numerical Evaluation of a Topologically Optimized Helmet with Advanced Architected Materials** N. Kladovasilakis [1,2], K. Tsongas[2], E.M. Pechlivani[1], D. Tzetzis *[1]Center for Research and Technology Hellas, Information Technologies Institute, 57001 Thessaloniki, Greece* *[2]Digital Manufacturing and Materials Characterization Laboratory, School of Science and Technology, International Hellenic Un., Thessaloniki, 57001, Greece*
I3D-11	**A refractometry sensor for the detection of pathogens in bioreactor samples** M. Chatzipetrou[1], E. Damianidou[2], M. Dimadi[2], A. Bokski[3], E. Schreuder[3], A. Klinakis[2] and I. Zergioti[1]. *[1] School of App. Mathematics and Physical Sci., National Technical Un. of Athens, Zografou 15780, Greece.* *[2] PhosPrint P. C. Lefkippos Technology Park, NCSR Demokritos, Patriarchou Grigoriou 5' & Neapoleos 27, 15341, Agia Paraskevh, Athens, Greece.* *[3] LioniX International B.V., Hengelosestraat 500, 7521 AN Enschede, The Netherlands*
I3D-12	**Multilayer laser printing of cells with hydrogels** S. Elezoglou[1], A. Hatziapostolou[2], A. Chalari[3], A. Rufino[4], C. Chandrinou[1], C. Custodio[4], A. Klinakis[3,5], and I. Zergioti[1,5] *[1]National Technical Un. of Athens, School of App. Mathematical and Physical Sci., Athens, Greece* *[2]Dept. of Naval Architecture, School of Engineering, Un. of West Attica, Athens, Greece* *[3]Biomedical Research Foundation of the Academy of Athens, Athens, Greece* *[4]Metatissue Edifício Central, PCI · Creative Science Park Aveiro Region, Via do Conhecimento, 3830-352 Ílhavo, Portugal* *[5]PhosPrint P.C., Attika Technology Park Lefkippos, Agia Paraskevi, Athens, Greece*
I3D-13 YRA CANDIDATE	**Surrogate model for exciton-polariton condensation** K. Kuba[1], M. Matuszewski[2,3], B. Piętka[1], A. Opala[1,2] *[1]Institute of Experimental Physics, Faculty of Physics, Un. of Warsaw,ul. Pasteura 5, PL-02-093 Warsaw, Poland* *[2]Institute of Physics, Polish Academy of Sci., Aleja Lotników 32/46, PL-02-668 Warsaw, Poland* *[3]Center for Theoretical Physics, Polish Academy of Sci. Aleja Lotników 32/46, 02-668 Warsaw, Poland*
I3D-14	**Compensating for Errors in a Gas Sensor Array Using Machine Learning and a Custom Laboratory Test System** F. Gerhat[1], M. Micjan[1], V. Rezo[1], *[1]Institute of Electronics and Photonics, Faculty of Electrical Engineering and Information Technology, Slovak Un. of Technology in Bratislava, Slovak Republic*
I3D-15	**High Secure Process Automation Frameworkto Improve Production Quality and Scalability** A. Takaluoma[1], Janne Rosberg[2] *Offcode Oy, Finland*
I3D-16	**From CHADA to CHAMEO:** **A reference system for characterisation data management** O. M. Roscioni[1], G. Goldbeck[1], P. Del Nostro[1], D. Toti[1] *1 Goldbeck Consulting LTD, CB4 0WS Cambridge, United Kingdom.*

Contents

Editors: Prof. S. Logothetidis, Dr. C. Gravalidis, A. Kostopoulou

Tuesday 2 July 2024

Workshop on Advanced Nanomaterials

09:00-11:00	**NN24 OPENING** **(Crystall Hall)** **Chair: A. Laskarakis**
09:30-9:30 **WELCOME**	**Welcome and Opening Remarks** **S. Logothetidis** **NN24 Chairman**
09:30-10:00 **NANOTEX** **KEYNOTE**	**High performance optoelectronic devices, based on Polyvinylidene Fluoride based copolymers, through ink formulation and printing process optimization** **Georges Hadziioannou** *Emeritus Chemistry Professor at University of Bordeaux, International member of the US NAE* *Laboratoire de Chimie des Polymères Organiques (LCPO) UMR CNRS 5629, Bordeaux France*
10:00-11:00	**Workshop on Advanced Nanomaterials** **(Crystall Hall)** **Chair: J. Pfleger**
10:00-10:30 **KEYNOTE**	**Purcell Effect Revisited: The impacts of photonic environment and quantum interferences** **E. Kapon** *Inst. of Physics, Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland*
10:30-11:00 **INVITED**	**1D Nanomaterials - Detailed Nanoscopic Investigations** **R. Arenal** *University of Zaragoza, Spain*

NANOTEX KEYNOTE TALK

High performance optoelectronic devices, based on Polyvinylidene Fluoride based copolymers, through ink formulation and printing process optimization

Prof. Georges Hadziioannou

Emeritus Chemistry Professor at University of Bordeaux
International member of the US NAE
Laboratoire de Chimie des Polymères Organiques (LCPO) UMR CNRS 5629, Bordeaux France

Highly polar fluorinated polymers such as Polyvinylidene Fluoride-Trifluoroethylene (P(VDF-TrFE)) are emerging materials in the field of flexible organic electronics because of their numerous applications as actuators, sensors, or energy harvesters. Due to the high polarity of C-F bonds, cooperative dipole orientation in crystalline domains can be induced and are primarily responsible for the electroactive properties of these polymers. The processing of these materials into thin films can be performed by solution printing or casting, offering a versatile and scalable method for the production of highly functional layers. Nevertheless, the implementation of such layers in practical devices is directly related to the rheological properties of the electroactive inks that determine the printability regimes leading to stable and functional electroactive layers. We evaluated the viscoelastic behavior of P(VDF-TrFE) solutions for solvents of different polarity, ranging from the dilute to the concentrated regime. From these measurements, we extracted using a scaling approach several polymer-solvent parameters that are highly dependent on the polymer composition and solvent polarity. Complementary light scattering measurements further correlated the polymer conformational changes with the polymer-solvent affinity extracted from the rheological analysis. Finally, we examined the impact of the ink formulation on the fabrication of PVDF-based electroactive devices by the screen-printing method in order to establish a correlation between the rheological parameters of the ink and the resistance to breakdown during the polarization cycles. In conclusion, this study provided a deeper understanding on the influence of the polymer dissolution on the printability regimes towards high performance electroactive layers.

Keywords: polymers, ferroelectricity, printing, viscosity.

KEYNOTE TALK

Purcell Effect Revisited:

The impacts of photonic environment and quantum interferences

E. Kapon

Institute of Physics, Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland

The Purcell effect demonstrates the important role of the density of electromagnetic states on the radiative transitions of any quantum light emitter. With the advent of nanotechnology, it has become possible to engineer not only “artificial” quantum states of electrons, but also the spectral density of photonic states in novel nanostructures surrounding the light emitter. An example of such systems comprises semiconductor quantum dots (QDs) embedded in photonic crystal (PhC) structures. By tailoring the density of states of the photonic modes in such confined systems, it is possible to enhance or reduce the emission rates of QD emitters due to the modified photonic environment (the Purcell effect). In this talk, it is shown how such nanosystems can be used to further manipulate the characteristics of light emission and absorption, using precisely site-controlled QDs incorporated in PhC structures. The fabrication of the structures consists first of growth of InGaAs/GaAs QDs emitting in the ~900nm wavelength range inside pyramidal pits produced at prescribed locations on (111)B-oriented GaAs substrates, using electron beam lithography, etching and organometallic vapor phase epitaxy [1]. Various PhC cavity and waveguide configurations are then nanofabricated around the QDs with positioning precision as good as ~20nm. The QDs are photo-excited at low temperatures and the light emitted is analyzed using optical spectroscopy. Several cavity-electrodynamic effects due to coupling into the PhC cavities are observed, including new features of the Purcell effect brought about by quantum interference among confined and radiation modes [2]. Integration of such QDs with more complex PhC structures for single-photon routing are also presented and discussed.

[1] A. Surrente, et al., *Nano Research* **9**, 3279 (2016); [2] A. Lyasota, et al., *Phys. Rev. X* **12**, 21042 (2022)

INVITED TALK

1D Nanomaterials - Detailed Nanoscopic Investigations

R. Arenal[1,2,3]

[1] Instituto de Nanociencia y Materiales de Aragon (INMA), CSIC-U. Zaragoza, 50009 Zaragoza, Spain
[2] Laboratorio Microscopias Avanzadas, U. Zaragoza, 50018 Zaragoza, Spain
[3] Fundacion ARAID, 50018 Zaragoza, Spain

Transmission electron microscopy (TEM) offers a formidable capability for examining materials' structure, chemistry, and certain properties at a local scale, often down to the atomic level [1-7]. In this contribution, I will present a selection of studies conducted on different 1D nanomaterials via advanced TEM and spectroscopic measurements. I will focus on the study of misfit layered compound nanotubes (NTs) [2-4,...] as well as on functionalized carbon NTs [5,6....]. These studies demonstrate the wealth of information attainable through such experiments and underscore their relevance in studying nanomaterials. These findings enhance our understanding of these intricate nanomaterials, which is essential for investigating their physical and chemical characteristics and unlocking their potential for future applications.

[1] Eds. L. Francis, A. Mayoral, R. Arenal, “Advanced TEM: Applications to Nanomaterials”, Springer (2015).
[2] M. Serra, R. Arenal, R. Tenne, Nanoscale 11, 8073-8090 (2019).
[3] S. Hettler, M.B. Sreedhara, M. Serra, S.S. Sinha, R. Popovitz-Biro, I. Pinkas, A.N. Enyashin, R. Tenne, R. Arenal, ACS Nano 14, 5445 (2020).
[4] K.S. Roy, S. Hettler, R. Arenal, L.S. Panchakarla, Materials Horizons 9, 2115-2127 (2022).
[5] A. Setaro, et al., Nature Comm. 8, 14281 (2017).
[6] R. Arenal, L. Alvarez, J.-L. Bantignies, Submitted.
[7] Research supported by the Spanish MICIU (PID2019-104739GB-100/AEI/10.13039/501100011033), the Government of Aragon (DGA) through the project E13_23R and the MICIU with funding from European Union NextGenerationEU (PRTR-C17.I1) promoted by the Government of Aragon.

Workshop on AI, ML, Intelligent Manufacturing and Automation 1 (NN24 & ISFOE24)

11:30-13:30	**Workshop on AI, ML, Intelligent Manufacturing and Automation 1 (NN24 & ISFOE24) (Timber Hall 1)** **Chair: S. Lebigre**
11:30-11:35	**Welcome & Opening Remarks** **S. Logothetidis** **ISFOE24/NN24 Chairman**
11:35-12:00 KEYNOTE	**Digital Era of Advanced Materials Design and Development** **N. Konchakova[1]**, S. Belloutar[2], F. Pirker[3], A. Laskarakis[4], P. Klein[5] *[1] Helmholtz-Zentrum Hereon, Geesthacht/ Germany,* *[2] LIST, Luxembourg,* *[3] AC2T Researchg GmbH,* *[4] LTFN, AUTh, Greece* *[5] Fraunhofer-Institut für Techno- und Wirtschaftsmathematik, Germany*
12:00-12:30 INVITED	**In-line and Real-time Nano-characterization technologies for the high yield manufacturing of Flexible Organic Electronics** **A. Laskarakis** *Nanotechnology Lab LTFN, Physics Department, Aristotle University of Thessaloniki, Greece*
12:30-13:00 INVITED	**Update on in-line characterization of compositional, electronic and structural properties of advanced thin film solar cells** **C. Defranoux**, F.Korsos, P.Basa, T.Brigancz, C.Balogh, A.Hajtman *Semilab Co. Ltd., Budapest, Hungary*
13:00-13:15	**Advancing Large-Scale Production: Intelligent Manufacturing of Flexible Printed Organic Photovoltaics** **I. Gkaragkos**, E. Mekeridis, S. Fachouri, S. Zygridou, S. Logothetidis *Organic Electronic Technologies P.C. 20th KM Thessaloniki - Tagarades, Thermi, Greece*
13:15-13:30	**Intelligent fabrication of OEs in the ELORPrintec** **S. Khiev** *ELORPrintec, France*

KEYNOTE TALK

Digital Era of Advanced Materials Design and Development

N. Konchakova[1], S. Belloutar[2], F. Pirker[3], A. Laskarakis[4], P. Klein[5]

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The discovery and utilization of innovation potentials in collaboratively developing new advanced materials and products along distributed production chains are the main goals and services of the VIPCOAT Open Innovation Platform (OIP). We will demonstrate the basic idea of this digital environment, focusing on the co-designing of new active protective coatings for aeronautics applications supported by interoperable data exchange. Since VIPCOAT understands that, in the end, industrial players and their respective ecosystems are responsible for delivering innovations fighting today's grant challenges, the new project DigiPass built on VIPCOAT to contribute to the twin green-digital transition as a cornerstone of today's European strategy. One idea of DigiPass is to support the industry, especially SMEs, in raising their respective digital maturity level and assist them in contributing to innovations in the area of advanced materials and (intermediate) products. The DigiPass goal is to coordinate and support activities to collect requirements and recognize the needs in Digital Materials and Product Passports for different industrial sectors and for collaborative innovation-by-design processes in a circular economy served by advanced materials.

Materials digitalization and Digital Product Passports are among the priorities included in the IAM4EU Strategic Research and Innovation Agenda. This partnership will support digitalization processes that lead to a circular, sustainable, and net-zero-emission European economy that works for society. The VIPCOAT and DigiPass objectives and workplan fit fairly well into these policy requirements as will be discussed in the presentation.

Acknowledgement: **VIPCOAT** H2020-NMBP-TO-IND-2020, Grant Agreement No. 952903; **DigiPass**, HORIZON-CL4-2023-RESILIENCE-01-39, Grant Agreement No. 101138510.

INVITED TALK

In-line and Real-time Nano-characterization technologies for the high yield manufacturing of Flexible Organic Electronics

A. Laskarakis

Nanotechnology Lab LTFN, Physics Department, Aristotle University of Thessaloniki, Greece

INVITED TALK

Update on in-line characterization of compositional, electronic and structural properties of advanced thin film solar cells

C.Defranoux, F.Korsos, P.Basa, T.Brigancz, C.Balogh, A.Hajtman
Semilab Co. Ltd., Prielle Kornelia 4/A. str., H-1117 Budapest, Hungary

As the result of continuous improvement in the performance of thin film solar cells, especially organic, perovskites and tandem cells, they are now ready for high-volume production. For this, the real challenge is to stabilize the layer quality and ensure high yield. Thus, fast, stable, well established and accurate inline characterization methods are required for the proper production control. As a company supplying metrology systems for offline and in line control, we are continuously challenged to improve and adapt our techniques and tools for the actual and in coming structure and device of solar cells. Thanks to our worldwide network, customers and partners, we are able to propose answers to the metrology needs.

This work consists of the actual review of the in-line compatible optical and electro-optical measurement techniques already established or being in development phase to access structural, compositional and electrical performance parameters during the production. Limitations, challenges, and the potential benefit of their in-line usage are discussed in detail via presenting recent results on novel thin-film solar cell layers.

Electrical properties of the various transparent conductive structures must be checked and control in line. We will review the most common and new methods. The control of single layer can be done after each process step and can be used to adjust the parameters of the process. Simple Spectroscopic reflectometer at multi-site on the line is the more practical method. For more complex multilayer, advanced Spectroscopic ellipsometer are used to determine complex and important parameters like thickness, optical properties of the layers. Finally, Photoluminescence and especially imaging PL are applicable to rate the electrical performance and the quality of organic and perovskite solar cell structures, in addition to the defect control in line.

Advancing Large-Scale Production: Intelligent Manufacturing of Flexible Printed Organic Photovoltaics

I. Gkaragkos, E. Mekeridis, S. Fachouri, S. Zygridou, S. Logothetidis
Organic Electronic Technologies P.C. 20th KM Thessaloniki - Tagarades, Thermi, Greece

Although Roll-to-Roll printing is used in the traditional coating and printing industry for many years, only in recent years has been adopted in the manufacturing processes of OPVs. OET in order to provide OPVs with Better Quality, Lower Costs, Higher Efficiencies and Maximum Yield had to move from lab scale non-automated production procedures, to semi-automated and finally to fully automated R2R manufacturing procedures. This presentation focuses on showing the steps that had to be made in order to reach todays state of the art Fully Automated Roll-to-Roll (R2R) technology, and state of the art Automated Assembly Line. Targeting applications in buildings, greenhouses, and electric vehicle (EV) car roofs, OET's OPVs are designed and produced with emphasis on performance, longevity, and societal acceptance. In an era where technology changes from day to day we use cutting edge technology to produce novel OPVs standing at the frontline of the sustainable energy.

Workshop on Bioelectronics 1 (NN24 & ISFOE24)

12:00-13:30	**Workshop on Bioelectronics 1 (NN24 & ISFOE24)** **(Dock Six 1)** **Chair: D. A. Koutsouras**
12:00-12:30 **INVITED**	**Organic Electrochemical Transistors for Disease Diagnostics** **Sahika Inal** *King Abdullah University of Science and Technology, Saudi Arabia*
12:30-13:00 **INVITED**	**Thin-film Electronics for Circumferential Bidirectional Interaction with the Spinal Cord** **Salim El Hadwe** *University of Cambridge, UK*
13:00-13:30 **INVITED**	**Biofunctionalized interfaces for single molecule detection** **G. Scamarcio[1,2],** C. Di Franco[1,2] M. Piscitelli[1] C. Scandurra[3] M. Catacchio[4] E. Macchia[3,4] Luisa Torsi[5] *[1]Dipartimento Interateneo di Fisica, Università degli Studi di Bari Aldo Moro, Bari, Italy* *[2] CNR, Istituto di Fotonica e Nanotecnologie, Sede di Bari, Italy* *[3] Dipartimento di Chimica, Università degli Studi di Bari Aldo Moro, Bari, Italy* *[4] Faculty of Science and Engineering, Åbo Akademi University, Turku, Finland* *[5] Dipartimento di Farmacia-Scienze del Farmaco, Università degli Studi di Bari Aldo Moro, 70125 Bari (Italy)*

INVITED TALK

Organic Electrochemical Transistors for Disease Diagnostics

Sahika Inal

Biological and Environmental Sciences and Engineering Division, King Abdullah University of Science and Technology (KAUST)

Thuwal, Saudi Arabia

Organic mixed ionic and electronic charge conductors provide a unique toolbox for establishing electrical communication with biological systems. In this talk, I will introduce this rising class of materials for bioelectronic interfacing and describe how their multifunctionality can be leveraged to develop next-generation electronic devices operating at aqueous electrolyte interfaces. I will focus on one application where these devices detect biochemical molecules, with several compelling advantages. I will introduce two types of organic electronic sensors: one that detects Alzheimer's disease-associated proteins with performance exceeding that of the state-of-the-art, and the other that detects coronavirus spike proteins at the physical limit. Having challenged these sensors with patient samples, I will discuss areas where proof-of-concept biosensor platforms may fail. By tackling these problems, we improve device performance to a level that marks a considerable step toward biochemical sensing of infectious and noninfectious disease biomarkers.

INVITED TALK

Thin-film Electronics for Circumferential Bidirectional Interaction with the Spinal Cord

Salim El-Hadwe [a,b], Ben J Woodington [a], Jiang Lei [b], Alejandro Carnicer-Lombarte [a], Amparo Güemes-González [a], Tobias E Naegele [a], Sam Hilton [a], Rikin A. Trivedi [c], George G Malliaras [a], Damiano G Barone [a,b]

[a] Department of Engineering, University of Cambridge, UK

[b] Department of Clinical Neuroscience, University of Cambridge, UK

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Background: Advancements in bioelectronics and Organic Mixed Ionic–Electronic Conductors (OMIECs) are propelling spinal cord research into new frontiers, particularly with the introduction of direct intra-dural implantation [1,2]. These developments have led to electrodes with low impedance and high charge storage capacity, enhancing electrochemical performance and minimizing tissue trauma [3,4]. Building on this progress, we have designed a groundbreaking flexible device that can be conformably wrapped around the spinal cord. This device leverages the functional anatomy of the spinal cord for precise, high-fidelity neural interfacing, representing a significant innovation in neuro-prosthetics [5].

Methods: We evaluated our device's efficacy and versatility through implantations in diverse models. Initially tested in rodents for basic functionality and safety, the study progressed to larger animals, examining its adaptability and performance. Trials on human cadavers were also conducted, simulating its clinical applicability and anatomical integration.

Results: Implanted in rodents and porcine models, the device demonstrated successful implantation and high-resolution interfacing with the spinal cord in animal models. This was evidenced by the elicited muscle activation and effective recording in chronic settings, signifying its potential for precise control and therapeutic application in spinal cord pathologies and research.

Conclusion: Our research marks a substantial leap in spinal cord interface technology. The success across diverse models underscores the device's adaptability and potential in clinical settings.

1. Jackson, A. & Zimmermann, J. B. Neural interfaces for the brain and spinal cord—restoring motor function. Nature Reviews Neurology. DOI: 10.1038/nrneurol.2012.219.

2. Minev, I. R., et al. Electronic dura mater for long-term multimodal neural interfaces. Science. DOI: 10.1126/science.1260318 .

3. Jiang, L., Woodington, B. J., Carnicer-Lombarte, A., Malliaras, G., & Barone, D. G. Spinal cord bioelectronic interfaces: opportunities in neural recording and clinical challenges. Journal of Neural Engineering, 19(2), 021003 (2022). DOI: 10.1088/1741-2552/ac605f.

4. Khodagholy, D., et al. NeuroGrid: recording action potentials from the surface of the brain. Nature Neuroscience. DOI: 10.1038/nn.3905.

5. Barone, D. G., Woodington, B. J., Lei, J., Carnicer-Lombarte, A., Güemes, A., Naegele, T., Hilton, S., El-Hadwe, S., Trivedi, R., & Malliaras, G. Flexible Circumferential Bioelectronics to Enable 360-degree Recording and Stimulation of the Spinal Cord. Preprint. DOI: 10.21203/rs.3.rs-3179147/v1.

INVITED TALK

Biofunctionalized interfaces for single molecule detection

Gaetano Scamarcio,[1,2] Cinzia Di Franco,[1,2] Matteo Piscitelli,[1] Cecilia Scandurra,[3] Michele Catacchio, [4] Eleonora Macchia,[3,4] Luisa Torsi [5]

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The structural and electrostatic properties of biolayers deposited on metallic substrates are central for biosensors operating via large-area transducing interfaces. The latter have demonstrated single molecule detection capability, selectivity, compactness, and robustness of the electronic transduction. Such a complex collective phenomenon generated at the biolayer interface is triggered by affinity binding events. We will review our recent experimental results and related modeling based on atomic force and Kelvin probe force microscopies, polarization-modulation infrared reflection-absorption spectroscopy (PM-IRRAS), electrolyte-gated field-effect transistor characteristics, and ζ-potential. The outcome of this comprehensive analysis has profound implications for assessing the role of the bio-film structure in the chain of irreversible and cooperative surface state transitions induced by a ligand/receptor interaction.

- E. Macchia et al. Large-Area Interfaces for Single-Molecule Label-free Bioelectronic Detection. Chem. Rev. (2022).
- C. Di Franco et al. Extended Work Function Shift of Large-Area Biofunctionalized Surfaces Triggered by a Few Single-Molecule Affinity Binding Events, Advanced Materials Interfaces, 2201829 (2022).

- C. Di Franco et al. Kelvin probe force microscopy on patterned large-area biofunctionalized surfaces: a reliable ultrasensitive platform for biomarker detection, J. Mat. Chem. C 12, 73 (2024).

Workshop on NanoPhotonics

12:00-13:30	**Workshop on NanoPhotonics** **(Dock Six 2)** **Chair: N. Kalfagiannis**
12:00-12:30 **INVITED**	**Synapse-Mimicking Memristive Phenomena in Carbazole-Bridged Metallo-supramolecular Polymer** **J. Pfleger**, A. Pandey, Y.R. Panthi *Inst.e of Macromolecular Chemistry CAS, Prague, Czech Republic*
12:30-12:45	**Granular Aluminum nanoSQUID** **S. Avraham[1,2]**, S. Bachar[1], A. G. Moshe[3], E. Farbaer[2], G. Deutscher[1] *[1]School of Physics and Astronomy, Tel Aviv Univ., Israel* *[2]Depts Physics & Electrical/Electronic Engineering, Ariel Un., Israel* *[3]Nat. Inst.e of Chemical Physics & Biophysics, Estonia*
12 :45-13:00	**0D + 1D = 2D Graphene-Like Heterostructures by Supramolecular Assembly of MWCNT** **J. Texter[1,2,3]**, Q. Li[1], and F. Yan[1] *[1]Dept. of Polymer Science and Engineering, College of Chemistry, Chemical Engineering and Materials Science, Soochow Un.Suzhou ,China* *[2]Coating Research Inst.e, School of Engineering,Eastern Michigan Un., USA* *[3]Strider Research Corporation, Rochester, USA*
13:00-13:15	**Investigation of photo response and carrier mobility in thin α-IGZO layers with the PDL-1000** **A. Bojtor[1,2]**, G. Paráda[1], P. Tüttő[1], H. Korka[1], K. Szőke[1], F. Korsós[1] *[1] Semilab Co. Ltd., Budapest, Hungary* *[2] Dept. of Physics, Inst.e of Physics, Budapest Un. of Technology and Economics, Hungary*
13:15-13:30	**Nonlinear optical phenomena in BIC metasurface** **K. Branko[1]**, E. Pruszynska-Karbownik,[1] T. Fas,[1] Dmitriy Yavorskiy[2,3] B, Stonio[4] J. Wrobel[3] T. Stefaniuk[1] R. Bozek[1] P. Karbownik[5] W. Pacuski[1] T. Czyszanowski[6] , J. Suffczynski[1] *[1]Faculty of Physics, Un. of Warsaw, Poland* *[2]Centera Laboratories, Inst.e of High Pressure Physics, Polish Ac. of Sci., Poland* *[3]Inst.e of Physics, Pol. Ac. Sci., Poland* *[4]CEZAMAT, Warsaw Univ. Techn., Poland* *[5]Center of Dev. & Implementation, Poland* *[6]Inst.e of Physics, Łódź Un. of Technology, Poland*

INVITED TALK

Synapse-Mimicking Memristive Phenomena in Carbazole-Bridged Metallo-supramolecular Polymer

J. Pfleger, A. Pandey, Y.R. Panthi

Inst.e of Macromolecular Chemistry CAS, Prague, Czech Republic

Memristors with neurosynaptic functionality acquire multimodal resistance values depending on the number and frequency of excitatory or inhibitory pulses, mimicking the modulated synaptic weight. Memristors made of organo-metallic complexes have been extensively studied for their application in non-volatile memory and brain-inspired neuromorphic computing. In the presented study, carbazole-linked bis-terpyridyl ligand was synthesized and complexed with different metal ions, forming a metallo-supramolecular polymers (SPM). The resistive memory and synaptic plasticity effects were studied using two terminal memristor device arrangement. With the ligand only, a non-volatile bistable memory behaviour was observed, with ON/OF ratio over 100, and the data retention time of 18 h, which makes the compound applicable in organic non-volatile memory devices. When complexed with Co(II) ions, a synaptic plasticity was observed, documented by more than 400 reproducible potentiation and depression cycles. Voltage-induced modulation of synaptic weight was found for small voltage (below 500 mV) and for short pulses (below 20 ms). The synaptic weight change of more than 12% was observed during paired-pulse facilitation, and more than 80% conductance decrease was achieved with paired- pulse depression, when the time between subsequent pulses was as low as 40 ms. The results show that the memristor with the active layer made of the SMP can learn and memorize like biological neurons and can be utilized in brain-inspired neuromorphic computing. The combined electronic and ionic conductivity of the SPM together with the redox activity of the ligand and of the Co(II) complex play a role in continuous resistance changes of the active layer, which are responsible for its behaviour simulating the synaptic plasticity.

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Granular Aluminum nanoSQUID

S. Avraham[1,2], S. Bachar[1], A. G. Moshe[3], E. Farbaer[2], G. Deutscher[1]

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Granular aluminum is an applied quantum material. It exhibits rich physics through its Mott metal-to-insulator transition and features useful properties such as high kinetic inductance, low microwave losses, and large nonlinearity, making it suitable for a wide range of applications [1]. Possible modeling of its superconducting state suggests a description in terms of an inter-grain Josephson junction network. We study this approach by investigating supercurrent interferometers based on granular aluminum nanobridges. Interestingly, despite being much longer than the superconducting coherence length, these nanobridges behave as Josephson junctions. Moreover, these devices exhibit high flux sensitivity and allow conventional readout, making them promising nano-superconducting quantum interference devices [2]. We attribute our devices' performance to a narrow grain size distribution in our films. This nanostructure may be considered as a network of Josephson tunnel junctions, formed by Al superconducting islands 2 nm in size, coupled through thin and uniform AlO_x insulating barriers with a thickness of 1 nm. It enables nanobridge length to increase while maintaining a single-valued current-phase relation.

[1] A. G. Moshe, E. Farber, and G. Deutscher, Appl. Phys. Lett. 117, 062601 (2020).

[2] S. Avraham, S. Bachar, A. G. Moshe, E. Farber, and G. Deutscher, Appl. Phys. Lett. 123, 172601 (2023).

0D + 1D = 2D Graphene-Like Heterostructures by Supramolecular Assembly of MWCNT

J. Texter[1,2,3], Q. Li[1], and F. Yan[1]

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Advances in catalytic coatings, membranes, and electrocatalysis are resulting from novel heterostructured multiphase materials of high specific surface area. We are developing nonwoven mats made by electrospinning that comprise 2D-heterostructures derived from dispersions of 0D-nanolatexes (NL) and 1D-MWCNT (multiwall carbon nanotubes) stabilized in aqueous polyvinyl alcohol (PVA) solutions. A recent report showed how to coat graphene nanosheets in randomly oriented networks with nanofiber network connectivity so that the 2D anisotropy inherent to such nanosheets is ***retained*** in the resulting coatings. This anisotropy result is obtained by operating close to a hydrodynamic linear instability, and here we further capitalize on operating close to such a hydrodynamic instability boundary between electrospraying and electrospinning. Rather than obtaining a typically fibrous web of predominantly 1D anisotropy, we observe the ***creation*** of graphene-like 2D membranes composed of close-packed MWCNT and bound by mixtures of NL and PVA. These meso-networks of 2D membranes, coated at 0.5-8 mg/cm^2 on current collectors, are composed of PVA and NL that remain after drying and are remnants of drained menisci supported by meso-networks of MWCNTs. Morphological aspects resolved at high magnification illustrate a redistribution of NLs during multiphase suspension formation, electrospinning, and drying that transfer NLs from MWCNT surfaces to μ-films supported between MWCNTs. These observations provide a basis for designing supramolecular 2D networks based on coupling a hydrodynamic instability with colloidal network re-equilibration.

Investigation of photo response and carrier mobility in thin α-IGZO layers with the PDL-1000

A. Bojtor[1,2], G. Paráda[1], P. Tüttő[1], H. Korka[1], K. Szőke[1], F. Korsós[1]

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Indium gallium zinc oxide (IGZO) is a popular material for thin film transistor and flat panel display fabrication. The amorphous (α-IGZO) variant has been recognized as an ideal channel layer for thin film transistors due to the low manufacturing temperature and outstanding electrical properties. The light induced change in the electrical properties of semiconductor materials can help with the understanding of processes that control charge carrier dynamics. This can lead to a better manufacturing process since desired sample parameters can be favoured during manufacturing. We used the Parallel dipole line (PDL) AC Hall effect measurement technique to monitor the saturation and relaxation of sample parameters during and after excitation with an UV LED. The PDL system utilizes rotating magnets to realize the AC Hall measurement with harmonical modulation of the magnetic field in a compact design. We conducted photoexcited measurements on an α-IGZO sample series that consisted of samples with varying layer thickness, oxygen concentration during the fabrication process, and the presence and absence of an insulation layer. During our measurements we observed the persistent photoconductivity (PPC) effect and measured the saturation and relaxation time of sample properties during and after illumination. We analysed the relaxation curves with an exponential decay and a decay based on power law. By comparing the two methods we found the power law to be a better fit for the saturation and relaxation processes we observed which agrees with the prediction of a distributed electron state density model within the band edge. This method is applicable for the characterization of samples showing the PPC effect. We investigate the effect of elevated temperatures on sample properties during and after illumination and observed the change in the characteristic time of PPC.

Nonlinear optical phenomena in BIC metasurface

K. Branko[1], E. Pruszynska-Karbownik,[1] T. Fas,[1] Dmitriy Yavorskiy[2,3] B, Stonio[4] J. Wrobel[3] T. Stefaniuk[1] R. Bozek[1] P. Karbownik[5] W. Pacuski[1] T. Czyszanowski[6], J. Suffczynski[1]

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Bound states in the continuum (BICs) represent a remarkable and counter-intuitive phenomenon in wave physics, where certain localised states do not decay despite coexisting with a continuum of radiating states. BICs are characterised by their ability to trap and maintain waves with an extremely high quality factor (Q). Although the concept was theoretically proposed many years ago, its application in photonics, particularly in the form of optical BICs, is relatively recent [1]. Optical BICs provide a unique opportunity to utilize periodically structured materials as high Q-factor resonators. A notable effect resulting from the presence of BICs in these structures is the confinement of light within an exceptionally small mode volume. This can be leveraged for various applications, including flat, ultra-compact devices for lasing or wavefront control [2]. In our study we investigate the process of third harmonic generation (THG) in a subwavelength diffraction grating engraved lithographically in ultrathin, MBE grown layer of MoSe2. Initially, using polarization-resolved reflectivity measurements, we confirm that the fabricated gratings host a specific type of confined optical mode exhibiting BIC behavior. Subsequently, we conducted wavelength- and angle-dependent measurements of THG. Our results show a significant enhancement of the signal compared to that of unstructured MoSe2, and we identify the conditions under which this effect is most pronounced.

[1] Marinica, D. C., Borisov, A. G. & Shabanov, S. V. Bound states in the continuum in photonics. *Phys. Rev. Lett.* **100**, 183902 (2008)

[2] Carletti, L., Koshelev, K., De Angelis, C., & Kivshar, Y. (2018). Giant Nonlinear Response at the Nanoscale Driven by Bound States in the Continuum. Phys. Rev. Lett., 121(3), 033903.

Workshop on Polymers

12:00-13:30	**Workshop on Polymers** **(Crystal Hall)** **Chair: E. P. Giannelis**
12:00-12:30 **INVITED**	**The nanolayering of polymers: a tool for the improvement of their mechanical and gas barrier properties** **A. Guinault** *PIMM lab, UMR Arts et Métiers, Cnrs and Cnam, France*
12:30-13:00 **INVITED**	**A humidity-responsive actuator with high sensitivity, based on cross-linked composite monolayer membranes with dual conductivity** I. Tzoumani[1], D. Druvari[1], K. C. Andrikopoulos[1], A. Dominguez-Alfaro[3], G. G. Malliaras[3], **J. K. Kallitsis[1,2]** *[1] Dept. of Chemistry, Un. Patras, Greece* *[2] Foundation for Research and Technology-Hellas, Inst.e of Chemical Engineering Sci. (FORTH/ICE-HT), Greece* *[3] Electrical Engineering Division, Dept. of Engineering, Un. of Cambridge, Cambridge, UK.*
12:30--13:00 **INVITED**	**Designing Nanostructured Single-ion Polymer Electrolytes for Solid State Lithium Metal Batteries** **E. Glynos** *Dept. Materials Science and Engineering, Un. of Crete, Greece & IESL FORTH, Greece*

INVITED TALK

The nanolayering of polymers: a tool for the improvement of their mechanical and gas barrier properties

A. Guinault

PIMM laboratory, CNAM, 151 bd de l'hôpital, Paris, France

The improvement of the properties of a polymer is currently realized by different techniques as crystallization, addition of fillers or nanofillers, combination with another polymer by blending or by coextrusion or stretching for example. New ways are studied to reach better properties. One of them consists in using the original layer-multiplying co-extrusion process (LMCP) in order to create nanometric thick layers alone or in combination with the latest classical techniques. This technology is environmentally friendly and health secured and has already proved its efficiency to improve the gas barrier properties for other polymers by the way of an improved crystallization.
We will present successively results on:
- the improvement of the gas barrier properties of PLA (Polylactic acid) where It has been shown that geometrical confinement at the nanometric scale generated by LCMP avoids the formation of a rigid amorphous fraction (RAF) during the crystallization, that was shown as a higher permeable phase in PLA,
- and the improvement of the mechanical and the gas barrier properties of PEF (Polyethylene Furanoate) in crystallized biaxially stretched nanolayered PET-PEF films. While PEF alone is too brittle to withstand any deformation, it was possible to biaxially stretch amorphous PEF/PET multilayered films with draw ratio as high as 4,5 x 4,5. After a subsequent crystallization, an improvement of a factor 4, compared to the bulk PEF, has been obtained for the gas barrier properties. It was also shown that the LCMP leaded to better puncture mechanical properties of the PET-PEF films compared to a classical 3-layers co-extrusion.

INVITED TALK

A humidity-responsive actuator with high sensitivity, based on cross-linked composite monolayer membranes with dual conductivity

I. Tzoumani[1], D. Druvari[1], K. C. Andrikopoulos[1], A. Dominguez-Alfaro[3], G. G. Malliaras[3], **J. K. Kallitsis[1,2]**

[1] Department of Chemistry, University of Patras, Greece
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[3] Electrical Engineering Division, Department of Engineering, University of Cambridge, UK.

CNT-based humidity-responsive membranes possess promising applications across diverse fields, owing to the distinctive characteristics of CNTs. Such sensors find utility in various applications including health and weather monitoring. Additionally, they hold potential for the development of actuators suitable for constructing non-contact human machine interfaces, energy harvesting applications or facilitating advancements in soft robotics[1,2,3]. In the present work, we present the development of intelligent monolayered membranes exhibiting exceptional sensitivity to humidity. Water-soluble functional polymers are employed to manufacture flexible cross-linked composite membranes with mixed conductivity through a simple evaporative casting technique. The production process of these membranes is both cost-effective and scalable, offering environmental friendliness by utilizing a water-based processing approach. The fabricated membranes are analyzed for their microstructure morphology, physicochemical, and mechanical properties, and their humidity sensing capabilities are extensively studied through conductivity and curvature measurements. These smart composite films, capable of responding to humidity gradient, are highly promising for applications such as non-contact switches or materials for soft robotics. Additionally, they demonstrate effectiveness as hygroelectric generators, introducing a novel approach to Moisture Electricity Generators (MEGs).

[1] Druvari, D. et al. *ACS Appl. Mater. Inter*. **2023**, *15*(8), 11193–11207.
[2] Wei, J. et al. *ACS Appl. Mater. Inter.* **2021**, *13*, 54417−54427.
[3] Guan, P. et al. *Small* **2022**, *18*, 2204603.

INVITED TALK

Designing Nanostructured Single-ion Polymer Electrolytes for Solid State Lithium Metal Batteries

E. Glynos

Department of Materials Science and Engineering, University of Crete, Greece & Institute of Electronic Structure and Laser, Foundation for Research and Technology-Hellas, Heraklion, Crete GR, Greece

Single-ion solid polymer electrolytes (SI-SPEs) hold the key for the realization of safe, high energy-density Li-metal batteries as their mechanical resistance could reduce, or even suppress Li dendrite formation and eliminate the associated safety hazards. Despite the significant research effort in SI-SPEs, the realization of their potential has been hindered by the incapability to design materials that possess simultaneously good mechanical properties, , high ionic conductivity, and cation transference number close to unity. In this talk, I will outline our current research effort towards the design and developement of high-performance SI-SPEs. In particular, I will introduce the use of novel, stiff/glassy, polyanion nanostructured polymer particles, as (i) single-component nanostructured materials where the entire SI-SPEs will be created by the nanoparticle as building blocks, and (ii) as additives to liquid, low molecular weight fast conducting polymer electrolytes. As it will be discussed during the talk, the proposed macromolecular design approach offers new means to control the morphology of SI-SPEs and to decouple and tune the antagonistic properties of ion-conductivity and shear modulus, which currently limits the realization of single-ion polymer electrolytes in lithium metal batteries.

Workshop on Energy

15:00-17:30	**Workshop on Energy** **(Crystal Hall)** **Chair: A. Guinault**
15:00-15:30 **KEYNOTE**	**Fine-Tuning the Surface and Interfacial Properties of Nanoparticles to Modulate and Control Assembly at Interfaces** **E. P. Giannelis** *Materials Science and Engineering, Cornell University, USA*
15:30-16:00 **INVITED**	**Nanoengineered interfacial materials for energy conversion and storage devices** **G.P. Demopoulos**, S. Wang, A. La Monaca *Materials Engineering, McGill University, Montreal, Canada*
16:00-16:30 **INVITED**	**Functionalized two-dimensional transition metal dichalcogenides for energy applications** **I. K. Sideri**, N. Tagmatarchis *Nat. Hellenic Research Foundation, Theoretical and Physical Chemistry Inst.e Greece*
16:30-17:00 **INVITED**	**Application of reduced graphene oxide for energy conversion and storage** **O. Okhay[1]**, A. Tkach[2] *[1]TEMA-Center for Mechanical Technology and Automation, Dept. of Mechanical Engineering, Un. of Aveiro, Portugal* *[2]CICECO – Aveiro Inst.e of Materials, Dept. of Materials and Ceramic Engineering, Un. of Aveiro, Portugal*
17:00-17:15	**Exploit4InnoMat: An Open Innovation Ecosystem for exploitation of materials for building envelopes towards zero energy buildings** **P. Angelopoulos**, A. Skaropoulou, C. Panagiotopoulou, A. Peppas, M. Taxiarchou *Laboratory of Metallurgy, School of Mining and Metallurgical Engineering, NTUA, Greece*
17:15-17:30	**Sustainable Synthesis Strategies for Nanosolutions with Dual Antibacterial and Photocatalytic Properties** **M. Adriana[1]**, M. Ornelas[1], R. G. Bárbara[1], C. Lorena[1], M. Giuliana[2,3], D. Francesca[4], A. Stefano[5], M. Marco[5] *[1] CeNTItvc - Centre for Nanotechnology and Smart Materials, Portugal* *[2] Dipartimento di Chimica, Università degli Studi di Torino (UNITO), Torino,Italy* *[3] NIS InterDept.al Centre, Università degli Studi di Torino, Torino, Italy* *[4] CNR Istituto per lo Studio dei Materiali Nanostrutturati, Italy* *[5] Consiglio Nazionale delle Ricerche (CNR) Istituto di Ricerca Sulle Acque (IRSA), Italy*
17 :30-17 :45	**6G industrially scalable metal oxide diodes fabricated via rapid photonic sintering** **L. Panagiotidis[1]**, H. Faber[1], Y. Yu[2], S. Doukas[3], L. Luo[1], M. Ghadiyali[1], G. T. Harrison[1], D. Naphade[1], S. Mandal[1], W. S. Alghamdi[1], H. F. Mazo-Mantilla[1], T. Maksudov[1], G. Pappas[1], U. Schwingenschlögl[1], S. Fatayer[1], E. Lidorikis[3], A. Shamim[2] and T. D. Anthopoulos[1] *[1] Physical Science and Engineering Division, KAUST Solar Center, KAUST, Saudi Arabia* *[2] Computer, Electr., Mathem. Science and Engineering Division, KAUST, Saudi Arabia* *[3] Dept Materials Science & Engineering, Un. Ioannina, Greece*

KEYNOTE TALK

Fine-Tuning the Surface and Interfacial Properties of Nanoparticles to Modulate and Control Assembly at Interfaces

E. P. Giannelis
Materials Science and Engineering, Cornell University, Ithaca, NY 14853, USA

Manipulating the properties of interfaces using nanoparticles has attracted widespread attention due to both scientific interest as well as use in practical applications including food, pharma, energy production and environmental remediation. For example, the assembly of nanoparticles at interfaces stabilizes emulsions (so called Pickering emulsions) and offers the possibility to synthesize materials with controlled interfacial properties. By varying the chemistry and dimensionality of the nanoparticles, the adsorption energy and thus the interfacial properties can be modulated and controlled. In some cases, interfacial assembly of nanoparticles leads to a solid-like behavior or *jamming* with interfaces behaving like an elastic membrane with high modulus. Surface functionalization of nanoparticles is a necessary and critical step to fine-tune their inter- and intramolecular interactions and thus their interfacial assembly. In this talk, I will present a newly developed family of nanoparticles and discuss their assembly as a means to fine-tune the properties of emulsions especially under harsh environmental conditions.

INVITED TALK

Nanoengineered interfacial materials for energy conversion and storage devices

G.P. Demopoulos, S. Wang, A. La Monaca
Materials Engineering, McGill University, Montreal, Canada

In this presentation the importance of interface nanoengineering for energy conversion and storage devices will be discussed. The presentation will cover the interface nanostructure influence in hybrid perovskite solar cells, extend into the nanolayer architecture of photocatalysts considered in photoelectrochemical hydrogen generation cells, and end with interfacial engineering of hybrid polymer-in-ceramic solid electrolytes for all-solid-state lithium metal batteries (ASSBs). In the case of perovskite solar cells, we address the hysteresis problem via interfacial engineering of the two charge extraction films, the ETL [*Nanoscale*, 2023, 15, 2152 – 2161] and HTL [*J. Phys. Chem. C*, 2024, 128, 2, 710–722]. In the former study, the electron transport layer (ETL) nanostructure effect on charge transfer resistance across perovskite interface and the appearance of inductance due to ionic accumulation at the ETL interface was analysed via EIS. In the latter case the impact of photo-induced doping of spiro-OMeTAD on hysteresis is analysed. After that the photocatalytic splitting of water using nanostructured bismuth vanadate as photoanode is addressed. The importance of hetero-junctioning in facilitating charge separation/extraction and passivation to prevent photocorrosion will be discussed. The final part of our presentation is devoted to the recent successful design and development of highly conducting and robust hybrid solid-state electrolytes (HSE) (garnet@polymer-LiTFSI) that show remarkable stability [*Advanced Materials,* Submitted]. The HSE is made of a novel mesoporous ceramic film built from near nanosized garnet particles [*JPS* 595 (2024) 234061] and molecular bonding enabling the attainment of Li-ion conductivity 200% higher than that of the best dense garnet film. The newly designed HSE structures show very low interfacial impedance and stable ASSB performance.

INVITED TALK

Functionalized two-dimensional transition metal dichalcogenides for energy applications

I. K. Sideri, N. Tagmatarchis
National Hellenic Research Foundation, Theoretical and Physical Chemistry Institute, Athens, Greece

Functionalized two-dimensional transition metal dichalcogenides (2D TMDs) have emerged as a promising avenue for advancing energy applications. In this talk the intricate methodologies that we have employed for the covalent functionalization of MoS_2, illuminating the strategies for precisely tuning the surface chemistry of TMDs, will be discussed. Leveraging covalent modifications with chromophores, the synergistic effects to engineer tailored properties in these 2D TMDs are harnessed. The capabilities of hybrid TMDs in facilitating electron and energy transfer phenomena pave the way for enhanced light harvesting and potential optoelectronic device performance. Electrochemical studies reveal their prowess in electrocatalysis, underscoring their potential in sustainable energy conversion technologies. Furthermore, the fabrication of cells for photocurrent measurements unveils their proficiency in harnessing solar energy. The realm of biosensing, capitalizing on host-guest interactions facilitated by hydrogen-bonding formations is subsequently explored. Through this comprehensive exploration, we aim to elucidate the transformative potential of functionalized 2D TMDs in diverse energy applications, driving forward the frontier of materials science towards sustainable and efficient energy solutions.
The research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the "2nd Call for H.F.R.I. Research Projects to support Faculty Members & Researchers" (Project Number 2482).

INVITED TALK

Application of reduced graphene oxide for energy conversion and storage

O. Okhay[1], A. Tkach[2]
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[2] CICECO – Aveiro Institute of Materials, Department of Materials and Ceramic Engineering, University of Aveiro, Portugal

Energy conversion and storage is one of the most important topics of scientific research today. Reduced graphene oxide (rGO) is a promising material for improving the structural - electrical property relationship of thermoelectric materials (used to transform temperature gradient into electrical energy) and the structural - electrochemical property relationship of capacitive electrodes (used in supercapacitors and batteries). In addition, rGO aerogel, which has a large specific surface area, is a more promising material for energy storage compared to dense rGO membranes obtained by vacuum filtration. Thus, the preparation process of rGO, as well as composite materials based on rGO, plays a significant role in the final material and device performance.

Acknowledgements
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6G industrially scalable metal oxide diodes fabricated via rapid photonic sintering

L. Panagiotidis[1], H. Faber[1], Y. Yu[2], S. Doukas[3], L. Luo[1], M. Ghadiyali[1], G. T. Harrison[1], D. Naphade[1], S. Mandal[1], W. S. Alghamdi[1], H. F. Mazo-Mantilla[1], T. Maksudov[1], G. Pappas[1], U. Schwingenschlögl[1], S. Fatayer[1], E. Lidorikis[3], A. Shamim[2], T. D. Anthopoulos[1]

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[3] Department of Materials Science and Engineering, University of Ioannina, Greece.

Emerging wireless radio-frequency applications require mass manufacturing of efficient high-speed devices, such as rectifiers, transistors, and antennas capable of operating at frequencies exceeding 1 GHz. However, precise and high-throughput fabrication of inexpensive electronics that can meet these stringent demands remains a challenge. Herein, we report the development of solution-processed indium- gallium-zinc-oxide (IGZO) Schottky diodes fabricated using a wafer-scale patterning technique called adhesion lithography (a-Lith). This method allows patterning devices with asymmetric interdigitated electrodes made from two dissimilar conductive materials separated by a gap < 20 nm. When combined with the n-type semiconductor IGZO, the nanogap electrode architecture enables the development of Schottky diodes with high cut-off frequency owing to short carrier transit times. We demonstrate that the performance and manufacturability of these planar diodes can be further advanced by replacing conventional thermal annealing (TA) of IGZO with rapid flash lamp annealing (FLA). This optical-based curing step is scalable and drastically reduces the processing time of the semiconductor to a few seconds while delivering better-performing diodes than those produced via TA. Furthermore, replacing the single material electron-injecting contact with a bilayer system allows for work function tuning and improved electron injection to the conduction band of IGZO. Diodes featuring bilayer injecting contacts and optical sintered IGZO exhibit lower turn-on voltage, high current rectification ratio (10^5), and an intrinsic cut-off frequency exceeding 180 GHz. RF rectifier circuits built using the optimized Schottky diodes exhibit extrinsic cut-off frequencies of over 50 GHz, making them ideal candidates for future ubiquitous RF applications.

Workshop on Bioelectronics 2 (NN24 & ISFOE24)

15:30-17:00	**Workshop on Bioelectronics 2 (NN24 & ISFOE24)** **(Dock Six 1)** **Chair: S. El-Hadwe**
15:30-16:00 **INVITED**	**Bioelectronic devices and Therapeutic applications** **D. A. Koutsouras** *Imec-NL, High Tech Campus 31, 5656 AE Eindhoven, The Netherlands*
16:00-16:15	**Detection of chloride in sweat with extended-gated organic electrochemical transistors** **C. Bortolotti[1,2,]** A. Kyndiah[2], A. Aliverti[1], M. Caironi[2] *[1] Dip. Elettronica, Inform. Bioing., Politecnico di Milano, Italy* *[2] Center for Nano Science and Technology @PoliMi, IIT, Italy*
16:15-16:30	**Monitoring of 3D-bioengineered biohybrid actuators by means of Organic Transistor-based mechanical sensors** **S. Lai[1]**, J. Fuentes Llanos[2], G. Casula[1], P. Cosseddu[1], M. Guix Noguera[3], S. Sánchez[2,4] *[1]Department of Electrical and Electronic Engineering, University of Cagliari, Italy* *[2]Institute for Bioengineering of Catalonia (IBEC), The Barcelona Institute of Science and Technology, Spain* *[3] Departament de Ciència dels Materials i Química Física, University of Barcelona (UB), 08028 Barcelona, Spain* *[4]Catalan Institute for Research and Advanced Studies, Spain*
16:30-16:45	**WGM Sensors for future diagnostics: identification of small molecules to whole organisms** **W.E.A. Krames[1,3],** D. I. Dayi[1], M. Borgolte[1], L. Kaiser[1], M. Himmelhaus[2], R. Csuk[3], H.-P. Deigner[1,4,5] *[1]Institute of Precision Medicine, Furtwangen Un. Germany* *[2]NanoBioAnalytics, Germany* *[3]Institute of Organic Chemistry, Martin-Luther University, Halle-Wittenberg, Germany* *[4]EXIM, Fraunhofer Institute IZI (Leipzig), Germany* *[5]Faculty of Science, Eberhard Karls Univ. Tuebingen, Germany*
16:45-17:00	**In vivo study of bioresorbable nanostructured chemical sensor for monitoring of pH level** **E. Vandini[1]**, M. Corsi[2], A. Paghi[2], S. Mariani[2], G. Golinelli[3], A. Debrassi[4], G. Egri[4], G. Leo[1], A. Vilella[1], L. Dähne[4], D. Giuliani[1], G. Barillaro[2]. *[1] Dept Biomedical, Metabolic and Neural Sciences, University of Modena and Reggio Emilia, Italy* *[2] Dept Information Engineering, University of Pisa, Italy* *[3] Dept Medical & Surgical Science Children & Adults, Univ. Hospital Modena & Reggio Emilia, Italy* *[4] Surflay Nanotec GmbH, Germany*

INVITED TALK

Bioelectronic devices and Therapeutic applications

D. A. Koutsouras

Imec-NL, High Tech Campus 31, 5656 AE Eindhoven, The Netherlands

Bioelectronics is the interdisciplinary field which couples biological systems and electronic devices to offer diagnostic and therapeutic solutions. With its origins dating back to the 18th century and the famous experiments of Luigi Galvani with the detached twitching frog legs, a plethora of bioelectronic devices is today available offering elegant ways to monitor and treat diseases. These devices include pacemakers and defibrillators to prevent or correct arrhythmias, cochlear implants to provide the sense of hearing and glucose monitoring devices to help diabetics. Nevertheless, the coupling between biology and electronics is limited by the materials that can form stable interfaces with the tissue and transduce signals across the biotic/abiotic ensemble. Recently, organic electronic materials have gained much attention as a way to overcome this limitation due to their unique properties, which include mixed ionic/electronic conductivity, mechanical flexibility, and enhanced biocompatibility.

In this talk, I will discuss what bioelectronics is and why it holds so much promise for meeting today's unmet medical needs. I will give examples of novel devices for interfacing biology, and I will show that organic electronic materials offer tremendous opportunities to study and treat pathologies.

Detection of chloride in sweat with extended-gated organic electrochemical transistors

C. Bortolotti[1,2], A. Kyndiah[2], A. Aliverti[1], M. Caironi[2]

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Cystic fibrosis (CF) is the most common progressive, life-limiting, multi-organ genetic disease that is caused by mutations affecting the CFTR anion channel, which is involved in chloride ion transport and fluid regulation. Diagnosis and treatment personalization are based on the monitoring of chloride levels in sweat. The current clinical procedure consists of sample collection in the clinic, while the analysis is performed in a laboratory set up by experienced and trained operators. These technical and ethical limitations raise the demand for convenient sweat analysis in non-centralized healthcare facilities and personalized diagnostics. Electrolyte-Gated Transistors (EGTs) have recently been shown to be a potential breakthrough in biosensing applications, since they can be effectively interfaced with biological samples transducing weak biological signal variations into readable electronic output. Therefore, their high amplification gain, compatibility with cost-effective manufacturing processes, miniaturization and operation at low voltages (<1V) make them ideal candidates for low-cost point-of care or wearable devices. In this work, a printed Organic Electrochemical Transistor (OECT) based on (poly(2-(3,3-bis(2-(2-(2-methoxyethoxy)ethoxy)ethoxy)-[2,2-bithiophen]-5-yl)thieno[3,2-b]thiophene) p(g2T-TT) extended-gate comprising of a partially chlorinated silver electrode is used for the monitoring of chloride ions. This architecture allows to exploit the transduction and amplification features of OECTs to convert the potentiometric signal of the sensing element selectively and accurately. The sensing element was first validated by carrying out standard potentiometry in physiologically relevant ranges of chloride, i.e. from 0.1 mM to 100 mM, obtaining a super-Nernstian sensitivity around 75 mV/dec. Additional tests employing different salts containing or not chloride were performed to assess device selectivity. Finally, the extended-gate OECT sensor was tested in the same conditions obtaining a noteworthy response which is superior to values reported in literature. This preliminary in-vitro validation paves the way for a future integration in a portable or wearable architecture.

A printed organic transistor-based ion sensor towards on-skin monitoring of calcium concentration

S. Lai[1], G. Casula[1], F. Mariani[2], F. Ceccardi[2], P. Cosseddu[1], I. Gualandi[2], E.Scavetta[2], A. Bonfiglio[1]
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Since the introduction of the Ion-Sensitive Field-Effect Transistor (ISFET) in the Seventies, the application of field-effect transistor to the detection of different ionic species has been thoroughly explored, mainly for in-vitro applications, with potential performances comparable with classic electrochemical devices and with all the advantages of electronic technologies. Nonetheless, in vivo operation of such sensors can be of great interest for the monitoring and diagnosis of some diseases, e.g. diabetes and cystic fibrosis, directly on biofluids including sweat and interstitial fluid. The suitability of FET-based ionic sensors in this peculiar field requires that technological and design aspects are deepen.

In this abstract, we report about the development of printed organic FET-based sensors for calcium concentration, suited for future integration over ultra-thin substrates that can be directly transferred on skin. The device is based on the working principle of the Organic Charge-Modulated FET (OCMFET), which can operate in a floating measurement environment, i.e. without requiring the integration of reference electrode in the device. Moreover, OCMFET can be designed following precise design rules, which allows adapting the device structure to the specific application field and, therefore, to tailor the sensitivity to the required analytes. In this case, the relatively high concentration of calcium in biofluids such as sweat and interstitial fluid (in the mM range) requires that technological aspects related to charge modulation in the device structure are thoroughly examined. Finally, by exploiting cost-effective technologies such as inkjet printing, future scale-up of the proposed approach to an industrial size is foreseen. A complete analysis of device performances will be discussed, including calibration curves at different device sizing, and sensitivity derivation.

WGM Sensors for future diagnostics: identification of small molecules to whole organisms

W.E.A. Krames[1,3], D. I. Dayi[1], M. Borgolte[1], L. Kaiser[1], M. Himmelhaus[2], R. Csuk[3], H.-P. Deigner[1,4,5]
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In a world that is constantly facing new challenges with diseases and pathogens, rapid diagnosis and determination of these is a decisive advantage. Rapid diagnostics are essential, particularly in view of the increasing incidence of antibiotic resistance and its impact on patient treatment. In addition, the diagnostic tools must be easy to use and have specificity and selectivity. This balancing act between rapid diagnosis, effectiveness and costs is not easy to achieve. In this article, we have looked at the possibilities of the WGM sensor and provided an overview of how this technology can be used in the future. WGM sensors offer a wide range of applications, which can be used not only for the rapid diagnosis of pathogens, but also for the detection of small molecules in very small quantities.

In vivo study of bioresorbable nanostructured chemical sensor for monitoring of pH level

E. Vandini[1], M. Corsi[2], A. Paghi[2], S. Mariani[2], G. Golinelli[3], A. Debrassi[4], G. Egri[4], G. Leo[1], A. Vilella[1], L. Dähne[4], D. Giuliani[1], G. Barillaro[2]

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In vivo chemical sensing could revolutionize health care providing access to the continuous monitoring of drugs and analytes in peripheral blood and tissues, and in turn to individualize reports on disease progression and drug efficacy in real-time. Bioresorbable materials provide a unique opportunity to engineer new electrical, optical, and sensing components into an in vivo biodegradable sensing system that eliminates any boundary between target molecules and sensing devices, without the need of secondary device-retrieval surgery. We report on the manufacturing and in vivo assessment of a bioresorbable nanostructured pH sensor. pH level in the interstitial fluid is an important clinical parameter, as in the areas near tumor structures may be there an acidification. Therefore, a device capable of monitoring pH in the interstitial fluid could provide useful information to verify the regression/progression of a tumor mass after treatment. The sensor consists of a µm-thick poroussilica membrane conformably coated layer-by-layer with a nm-thick multilayer stack of 2 polyelectrolytes labeled with a pH-insensitive fluorophore. The sensor fluorescence changes linearly with the pH value intherange 4 to 7.5 upon swelling/shrinking of the polymer multilayer and enables performing real-time measurements of pH level with high stability, reproducibility, and accuracy, over 100 hours of continuous operation. In vivo studies carried out implanting the sensor in the subcutis on the back of mice confirm real-time monitoring of the local pH level through skin. Full degradation of the pH sensor occurs in 1 week from implant in the animal model, and its biocompatibility after 2 months is confirmed by histological and fluorescence analyses. This approach can be used to detection of biomarkers in vivo by engineering the functionality of one of the polyelectrolytes with suitable receptors, paving the way to implantable bioresorbable chemical sensors.

Workshop on AI, ML, Intelligent Manufacturing & Automation 2 (NN24 & ISFOE24)

15:00-17:00	**Workshop on AI, ML, Intelligent Manufacturing & Automation 2 (NN24 & ISFOE24) (Timber Hall 1)** **Chair: N. Konchakova**
15:00-15:30 **KEYNOTE**	**Digitalization of every step in the production value chain: How to get from digital twins to Coating as a service** **T. Kolbusch** *COATEMA, Germany*
15:30-16:00 **INVITED**	**Efficient mass production for the automated manufacturing of flexible organic photovoltaics by roll-to-roll printing** **E. Mekeridis**, V. Kyriazopoulos, S. Fachouri, S. Logothetidis *Organic Electronic Technologies P.C, Thermi, Greece*
16:00-16:30 **INVITED**	**Sustainable nano-functionalised packaging meeting the challenges of Circular Economy** **S. Lebigre** *CT-IPC, France*
16:30-16:45	**Organic photovoltaic systems integrated in buildings** **S.Zygridou**, E. Mekeridis, I. Gkaragkos, S. Fachouri, S. Logothetidis *Organic Electronic Technologies (OET), 20th KM Thessaloniki - Tagarades, 57001 Thermi Greece*
16:45-17:15 **INVITED**	**Organic and Perovskite Solar Cells: Upscaling Challenges and the Research Revolution via AI-Driven Automatic Experiments** **L. Sutherland** Commonwealth Scientific and Industrial Research Organisation (CSIRO), Melbourne, Australia

KEYNOTE TALK

Digitalization of every step in the production value chain: How to get from digital twins to Coating as a service

T. Kolbusch

COATEMA, Germany

The author describes several developments in the equipment business. The industry is moving from just selling equipment to a different form of customer–supplier relationship called equipment as a service. In the case of Coatema coating equipment, we call it coating as a service. It is not a reality today in all equipment industries but will be in the next 10 years.

In general, the equipment maker supplies time on a production line not owned by the customer anymore and is just charging the used capacity plus service and other fees. This is only possible if several developments are being made.

The full implementation of Industry 4.0, the full control of machine and quality control system data, and the use of this data to improve yield and carbon footprint by implementing AI and having a direct feedback loop into the equipment without the use of a human operator. We could call it an autonomous coating operation in the case of Coatema.

The author describes two possible developments for the European industry, will show integrated quality control systems in several European-funded projects, and will use the production line of the Horizon Europe project Flex2Energy as a case for the implementation approach. A short overview of digital twins and the use of simulation will also be given, to summarize all needed processes.

In the final part of the talk the author will describe the business case of a coating as a service approach and summarize the necessary steps to get there.

INVITED TALK

Efficient mass production for the automated manufacturing of flexible organic photovoltaics by roll-to-roll printing

E. Mekeridis[1], V. Kyriazopoulos[1], S. Fachouri[1], S. Logothetidis[1]

[1] *Organic Electronic Technologies P.C. 20th KM Thessaloniki - Tagarades, Thermi, Greece*

The renewable energy sector is poised for a transformative leap with OPV technology. OPVs, which leverage organic compounds for sunlight-to-electricity conversion, play a pivotal role in this transition, representing a significant departure from traditional manufacturing processes. OET aims to upscale Organic Photovoltaic (OPV) technology from its pilot scale to a full-scale Giga Fab production. This presentation focuses on establishing an industrial-grade manufacturing line for OPVs using Automated Roll-to-Roll (R2R) technology, including R2R Printing and Automated Assembly Machines. Targeting applications in buildings, greenhouses, and electric vehicle (EV) car roofs, OET's OPVs are designed to minimize landscape impact through a sustainable energy production. Emphasizing performance, longevity, and societal acceptance, the project ensures that the OPV manufacturing to Giga Fab transition is not only revolutionary but also eco-friendly. In an era where scalable and eco-conscious energy solutions are imperative, OET's OPV propels us toward a sustainable and innovative energy paradigm. By bridging the gap between OPV development and large-scale manufacturing, OET stands at the frontline of the sustainable energy revolution.

INVITED TALK

Sustainable nano-functionalised packaging meeting the challenges of Circular Economy

S. Lebigre, S. Mani, F. Isnard

IPC (Centre Technique Industriel de la Plasturgie et des Composites), France

In many applications, packaging materials are essential to extend the shelf life or to protect delicate products from damaging environmental influences. In the meantime, recycling of plastics and using recycled materials is an important cornerstone in moving towards the Circular Economy. Nowadays, packaging are often composed of multi-layer laminates that offer high barrier properties to water vapor and oxygen and therefore are highly protective. However, these products are, most of the time, not recyclable. Nanotechnologies is being discussed as a solution approach to replace multilayer materials with a recyclable alternative. Within FlexFunction2Sustain, the objective was to replace multilayer drink pouches by fully recyclable monomaterial laminates in which the gas barrier performance is provided by thin film functionalisation. Thanks to the nanotechnologies applied on this demonstrator, the innovative mono-material pouches can guarantee a comparable shelf life as standard pouches. Likewise, it has been concluded that the new mono-material pouches sufficiently protect the product from UV light and preserve its quality. This recyclable mono-material pouch has recently been launched on the market. This FlexFunction2Sustain technology and many others are gathered into an ecosystem aiming at accelerating the market uptake of nanotechnologies towards the next generation of environmentally friendly plastic and paper products.

Organic photovoltaic systems integrated in buildings

S.Zygridou[1], E. Mekeridis[1], I. Gkaragkos[1], S. Fachouri[1], S. Logothetidis [1]

[1] Organic Electronic Technologies P.C. 20th KM Thessaloniki - Tagarades, Thermi, Greece

The global energy demand increases the last decades and it is mainly covered by the use of fossil fuels. Buildings are responsible for 40% of the European Union's (EU's) total energy consumption and 36% of its greenhouse gas (GHG) emissions. This is the reason why EU has set as target to reduce buildings' GHG emissions to 60% by 2030. Renewable resources of energy are being increasingly used the last years in order to reduce the total GHG emissions. The Sun, as an endless source of energy, has captured human interest and conventional photovoltaics' (PVs) use increases exponentially the last years. The drawbacks of the PV installations though, such as heavy and fixed solar modules, eliminate the range of their applications. Organic Photovoltaics (OPVs) though have emerged as a promising technology and due to their light weight, flexibility, transparency, and recyclability, they can be installed on numerous surfaces, such as glass surfaces and roofs, without the use of a heavy installation. Organic Electronic Technologies (OET) P.C. has successfully produced such flexible printed electronics and has installed them in Buildings, Agriculture and Automotive sectors. The Building-Integrated Organic Photovoltaics (BI(O)PVs) harness the energy of the Sun for a sustainable future. These innovative installations shape a new and promising energy landscape and can facilitate the goal to achieve the EU target for energy savings. The case studies of these successful projects can pave the way to countless applications and therefore, to a greener future. These applications are identified as market opportunities worldwide and especially the countries with high sunshine duration and optimum climate zone, such as the Mediterranean countries.

Organic and Perovskite Solar Cells: Upscaling Challenges and the Research Revolution via AI-Driven Automatic Experiments

L. Sutherland

Commonwealth Scientific and Industrial Research Organisation (CSIRO), Melbourne, Australia

Organic photovoltaics (OPV) and organic-inorganic hybrid perovskite photovoltaics (PePV) are promising PV technologies that can be manufactured using industrial roll-to-roll (R2R) printing which is a widely used mass-production technique for low-cost products. These emerging PV technologies have been making exciting progress toward commercial applications and the efficiencies of the laboratory cells (19.2 % for OPV and 26.1 % for PePV) are already high enough to enter the PV market. However, the efficiency of R2R-produced PV still lags behind those achieved for champion laboratory cells. This is attributed to the materials, processes and device configurations developed for research purposes not being readily translatable to R2R printing, with significant material and process optimisation required to achieve compatibility with scalable R2R processes. The time-consuming optimisation process has delayed the translation of these technologies to the marketplace, necessitating a new revolutionary research method.

Therefore, an automated R2R research platform has been developed to accelerate the progress of R2R-fabricated solar cell technologies. A bespoke R2R coater was developed to optimise formulations and fabrication parameters including deposition conditions, coating speed, and annealing temperature. An *in-situ* formulation technique was introduced to fabricate over 10,000 unique cells a day via unmanned operation, and an automated R2R PV measurement unit has also been developed to test this number of cells in a single day. This revolutionary approach has enabled the rapid progress of R2R-fabricated solar cells, resulting in vacuum-free R2R-fabricated PePV and OPV devices achieving PCEs of 15% and 11%, respectively, both of which are record PCEs in their class. All processing and testing parameters are digitalised to be used as training data for machine learning (ML). The recent progress and the potential of ML-assisted research will be discussed in this talk.

PLENARY SESSION

18:30	**Official Opening Ceremony**
18:30-18:45	**Welcome to NANOTEXNOLOGY** **Prof. S. Logothetidis** **NANOTEXNOLOGY2024 Chairman**
18:45-19:00	**Official Salutations**
19:00-19:45	**PLENARY SESSION** **Carbon Nanotechnology: A Route for Technology Platforms** **Prof. S. Ravi P. Silva** **Director of Advanced Technology Institute (ATI) and Head of NanoElectronics Centre, University of Surrey, UK**
19:45-20:45	**FUTURISTIC NANOTECHNOLOGY EVENT** **A unique show for Applied Nanotechnologies in Fashion, Healthcare & Beauty**
21:00	**OFFICIAL NANOTEXNOLOGY GALA DINNER** **PORTO PALACE CONFERENCE CENTRE & HOTEL - ROOF GARDEN**

Wednesday 3 July 2024

Workshop on Theoretical Modeling in Nanoscale

09:30-11:00	**Workshop on Theoretical Modeling in Nanoscale** **(Crystal Hall)** **Chair: V. Harmandaris**
09:30-10:00 **INVITED**	**Doping of ZnO nanowires grown by chemical bath deposition: the specific case of Ga investigated by X-ray Linear Dichroism and ab-initio calculations** **E. Sarigiannidou[1]**, F. Wilhelm[2], J. Kioseoglou[3], P. Gaffuri[1], E. Appert[1], V. Consoni[1] *[1] Univ. Grenoble Alpes, CNRS, Grenoble INP, LMGP, F-38000 Grenoble, France* *[2] European Synchrotron Radiation Facility (ESRF), France* *[3] Physics Dept., Aristotle Un. of Thessaloniki, 54124 Thessaloniki, Greece*
10:00-10:30 **INVITED**	**Sustainable nano-functionalised packaging meeting the challenges of Circular Economy** **G. Makov** *Dept. of Materials Engineering, Ben-Gurion Un. of the Negev Beer Sheva, Israel*
10:30-10:45	**Molecular Dynamics Study of Nanoribbon Formation by Encapsulating Cyclic Hydrocarbon Molecules inside Single-Walled Carbon Nanotube** **S. Eskandari[1]**, J. Koltai[1], I. László[2], J. Kürti[1] *[1] Dept. of Biological Physics, Eötvös Un., Hungary* *[2] Dept. of Theoretical Physics, Budapest Un. of Technology and Economics, Budapest, Hungary*
10:45-11:00	**Molecular dynamics simulation of the formation of W-centers in silicon by Ga ion irradiation** **C. Gennetidis**[1], P. Chantrenne[1], T. Wood[2] *[1]INSA-Lyon, Université Claude Bernard Lyon, CNRS, MATEIS, France* *[2]INSA-Lyon, Ecole Centrale de Lyon, Université Claude Bernard Lyon, CPE Lyon, CNRS, INL, France*

INVITED TALK

Doping of ZnO nanowires grown by chemical bath deposition: the specific case of Ga investigated by X-ray Linear Dichroism and ab-initio calculations

E. Sarigiannidou[1], F. Wilhelm[2], J. Kioseoglou[3], P. Gaffuri[1], E. Appert[1], V. Consoni[1]

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The low-cost and low-temperature growth by chemical bath deposition (CBD) allows controlled synthesis of ZnO nanowire (NWs) arrays on various substrates with a large surface area. Incorporating group III elements into ZnO NWs increases the charge carrier density, up to the metal-nonmetal Mott transition without distorting the wurtzite structure [1]. Among these elements, Ga has garnered attention for nanoscale engineering devices like LEDs, and transparent electrodes for photovoltaics. Usually, the modification of the properties of Ga-doped ZnO NWs has systematically been attributed to the formation of GaZn defects acting as shallow donors. Our group combined thermodynamic computations and experiments, and managed to elucidate the physicochemical processes of ZnO NWs by CBD using Ga nitrate as an additive for their doping in aqueous solution [2]. However, the exact nature of related defects in Ga-doped ZnO NWs remains unclear, with hydrogen's role in aqueous solution being a consideration. Here, we employ hard X-ray linear dichroism (XLD) to unveil Ga dopant atoms' local structure and atomistic configurations in the ZnO NW lattice. Theoretical computations of Ga absorption K-edge using ab initio calculations via FDMNES and relaxed crystal structures by VASP are performed, considering different Ga atom positions and all possible defect complexes with zinc vacancies, with or without hydrogen atoms. This investigation re-examines ZnO NW doping with Ga and underscores the correlated contribution with hydrogen when using a medium in aqueous solution [3].

[1] A. Janotti, C.G. Van De Walle, Reports Prog. Phys. **2009**, 72, 126501
[2] P. Gaffuri et al, Inorg. Chem. **2019**, 58, 10269
[3] E. Sarigiannidou et al, Physical Review Materials, **2023,** 7, 076001

INVITED TALK

Novel nanometric phases of the monochalcogenides: Theory meets experiment

G. Makov

Department of Materials Engineering, Ben-Gurion University of the Negev Beer Sheva, Israel

Tin and germanium monochalcogenide binary compounds, M(=Ge,Sn)X(=S,Se), are earth-abundant, low-toxicity material families relevant for energy applications. They have recently been found to present multiple novel phases with new functional properties at the nanoscale. These phases belong to an extended family of *metastable* phases in the bulk. Since they have been synthesized experimentally, it was hypothesized that they are stabilized as nanometric particles by size effects, solution ligands, or the substrate surface. To identify the controlling mechanisms in stabilizing metastable phases, we modeled the surface energies, effects of ligand absorption, and the interactions with substrate surfaces, focusing on the low-symmetry cubic-pi- and gamma-phases of SnS and SnSe. Our results explain the experimental conditions and elucidate the role of ligands and substrate effects on these processes. This approach can help design ab initio syntheses of metastable phases.

E. Segev et al., CrystEngComm 20, 4237 (2018)
R.E. Abutbul et al., Nanoscale 11, 17104 (2019)
R.E. Abutbul et al. ACS Crystal Growth & Design (2022)
N. Mishra et al. ACS Crystal Growth and Design (2023)
N. Zakay et al. ACS Applied materials and Interfaces (2023)
N. Zakay et al. Mater. Chem. Front. (2023)

Molecular Dynamics Study of Nanoribbon Formation by Encapsulating Cyclic Hydrocarbon Molecules inside Single-Walled Carbon Nanotube

S. Eskandari[1], J. Koltai[1], I. László[2], J. Kürti[1]

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Carbon nanotubes filled with organic molecules can serve as chemical nanoreactors. Recent experimental results show that, by introducing cyclic hydrocarbon molecules inside carbon nanotubes, they can be transformed into nanoribbons or inner tubes, depending on the experimental conditions. In this paper, we present our results obtained as a continuation of our previous molecular dynamics simulation work. In our previous work, the initial geometry consisted of independent carbon atoms. Now, as an initial condition, we have placed different molecules inside a carbon nanotube (18,0): C5H5 (fragment of ferrocene), C5, C5+H2; C6H6 (benzene), C6, C6+H2; C20H12 (perylene); and C24H12 (coronene). The simulations were performed using the REBO-II potential of the LAMMPS software package, supplemented with a Lennard-Jones potential between the nanotube wall atoms and the inner atoms. The simulation proved difficult due to the slow dynamics of the H abstraction. However, with a slight modification of the parameterization, it was possible to model the formation of carbon nanoribbons inside the carbon nanotube.

Molecular dynamics simulation of the formation of W-centers in silicon by Ga ion irradiation

C. Gennetidis[1], P. Chantrenne[1], T. Wood[2]

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Light emitting defect centers can be utilized for quantum telecommunication technologies due to their ability to emit single photons. One of the most promising among the different defects is the W-center in silicon, consisting of a self-tri-interstitial defect cluster, which can be fabricated by the employment of the focused ion beam irradiation technique followed by an annealing step. The selection of the appropriate experimental parameters such as the ion beam energy, fluence and incident angle as well as the annealing temperature is a challenging task which requires a lot of time and resources. Molecular Dynamics (MD) simulations can simulate such processes and hence facilitate the optimization of the experimental parameters. Thus, the formation of Si tri-interstitial clusters after Ga ion irradiation of a silicon substrate and a subsequent annealing step has been investigated using MD simulations. A tri-interstitial cluster identification method is proposed which considers the configuration of the clusters in the Si lattice in order to identify the defects which will act as candidates for the W center. The simulation results showed that higher irradiation energies, under normal incidence favors the creation of tri-interstitial clusters deeper into the Si, in a less damaged region below a volume severely affected by the impact cascade. The final population of clusters consists of those generated from irradiation and those produced during the annealing process. Furthermore, the annealing can eliminate a lot of the unwanted damage whilst retaining the population of the tri-interstitial clusters. This investigation sheds light on the theoretical aspect of the fabrication process of W-centers and helps to understand their dynamic formation and evolution under different irradiation and annealing conditions.

Workshop on Nanomedicine in Cancer

09:00-11:00	**Workshop on Nanomedicine in Cancer** **(Dock Six 1)** **Chair: Y. Missirlis**
09:00-09:30 **KEYNOTE**	**Hybrid Nanostructures for Combined Therapeutics and Tissue Repair** **Prof. Pablo Taboada** *University of Santiago de Compostela, Spain*
09:30-10:00 **INVITED**	**Systems pharmacology and machine learning to advance the development and productivity of targeted therapeutics in the era of precision medicine** **I S. Vizirianakis[1,2]** *[1] Laboratory of Pharmacology, School of Pharmacy, Aristotle Un. of Thessaloniki, Greece* *[2] Dept. of Health Sci., School of Life and Health Sci., Un. of Nicosia, Cyprus*
10:00-10:15 **YRA** **CANDIDATE**	**Up-converting nanostructures with potential magnetic properties for application in photodynamic therapy** **R. Pasławska**[1,2,3], T. Wojciechowski[1], K. Sobczak[4], P. Joshi[1], W. Lewandowski[3], B. Sikora[1] *[1]Inst.e of Physics, Polish Ac. of Sci., Poland* *[2]Faculty of Physics, Un. of Warsaw, Poland* *[3]Faculty of Chemistry, Un. of Warsaw, Poland* *[4]Biological and Chemical Research Centre, Un. of Warsaw, Poland*

KEYNOTE TALK

Hybrid Nanostructures for Combined Therapeutics and Tissue Repair

Prof. Pablo Taboada

Collois and Polymers Physics Group, Department of Particle Physics and Institute of Materials (iMATUS), University of Santiago de Compostela, Spain

The development and application of novel nanostructured materials for biomedical applications such as the sustained and controlled release of bioactive compounds, medical imaging, therapy, biosensing or tissue engineering is a continuously growing area that has captured the interest of researchers from different backgrounds giving rise to the new discipline of Nanomedicine.[1] This new field of research is very promising in order to achieve the so-called "personalized medicine" (one patient, one specific treatment) for a wide range of diseases, facilitating the translation from long, aggressive treatments/therapies to more effective, safer and specific ones. In this regard, the design and characterization of new nanomaterials in the form of individual nanoscopic-sized stimuli-responsive particles and advanced complex materials with suitable nano/microstructures and physicochemical properties as well as the development of new technologies for their fabrication are key to meet the current challenges. In this talk, the requirements that a (nano)material must have to be used in biomedical applications will be presented, and several relevant examples of the application of stimuli-responsive hybrid nanosystems developed in our group in the fields of theranostics and tissue regeneration are presented.

References:

1. Domingues, C., et al. (2021), *ACS Nano*, 16, 9994-10041.
2. Huang, J., et al. (2021), *J. Mater. Chem. B*., 9, 9642-9657.

INVITED TALK

Systems pharmacology and machine learning to advance the development and productivity of targeted therapeutics in the era of precision medicine

I. S. Vizirianakis[1,2]

[1] *Laboratory of Pharmacology, School of Pharmacy, Aristotle University of Thessaloniki, Greece*

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Nowadays, nanotechnology and genomics contribute valuable knowledge and innovative practices, enabling pharmacological interventions, pharmacogenomics-based information, as well as therapeutic decisions to be applicable on a personal basis, i.e., establishing precision (personalized) medicine approaches into the clinical setting. Besides applying physiologically-based pharmacokinetics (PBPK) models, recent advancements in data analysis, informatics, and bioinformatics provide capabilities to a more digitized, robust, as well as information-based environment in biomedicine and healthcare. Within this frame, the task of precision in therapy is better ensured through the application of computerized platforms, as well as interdisciplinary integrated analysis and decision-making. Also, artificial intelligence (AI) and machine learning (ML) methodologies are used in translational research and the clinical setting to develop predictive risk-stratification models from big data accumulated from diverse sources of datasets. Complementary, systems pharmacology and physiology-based mechanistic modeling is applied to improve new drug development productivity, as well as the safety and efficacy of delivered therapeutics and the clinical outcome. To this end and in order to support the aforementioned advancements in, work from our research group will be presented by focusing on molecular pathophysiology of multifactorial diseases, e.g., cancer and cardiovascular disorders (CVDs), the development of innovative therapeutics, the design of pharmacogenomics-based clinical trials, as well as the establishment of ML risk-stratification prediction models that are adjustable and accountable of the molecular heterogeneity of biological systems for individual patients and in real-time at the point-of-care and the clinical setting.

Up-converting nanostructures with potential magnetic properties for application in photodynamic therapy

R. Pasławska[1,2,3], T. Wojciechowski[1], K. Sobczak[4], P. Joshi[1], W. Lewandowski[3], B. Sikora[1]

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Our research aimed to develop nanostructures with both, up-converting and magnetic properties for application in photodynamic therapy (PDT) and bioimaging. The up-converting core – nanoparticles (UCNPs) of yttrium sodium fluorides doped with Yb3+ and Er3+ ions were covered in SiO2 layer with encapsulated particles of photosensitizers (PS). In this work Methylene Blue (MB) and Rose Bengal (RB) were used. Under near-infrared (980 nm) laser excitation, the UCNPs emit green and red light, which is efficiently absorbed by MB and RB, respectively. Between the core and the chosen PS energy transfer occurs due to the close proximity of the two and the overlap between the UCPNs emission spectrum and PS absorption spectrum. Based on the measurements of luminescence decays it is possible to determine the specific mechanism of the transfer. Upon excitation with 980 nm radiation, these final nanostructures generate Reactive Oxygen Species (ROS). Obtained nanoparticles were incubated with HeLa tumour cells. Their toxicity was assessed with the use of PrestoBlue analysis. To obtain magnetic properties, Fe3O4 nanoparticles can be attached to the surface of the core-shell structures.

Workshop on AI, ML, Intelligent Manufacturing & Automation 3 (NN24 & ISFOE24)

09:00-11:00	**Workshop on AI, ML, Intelligent Manufacturing & Automation 3 (NN24 & ISFOE24) (Timber Hall 1)** **Chair: A.Kneer**
09:00-09:30 KEYNOTE	**Machine Learning Guided Design of Low-Dimensional Hybrid Lead Halide Perovskites with Enhanced Optical Properties** **R. Gautier**, H. Yuan, F. Massuyeau, R. Laref *Nantes Université, CNRS, Inst. des Matériaux de Nantes Jean Rouxel, France*
09:30-10:00 INVITED	**Towards explainable, interpretable, and physical-based artificial intelligence for materials science and engineering** **F. Sofos**, T.E. Karakasidis *Condensed Matter Physics Lab, Department of Physics, University of Thessaly Lamia, Greece*
10:00-10:30 INVITED	**Machine Learning techniques in microscopy and nanometrology** **V. Constantoudis[1,2]**, E. Giannatou[2], G. Papavieros[1,2], M. Chatzigeorgiou[1], N. Boukos[1], M. Vrigkas[3], A. Vekinis[1], A. Stellas[2], E. Almpanis[1], N. Papanikolaou[1] *[1] Institute of Nanoscience and Nanotechnology, NCSR Demokritos, Greece* *[2]Nanometrisis p.c., Greece* *[3] Department of Communication and Digital Media, University of Western Macedonia, Greece*
10:30-10:45	**Optimizing Inks and Paste Formulations for the Printed Electronics Industry:Advancements in Additive Manufacturing Materials** **L. Schneider**, A. Motyka, M. Łysień, S. Drozdek *XTPL SA; Stabłowicka 147, 54 066 Wrocław, Poland*
10:45-11:00	**AI guided materials discovery of two-dimensional magnets** **T. D. Rhone** *Dept. of Physics, App. Physics and Astronomy, Rensselaer Polytechnic Inst.e*

KEYNOTE TALK

Machine Learning Guided Design of Low-Dimensional Hybrid Lead Halide Perovskites with Enhanced Optical Properties

R. Gautier, H. Yuan, F. Massuyeau, R. Laref
Nantes Université, CNRS, Inst. des Matériaux de Nantes Jean Rouxel, France

The discovery of new materials with specific properties is a complex task due to the drastic effects that very slight modifications on the synthesis of materials can have on the crystal structures and the resulting properties. Machine learning can be a very useful tool in such situations and can drastically accelerate the discovery of new functional materials as well as assist us to rationalize complex mechanisms.

In this presentation, the accelerated discovery of new hybrid lead halides by machine learning will be presented. These materials have recently shown a great potential in optoelectronic applications. For this reason, many research groups are currently exploring this chemical system to discover new low dimensional hybrid lead halides of perovskite types. However, discovering such materials is challenging as the necessary structure determination by X-ray diffraction is time consuming and non-perovskite compounds are very often synthesized. In this presentation, three approaches will be introduced which guided us towards the synthesis of new hybrid lead halides of specific properties or structures: (i) the use of active learning to target white phosphors with specific correlated color temperatures and optimal color rendering index for solid-state lighting, (ii) the use of deep learning to automatically identify hybrid perovskites from powder X-ray diffraction patterns, and (iii) the use of molecular descriptors to identify organic amines with high probability to lead to the synthesis of hybrid perovskites.

INVITED TALK

Towards explainable, interpretable, and physical-based artificial intelligence for materials science and engineering

F. Sofos, T.E. Karakasidis
Condensed Matter Physics Lab, Department of Physics, University of Thessaly Lamia, Greece

Under the general framework of artificial intelligence, there has been a wealth of machine learning algorithms proposed throughout the years which have been proven effective and accurate on dealing with small/medium datasets, referring to computational or experimental output in physical sciences and engineering. On the next level of abstraction, deep learning has been introduced to exploit big and complex data by mapping it to multiple layers in order to extract information and make predictions. These models most of the times lack in interpretability and they cannot be easily bound to physical laws. On the other hand, evolutionary computing and genetic programming principles, as expressed by the symbolic regression technique, can provide the framework to express data behavior through mathematical expressions. In materials science and engineering, the concept of obtaining an analytical expression to describe phenomena at all scales only by diving into a dataset is practical and can be intriguing, paving the way towards generalizability and interpretability. Examples of successful application of symbolic regression include the calculation of the transport properties of fluids, novel materials (such as ionic liquids) properties, construction materials and energy applications.

Acknowledgement: This research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the "2nd Call for H.F.R.I. Research Projects to Support Faculty Members and Researchers" (Project Number: 4584).

INVITED TALK

Machine Learning techniques in microscopy and nanometrology

V. Constantoudis[1,2], E. Giannatou[2], G. Papavieros[1,2], M. Chatzigeorgiou[1], N. Boukos[1], M. Vrigkas[3], A. Vekinis[1], A. Stellas[2], E. Almpanis[1], N. Papanikolaou[1]

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In recent years, we are witnessing a tremendous growth of AI and ML techniques with applications penetrating horizontally all fields of science and technology and changing accordingly all aspects of our societal life. However, a systematic assessment of their success and of the proper upgrades needed in specific scientific and technological areas remain still open issues. In this talk, we start with a brief review of the applications of Machine Learning methods to enhance the performance of Scanning Electron (SEM) and Atomic Force Microscope (AFM). Then we focus on specific challenges related to the metrology output of microscope measurements. In all cases, the benefit of having available well-developed mathematical and computational models is proved critical in the training of ML models. Concerning SEM applications, we discuss two issues. The first is the presence of noise which deteriorates measurement accuracy especially when SEM is used in lithographic structures of nanoelectronic devices deep in nanoscale range. A properly designed Convolutional Neural Network is applied and compared with conventional metrology methods. Secondly, we focus on the segmentation of SEM images needed in the inspection of composite multiphase materials. A neural network is developed to provide the automatic evaluation of the accuracy of the widely used segmentation method of Gaussian Mixture Models for all material phases. In AFM, we concentrate on the tip effects on roughness measurements and develop a neural network approach to evaluate their importance allowing for a fast and efficient probe-tip selection process reducing the operational costs of an AFM measurement. Finally, we present a ML approach to solve the inverse problem in scatterometry with application in the prediction of the structural parameters of a pillar pattern from the reflectance spectrum of an incident white light beam.

Optimizing Inks and Paste Formulations for the Printed Electronics Industry: Advancements in Additive Manufacturing Materials

L. Schneider, A. Motyka, M. Łysień, S. Drozdek

XTPL SA; Stabłowicka 147, 54 066 Wrocław, Poland

The relentless drive for device miniaturization, sustainability, and performance enhancement is propelling the development of innovative materials compatible with additive manufacturing technologies. In this context, maskless printing methods such as Aerosol Jet, Inkjet, Laser-Induced Forward Transfer (LIFT), Micro-dispensing and Ultra-Precise Deposition (UPD) have garnered significant attention. Material research in the printed electronics industry encompasses a range of metallic elements such as silver, copper, gold, and indium, which must be formulated into printing technology compatible inks or pastes. The presented findings highlight the importance of key parameters such as particle size and shapes, size distribution, viscosity, surface tension, and rheological properties in optimizing ink and paste formulations. The results showcased in the presentation demonstrate the successful printing of intricate structures with high precision and resolution, ranging from 0.5 to 100 micrometers, indicating their potential utility across diverse applications. The primary focus of the presentation lies in the utilization of nanomaterials, conductive polymers, and dielectric materials and the formulation thereof, to address the needs of the printed electronics industry. Important application areas include those related to display industry, semiconductors, sensors and optics. The study aims to offer valuable insights into nanomaterials and associated formulation processes, facilitating the development of tailored inks and pastes. By advancing the fields of materials science and formulation chemistry, this research contributes to the creation of original, technology-compatible solutions, driving innovation across sectors reliant on high-precision printing technologies.

AI guided materials discovery of two-dimensional magnets

T. D. Rhone

Dept. of Physics, App. Physics and Astronomy, Rensselaer Polytechnic Inst.e

The discovery of van der Waals (vdW) materials with intrinsic magnetic order in 2017 has given rise to new avenues for the study of emergent phenomena in two dimensions. In particular, monolayer CrI3 was found to be ferromagnet. Other vdW transition metal halides were later found to have different magnetic properties. How many vdW magnetic materials exist in nature? What are their properties? How do these properties change with the number of layers? A conservative estimate for the number of candidate vdW materials (including monolayers, bilayers and trilayers) exceeds ~106 . A recent study showed that artificial intelligence (AI) can be harnessed to discover new vdW Heisenberg ferromagnets based on Cr2Ge2Te6 [1,2]. In this talk, we will harness AI to efficiently explore the large chemical space of vdW transition metal halides and to guide the discovery of magnetic vdW materials with desirable spin properties. That is, we investigate crystal structures based on monolayer Cr2I6 of the form A2X6, which are studied using density functional theory (DFT) calculations and AI. Magnetic properties, such as the magnetic moment are determined. The formation energy is also calculated and used as a proxy for the chemical stability. We show that AI, combined with DFT, can provide a computationally efficient means to predict the thermodynamic and magnetic properties of vdW materials [3]. This studypaves the way for the rapid discovery of chemically stable magnetic vdW materials with applications in spintronics and data storage.

[1] T. D. Rhone, et al., “Data-driven Studies of Magnetic Two-dimensional Materials,” Scientific Reports 10, 15795 (2020).
[2] Y. Xie, et al., “Data-Driven Studies of the Magnetic Anisotropy of Two-Dimensional Magnetic Materials,” J. Phys. Chem. Lett., 12, 50, 12048–12054 (2021).
[3] T. D. Rhone et al., “Artificial Intelligence Guided Studies of van der Waals Magnets,” Adv. Theory Simulations, 6, 2300019 (2023).

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Workshop on Bioelectronics 3 (NN24 & ISFOE24)

09:30-11:00	**Workshop on Bioelectronics 3 (NN24 & ISFOE24)** **(Dock Six 1)** **Chair: S. Inal**
09:30-10:00 **INVITED**	**Charge Carrier Density in Organic Semiconductors Modulates the Effective Capacitance of Electrolyte Gated Organic Transistors: a Unified View of EGOFET and OECT** **Fabio Biscarini** *Italian Institute of Technology & University of Modena and Reggio Emilia, Italy*
10:00-10:15	**Integration of flexible organic force sensors on biohybrid catheters for endoscopic applications** **G. Casula[1]**, U. Mahmood[1], A. Bartolucci[2], P. Cosseddu[1], L. Vannozzi[2], L. Ricotti[2], S. Lai[1] *[1] Department of Electrical and Electronic Engineering, University of Cagliari, Italy* *[2]The Biorobotic Institute, Scuola di Studi Superiori Sant'Anna, Pontedera, Italy*
10:15-10:30	**A flexible electrochemical platform for health status monitoring in diabetic patients** **F. Ceccardi[1]**, F. Mariani[1], S.Lai[2], G. Casula[2], I.Gualandi[1], A. Bonfiglio[2], E. Scavetta[1] *[1] Department of Industrial Chemistry "Toso Montanari", University of Bologna, Bologna, Italy* *[2] Department of Electronic Engineering, Cagliari, Piazza d'Armi, 09123, Cagliari, Italy*
10:30-10:45	**A printed organic transistor-based ion sensor towards on-skin monitoring of calcium concentration** **S. Lai[1]**, G. Casula[1], F. Mariani[2], F. Ceccardi[2], P. Cosseddu[1], I. Gualandi[2], E.Scavetta[2], A. Bonfiglio[1] *[1] Department of Electronic Engineering, Cagliari, Piazza d'Armi, 09123, Cagliari, Italy* *[2] Department of Industrial Chemistry "Toso Montanari", University of Bologna, Bologna, Italy*
10:45-11:00	**Potentiodynamic sensing with Organic Electrochemical Transistors** **F. Mariani[1]**, I. Gualandi[1], D. Arcangeli[2], F. Ceccardi[1], L. Salvigni[2], F. Decataldo[3], M. Tessarolo[3], D. Tonelli[1], B. Fraboni[3], E. Scavetta[1] *[1] Department of Industrial Chemistry "Toso Montanari", University of Bologna, Bologna, Italy* *[2] Organic Bioelectronics Laboratory, Biological and Environmental Science and Engineering Division (BESE), KAUST, Saudi Arabia* *[3] Department of Physics and Astronomy, University of Bologna, Bologna, Italy*

INVITED TALK

Charge Carrier Density in Organic Semiconductors Modulates the Effective Capacitance of Electrolyte Gated Organic Transistors: a Unified View of EGOFET and OECT

Rian Zanotti[a,b], Matteo Sensi[a], Marcello Berto[a], Alessandro Paradisi[a], Pierpaolo Greco[c,d], Carlo Augusto Bortolotti[a], Michele Di Lauro[c], **Fabio Biscarini[a,c*]**

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[b.] Dipartimento di Fisica, Informatica e Matematica, Università di Modena e Reggio Emilia, Modena, Italy

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A framework for electrolyte gate organic transistors (EGOTs) which unifies the view of interfacial capacitive coupling of EGOFETs with that of the "volumetric" capacitance in organic electrochemical transistors (OECTs) is proposed and validated against experimental data. The model is based on the distribution of voltage drop across the EGOT, assuming that an organic semiconductor channel with exponential disorder in the HOMO LUMO gap plays the role of active layer. The application of a gate bias to the electrolyte where the channel is immersed yields a shift of the electrochemical potential of the channel which depends on the DOS of the organic semiconductor within the HOMO-LUMO gap. We solve the analytical equation for the shift of charge carrier density and extract the expression for the gate-voltage dependent effective capacitance where the weight of the in-series chemical (or quantum) capacitance with respect to the interfacial capacitance is modulated by the gate voltage. Our model predicts the shape of the whole transfer curve of an EGOT, and allows us to extract accurate values for the threshold voltage and the interfacial transconductance, without using *ad hoc* assumptions, reduction of experimental data and without invoking the concept of volumetric capacitance. The model is assessed on recent experimental data of immunosensors and sensors of relevant pollutant molecules, and yields the actual dependence of the dose curve of the analyte on the threshold voltage

Integration of flexible organic force sensors on biohybrid catheters for endoscopic applications

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Recently, the field of biohybrid machines (BHM), which integrate living biological elements with artificial soft materials, has gained a growing attention and research interest. Indeed, compared to standard robots, BHM exhibit greater softness, energy efficiency, environmental safety and compatibility, thus showing a great potential for different biomedical applications. In particular, since the employment of intravascular catheters for targeted drug delivery has been widespread, the development of a BHM catheter for in vivo applications is crucial. In this work, the integration of force sensors on a biohybrid catheter is presented. Specifically, Organic Field Effect Transistors (OFETs) are employed to ensure flexibility and biocompatibility, as well as a complete integration with the elastomer-based catheter realized by mold-casting processes. The fabrication process is performed on a plastic support, but the actual substrate of the sensor is a 700-nm-thick Parylene C layer deposited by Chemical Vapor Deposition on a spin-coated sacrificial layer. The device structure is fabricated by inkjet printing employing a PEDOT:PSS-based ink. Thanks to the sacrificial layer, the sensor can be mechanically removed from supports after fabrication. Low operating voltages (5 V), significant charge carrier mobility (0.2 $cm^2V^{-1}sec^{-1}$), and a quasi-zero threshold voltage have been obtained. Specifically, electrical characterizations are performed before and after peel-off of the sensors from the support, as well as after integration with the catheters. Interestingly, only minimal variations on OFETs performances are obtained after peel-off from the plastic supports, but also after integration on catheter. Finally, an electromechanical characterization of the sensorized catheter is presented, showing a complete calibration of the sensor output with respect to mechanical deformation suitable for its final application in endoscopic procedures.

A flexible electrochemical platform for health status monitoring in diabetic patients

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One of the main goals of scientific research regards taking care of people's health, therefore the need to monitor the body status for accurate and rapid management of critical health conditions has become a priority. Many electrochemical systems have been developed to monitor important biomarkers and the world of sensors for healthcare is wide. Scientific interest is moving nowadays towards the design of wearable and non-invasive devices for continuous and real time monitoring, but many technological challenges are still unaddressed. The activity of our research group has recently focused on the development of flexible sensing platforms based on both OECTs (Organic ElectroChemical Transistors) and amperometric sensors configuration, fabricated by ink-jet printing technique. The matrix selected for the detection is the biofluid placed between cells and tissues called interstitial fluid (ISF), which reflects blood composition and might be non-invasively extracted through the skin without the use of needles, e.g. by reverse iontophoresis. The first step in designing the sensing platform concerned the development and optimization of a glucose sensor printed on a flexible plastic support. In particular, a soft material like the organic semiconductor PEDOT (poly(3,4-ethylenedioxy-thiophene)) doped with PSS (poly(styrene sulfonate)) was chosen as the electrochemical transducer and was then functionalized with the proper enzyme (glucose oxidase) in order to make the device sensible to glucose. After evaluating performances and analytical parameters like repeatability and reproducibility, the following steps were focused on taking into consideration possible interference compounds, like lactate and paracetamol, and the evaluation of temperature's impact on the measurements.

A printed organic transistor-based ion sensor towards on-skin monitoring of calcium concentration

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Since the introduction of the Ion-Sensitive Field-Effect Transistor (ISFET) in the Seventies, the application of field-effect transistor to the detection of different ionic species has been thoroughly explored, mainly for in-vitro applications, with potential performances comparable with classic electrochemical devices and with all the advantages of electronic technologies. Nonetheless, in vivo operation of such sensors can be of great interest for the monitoring and diagnosis of some diseases, e.g. diabetes and cystic fibrosis, directly on biofluids including sweat and interstitial fluid. The suitability of FET-based ionic sensors in this peculiar field requires that technological and design aspects are deepen.

In this abstract, we report about the development of printed organic FET-based sensors for calcium concentration, suited for future integration over ultra-thin substrates that can be directly transferred on skin. The device is based on the working principle of the Organic Charge-Modulated FET (OCMFET), which can operate in a floating measurement environment, i.e. without requiring the integration of reference electrode in the device. Moreover, OCMFET can be designed following precise design rules, which allows adapting the device structure to the specific application field and, therefore, to tailor the sensitivity to the required analytes. In this case, the relatively high concentration of calcium in biofluids such as sweat and interstitial fluid (in the mM range) requires that technological aspects related to charge modulation in the device structure are thoroughly examined. Finally, by exploiting cost-effective technologies such as inkjet printing, future scale-up of the proposed approach to an industrial size is foreseen. A complete analysis of device performances will be discussed, including calibration curves at different device sizing, and sensitivity derivation.

Potentiodynamic sensing with Organic Electrochemical Transistors

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In recent years, bioelectronic interfaces have showed potential to successfully address some challenging applications of bioelectrochemistry. In particular, Organic Electrochemical Transistors (OECTs) based sensors and devices capable of on-site amplification and transduction of biochemical events have entered a variety of scientific fields, including wearable electronics, live cells monitoring and neural interfaces. Focusing on OECT-based sensors, conventional routes as well as more innovative strategies are exploited nowadays to functionalise the transistor elements and achieve the desired sensing performance. However, most of them rely on potentiostatic operation, where the poor control of electrochemical potentials due to the absence of a reference electrode intrinsically limits the achievement of a selective and reproducible response. Among all electrochemical methods, potentiodynamic techniques were applied to OECT sensing by our research group to overcome those issues and develop robust analytical tools towards quantitative, real-life applications. With this contribution, we present the main advantages offered by the potentiodynamic approach when OECT sensing is applied to the detection of redox-active molecules and ions. Upon optimization of the gate potential window and scan rate, poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate) (PEDOT:PSS) based OECT sensors were successfully used to selectively detect dopamine in the presence of uric and ascorbic acid without any chemical or electrochemical functionalisation. Moreover, we have recently explored fat-soluble vitamins detection and proposed the first OECT sensor working in organic media. At the moment, the unique advantages of the OECT configuration are allowing us to investigate the potentiodynamic detection of a wound healing biomarker under flow conditions using a fully textile OECT.

Workshop on Theoretical Modeling in Nanoscale

11:30-13:30	**Workshop on Theoretical Modeling in Nanoscale** **(Crystal Hall)** **Chair: E. Sarigiannidou**
11:30-12:00 **KEYNOTE**	**Obstructed limits in Q1D and Q2D crystals** **M. Damnjanović** *Serbian Academy of Sci. and Arts, Belgrade, Serbia, NanoLab, Faculty of Physics, Uni Belgrade, Belgrade, Serbia*
12:00-12:30 **INVITED**	**Structure-Property Relationships of Nanostructured Materials via Simulations Across Scales and Machine-Learning Algorithms** **V. Harmandaris** *Computation-based Science and Technology Research Center, The Cyprus Institute, Cyprus, & Dept. of Mathematics and App. Mathematics, Un. of Crete, Greece*
12:30-13:00 **INVITED**	**An Effective Algebraic Method for Determining the Existence of Flat Bands in Crystal Lattices** I. Damnjanović[1,2,3], M. Damnjanović[4,5], **I. Milošević[4]**, D. Stevanović[6,7] *[1] Faculty of Electronic Engineering, Un. of Niš, Serbia* *[2] Diffine LLC, San Diego, CA, USA* *[3] Faculty of Mathematics, Natural Sci. & Information Technology, Uni of Primorska, Koper, Slovenia* *[4] Faculty of Physics, Un. of Belgrade, Serbia* *[5] Serbian Academy of Sci. and Arts, Belgrade, Serbia* *[6] College of Integrative Studies, Abdullah Al-Salem Un., Kuwait* *[7] Mathematical Inst.e of Serbian Academy of Sci. and Arts, Belgrade, Serbia*
13:00-13:15	**Structuring magnetic fields for greener microfabrication** **N. Ntallis[1]**, S. Sadewasser[2], D. Colombara[3], T. Böhnert[2], K.N. Trohidou[1] *[1] Inst.e of Nanoscience and Nanotechnology, NCSR "Demokritos", Greece* *[2] InterNat. Iberian Nanotechnology Laboratory, Portugal* *[3] Dept. of Chemistry and Industrial Chemistry Università degli Studi di Genova, Italy*
13:15-13:30	**A twist for tunable electronic and thermal transport properties of nanodevices** **A. Ostovan[1]**, K.Z. Milowska[2,3], C.J. García-Cervera[1,4] *[1] Mathematics Dept., Un. of California, USA* *[2] CIC nanoGUNE, Tolosa Hiribidea 76, 20018 Donostia-San Sebastián, Spain* *[3] Ikerbasque, Basque Foundation for Science, Bilbao, Spain* *[4] Basque Center for App. Mathematics, Bilbao,Spain*

KEYNOTE TALK

Obstructed limits in Q1D and Q2D crystals

M. Damnjanović

Serbian Academy of Sciences and Arts, Knez Mihajlova 35, 11000 Belgrade, Serbia, Department, NanoLab, Faculty of Physics, Uni Belgrade, 1000 Belgrade, Serbia

Obstructed atomic limit (OAL) appears when the system configuration enables to obtain electrons centered in some special Wyckoff positions which do not coincide with atomic positions [1]. We present group theoretical analysis, based on the band representations [2], of the notion of OAL, resulting in clear and general group criterion when such situations are allowed. Then, this criterion is applied to line [3] and layer [4] groups, symmetry groups of low-dimensional crystalline structures. The results are listed, enabling search for the materials with OAL topology. Some other related topological and computational aspects are discussed.

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INVITED TALK

Structure-Property Relationships of Nanostructured Materials via Simulations Across Scales and Machine-Learning Algorithms

V. Harmandaris

Computation-based Science and Technology Research Center, The Cyprus Institute, Nicosia, Cyprus, & Department of Mathematics and Applied Mathematics, University of Crete & IACM FORTH, Heraklion, Crete, Greece

The computational study of complex nanostructured materials is a very challenging field, due to the broad spectrum of the underlying length and time scales. Here, we present a hierarchical methodology for predicting the macroscopic properties of polymer-based nanostructured systems, which involves multi-scale simulations and Machine Learning (ML) algorithms. The simulations include atomistic, coarse-grained, as well as continuum models. The coarse-grained (CG) models are derived through a "bottom-up" data-driven strategy, using information from the detailed atomistic scale, for the given chemistry. 1-2]. At the same time, machine ML algorithms have been developed to re-introduce atomic detail in the CG scale, and thus obtaining atomistic configurations of high molecular weight polymers [2]. The proposed hierarchical computational scheme allows the study of macromolecular systems, of high molecular weight, over a broad range of time scales, from a few *fs* up to *ms*. and the prediction of their (structural, dynamical, rheological, etc.) properties [3,4]. Here we focus on the study of the heterogeneous mechanical behavior of polymers and polymer nanocomposites by computing local stress and strain fields. Finally, we propose a new deep learning model for predicting the mechanical behavior of complex multi-component materials [4].

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INVITED TALK

An Effective Algebraic Method for Determining the Existence of Flat Bands in Crystal Lattices

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A novel algebraic method termed *the polynomial indicator of flat bands*, is introduced for constructing flat bands in crystal lattices. This method utilizes the tight-binding Bloch Hamiltonian eigendeterminant functional to establish conditions ensuring the presence of non-dispersive eigenvalues. Additionally, an investigation is conducted to determine whether the identified flat bands exhibit nontrivial topological features. Through the application of this algebraic approach, a contribution is made to the growing body of research on flat bands, offering a new perspective on their construction and properties. Apart from aiding in the understanding of the plethora of phenomena exhibited by materials with flat bands, these findings have the potential to lead to advancements in various technological applications, such as waveguide arrays and superconducting networks.

Structuring magnetic fields for greener microfabrication

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Photolithography is most common to fabricate heterogeneous substrates with length scales below micrometers for biomedicine and energy applications [1]. In the framework of the REMAP project (reusable mask patterning), we aim to generate a greener patterning method based on the remote manipulation of smart magnetic fluids onto a substrate's surface, as to form patterning masks with flexible designs [2]. Our take uses an array of current elements to drive the assembly of fluidic masks. To this end, a magnetic field distribution with homogenous regions (spots) should provide high contrast but also a sufficient gradient to drive the magnetic elements. We propose a current line setup that provides these criteria efficiently with low energy requirements. To optimize the current line array, we perform Finite Element Method (FEM) calculations of the coupled magnetostatics/heat transfer problem. The calculations are performed by varying the length, width, height, in-plane, and out-of-plane distance of the lines and current density. The proposed setup can provide on demand spatial resolution (spot separation) by varying the geometric properties of the lines. Moreover, very high gradients can be achieved due to proprietary geometric features. By properly manipulating width and height of the current lines, we can achieve operational conditions, while limiting Joule heating to levels that do not impact the process temperature.

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A twist for tunable electronic and thermal transport properties of nanodevices

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Twisted graphene-layered materials with nonzero interlayer twist angles (θ) have recently become appealing, as they exhibit a range of attractive physical properties, which include a Mott insulating phase and superconductivity. In this study, we consider nanodevices constructed from zigzag graphene nanoribbons with a top rectangular benzenoid [6,3]-flake. Using density functional theory and a non-equilibrium Green's function approach, we explore how the electronic and thermal transport properties in such nanodevices can be tuned through a twist of the top flake by an angle $0° \leq \theta \leq 8.8°$ for different stacking configurations. We found a strong dependency of the electronic structure on the stacking type, as well as on the twisting regime, specifically in AA-stacking devices. Electron and hole van Hove singularities (vHSs), which originate, respectively, from the flatness of the top of the valence band for the minor-spin component and the bottom of the conduction band for the major-spin component, are found very close to the Fermi level in the density of states and electronic transmission spectra of AA-stacking devices with a twist angle of 1.1°. We establish that these vHSs in AA-1.1° devices are stable at higher temperatures and, with the increased number of available states, lead to larger values of electron thermal conductivity and finally total thermal conductivity in AA-1.1°. Our work highlights the essential role of twisting and stacking for the fabrication of nanoscale charge and heat switches and spurs future studies of twisted layered structures.[1]

[1]*Nanoscale* 2024, DOI: 10.1039/D4NR00058G

Special Session for I-SMarD

12:00-13:30	**Special Session for I-SMarD** **(Dock Six 1)** **Chair: A Jha**
12:00-12:30 **INVITED**	**Pulsed Laser based Deposition for Adhesive bonding of Micro-to-Nanoscale Glass, Ceramic, and Polymer Composite Thin Films for Medical Device Applications** S. Loganathan, G. Sharma, E. Kumi-Barimah, E. Daskalakis, **A. Jha** *School of Chemical and Process Engineering, Engineering Building, Woodhouse Lane, Un. of Leeds, Leeds, UK*
12:30-13:00 **INVITED**	**Silica-based mesoporous nanoparticles in tissue engineering applications** **E. Kontonasaki,** G. Pouroutzidou, I. Tsamesidis, M. Bousnaki *Department of Dentistry, Aristotle University of Thessaloniki, Greece*
13:00-13:30 **INVITED**	**Microfluidics for sustainable development of bio and nano- materials** **A.D. Anastasiou,** W.A. Oates, K. Tsachouridis *Lab of Complex Fluids and Microfluidics, Department of Chemical Engineering, University of Manchester, UK*

INVITED TALK

Pulsed Laser based Deposition for Adhesive bonding of Micro-to-Nanoscale Glass, Ceramic, and Polymer Composite Thin Films for Medical Device

S. Loganathan, G. Sharma, E. Kumi-Barimah, E. Daskalakis, **A. Jha**

School of Chemical and Process Engineering, Engineering Building, Woodhouse Lane, University of Leeds, UK

In this presentation, we demonstrate on novel glass, ceramic, and glass-polymer thin films deposited on glass and metal substrates using nano-second (ns) and femto-second (fs) pulsed lasers. In the first example, we demonstrate the application of rare-earth ion (Er,Yb)3+ doped silicate and phosphate glasses on silica substrates for engineering photonic device waveguides for photonic applications; e.g. sensing, optical imaging for compact medical photonic device engineering. The second example focusses on fs-pulsed-laser engineering demonstrates the restoration of acid-eroded lesions on tooth surface using hydroxyapatite coating on human enamels for preventing the onset of hypersensitivity and progression of tooth wear. The discovery of this methodology has led to the applications of restoring extracted human tooth samples by demonstrating in vitro pulsed laser-based restoration of 20 acid-induced enamel lesions, followed using the in situ mouth appliances for oral challenge test of restored enamels in 20 different selected healthy volunteers. The preliminary results of in situ appliance tests in volunteers' mouth were compared with the control untreated enamels using brushing trials. The results demonstrate a pathway for laser-based surgical restoration of acid-damaged and worn teeth for personalized treatment in which the sensing and imaging technologies may play important roles.

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INVITED TALK

Silica-based mesoporous nanoparticles in tissue engineering applications

E. Kontonasaki, G. Pouroutzidou, I. Tsamesidis, M. Bousnaki

Department of Dentistry, Aristotle University of Thessaloniki, Greece

Mesoporous silica nanoparticles (MSNs) have been widely investigated as nanocarriers for the delivery of various cargoes in biomedical applications due to their unique properties, such as high specific surface area, tuneable size (2–50 nm) and pore volume, feasible functionalization, and good biocompatibility. They are synthesized by soluble silica precursors that are assembled into liquid-crystalline mesophases by adding amphiphilic surfactants as structure-directing agents. The application of MSNs in tissue engineering has gained much research interest, as MSNs can by synthesized to possess bioactive properties or tailored to carry bioactive substances and growth factors to assist tissue regeneration. The incorporation of ions, such as Ca^{2+}, Sr^{2+} and Mg^{+2} can induce mineralization and promote osteogenic differentiation of cells, while ions such as Ce^{+3}, Ag^{+} and Cu^{2+} can provide proangiogenic and antibacterial functions, transforming MSNs to multifunctional vehicles in tissue engineering. Using the sol-gel method, ion-doped MSNs MCM-41 type were synthesized and evaluated in terms of their potential to promote the osteogenic differentiation of human periodontal ligament cells, targeting periodontal regeneration. Their physicochemical properties were verified with FTIR, XRD, SEM-EDS and TEM, and their osteogenic differentiation capacity by means of real-time qPCR, Alkaline phosphatase activity, and Alizarin red staining. The investigation of their systemic toxicity and development of industrial scale up synthesis methods, as well as their efficacy in clinical trials, are needed to enhance their clinical translation and expand their application in dental and skeletal regenerative medicine. Acknowledgments: This work was supported by European Union's Horizon 2020 research and innovation programme under grant agreement No 953128, I-SMarD Project: Smart, Multifunctional Dental Implants: A solution for peri-implantitis and bone loss.

INVITED TALK

Microfluidics for sustainable development of bio and nano- materials

A.D. Anastasiou, W.A. Oates, K. Tsachouridis

Lab of Complex Fluids and Microfluidics, Department of Chemical Engineering, University of Manchester, UK

Sustainable development of bio and nanomaterials is an emerging trend in the general field of materials but also in biomedical engineering. The development of biomaterials includes many, time consuming and complicated steps, from lab synthesis, in vitro cell tests and animal trials to scaling up and eventually clinical translation. In this work we give two examples regarding how microfluidics can contribute to more sustainable biomaterials at two different steps of their development;

a) ***in vitro evaluation***: Our objective is the design and evaluation of novel microfluidic devices in which we can replicate in vivo conditions and can be used for the study of pharmacokinetics of materials for Local Drug Delivery (LDD) systems. Microfluidics is an ideal option to achieve the in vivo like environment due to the perfusion of small volumes of liquid, similar with what we expect around implanted medical devices in human body, allowing replication local drug concentrations and chemical gradients. As a case study we replicate the complex, dynamic micro-environment of oral cavity, and we test the sensing capabilities of the proposed microfluidic device for the detection of doxycycline (DOX) released from a chitosan (CS), mineral scaffold.

b) ***synthesis of nanoparticles and scaling up***: One of the most significant advantages of microfluidics is their potential for straightforward scaling up. Once the process is optimized in a single microreactor, an increase in the production volume can be achieved by operating multiple identical microreactors in parallel (numbering up). In this work we compare different microreactors for the synthesis of nanoparticles and try to evaluate them in terms of operability for scaling up and continuous synthesis. As particle systems we have selected cerium oxide nanoparticles and bruhite crystals, covering this way particles of different size and shape.

Workshop on Thin Films

15:00-17:00	**Workshop on Thin Films** **(Crystal Hall)** **Chair: A. Guinault**
15:00-15:30 **KEYNOTE**	**Development of Superhydrophobic Polymer Nanocomposite Coatings with Antimicrobial Properties** **S. Anastasiadis** *University of Crete & FORTH IESL, Greece*
15:30-16:00 **INVITED**	**Hydrogenation of graphene on Ni (111) by H2 under Near Ambient pressure conditions** **Luca Vattuone** *DIFI, Un. of Genoa, Italy*
16:00-16:15 **YRA CANDIDATE**	**Characteristics of optical properties in chiral liquid crystalline thin films with laser patterning capability** **M. Zarzeczny[1]**, D. Szepke[1], P. Roszkowski[1], M. Kotkowiak[2], W. Lewandowski[1] *[1] Faculty of Chemistry, Un. of Warsaw, Ludwika Pasteura 1, 02-093 Warsaw, Poland* *[2] Inst.e of Physics, Poznan Un. of Technology, Piotrowo 3, 60-965 Poznan, Poland*
16:15-16:30	**Filtration of nanoparticle with different morphology on fibrous filters** **F. Furgiuele[1]**, L. Boskovic[2], I.E. Agranovski[1] *[1] School of Engineering and Built Environment, Griffith Un., Nathan, Queensland, Australia* *[2] Torrens Un., Queensland, Australia*

KEYNOTE TALK

Development of Superhydrophobic Polymer Nanocomposite Coatings with Antimicrobial Properties

S. Anastasiadis

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The development of antifouling and antimicrobial surfaces that would prevent the transfer of bacteria has gained the scientific interest during the recent years. In this work, polymer nanocomposite coatings are developed to provide surfaces with antifouling and antimicrobial properties. This was achieved via deposition of a nanohybrid coating containing the appropriate polymer and either alumina or titania nanoparticles or layered Mxene nano-additives. The wetting properties were evaluated via contact angle and contact angle hysteresis measurements, the morphology of the coated surfaces was examined using Scanning Electron Microscopy (SEM), while the surface chemical composition was determined via Energy Dispersive Spectroscopy (EDS). The nanohybrid composition was optimized in order to achieve the desired wetting properties. For the optimized nanocoating composition, a superhydrophobic (CA > 150°) and water repellent (hysteresis < 5°) surface was obtained for all nano-additives. The stability of the coated surfaces with time or under temperature was examined whereas their antimicrobial properties were evaluated as well.

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In collaboration with K. Chrissopoulou, F. Gojda, A. Thomos, E. Petsi, M. Stylianakis and F. Krasanakis.

INVITED TALK

Hydrogenation of graphene on Ni (111) by H2 under Near Ambient pressure conditions

Luca Vattuone

DIFI, University of Genoa, Genova, Italy

Graphene hydrogenation on Ni(111) using molecular H_2 in the mbar region was investigated by combining Near Ambient Pressure X-ray Photoemission Spectroscopy and Density Functional Theory calculations. Both a closed and nearly perfect graphene single layer and an incomplete, defective monolayer were exposed to a methanation mixture (H_2+CO/CO_2) with large excess of H_2, finding a quite different behaviour for the two systems.
For closed graphene the C 1s spectrum shows new components corresponding to hydrogenated C atoms (G_{hyd}) and to their first nearest neighbours ($G_{hyd\ 1st}$). Defected G, grown in presence of sulphur contamination and consisting in a mixture of strongly and weakly interacting graphene with a significant amount of dissolved C, evolves with the formation of sp^3 carbon and patches of Ni oxide/hydroxide. sp^3 C is assigned to hydrogenated G edges. When NiO is reduced in H_2 at 150 °C, also sp^3 C disappears, indicating a lower thermal stability of these hydrogenated sites.

Characteristics of optical properties in chiral liquid crystalline thin films with laser patterning capability

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In recent years chiral thin films contributed significantly to the development of multiple optoelectronic technologies. One of the most studied are organic films based on a chiral liquid crystalline B4 phase. It occurs via spontaneous symmetry breaking of an achiral compound during crystallization, leading to the formation of helical nanofilaments. This type of structure exhibits anisotropy of alignment, which results in an entanglement of emerging linear and circular effects, effectively binding the optical properties of the film with its orientation. Consequently, this complicates the study of optical characteristics using standard spectroscopic methods. Furthermore, the application of such composites can be hampered by the lack of control over the enantiomeric composition of the formed helices.

In my work, I present comprehensive research on the optical properties of a series of compounds forming helical liquid crystalline phases using a state-of-the-art Mueller Matrix Polarimetry (MMP) method. This technique allowed us to disentangle the total chiroptical response of the material into contributions from circular dichroism (CD), circular birefringence (CB) and analogous linear phenomena. Optical properties were characterised for thin films with a thickness ca 10 micrometres. Next, I conducted studies to achieve enantiomeric excess of one chirality at specific locations on the composite. Using a laser-in-microscope system, the compounds were locally remelted with close control of the time and direction of the crystallization front. This resulted in obtaining a series of patterns composed of 250x250 μm^2 pixels with opposite handedness.

This work was supported by the National Science Center in Poland by the project 2019/35/D/ST4/02037.

Filtration of nanoparticle with different morphology on fibrous filters

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Filtration is the most ancient and widespread method of controlling aerosols in gas streams. However, the classical filtration theory, which was mostly developed in the latter half of the 20th, does not focus on the shape of the particles. Neglect of this kind can introduce significant differences in the theoretical and actual efficiency of fibrous media commonly used for air filtration. This project investigates the removal efficiency of nanosized particles of various shapes on a low efficiency fiber filter. The use of a low-efficiency filter allows the most detailed demonstration of the studied effect of the influence of the particle shape on the filtration efficiency.

The experimental setup similar to one discussed in Boskovic et al. (2005) was used in this investigation.

Nanoparticle of different shape were used in this project: Fe2O3 – almost perfect spheres, MgO – perfect cubes, the straight rod shaped ZnO and curved nanotubes. All particles demonstrate similar and well expected trend – the efficiency is decreasing towards the most penetrating particle size (MPPS), which is around 250-300nm. However, the efficiency of removal of spherical particles is higher as compared to all other shapes. The removal of short nanorods of ZnO showed the lowest efficiency, which might be explained by the particle's smallest size if it travels through the filter pores normally to the filter face. Nanotubes showed slightly higher efficiency, due to their cylindrical structure, which makes it easier for them to adapt to the curvature of the fibres. The intermediate efficiency at smallest particle sizes was observed for the MgO nano-cubes. Such result is in excellent agreement with the outcomes demonstrated in Boskovic et al. (2005).

Boskovic, L., Altman, I., Agranovski, I., Braddock, R., Myojo, T. and Choi, M. (2005). Aerosol Sci. Tech., 39, 1184–1190

Workshop on Nanoparticles for Clinical Applications II

16:00-17:00	**Workshop on Nanoparticles for Clinical Applications II** **(Dock Six 1)** **Chair: I. S. Vizirianakis**
15:30-16:00 **INVITED**	**Electrospinning for biomedical applications: tissue engineering scaffolds, sensors and vascular grafts** **V. Koutsos** *School of Engineering, Inst.e for Materials and Processes, The Un. of Edinburgh, Robert Stevenson Road, United Kingdom)*
16:00-16:30 **INVITED**	**N-isopropyl acrylamide-based nanogels for drug delivery to the brain** **M. Resmini** *Dept. of Chemistry, SPCS, Queen Mary Un. of London, London E1 4NS, UK*
16:30-16:45	**Impact of crystalline structure on the magnetic properties of Co-based iron spinels** **Balan V.**[1,3], Nistor M.[1,2], Pui A.[2], Zara-Danceanu C.-M.[1,4], Stiufiuc, R.-I.[1,5], Dragoi B.[1,2] [1]*Nanotechnology Laboratory, TRANSCEND Research Center, Regional Inst.e of Oncology, Romania* [2]*Faculty of Chemistry, Alexandru Ioan Cuza Un. of Iași, Romania* [3] *Biomedical Sci. Dept., Faculty of Medical Bioengineering, Grigore T. Popa Un. of Medicine and Pharmacy of Iasi, Romania* [4]*Nat. Inst.e of Research and Development for Technical Physics, Iasi, Romania* [5]*Dept. of Nanobiophysics, MedFuture Research Center for Advanced Medicine, "Iuliu Hatieganu" Un. of Medicine and Pharmacy, Romania*
16:45-17:00	**Cell cultivation in dynamic patterning conditions for tissue regeneration applications** **K. Tsimenidis**, A. Orfanos, V. Karagkiozaki *BL Nanobiomed P.C., Greece*

Electrospinning for biomedical applications: tissue engineering scaffolds, sensors and vascular grafts

V. Koutsos

School of Engineering, Institute for Materials and Processes, The University of Edinburgh, United Kingdom

Electrospinning is a versatile process used for producing fibres with diameters on the order of tens of nanometres to micrometres. The electrospun nano/microfibres have attracted significant attention due to their ease of synthesis, high aspect ratio and their ability to organise in macroscopic mats with high surface-to-volume ratio and porosity (generally ≥70%). Such porous structures can be used in diverse applications such as filtration, drug delivery, tissue engineering, wound dressing, sensors, and smart composites. In this talk, I will present a novel method of high-throughput electrospinning based on a nozzle-free set-up [1] and give specific examples for the fabrication of tissue engineering scaffolds [2], biomedical sensors [3], and vascular grafts [4, 5] based on electrospun nano/microfibres.

[1] M. Waqas, A. Keirouz, M. K. S. Putri, F. Fazal, F. J. D. Sanchez, D. Ray, V. Koutsos, N. Radacsi. Medical Engineering & Physics 2021, 92, 80-87

[2] A. Keirouz, M. Zakharova, J. Kwon, C. Robert, V. Koutsos, A. Callanan, X. Chen, G. Fortunato, N. Radacsi. Materials Science & Engineering C 2020, 112, 110939, 1-11

[3] M. Chung, W. H. Skinner, C. Robert, C. J. Campbell, R. M. Rossi, V Koutsos, N. Radacsi. ACS Applied Materials & Interfaces 2021, 13 (43), 51504–51518

[4] F. Fazal, F. P.W. Melchels, A. McCormack, A. F Silva, A. Callanan, V. Koutsos, N. Radacsi. Journal of the Mechanical Behavior of Biomedical Materials 2023,139, 105665

[5] F. Fazal, F. J. D. Sanchez, M. Waqas, V. Koutsos, A. Callanan, N. Radacsi. Medical Engineering & Physics 2021, 94, 52-60

N-isopropyl acrylamide-based nanogels for drug delivery to the brain

M. Resmini

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Covalently crosslinked nanogels are interesting materials, combining properties of hydrogels with nanoparticles, and offering advantages such as very small particle size, swelling behaviour and high colloidal stability, with an easy-to-tailor formulation, which allows to introduce stimuli-responsive properties such as temperature. When developing drug delivery systems it is important to evaluate how these interact with biological systems and their potential toxicity. NIPAM nanogels functionalised with negatively charged monomers were synthesed, characterised and their interactions with proteins evaluated, focusing on the effects that protein corona had on their thermoresponsive behaviour.

The nanoparticles were also evaluated as potential delivery systems for the brain. The nanogels were evaluated using an *in vitro* human blood-brain barrier model, obtained from CD34 positive-derived endothelial cells in co-culture with pericytes, and their permeation was studied up to 24 hours. Internalization in the BBB endothelial cells was confirmed by confocal microscopy, via clathrin-mediated endocytosis, using fluorescently labelled nanogels. The ability of nanogels to cross the BBB *in vivo* without inducing a toxic effect was evaluated on zebrafish, up to 10 days post fertilization.

Impact of crystalline structure on the magnetic properties of Co-based iron spinels

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[4]*National Institute of Research and Development for Technical Physics, Iasi, Romania*

[5]*Department of Nanobiophysics, MedFuture Research Center for Advanced Medicine, "Iuliu Hatieganu" University of Medicine and Pharmacy, Romania*

Magnetic nanoparticles (NPs) have emerged as versatile tools in the biomedical field, offering unprecedented opportunities to enhance the diagnosis and treatment of cancer. In this study, we report the successful synthesis of various NPs, including pure magnetite, magnetite doped with varying concentrations of cobalt (1%, 5%, 10%), and cobalt ferrite NPs. The NPs were synthesized by coprecipitation method, employing Pluronic F127 surfactant as dispersant. XRD analysis confirmed the formation of the cubic spinel structure (Fd-3m space group type) for all samples. DLS revealed hydrodynamic sizes in the range of 127 and 525 nm (PDI of 0.01 – 0.02) and Zeta potential values in the range of -24 and +41 mV. TEM images displayed sphere-like particles for $CoFe_2O_4$ while sphere- and cubic-like mixed morphology with a large size distribution (10 – 50 nm) was obtained for the Co-doped Fe_3O_4. FT-IR and Raman spectra displayed the typical vibration bands for F127 and Me-O. In addition, Raman spectra recorded at 10 and 100% laser power revealed that a low amount of cobalt favors the phase transition from magnetite to maghemite while 10% Co stabilized the structure. According to VSM, cobalt impacted the magnetic properties of the final material especially at low concentration, when the magnetization decreased 1.24-fold times as compared with pure magnetite (58 emu/g for magnetite). The magnetization increased again with the increase in Co amount, approaching that of pure magnetite. Interestingly, cobalt ferrite has a significantly lower magnetization (19.5 emu/g) as compared to magnetite, indicating the role played by the crystalline phase in magnetic properties. In vitro analysis demonstrated high biocompatibility, non-toxic effects as well as no morphological changes under all testing conditions.

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Cell cultivation in dynamic patterning conditions for tissue regeneration applications

K. Tsimenidis, A. Orfanos, V. Karagkiozaki

BL Nanobiomed P.C., 20th Km Thessaloniki – Tagarades Road, Thessaloniki, Greece.

Advancements in tissue regeneration hold immense potential for revolutionizing regenerative medicine. In the Laboratories of BL NANOBIOMED, we investigate the impact of dynamic conditions on cellular proliferation, aiming to optimize tissue regenerative strategies. We present a novel approach that leverages dynamic modulation techniques to enhance cellular proliferation. By subjecting cells to controlled dynamic environments, we observed up to 30% improvements in cellular proliferation rates when compared to static culture conditions. Our findings suggest that these dynamic conditions stimulate cell behaviour and contribute to accelerated tissue regeneration. The results highlight the potential of non-traditional approaches in tissue engineering and offer valuable insights for the development of innovative strategies in regenerative medicine.

Workshop on Artificial Intelligence, Machine Learning, Intelligent Manufacturing and Automation 4 (NN24 & ISFOE24)

15:00-17:00	**Workshop on Artificial Intelligence, Machine Learning, Intelligent Manufacturing and Automation 4 (NN24 & ISFOE24)** **(Timber Hall 1)** **Chair: R. Gautier**
15:00-15:30 **INVITED**	**Organic Photovoltaic Material and Device Insights from High-Throughput Experiments, Data Science and Machine-Learning Methods** **X. Rodríguez-Martínez** *Universidade da Coruña, Spain*
15:30-16:00 **INVITED**	**An Experimentally validated Numerical Approach for Predicting Adsorption Processes on Membrane-Coated Adsorbents in the Field of Water Remediation** **A. Kneer** *TinniT Technologies GmbH, Germany*
16:00-16:15	**Enhancing plasma etching efficiency, repeatability, and environmental footprint via AI-based modeling and optimization (plasmAI)** **V. Constantoudis**[1,3], E. Gogolides[1,3], T. Giannakopoulos[2], S. Konstantopoulos[2], A. Armaou[4], G. Kokkoris[5] *[1] Institute of Nanoscience and Nanotechnology, NCSR Demokritos, Greece* *[2] Institute of Informatics and Telecommunication, NCSR Demokritos, Greece* *[3] Nanometrisis p.c., Neapoleos 27, Greece* *[4] School of Chemical Engineering, NTUA Athens, Greece*
16:15-16:30	**Advancing Additive Manufacturing: A Data-Driven Strategy for Integrated L-PBF Process Optimization** P. Stavroulakis[1], P. Kolozis[1], L. Gargalis[2], L. Karavias[2], E. Karaxi[2], E. P. Koumoulos[1] *[1]IRES - Innovation in Research Engineering Solutions, Bluepoint, Schaerbeek, Belgium* *[2] Conify P.C., Greece*
16:30-16:45	**Real Time & Digital controlling of high precision electrode deposition by Spectroscopic Ellipsometry Tool for Electronic Devices fabrication on OVPD Cluster PPL** **M. Chatzidis**[1], A. Zachariadis[1], P.K. Baumann[2], A. Laskarakis[1], M. Gioti[1], S. Logothetidis[1] *[1] Nanotechnology Lab LTFN, Aristotle University of Thessaloniki, Thessaloniki, Greece* *[2] AIXTRON SE, Dornkaulstr. 2, 52134 Herzogenrath, Germany*
16:45-17:00	**3D printing of Luminescent Solar Concentrators** R. Capener, J. Manning, P. Itrych, S. Baldock, **L. Danos** *Department of Chemistry, Energy Lancaster, Lancaster University, Lancaster, LA1 4YB, UK*
17:00-17:15	**Optimization of perovskite solar cells using data science analysis and machine learning predictions** **M. M. Elsenety**[1,2], C. Falaras[3], E. Stathatos[3], Y. Niu[4], L. Hu[4] *[1] Inst. Nanoscience & Nanotechnology, Nat. Center for Sc. Res. "Demokritos", Greece* *[2] Dept of Chemistry, Al-Azhar University, Cairo, Egypt* *[3] Electrical and Computer Engineering Dept., Univ. of the Peloponnese, Patras, Greece* *[4] Institute of Solid State Physics, Hefei Inst. Physical Science, Chinese Acad. Sciences, P.R. China*

INVITED TALK

Organic Photovoltaic Material and Device Insights from High-Throughput Experiments, Data Science and Machine-Learning Methods

X. Rodríguez-Martínez

Institute for Physical Chemistry, Heidelberg University, Germany

Organic photovoltaics (OPVs) is a sustainable energy technology in which active materials can be readily printed via low-cost methods in flexible and semi-transparent form factors, thus motivating their integration into buildings (indoors, façades, agrivoltaics) and as off-grid energy source in portable and lightweight electronic devices (e.g., as battery replacement). Efficiency and stability advances in OPVs are tied to the discovery of novel light harvesting materials with improved photovoltaic properties, and to the often-tedious optimization of devices in intricate multi-dimensional spaces. In this scenario, the concomitant use of high-throughput experimentation (HTE) approaches with machine-learning (ML) methods is poised to accelerate organic solar cell material's discovery and device optimization at unprecedented paces (Energy & Environmental Science 14 (6), 3301-3322).

In this talk I will present our most recent advances on the exploitation of data science and ML in myriad topics concerning organic solar cells. First, I will discuss about the material design rules toward improved sunlight absorbers e tracted from big theoretical and experimental datasets with the help of data science and ML (Energy & Environmental Science 15 (7), 2958-2973). Following, I will present our pioneer work on the use of ML and a Bayesian machine-scie tist to predict the sweet spot in regard to performance and active layer composition in organic solar cells (Energy & Environmental Science 14 (2), 986-994). Finally, I will discuss our most recent (unpublished) results on the understand ing of the device properties making thick organic solar cells a high-performing reality, obtained through a combination of kinetic Monte Carlo simulations, HTE and ML methods. These advances are poised to inspire the use of similar workflows in organic electronics and beyond.

INVITED TALK

An Experimentally validated Numerical Approach for Predicting Adsorption Processes on Membrane-Coated Adsorbents in the Field of Water Remediation

A. Kneer[a], A. Reiter[a,b], A. August[b,c], G. Rehner[e] , M. Reder[b,c], D. Kneer[a], S. Kneer[a] , S. Barbe[d], M. Esslinger[e], E. Alesi[e] , B. Nestler[c,b]

[a]*TinniT Technologies GmbH, Essenweinstr, Germany*

[b]*Hochschule Karlsruhe, University of Applied Sciences, Istitute of Digital Materials Science (IDM)Germany*

[c]*Karlsruhe Institute of Technology, Institute of Applied Materials, Microstructure Modelling and Simulationials Science (IAM-MMS), Germany*

[d]*Technical university cologne, Leverkusen, Germany*

[e] *IEG Technologie GmbH, Hohlbachweg, Germany*

Various technologies are utilized for water remediation, including fixed bed reactors, alongside fluidized bed reactors. Fixed bed reactors, housing adsorptive materials, effectively remove contaminants via adsorption as water flows through them. Activated carbon, with its cylindrical structure and microporous interior, is commonly favored for its surface-enhancing properties. Alternatively, biofilter media like MBBR (Moving Bed Biofilm Reactor), which are coated by membranes, are interesting. For this application the membrane is doped with activated carbon powder, offering efficient pollutant removal with minimal pressure loss compared to traditional activated carbon beds. The complex gear-like hollow structure of MBBR carriers poses challenges in reactor design and operation. To address these challenges, a cross-scale methodology combining advanced experimental and computational processing components has been developed within a research project. This methodology enables the calculation of adsorption on membrane layers, extending from the microscopic pore scale to realistic reactor dimensions. The approximation of the adsorption isotherms and the kinetics of the adsorption for defined contaminants, which are derived from experimental data, are used as integral part of a numerical solver suite. The resolution in the pore scale for the membrane is utilized to determine effective adsorption rates. The effective quantities on the pore scale are transferred to the MBBR scale to predict the adsorption rates for one or several MBBRs, which are influenced by the flow behavior around it. As the next consistent upscaling step effective rates are extracted for the full reactor model which is then computed using the dual porosity approach. Experimental validation of the numerical methods further enhances their reliability. By combining experimental results with numerical cross-scale simulations, this study offers a comprehensive approach to understanding and optimizing water remediation processes, particularly in fixed bed reactors utilizing membrane-coated adsorbents. This abstract concisely outlines the development and application of a crossscale methodology for predicting adsorption on membrane-coated carrier beds, highlighting its potential for advancing water remediation technologies.

Enhancing plasma etching efficiency, repeatability, and environmental footprint via AI-based modeling and optimization (plasmAI)

V. Constantoudis[1,3], E. Gogolides[1,3], T. Giannakopoulos[2], S. Konstantopoulos[2], A. Armaou[4], G. Kokkoris[5]

[1] *Institute of Nanoscience and Nanotechnology, NCSR Demokritos, Greece*
[2] *Institute of Informatics and Telecommunication, NCSR Demokritos, Greece*
[3] *Nanometrisis p.c., Neapoleos 27, Greece*
[4] *School of Chemical Engineering, NTUA Athens, Greece*

Plasma etching, extensively used in semiconductor manufacturing for pattern transfer, suffers from macroscopic non-uniformity (at the wafer level) and batch-to-batch shifts due to reactor wall changes, necessitating frequent seasoning; both mishits increase the production cost. A dominant demand is also “greener” recipes, i.e., processes with lower global warming potential (GWP), non-toxic gases, and efficient energy use. Additionally, the quest for chemistries and the design of recipes suitable for plasma etching of new materials entering the stack is a difficult task and is usually based on minimal literature data and/or a trial-anderror procedure. In this project, we envision a universal solution with the potential to tackle all modern challenges of plasma etching process: A computationally fast and accurate data-driven model of the process will be developed and, through optimization algorithms, will be utilized to provide answers to important questions regarding the cost, the uniformity, the drifts, the environmental footprint, and the design of new recipes. The development of the model will be based on data computed from first-principles models (physics-based models) and collected from apt experimental measurements; these data can be used to train a machine learning system to approximate the outputs of the physical process. Artificial intelligence models (AI-models) are essential as physics-based modeling, although theoretically feasible to deal with all the above-mentioned challenges, entails a high computational cost. This computational efficiency allows the quick exploration of the complete parameter space, which is critical when performing optimization studies to address the plasma etching challenges. [The project is funded by the program “ AI-Aware pathways to Sustainable Semiconductor Process and Manufacturing Technologies (AWASES)” of the companies Intel and Merck.

Advancing Additive Manufacturing: A Data-Driven Strategy for Integrated L-PBF Process Optimization

P. Stavroulakis[1], P. Kolozis[1], L. Gargalis[2], L. Karavias[2], E. Karaxi[2], E. P. Koumoulos[1]

[1]*IRES - Innovation in Research Engineering Solutions, Bluepoint, Schaerbeek, Belgium*
[2] *Conify P.C., Greece*

Optimizing manufacturing processes requires extensive data and advanced analysis techniques to identify trends and reveal any hidden interdependencies. Nevertheless, as data scarcity is a common issue in research, extensive experimentation is required to create sufficiently-sized databases for the application of such approaches. In this work, a multilayer approach for optimizing the as-printed component density of additively manufactured (AM) duplex stainless (DSS) and superduplex (SDSS) steels combining data analysis and experimentation is proposed. A computational software tool is utilized to define a process window based on the powder particle characteristics and thermophysical properties. Samples are subsequently manufactured according to these predictions. The relative density of the longitudinal and transverse build direction is then measured through means of optical microscopy (OM) and recorded alongside the process parameters (laser power, scan speed, hatch distance) for each sample. Subsequently, linear and nearest-neighbor interpolation is applied to refine the process window, with the minimum relative density acceptance threshold set at 99.5%. The refined process window is validated by printing samples meeting the desired density. As more data is gathered, an iterative approach can be applied where experiments are guided by continuously updated model predictions, incorporating user corrections to improve accuracy. Once a critical data volume is achieved, machine-learning (ML) methods can then be applied to expand the analysis to accommodate additional material features. This iterative, data-driven approach accelerates the development of AM processes, enabling continuous optimization until components with desirable properties are achieved. This research was funded by the European Commission under the HORIZON2020 Framework Programme Grant Agreement no. 952869.

Real Time & Digital controlling of high precision electrode deposition by Spectroscopic Ellipsometry Tool for Electronic Devices fabrication on OVPD Cluster PPL

M. Chatzidis[1], A. Zachariadis[1], P.K. Baumann[2], A. Laskarakis[1], M. Gioti[1], S. Logothetidis[1]
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[2] AIXTRON SE (Dornkaulstr. 2, 52134 Herzogenrath, Germany)

Organic Vapor Phase Deposition technology utilizes inert gas for transporting organic vapors for the deposition of small molecular organic thin films used for organic electronics devices. OVPD technology ensures the homogeneity and uniformity of organic thin films over large areas and it is already on use for high quality OLEDs and lab–scale OPVs. In this work, the unique Cluster PPL-OVPD connected with Electrode Deposition Chamber (EDC) combine the depositions of inorganic nano-layers and nanostructures finalizing the Top-Electrode synthesized system of OE devices. Facilitating Real-Time deposition control of metal materials such as Aluminum (Al) and Silver (Ag) is achieved through the guidance and operation of the Vacuum Thermal Evaporation Chamber (VTEC)/EDC (Electrode Deposition Chamber). This process is enriched by the integration of advanced tools, including the Optical Tool RT-SE, the Piezoelectric Tool QCM (Quartz Control Meter), and the software tool digital-SE. The RT-SE provides optical insights, the QCM offers precise control using piezoelectric technology, and the digital-SE with MCP Platform introduces sophisticated software capabilities.

Real-Time Spectroscopic Ellipsometry (RT-SE) offers real-time insights, providing additional information to refine existing flat values of Quartz Control Meter (QCM) and recalculate/ recalibrate the tooling factor of the active source. This calibration ensures the smooth deposition of inorganic materials especially on the thickness level 0-10nm. In parallel time, **Digital Spectroscopic Ellipsometry** (D-SE) actively stores incoming spectral data, enhancing its simulation run capabilities and thickness control accuracy within the suite. This is facilitated and supported by an AI-Closed Loop Process software machine.

The scope of this investigation is the comprehensive management of high accuracy deposition process parameters in real-time for inorganic thin films, encompassing a deposition control range from 0.1Å/s to 10 Å/s. The aim is to achieve the desired optical, structural, and electrical properties. Additionally, precise teaching and optimization of the Deposition Chamber are accomplished through tooling factor control, enhancing the overall efficiency and accuracy of the deposition process under UHV environment.

3D printing of Luminescent Solar Concentrators

Richard Capener, Jake Manning, Piotr Itrych, Sara Baldock, **Lefteris Danos**
Department of Chemistry, Energy Lancaster, Lancaster University, Lancaster, UK

Luminescent Solar Concentrators (LSCs) are devices that aim to enhance the efficiency of solar energy harvesting by utilizing luminescent materials. They are a type of solar concentrator that can collect and concentrate sunlight onto photovoltaic (PV) cells. The basic structure of an LSC consists of a transparent waveguide or panel, typically made of glass or plastic, doped with luminescent materials. These materials can be organic dyes, quantum dots, or other types of phosphors. When sunlight enters the LSC, the luminescent materials absorb a portion of the light and re-emit it at longer wavelengths, usually in the visible or near-infrared spectrum. The emitted light travels within the waveguide by total internal reflection, bouncing off the edges until it reaches a PV cell placed along one or more edges of the LSC, which converts the concentrated light to electricity. LSCs can concentrate both direct and diffuse sunlight, enabling them to capture light from different angles and under varying weather conditions. Recent developments in LSCs prove to be a useful alternative and even a necessary supplement to the building-integrated renewable energy systems towards achieving net zero emissions. In this presentation, we will show 3D-printed LSC plates optimised for improved performance doped with luminescent organic (perylene) dyes. The surfaces of the LSC plates are polished to achieve optical quality and good transparency and are characterised using optical spectroscopy (absorption and emission). Their electrical performance (I-V characteristic) using silicon solar cells is measured and compared to the performance of similar injection moulded LSCs. High-efficiency silicon solar cells are used to construct 10 cm x 10 cm x 0.5 cm LSC plates for a demonstration of an LSC device capable of powering small electronic devices.

Optimization of perovskite solar cells using data science analysis and machine learning predictions

Mohamed M. Elsenety[1,2], Christos Falaras[3], Elias Stathatos[3], Yunjuan Niu[4], Linhua Hu[4]

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[2] *Department of Chemistry, Al-Azhar University, Cairo, Egypt*

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[4] *Institute of Solid State Physics, Hefei Institutes of Physical Science, Chinese Academy of Sciences, China*

Innovative interface engineering was employed to enhance the performance of perovskite solar cells (PSCs). The perovskite functionalization by 3,4-Bis(4-bromophenyl)cyclobut-3-ene-1,2-dione (BED) of resonant structure leads to devices achieving power conversion efficiency (PCE) of 23.82% and greatly improved stability. The introduction of polyvinylpyrrolidone (PVP) to the $MAPbI_3$ perovskite precursor results in PSCs presenting self-healing ability in a moisture environment and PCE of up to 20.32%. J-V data analysis was performed using Python programming to investigate the inter-correlation between power conversion efficiency (PCE) and cell parameters. The impact of each feature's influence was qualitatively explored using Orange software to elucidate the role of the functional interlayers in developing efficient, robust and low cost PSCs. For the resonant derivative, calculations employing Python code combined with libraries demonstrated that in reference cells the PCE correlates negatively with active area (AE) for 57%, however this correlation drops to~9% in the case of BED-treated cells. The use of Orange toolkit showed that the PCE of cells functionalized with BED is mainly affected by V_{oc}, FF, and J_{sc}, in contrast to pristine cells which are mostly affected by J_{sc}, and AE. These results confirm that size escalation is not expected to cause changes in PCE and this is a promising prediction of the scale-up ability of the modified devices. In the case of PVP-passivated cells the corresponding Python code analysis indicated that the correlation between PCE and AE drops to~1% (from 40% for reference cells). The use of Orange software has shown that the PCE of passivated cells with PVP is mainly affected by J_{sc}, FF and V_{oc}, in contrast to non-treated devices where PCE largely depends on R_{sh} and R_s resistances. This is in agreement with the observed enhanced perovskite quality following PVP treatment.

Thursday 4 July 2024

Workshop on Nanoenergy

09:00-11:00	**Workshop on Nanoenergy** **(Timber Hall 2)** **Chair: N. Kalfagiannis**
09:00-9:30 **KEYNOTE**	**Solar Hydrogen Innovation with Flux-Grown Photocatalytic Crystals** **K. Teshima[1,2,3,4]**, T. Yamada[1,2], F. Hayashi[2], M. Tipplook[1], C. Terashima[1,4] *[1]Research Initiative for Supra-Materials, [2]Dept. of Materials Chemistry, Shinshu Un.,* *[3]Verne Crystal Inc.,[4]Research Center for Space System Innovation, Tokyo Un. of Science, Japan*
9:30-10:00 **INVITED**	**High Performance Bioderived Triboelectric Nanogenerators (TENGs) for Sustainable and Green Electronics** **C. Pitsalidis** *Khalifa Un., Abu Dhabi, UAE*
10:00-10:15	**Towards sustainable plasmonics: shapes and optical properties of magnesium nanoparticles** **C. Boukouvala[1,2]**, J. Asselin[1,2] C. A. West[1,2] A. Ten[1,2] E. R. Hopper[1,2], Q. M. Ramasse[3,4,5] J. S. Biggins[6] and E. Ringe[1,2] *[1]Dept. of Materials Science and Metallurgy, Un. of Cambridge, UK* *[2]Dept. of Earth Sci., Un. of Cambridge, Cambridge* *[3]School of Chemical and Process Engineering, Un. of Leeds, UK* *[4]School of Physics and Astronomy, Un. of Leeds, UK* *[5]SuperSTEM, SciTech Daresbury Science and Innovation Campus, UK* *[6]Dept. of Engineering, Un. of Cambridge, Trumpington Street, UK*
10:15-10:30	**Energy transfer between tunneling electrons and excitons in van der Waals light sources and photodetectors** **S. Papadopoulos[1]**, L. Wang[1], F. Iyikanat[2], Y. Koyaz[3], S. Shan[1], J. Huang[1], R. Khelifa[1], T. Taniguchi[4], K. Watanabe[5], F. Javier García de Abajo[2], L. Novotny[1] *[1]Photonics Laboratory, ETH Zürich, Zürich, Switzerland.* *[2]Inst. de Ciències Fotòniques (ICFO), The Barcelona Inst.e of Science and Technology,Castelldefels, Spain* *[3]Photonic Systems Laboratory, EPFL, Switzerland* *[4]InterNat. Center for Materials Nanoarchitectonics, Nat. Inst.e for Materials Science, Tsukuba, Japan.* *[5] Research Center for Functional Materials, Nat. Inst.e for Materials Science, Tsukuba, Japan.*
10:30-10:45	**Development of light harvesting structures for photovoltaic applications** H. Banks, B. Wood, J. Manning, M. Coogan, **L. Danos** *Dept. of Chemistry, Lancaster Un., UK.*

KEYNOTE TALK

Solar Hydrogen Innovation with Flux-Grown Photocatalytic Crystals

K. Teshima[1,2,3,4], T. Yamada[1,2], F. Hayashi[2], M. Tipplook[1], C. Terashima[1,4]
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Crystal growth is fundamental and practical in materials science. Controlling the size, morphology and exposed surface features of crystals and discovering new materials with novel structures are fundamental issues in the field of “Solar Hydrogen”, that is, visible-light driven photocatalysts. Flux crystal growth allows control of crystal size, morphology and exposed surface features by using alkali and alkaline earth metal salts (e.g. NaCl, KCl, SrCl2, NaOH, NaNO3, Na2SO4 and so on) as a flux heated below the melting temperature of the material. In recent years, advances in theoretical calculations and materials informatics have led to advances in flux crystal growth.
Photocatalytic water splitting using visible light responsive particulate semiconductors offers great potential for producing green hydrogen. We have reported on the flux growth of a variety of visible-light driven photocatalysts, including oxides, (oxy)nitrides and (oxy)sulphides. These crystalline photocatalysts exhibit good photocatalytic properties for hydrogen and oxygen evolution under visible light. Details of the flux growth of (oxy)nitride and (oxy)sulphide crystals and their functional properties will be presented at NN24.
Acknowledgements
This research was partially supported by Council for Science, Technology and Innovation (CSTI), Cross-ministerial Strategic Innovation Promotion Program (SIP), the 3rd period of SIP and NEDO-GI-ARPChem..

INVITED TALK

High Performance Bioderived Triboelectric Nanogenerators (TENGs) for Sustainable and Green Electronics

C. Pitsalidis

Department of Physics, Khalifa University, Abu Dhabi, UAE

Over the past decade, the need to develop self-sustaining and eco-friendly energy solutions for human use has significantly intensified. Triboelectric nanogenerators (TENGs) have emerged as revolutionary sustainable devices, particularly in the fields of wearable electronics and bioelectronics. By harnessing the triboelectric effect, TENGs convert mechanical energy from body movements or environmental sources into electrical energy, offering a green and efficient energy solution. Our research introduces a novel approach to enhance the performance of TENGs by incorporating bio-derived active layers and integrating advanced nanomaterials. Specifically, we have developed a technique to boost energy conversion efficiency through the strategic use of these materials, significantly improving the overall output and reliability of the devices. In our pursuit of fully biodegradable TENGs, we investigate the use of biopolymer-based substrates and solution-processed electrodes. These materials enhance the devices' sustainability and contribute to their biodegradability, aligning with global environmental goals. The bio-TENGs produced through this process demonstrate exceptional flexibility, biocompatibility, and breathability, making them ideally suited for wearable electronics that harvest energy from biomechanical movements. These advanced bio-TENGs exhibit superior performance, achieving output voltage and power density values that surpass those of conventional TENG devices. Our findings indicate that these devices can operate efficiently under various conditions, making them highly adaptable for diverse applications in sustainable energy harvesting. By advancing the design and functionality of TENGs, our research contributes to developing next-generation, eco-friendly energy solutions, addressing the critical need for sustainable technology in our society.

Towards sustainable plasmonics: shapes and optical properties of magnesium nanoparticles

C. Boukouvala[1,2], J. Asselin[1,2] C. A. West[1,2] A. Ten[1,2] E. R. Hopper[1,2], Q. M. Ramasse[3,4,5] J. S. Biggins[6] and E. Ringe[1,2]

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Nanoparticle (NP) shape is critical for nanoscale phenomena including plasmonics, self-assembly, and catalysis. The common plasmonic metals Au, Ag, Cu and Al all form FCC structures with variants of cuboctahedral, singly twinned, pentatwinned, and icosahedral shapes. In contrast, the cheap and Earth-abundant Mg crystallises in a HCP configuration, giving rise to not only typical single crystal hexagonal plates but also a large array of striking NP shapes. Here, we apply the Wulff construction to model the full range of possible Mg NP shapes based on the known HCP twin planes, i.e. $(10\bar{1}x)$, x= 1, 2, 3 and $(11\bar{2}y)$, y= 1, 2, 3, 4, otherwise known as first and second order pyramidal planes respectively. Twin and re-entrant enhancement parameters in the Wulff model allow to control the aspect ratio of these structures and simulate the growth of the inner facets adjacent to the twin plane respectively; the latter leads to various "filled" convex shapes akin rods. Our models agree well with the variety of shapes observed in colloidal and gas phase Mg NP syntheses. We explore the effects of these unusual shapes on the near-field and far-field plasmonic response with electromagnetic simulations as well as experimental electron-beam and optical spectroscopy approaches. Numerical techniques are further employed to understand the shape-dependent photothermal behaviour of the NPs. Tip rounding and the presence of an MgO layer, native to synthesised Mg NPs, are also found to significantly affect the NPs' plasmonic and photothermal behaviour. Overall, our findings are instructive for the design and potential use of Mg NPs as an alternative plasmonic platform in enhanced spectroscopies and photothermal applications.

Energy transfer between tunneling electrons and excitons in van der Waals light sources and photodetectors

S. Papadopoulos[1], L. Wang[1], F. Iyikanat[2], Y. Koyaz[3], S. Shan[1], J. Huang[1], R. Khelifa[1], T. Taniguchi[4], K. Watanabe[5], F. Javier García de Abajo[2], L. Novotny[1]

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Van der Waals heterostructures have shown great potential for optoelectronic and photonic applications. By stacking atomically thin materials like graphene, hexagonal Boron-Nitride (hBN) and transition metal dichalcogenides, (TMDs), optical sources and photodetectors can be realized. Despite the overall progress, our understanding of the physical mechanisms involved in such devices remains incomplete and puts a limit to our capabilities of designing high-performance devices. Here, we present our experimental findings on the important role of energy transfer (ET) between tunneling electrons and excitons in understanding and designing efficient optical sources and detectors. We first introduce a light-emitting device (LED) where a monolayer TMD is positioned on-top of a van der Waals tunnel junction. Despite the fact that the TMD is placed outside of the tunneling pathway we show that excitons are efficiently generated solely through optical coupling. We further discuss that such LEDs present resonant peaks in their differential conductance curve which can be attributed to strong interaction between electrons and indirect excitons in the TMDs. Additionally, we explore ET effects that lead to overbias excitonic light emission through a two-electron process. Finally, based on the acquired knowledge on the ET-based mechanisms, we employ a monolayer WS2 flake, that acts as a light harvesting antenna, on-top of a photodetector to demonstrate an 18-fold responsivity enhancement. Collectively, our work expands our understanding of van der Waals devices by revealing the crucial role of ET in the design and performance of optoelectronic devices.

Development of light harvesting structures for photovoltaic applications

H. Banks, B. Wood, J. Manning, M. Coogan, **L. Danos**

Department of Chemistry, Lancaster University, Lancaster, UK

The fabrication of "light harvesting" structures is important in solar energy research for improving the capture of the dilute incident solar spectrum. Previous work has already shown efficient excitation energy transfer from dyes close to the silicon surface [1-3] towards the development of a silicon photosensitized silicon solar cell. In this presentation we will show research examples developed from light harvesting monolayer structures based on Langmuir Blodgett films demonstrating efficient energy transfer and polystyrene microspheres functionalized with ratios of luminescent donor and acceptor dyes. Furthermore, direct covalent attachment of dye molecules on the surface of silicon substrates is demonstrated for the photosensitization of silicon. A modification of a two-step halogenation/Grignard route, involving a chlorination-alkylation reaction is used to passivate the surface of crystalline silicon can be further modified via functionalization in order to photosensitive Si(111) with the attachment of light-harvesting complexes such as porphyrin and perylene derivatives. We will show how efficient energy transfer can be employed to create artificial light harvesting structures for different PV applications such as silicon photosensitization and Luminescent Solar Concentrators.

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Workshop on AI, ML, Intelligent Manufacturing and Automation 5 (NN24 & ISFOE24)

09:00-11:00	**Workshop on AI, ML, Intelligent Manufacturing and Automation 5 (NN24 & ISFOE24) (Timber Hall 1)** **Chair: S. Khiev**
09:00-09:30 INVITED	**Laser Induced Forward Transfer as a bioprinting method and applications** **I. Zergioti[1,2]** *[1]School of Applied Mathematical and Physical Sciences, NTUA, Athens, Greece* *[2]PhosPrint P.C., Athens, Greece*
09:30-10:00 INVITED	**Exosome Enhanced Bioprinting: Promises and Challenges** **A, Sendemir[1-5]**, P. İlhan[2], E. M. Namli[3], Z. Morcimen[1], D. Sabirtas[5], S. Tasdemir[5] *[1]Department of Bioengineering, Faculty of Engineering, Ege University, Izmir, Türkiye* *[2]PA Biotechnology, Ege Technopark, Izmir, Türkiye* *[3]Dept Stem Cell, Ege University, Izmir, Türkiye* *[4]Dept Biomedical Technologies, Ege University, Türkiye* *[6]Department of Bioengineering, Faculty of Engineering, Celal Bayar University, Manisa, Türkiye*
10:00-10:15	**Itaconic acid: a versatile biobased building block for the replacement of (meth)acrylic acid in photocurable formulations for 3D printing** **M. Maturi[1,2],** A. Sanz de Leon[1], M. Comes Franchini[2] and S. I. Molina[1] *[1] Dept. of Materials Science, Metallurgic Engineering, and Inorganic Chemistry, University of Cadiz, Avda. Universidad de Cádiz 10, Campus Universitario de Puerto Real (Spain)* *[2] Dept. of Industrial Chemistry, University of Bologna, Via Gobetti 85, Bologna, Italy*
10:15-10:30	**Design of a Novel Printed Matrix for Composite Graft Using 3D Printing Techniques** **A. Orfanos[1]**, K. Tsimenidis[1], V. Karagkiozaki[1] *[1]BL Nanobiomed P.C., 20th Km Thessaloniki – Tagarades Road, Thessaloniki, Greece, 57001*
10:30-10:45	**Rheological analysis of bioinks used for Laser Induced Forward Transfer** **S. Elezoglou[1]**, K. Giannakopoulos[1], A. Hatziapostolou[3], A. Klinakis[2,3], I. Zergioti[1,3] *[1]National Technical University of Athens, School of Applied Mathematical and Physical Sciences, Athens, Greece* *[2]Biomedical Research Foundation of the Academy of Athens, Athens, Greece* *[3]Department of Naval Architecture, School of Engineering, University of West Attica, Athens, Greece*

INVITED TALK

Laser Induced Forward Transfer as a bioprinting method and applications

I. Zergioti[1,2]

[1]School of Applied Mathematical and Physical Sciences, National Technical University of Athens, Greece

[2]PhosPrint P.C., Attika Technology Park Lefkippos, Athens, Greece

Laser Induced Forward Transfer (LIFT) is a bioprinting technique that uses a laser to transfer living cells or biological materials onto a substrate or scaffold to create complex 3D biological structures. In LIFT, a laser pulse is used to create a pressure wave that ejects droplets of a bioink, consisting of living cells or biomaterials, onto the desired location with high precision and resolution (μm scale). In terms of advancements, new applications for LIFT bioprinting are explored such as the development of tissue-engineered constructs for regenerative medicine and the fabrication of organs-on-chip for drug testing and disease modelling. In the present study, we utilize laser-induced forward transfer (LIFT) to print cell-laden bioinks based on methacrylated platelet lysate (platelet lysate methacrylate-PLMA), which can be polymerized in the presence of appropriate photoinitiators and light. For printing, we employed a nanosecond Nd:YAG laser source at 532 nm wavelength. We used primary smooth muscle (pSMC) and urothelial cells (pUC) of human and mouse origin isolated from healthy biopsies. We have optimized the printing conditions for the bioinks, the PLMA concentration and polymerization, and the media composition to achieve optimal cell growth ex vivo. As a result, we have managed to print bladder explants composed of multiple cell layers recapitulating the histological structure of the urinary bladder. These explants can be transplanted in animals to test bladder functionality. Moreover, the DNA damage profiles are assessed on different laser wavelengths used. The laser transfer dynamics is investigated by high speed imaging and the positioning of the cells in the hydrogels can be controlled. Single printing of organoids is also demonstrated.

INVITED TALK

Exosome Enhanced Bioprinting: Promises and Challenges

A. Sendemir[1-5], P. İlhan[2], E. M. Namli[3], Z. Morcimen[1], D. Sabirtas[5], S. Tasdemir[5]

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Bioprinting have been a revolutionary additive manufacturing technique for tissue engineering and regenerative medicine, since it can mimic the complex and hierarchical microarchitecture of human tissues. The success of bioprinting lies in its combination of top-down and bottom-up approaches, giving us the freedom to design the macro architecture of the tissue, while allowing autonomous self-assembly of the cells within the printed structures. Bioinks have been mainly considered as a combination of living cells with hydrogels supplemented with essential biomolecules that can be extruded in desired size and geometry. Recently, exosomes became a popular addition to the bioink compositions. Exosomes are a subset of extracellular vesicles that originate from the endosomal compartment of various cell types. Exosomes are naturally loaded with a rich, cell-specific cargo of cell signalling molecules, including proteins, lipids and nucleic acids with very high therapeutic potential. Use of exosomes within bioinks allows the delivery of these therapeutic nanocarriers directly with the cells at precisely targeted locations. However, maintaining the stability and biological activity during bioprinting still remains as a challenge. Incorporation of these powerful natural nanocarriers into bioprinting technology has to be investigated more intensely for more controlled and effective translation into clinics.

Itaconic acid: a versatile biobased building block for the replacement of (meth)acrylic acid in photocurable formulations for 3D printing

M. Maturi[1,2], A. Sanz de Leon[1], M. Comes Franchini[2] and S. I. Molina[1]

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Recent studies have highlighted the risks and concerns associated with the use of fossil-derived formulations in various industries, especially in the field of additive manufacturing. Vat photopolymerization (VP) heavily relies on toxic and polluting components such as (meth)acrylic acid derivatives. These components not only pose a threat to the environment but also to the health and safety of workers involved in the manufacturing process. To address this pressing issue, researchers are now focusing on itaconic acid (IA), an emerging building block that can be used to create liquid compounds that photopolymerize under radical conditions. Unlike traditional fossil-based formulations, IA is produced by fermentation of biomasses with engineered bacterial strains. It is one of the few fully biobased compounds that contain the acrylate moiety in their chemical structure, making it an ideal alternative to (meth)acrylic acid in photocurable formulations. IA, being a dicarboxylic acid, has been utilized to develop polyesters, poly(ester amide)s, and poly(ester thioether)s, but it was also used as a functionalizing moiety for non-photocurable biobased compounds such as branched polycaprolactone and non-isocyanate diurethanes. In our work, we have combined these macromers with small molecular weight IA-based reactive diluents to create fully biobased resins that photocure into solid 3D printed objects via VP. The resulting objects, which exhibit mechanical properties and thermal stabilities fully comparable to traditional fossil-based formulations, can be printed with great dimensional accuracy and they are characterized by elastic moduli that range from a few MPa to 1 GPa, depending on the formulation. Such approaches offer a sustainable and eco-friendly solution to the challenges posed by the use of fossil-derived formulations in the VP industry.

Design of a Novel Printed Matrix for Composite Graft Using 3D Printing Techniques

A. Orfanos, K. Tsimenidis, V. Karagkiozaki

BL Nanobiomed P.C., 20th Km Thessaloniki – Tagarades Road, Thessaloniki, Greece, 57001

The role of 3D printing technologies in tissue engineering and its application is crucial. In tissue engineering, the matrix serves as a fundamental scaffold for the growth of new tissue, providing the necessary support and structure. One important aspect to consider is the size of the pores within the matrix, which must strike a delicate balance. These pores need to be large enough to allow the flow of essential nutrients while maintaining the structural integrity of the affected area during mechanical stressing operations.

In this study, BL Nanobiomed has designed various geometries to create an appropriate model for the 3D matrix. By exploring different materials and conditions, the matrix model was 3D printed using DLP technology, enabling the creation of a porous support for the 3D bio-printed graft. By combining FDM and DLP 3D printing technologies, we have successfully achieved a matrix that allows for fluid flow while being rigid yet possessing elastic properties. This designed matrix is intended for growing tissues under dynamic circumstances

Rheological analysis of bioinks used for Laser Induced Forward Transfer

S. Elezoglou[1], K. Giannakopoulos[1], A. Hatziapostolou[3], A. Klinakis[2,3], I. Zergioti[1,3]

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[2]Biomedical Research Foundation of the Academy of Athens, Athens, Greece
[3]Department of Naval Architecture, School of Engineering, University of West Attica, Athens, Greece

The study explores the utilization of Laser Induced Forward Transfer (LIFT) in bioprinting for tissue fabrication and regenerative medicine. LIFT enables precise deposition of bioinks with sustained cell viability, facilitating the creation of 3D structures using a Nd:YAG laser source at a 532 nm wavelength. Various cell-laden bioinks mixed with different biomaterials were printed, with two distinct cell concentrations (10,000 & 75,000 cells/μl) examined. Rheological characterization of the bioinks using a microfabricated rheometer-viscometer-on-a-chip (RheoSense) revealed their behavior under different shear stresses, distinguishing between Newtonian and non-Newtonian fluids. The viscosity of each bioink was measured, with non-Newtonian bioinks further classified as shear thinning or Bingham-like fluids. The study assessed the impact of bioink viscosity on the LIFT bioprinting process, integrating a high-speed camera to monitor the printing dynamics and compare the propagation of each bioink. The LIFT process was also used to deposit cells within or on top of an Extracellular Matrix (ECM), with a parametric study conducted to create monolayers and develop a protocol for precise deposition inside hydrogels. By guiding light with the appropriate optical setup, controlled immobilization of cells at desired depths within ECMs was achieved. The high-speed camera was employed to monitor transfer dynamics within the ECM. During printing, morphological characteristics of the cell-laden jets were examined, revealing the presence of two sequentially generated jets with distinct dimensions and impact velocities. These jets played unique role during printing inside the ECM. The study demonstrated that increasing laser fluence led to cells being deposited at varying depths exceeding 3 mm at a printing distance of 1 mm. Overall, the research highlights the unique advantages of LIFT bioprinting in developing highly controlled building structures and lays the groundwork for fabricating ex vivo structures with potential applications in tissue engineering and regenerative medicine.

Special Session for Bio2Brain MCS Project

11:30-13:30	**Special Session for Bio2Brain MCS Project** **(Dock Six 1)** **Chair: Martino Calamai**
11:30-12:00 **INVITED**	**Single molecule imaging to track cellular proteins, increase diagnosis sensitivity and follow drug release from nanoparticles** **Dr. Martino Calamai** *LENS, Un. of Florence, Italy*
12:00-12:30 **INVITED**	**Unleashing Innovative Pharmaceutics: Technology Transfer and Scale-Up for GMP Compliance** **N. Günday-Türeli** *MyBiotech GmbH, Germany*
12:30-12:45	**Nose-to-Brain Delivery of Biopharmaceutics for the Therapy of Central Nervous System Diseases – Bio2Brain** **C. Gruber-Traub** *Dept. of Functional Surfaces and Materials, Fraunhofer Inst.e for Interfacial Engineering and Biotechnology IGB, Stuttgart*
12:45-13:00	**Mucoadhesive microgels for nose-to-brain drug delivery of neurotherapeutics** **G. Rath**, D. Mazzali, A. Zarbakhsh, M. Resmini *School of Physical and Chemical Sci., Queen Mary Un. of London, London, UK*
13:00-13:15	**Rational Design of Nanobodies Targeting LINGO-1** **A. Röntgen[1]**, V. Roy Chowdhury[1], A. Ramon[1], M. Rojas-Rodríguez[2], M. Greenig[1], X. Xu[1], M. Calamai[2,3], P. Sormanni[1], M. Vendruscolo[1] *[1]Yusuf Hamied Dept. of Chemistry, Un. of Cambridge, UK* *[2]European Laboratory for Non-Linear Spectroscopy, Un. of Florence, Italy* *[3]Nat. Inst.e of Optics – Nat. Research Council (CNR-INO), Italy*
13:15-13:30	**Sustainable and Surfactant-Free Synthesis of Negatively Charged Acrylamide Nanogels for Biomedical Applications** **D. Mazzali[1]**, G. Ra[1], A. Roentgen[2], V. Roy Chowdhury[2], M. Vendruscolo[2], M. Resmini[1] *[1] Dept. of Chemistry, Queen Mary Un. of London, UK* *[2] Centre for Misfolding Diseases, Yusuf Hamied Dept. of Chemistry, Un. of Cambridge, Cambridge, UK*

INVITED TALK

Single molecule imaging to track cellular proteins, increase diagnosis sensitivity and follow drug release from nanoparticles

M. Calamai

National Institute of Optics - National Research Council
LENS - European Laboratory for Non-Linear Spectroscopy, Firenze, Italy

With respect to bulk techniques, single molecule imaging with advanced microscopy approaches can be used to study the spatial distribution and trafficking of individual cellular proteins, allowing to reach nanoscale resolution and highlight potential heterogeneities within sample populations.
The application of single molecule imaging is not limited to study the cellular trafficking and interactions between candidate proteins in the field of neurodegenerative diseases, but it can also be extended to diagnostic purposes and improve the detection and quantification of pathological biomarkers in biological fluids.
We have also applied it to monitor the release of biopharmaceuticals from nanoparticles embedded in hydrogels of different compositions.

INVITED TALK

Unleashing Innovative Pharmaceutics: Technology Transfer and Scale-Up for GMP Compliance

N. Günday-Türeli

MyBiotech GmbH, Germany

Many novel nano-pharmaceuticals are being developed across globe which hold strong potential for providing more effective and safer therapies and diagnostic procedures for a wide range of diseases. However, scale-up and GMP production of innovative pharmaceuticals is still challenging to main players due to the lack of GMP manufacturing sites flexible enough to accommodate the vast amount of methods and equipment necessary for the broad palette of novel pharmaceuticals that are currently in the development pipelines. Additionally, novel pharmaceuticals are mostly produced in small scale and conventional methods that are present in the labs which are appropriate for small scale production. But most of these methods are not GMP conform and limited with the batch size which is not sufficient to supply clinical trials and stability studies. Thus, there is an urgent need for flexible scale-up approaches for implementation during technology transfer to GMP environment.

The lack of affordable GMP manufacturing facilities and services for successful implementation of the advances novel pharmaceuticals are main obstacles to further enhance the growth and innovation capacity. The most common difficulties faced during tech transfer and scale-up and the gateway that links lab processes to the clinics for the production of novel pharmaceuticals under GMP conditions are visited in this talk and the strategies are introduced to overcome these obstacles as prerequisites for achieving this goal.

Nose-to-Brain Delivery of Biopharmaceutics for the Therapy of Central Nervous System Diseases – Bio2Brain

C. Gruber-Traub

Department of Functional Surfaces and Materials, Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB, Stuttgart

There is a critical need for new strategies in treating diseases of the central nervous system (CNS). Novel therapeutics, especially for the treatment of previously incurable diseases such as cancer or central nervous system (CNS) disorders like Multiple Sclerosis (MS) or Alzheimer's, often rely on the use of biomolecules like proteins, monoclonal antibodies (mAb) or nanobodies. This has resulted in new challenges in terms of the bioavailability of these biopharmaceuticals in the CNS, as well as their formulation and storage. Intranasal administration has emerged as a promising approach to bypass the blood-brain barrier (BBB) and directly deliver drugs from the nose to the brain and CNS. To safely and efficiently deliver biopharmaceuticals from the nose to the brain, innovative technologies are crucial. The Marie Skłodowska-Curie Action (MSCN) Doctoral network Bio2Brain aims to address this challenge by combining diverse expertise, offering exceptional training, and fostering a collaborative environment. The Bio2Brain network is a research and training program that educates young scientists in developing innovative technologies to effectively deliver biopharmaceuticals from the nose to the brain. This program provides a distinctive chance for 13 early career researchers to explore new approaches and treatments for neurological diseases. Bio2Brain aims to establish the fundament for the future implementation of these technologies in clinical development and GMP manufacturing.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 956977.

Mucoadhesive microgels for nose-to-brain drug delivery of neurotherapeutics

G. Rath, D. Mazzali, A. Zarbakhsh, M. Resmini

School of Physical and Chemical Sciences, Queen Mary University of London, UK

Nanomedicine has shortened the path of treating the so-far incurable diseases, as it can overcome the limitations of free therapeutics to navigate through biological barriers, such as the blood-brain barrier (BBB). Within all nanosized drug delivery systems, microgels stand out for their versatility and easiness of production. Microgels are cross-linked polymeric networks that behave as colloidal dispersions in aqueous media. Their properties can be finely tailored to the drug, disease, and route of administration by changing synthetic conditions, composition, and cross-linking degree. Besides, their high drug uploading capability makes microgels ideal candidates to deliver biopharmaceutics for the therapy of neurological diseases. Despite many advances, the delivery of biopharmaceutics to the brain is still limited by the presence of BBB. In this context, the intranasal route is a promising strategy to deliver large molecules from nose-to-brain (N2B), as it bypass the BBB while being non-invasive. Chitosan has been extensively explored for N2B administration due to its mucoadhesive properties; however, its limited solubility in physiological conditions makes it a challenging excipient. In this study, we explore the potential of microgels as alternatives to chitosan as intranasal drug delivery vehicles for the brain. We synthesized a small library of covalently cross-linked *N*-isopropylacrylamide (NIPAm) microgels via free radical polymerization in water, copolymerised with varied functional monomers, designed to mimic chitosan structure and properties. Nuclear magnetic resonance, dynamic light scattering, and UV-*vis* spectroscopy were used to characterise the polymers. Mucoadhesive properties of the microgels were quantified and compared to chitosan by an optimised colorimetric assay. We showed that synthetic conditions, cross-linking degree, and presence of co-monomers have a dramatic effect on the microgel's properties.

Rational Design of Nanobodies Targeting LINGO-1

A. Röntgen[1], V. Roy Chowdhury[1], A. Ramon[1], M. Rojas-Rodríguez[2], M. Greenig[1], X. Xu[1], M. Calamai[2,3], P. Sormanni[1], M. Vendruscolo[1]

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Background: One of the most potent inhibitors of neurite growth and regeneration in the adult mammalian central nervous system (CNS) is the oligodendrocyte-derived membrane protein Nogo-A. Blocking its function *via* antibody promotes recovery in animal models of multiple sclerosis (MS), amyotrophic lateral sclerosis (ALS), spinal cord injury (SCI) and stroke, making it a promising therapeutic target. Single-domain antibodies, also called nanobodies, offer clinical and therapeutic advantages over full-length antibodies for the neutralisation of CNS targets such as Nogo-A because of their small size, CNS penetrance, similar target affinity, and ease of production. This study aims to develop nanobodies designed *in silico* to target Nogo-A for diagnostic or therapeutic purposes. *Methods:* We employed the cascade method (Sormanni *et al., PNAS,* 2015) to rationally design epitope-specific CDR3 loops that are grafted onto a pre-optimised human V_HH scaffold to create a panel of nanobodies. These designed nanobodies are screened for their thermostability, solubility, and binding affinity towards the target antigen to select the best candidate. *Results:* Computational and functional analyses of Nogo-A have led us to identify targetable epitopes, based on which, we designed a panel of CDR3 loops. The top-ranking candidates in terms of specificity, lack of promiscuity, and solubility have been grafted onto the nanobody scaffold. Initial round of stability testing and screening of epitope binding has yielded a promising candidate nanobody that binds to an epitope in human Nogo-A ectodomain. Determination of its target binding kinetics and studies to improve its binding efficacy are underway. *Conclusions:* This method of rational design of nanobodies can target almost any disordered epitope, even if weakly immunogenic. It holds the promise to significantly reduce the lead time of antibody development for Nogo-A detection and inhibition for CNS therapeutics.

Sustainable and Surfactant-Free Synthesis of Negatively Charged Acrylamide Nanogels for Biomedical Applications

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Nanomaterials, with their distinct properties, have revolutionised scientific fields, enabling discoveries and opening new avenues of research[1]. Among these materials, nanogels are extensively studied due to their high surface-to-volume ratio, scalable synthesis methods, and easily tailored formulations with stimuli-responsive capabilities[2]. These properties make nanogels attractive for drug delivery, but sustainable synthetic methods, particularly utilizing water instead of organic solvents, are a priority for large-scale applications. This work describes a sustainable method for synthesising acrylamide-based nanogels crosslinked with methylene bis-acrylamide and incorporating acryloyl-L-proline for negative charge[3]. We optimised the water-based synthesis to achieve high monomer conversions and chemical yields. Nanogels were characterised using dynamic light scattering, and toxicity was assessed on SH-SY5Y cells. This was compared to polymers prepared in dimethyl sulfoxide to study the impact that changing to water has on surface charge, size, and cell viability.

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Workshop on Nanoelectronics

11:30-13:30	**Workshop on Nanoelectronics** **(Timber Hall 2)** **Chair: A. Christou**
11:30-12:00 **INVITED**	**Low Dimensional Materials and Devices for Neuromorphic Computing** **D. G. Georgiadou[1]** *Electronics and Computer Science & Optoelectronics Research Centre, Un. of Southampton, UK*
12:00-12:30 **INVITED**	**How to Enhance the Sensing Performance of Chemiresistive Gas Sensors** **Sang Sub Kim** *Dept. of Materials Science and Engineering, Inha Un., Republic of Korea*
12:30-12:45	**Enhancing Electrical Transport in Hybrid Carbon Nanotube–Graphene Networks for Advanced Electronic Applications** **A. Lekawa-Raus[1]**, K. Milowska[2], S. Lepak-Kuc[3,1] *[1]Centre for Advanced Materials and Technologies, CEZAMAT, Warsaw Un. of Technology, Poland* *[2]CIC nanoGUNE, Spain* *[3]Fac. of Mechanical and Industrial Engineering, Warsaw*
12:45-13:00	**Improved Carrier Extraction via HTL variation leads to increased Efficiency in planar Antimony Sulfide (Sb_2S_3) solar cells** **L.Theofylaktos[1,2]**, A. Kalafatis[1], P. Harlaftis[1], S. Orfanoudakis[1], E. Symeonidou[1,2], M. Karnachoriti[3], P. Dimitrakis[1], A. G. Kontos[3], T. Stergiopoulos[1,] *[1]Inst.e of Nanoscience and Nanotechnology, N.C.S.R. Demokritos, Greece* *[2]Dept. of Chemistry, Aristotle Un. of Thessaloniki, Greece* *[3]School of App. Mathematical and Physical Sci., Nat. Technical Un. Greece*
13:00-13:30 **INVITED**	**Light-based processing of solution-processable materials for future electronic applications** **N. Kalfagiannis** *Un. of Ioannina, Dept. of Materials Science and Engineering, 45110, Ioannina, Greece*

INVITED TALK

Low Dimensional Materials and Devices for Neuromorphic Computing

D. G. Georgiadou

Electronics and Computer Science & Optoelectronics Research Centre, University of Southampton, United Kingdom

Neuromorphic engineering is poised to revolutionise current computing as it is holds promise for ultra-low power operation. Drawing inspiration from the brain, its dense network of interconnected neurons and the way of transmitting and processing information via neuronal spiking events at the biological synapses, several new nanodevice paradigms have emerged for developing artificial intelligence (AI) hardware and cognitive computing systems. Among these nanodevices, memristive devices have gained a lot of attention due to their advantages, such as low power consumption, high integration density and the capability to replicate synaptic plasticity, which align with the requirements of neuromorphic computing. In this work, we explore two nanomaterial classes, namely zero-dimensional (0D) Bismuth halide perovskites and two-dimensional (2D) transition metal dichalcogenide (TMD) materials, to facilitate the development of efficient optoelectronic neuromorphic hardware. We first tune the cation size in non-toxic solution-processed Bi-based perovskites to emulate synaptic functionalities and demonstrate application in reservoir computing. We further compare different device structures able to accommodate such low dimensional nanomaterials, namely a coplanar nanogap separated electrodes vs the more conventional sandwich or crossbar architecture. The utilisation of MoS_2 in 2-terminal devices fabricated with nanogap electrodes showcases the potential to reduce switching voltages to a crucial minimum. In conclusion, by combining functional green nanomaterials, such as perovskites and 2D materials, with nanoscale device architectures and looking into their future incorporation into artificial neural networks, we can expect significant advancements in neuromorphic computing, bringing us closer to a future, where computational systems mimic the remarkable efficiency and adaptability of the human brain.

INVITED TALK

How to Enhance the Sensing Performance of Chemiresistive Gas Sensors

S. S. Kim

Department of Materials Science and Engineering, Inha University, Republic of Korea

The repeatable, reliable and ultra-high sensitive, humidity tolerant, selective, initial-stage detection of toxic and hazardous gaseous species has become increasingly important in modern industries and normal living places as well. The unique purpose of gas sensors include safety both in industry and at home, health care, defense of terror and chemical warfare, and environment monitoring. There are a variety types of gas sensors including chemiressitive-type, electrochemical type, optical type, and catalytic type, etc. They have their own advantages and disadvantages, and can be classified in terms of materials used, sensing principles, etc. Chemiresesistive-type gas sensors have been extensively investigated for the purpose of exploiting its merits such as easy fabrication, low cost, adaptability to nanostructures, and potential possibility of attaining extremely high sensing performances. However, for practical application of the chemirsistive-type gas sensors, several sensing properties need to be further improved: higher selectivity to a target gas, long time stability, humidity tolerance, minimized temperature dependency, and specific detection, etc. In order to enhance such sensing capabilities, considerable efforts have been made so far. Various techniques have been employed to improve the sensing capabilities of metal oxide chemiresisitive-type gas sensors. In particular surface modification techniques are most widely used. Here, recent advancement and experimental results on surface modifications are discussed. Beam irradiation and surface decoration lead to great enhancement in sensing properties and will be discussed in detail.

Enhancing Electrical Transport in Hybrid Carbon Nanotube–Graphene Networks for Advanced Electronic Applications

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[2]CIC nanoGUNE Tolosa Hiribidea,, Spain
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Hybrid carbon nanotube–graphene networks are very promising materials for a range of next-generation electronic applications including sensors, conductors, batteries, and supercapacitors. Here, we demonstrate that integrating graphene nanoflakes into carbon nanotube networks significantly enhances electrical conductivity and current-carrying capacity, while also improving doping effectiveness. To rationalize the observed improvements, we propose a theoretical model highlighting the dual role of graphene: not only does it serve as an efficient conductive filler within carbon nanotube network, but it also acts as a bridge introducing additional electronic states at the Fermi level of carbon nanotubes. These findings underscore the potential of hybrid carbon nanotube–graphene networks in advancing electronic and electrical technology, offering insights into their fundamental transport mechanisms and practical applications.

Improved Carrier Extraction via HTL variation leads to increased Efficiency in planar Antimony Sulfide (Sb_2S_3) solar cells

L.Theofylaktos[1,2], A. Kalafatis[1], P. Harlaftis[1], S. Orfanoudakis[1], E. Symeonidou[1,2], M. Karnachoriti[3], P. Dimitrakis[1], A. G. Kontos[3], T. Stergiopoulos[1]

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Antimony Sulfide is increasingly recognized as a promising semiconductor material for solar energy harvesting, thanks to its high absorption coefficient, stability in ambient conditions, non-toxic components, and the abundance of the Stibnite mineral. However, progress in power conversion efficiency (PCE) has recently plateaued, largely due to difficulties in identifying the causes of significant voltage losses and optimizing charge extraction. This study explores the charge extraction capabilities of Sb_2S_3-based planar solar cells using a thiophene-based hole transport layer (HTL). The research aims to enhance performance by optimizing the properties of a proven stable HTL, by varying the thickness of the P3HT (HTL) layer and conducting extensive electrical and optoelectronic measurements on both the hole transport layers and complete devices. The optimal configuration achieved a PCE of 5.25%, a fill factor (FF) of 54.4%, a short-circuit current density (J_{sc}) of 15.5 mA/cm^2, and an open-circuit voltage (V_{oc}) of 622 mV, which-to our knowledge-is the best performance of planar Sb_2S_3 based solar cells employing P3HT as HTL.

INVITED TALK

Light-based processing of solution-processable materials for future electronic applications

N. Kalfagiannis

University of Ioannina, Department of Materials Science and Engineering, Ioannina, Greece

Digital transformation is accelerating growth in markets such as the Internet-of-Things, cloud connectivity, space, and defense, leading to unprecedented global demand for electronic devices. This surge highlights the critical need for sustainable manufacturing processes, given the environmental burdens imposed by traditional fabrication methods. Conventional production of thin film transistors (TFTs)—key components in large-area electronics—often involves high-temperature processing and hazardous materials, resulting in significant energy consumption and environmental impact.

In parallel, the European Union has enacted the European Chips Act to bolster the continent's competitiveness in semiconductor manufacturing while emphasizing sustainability and supply chain autonomy as critical pillars for the industry's future. To achieve these objectives, breakthroughs in scalable and high-throughput manufacturing techniques, such as advanced printing technologies, are essential. However, transitioning printed electronics from laboratory settings to industrial-scale fabrication (lab-to-fab) faces challenges in performance and cost-efficiency.

We propose a novel strategy to address these barriers by integrating solution-processable inorganic materials with state-of-the-art light-based processing techniques. This approach aims to replace traditional high-energy manufacturing processes, providing rapid processing times, enhanced throughput, scalability, and precise energy delivery. By employing detailed opto-thermal simulations and advanced optical characterization through IR spectroscopic ellipsometry, we elucidate the critical light-matter interactions pivotal to the proposed processing scheme. Our investigations focus on temperature rise profiles and the chemical transformation stages of precursor materials into the metal-oxide state. These findings are compared with electrical characterizations of thin film transistors fabricated using this methodology.

Workshop on Centers of Excellence (NN24 & ISFOE24)

11:30-13:30	**Workshop on Centers of Excellence (NN24 & ISFOE24)** **(Dock Six 2)** **Chair: G. Hadziioannou, A. Laskarakis**
11:30-12:00	**Centre of Excellence for Organic, Printed Electronics & Nano-Technologies (COPE-Nano)** **S. Logothetidis** *Nanotechnology Lab LTFN, Aristotle University of Thessaloniki, Greece*
12:00-12:15	**Latvia: Excellence Centre of Advanced Material Research and Technology Transfer (CAMART2)** **T. Safiulins** *Institute of Solid State Physics, University of Latvia, Latvia*
12:15-12:30	**Latvia: Baltic Biomaterials Centre of Excellence (BBCE)** **A. Dubnika** *Riga Technical University, Latvia*
12:30-12:45	**InnoRenew CoE - Renewable Materials and Healthy Environments Research and Innovation Centre of Excellence** A. Kutnar[1,2], **W. Pajerski[1],** A. Sandak[1,2] *[1] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia* *[2] University of Primorska, Titov trg 4, 6000 Koper, Slovenia*
12:45-13:00	**Hellenic Robotics Center of Excellence (HERON)** **E. Papadopoulos** *Institute of Robotics, ATHENA Research Center, Greece*
13:00-13:30	**Round Table Discussion: Building and Governing a successful CoE** - CoE Establishment and Complementary Funding - Challenges during the expansion of Centers - Business Models of CoE and Best Practices - Discussion on Future Collaboration

Exploring Collaboration Opportunities with Baltic Biomaterials Centre of Excellence

***A. Dubnika*[1,2]**, *D. Loca*[1,2], *J. Locs*[1,2]
[1]*Institute of Biomaterials and Bioengineering, Faculty of Natural Sciences and Technology, Riga Technical University, Latvia*
[2]*Baltic Biomaterials Centre of Excellence, Headquarters at Riga Technical University, Riga, Latvia*

Baltic Biomaterials Centre of Excellence (BBCE) is established as a joint research centre for advanced biomaterials development by three internationally recognized research institutions Riga Technical University, Latvian Institute of Organic Synthesis, Riga Stradins University (RSU) and clinical partner RSU Institute of Stomatology operating in Latvia with a support from the international leading research institutes AO Research Institute Davos (ARI), Switzerland and Friedrich-Alexander University of Erlangen-Nuremberg (FAU), Germany, which main tasks is to support the research studies, commercialization processes, knowledge transfer and management. Strategic **research direction** of BBCE is development of patient specific personalized solutions for bone regeneration in 3 levels: biomaterial composition, geometry and bioactive compound delivery. BBCE ensures full cycle of biomaterials for bone regeneration development, starting from the material design and characterization to preclinical investigations and clinical trials. Six scientific focus groups are established in the research centre developing calcium phosphate based biomaterials, inorganic/organic composites, inks for 3D bioprinting, local drug, ion and cell delivery systems using bone cements, hydrogels, organic/inorganic composites, and bioceramic scaffolds as matrices as well as exploring the current understanding of the underlying molecular mechanisms of cell-material interactions, investigation of osteoconductive and osteoinductive properties and mechanisms of bone healing with the aim for further design of clinical studies.
Acknowledgments: The authors would like to thank the EU Horizon 2020 Grant agreement No. 857287.
Webpage: https://bbcentre.eu/

InnoRenew CoE - Renewable Materials and Healthy Environments Research and Innovation Centre of Excellence

A. Kutnar[1,2], ***W. Pajerski*[1]**, *A. Sandak*[1,2]
[1] *InnoRenew CoE, Izola, Slovenia*
[2] *University of Primorska, Slovenia*

InnoRenew CoE, located in Slovenia and established in 2017, is a leading research institute dedicated to advancing the science and application of renewable materials, with a particular focus on wood and sustainable building practices. Its mission is to advance regenerative sustainability through interdisciplinary research and industrial collaboration.

The institute's core research areas encompass material advancements, engineered living materials, and sustainable design solutions. These efforts aim to enhance forest sustainability, foster healthier built environments, and stimulate growth in the forest sector.

From its establishment, researchers published almost 1500 scientific papers and other communications, secure over €13 million in new funding, and engaging with over 600 global partners. InnoRenew CoE has also contributed to significant policy changes in Slovenia and beyond by promoting renewable materials in construction.

The presentation will provide an overview of InnoRenew CoE's research focus and achievements, aiming to stimulate collaboration and knowledge exchange within the renewable materials and healthy environments community. Furthermore, short overview of main milestones of the Horizon Teaming project that enabled the establishment of the InnoRenew CoE will be shared.

Workshop on Nanoparticles-Nanocomposites

15:00-16:30	**Workshop on Nanoparticles-Nanocomposites** **(Timber Hall 2)** **Chair: C. Gravalidis**
15:00-15:30 **INVITED**	**Enhancing Nanoscience and Nanotechnology: The Role of ESRF-EBS in Advanced Nanomaterials Research** **E. Capria** *The European Synchrotron (ESRF), Grenoble, France*
15:30-16:00 **INVITED**	**Bio-Based Photo-Initiators for UV-Nano-Imprint Resins** **D. Nees**, S. Ruttloff, J. Götz, U. Palfinger, A. Haase. P. Melchior, B. Stadlober *MATERIALS, JOANNEUM RESEARCH Forschungsgesellschaft mbH, Weiz, Austria*
16:00-16:15	**Synthesis of Starch Nanocrystals from Pearl Millet Varieties with Different Amylose Content and its Mathematical Modelling** **D. Chandra Saxena** *Dept. of Food Engineering & Technology, Sant Longowal Inst.e of Engineering & Technology Longowal, India*
16:15-16:30	**Microwave plasma activated direct synthesis of the graphene on Si (100) and SiO_2 substrates for photovoltaic and biosensor applications** **S. Meskinis,** S. Jankauskas, A. Guobiene, A. Vasiliauskas, R. Gudaitis *Inst.e of Materials Science, Kaunas Un. of Technology, Kaunas, Lithuania*

INVITED TALK

Enhancing Nanoscience and Nanotechnology: The Role of ESRF-EBS in Advanced Nanomaterials Research

E. Capria[1]
The European Synchrotron (ESRF), Grenoble, France

The European Synchrotron Radiation Facility (ESRF), with the implementation of its novel Extremely Brilliant Source (EBS), stands at the forefront of advancements in nanoscience and nanotechnology. This first-of-his- kind upgrade allow to the ESRF to deliver unprecedented performance in the analysis and characterisation of nanomaterials. The EBS enables significantly higher brightness and coherence, providing researchers with exceptional capabilities for studying the structural, chemical, and physical properties of nanomaterials at the atomic and molecular levels.

In this presentation, we will explore the profound impact of the ESRF-EBS on nanoscience and nanotechnology. We will discuss the enhanced imaging and diffraction techniques that facilitate detailed observation of nanoscale structures, offering insights into their composition, dynamics, and functionalities. These advancements are critical for the development of novel nanomaterials and the advancement of various applications, including electronics, medicine, energy, and environmental science.

Furthermore, we will highlight case studies demonstrating the application of ESRF-EBS in cutting-edge nanotechnology research. These examples will illustrate how the facility's superior analytical capabilities support the synthesis, manipulation, and real-time observation of nanomaterials, driving innovation and scientific breakthroughs.

INVITED TALK

Bio-Based Photo-Initiators for UV-Nano-Imprint Resins

D. Nees, S. Ruttloff, J. Götz, U. Palfinger, A. Haase. P. Melchior, B. Stadlober
MATERIALS, JOANNEUM RESEARCH Forschungsgesellschaft mbH, Weiz, Austria

The coating industry is making great efforts to replace fossil with renewable carbon sources. Major suppliers have recently launched entire product portfolios of UV-curable mono- and oligomers, which are partially made from bio-based raw materials. However, so far only petro-chemical aromatic photo-initiators are utilized throughout industry for starting the photo-polymerization even of such partially bio-based coatings. Photo-initiators - typically added at a few w-% - are key components in photo-curing coating formulations. They absorb UV-radiation and generate radicals for starting the free radical polymerisation - i.e. UV-curing reaction. We have formulated fast curing high fidelity UV-nano-imprint resins based on mono- and oligomers partially made from renewable raw materials like soy-bean oil having a bio-renewable carbon content (BRC) of more than two thirds. For photo-initiation we use e.g. 1 w-% of simple bio-based aliphatic a-ketoacids like pyruvic or ketoglutaric acid as well as corresponding esters. Upon irradiating with wavelength l = 365 nm the UV-curing i.e. photo-polymerisation of the investigated resins proceeds at competitive rates and to similar final photo-conversions like with conventional petro-chemical photo-initiators. In a first application, optically variable anti-counterfeiting features have been R2R-UV-nano-imprinted into a 67 % BRC resin on 70 % post-consumer recycled (PCR) PET substrate film as well as on 98 % BRC cellophane film. Anti-reflective, water-repelling, drag reducing and anti-bacterial bionic surfaces have been UV-imprinted as well in similar partially bio-based resins utilizing a-ketocarboxylic photo-initiators. Furthermore, beyond UV-nano-imprinting – by using these new photo-initiators 100 % BRC UV-curing e.g. screen-, jet- or 3D- printing inks are within reach for a wide range of applications as soon as 100 % BRC UV-curing meth(acrylate) mono- and oligomers become commercially available.

Synthesis of Starch Nanocrystals from Pearl Millet Varieties with Different Amylose Content and its Mathematical Modelling

D. C. Saxena

Department of Food Engineering & Technology, Sant Longowal Institute of Engineering & Technology, India

The applications of starch nanocrystals are overwhelming. Starch nanocrystals have been explored in biodegradable packaging as reinforcing fillers improving the mechanical, barrier, and thermal properties, as a “green” alternative to stabilizers in Pickering emulsions, as potential carriers of drugs and bioactive compounds in encapsulated systems. In the present study, starch nanocrystals were developed from Pearl millet varieties, HHB 67 and ProAgro 9444, differing in amylose content and mathematical model equations were proposed for synthesis. Acid hydrolysis parameters, temperature, acid concentration, and hydrolysis time are optimized, thereafter, characterization of starch nanocrystals is done. Starch extraction is done by wet milling, yield, and amylose content of 41.23% and 15.05% for HHB 67 and, 45.66% and 20.21% for ProAgro 9444, respectively, are obtained. Rate constant values of kinetic studies reflect dependency of yield on temperature, duration, and acid concentration. Full factorial design is used for obtaining the model equations and optimizing the process parameters. Optimized yield of 19.12% and hydrodynamic diameter of 152 nm are obtained for HHB67 at 3.19 M acid concentration for 3 days at 45 °C, and for ProAgro9444 (15.68%, 200 nm) at 3.24 M acid concentration for 3 days at 45 °C. Yield is less, hydrodynamic particle size is more for ProAgro 9444 as compared to HHB 67. Morphological characteristics reveal irregular polygonal native starch granules whereas nanocrystals are spherical (30–70 nm). The crystallinity index increases appreciably after hydrolysis. No gelatinization behaviour is observed in pasting curve for nanocrystals. Moreover, steady shear curves depict pseudoplastic behaviour.

Microwave plasma activated direct synthesis of the graphene on Si (100) and SiO_2 substrates for photovoltaic and biosensor applications

S. Meskinis, S. Jankauskas, A. Guobiene, A. Vasiliauskas, R. Gudaitis

Institute of Materials Science, Kaunas University of Technology, Kaunas, Lithuania

Graphene is at the top of considerable interest due to the giant electron and hole mobility, flexibility, optical transparency, chemical inertness. One of the main limitations of stopping graphene's broader application in semiconductor device technology is a complex graphene transfer procedure. Recently there was shown that direct synthesis of graphene on semiconducting or dielectric substrates is possible. However, the development of this technology is the very beginning.

In the present research, graphene layers were directly synthesized by microwave plasma-enhanced chemical vapor depositionon the monocrystalline Si(100) and SiO2 substrates. The films' structure was investigated by multiwavelength Raman scattering spectroscopy, atomic force microscopy, Kelvin probe microscopy, scanning electron microscopy. Graphene/Si(100) Schottky diodes and graphene-based field effect transistors (FET) were fabricated.

Effects of the deposition conditions on the structure of the graphene layers were studied. There were revealed that both vertical graphene flakes and planar graphene layers could be synthesized by setting appropriate deposition conditions. Current-voltage characteristics, and photovoltaic and photoelectric properties of the graphene/Si diodes, were investigated. The relation between photovoltaic properties, graphene structure, and doping was found. Graphene-based field effect transistors were fabricated. Relations between the graphene-based FET work-characteristics and graphene structure were considered. Graphene field-effect transistors were applied for detecting COVID-19 spike S protein and its receptor ACE2.

Special Session for Bio2Brain MSC Project

15:00-17:00	**Special Session for Bio2Brain MSC Project** **(Dock Six 1)** **Chair: N. Günday-Türeli**
15:00-15:15	**Role of Fc receptors for transmucosal drug delivery of therapeutic antibodies** **N. Ruggeri**, D. Abdeldaim, I. Shrimo, M. Sickinger, K. Mayer, K. Schindowski *Inst.App. Biotechnology, Biberach Un. of App. Sci., Biberach an der Riss, Germany*
15:15-15:30	**Spray-dried microparticles based on thiolated chitosan for nose-to-brain drug delivery** **B. Di Lelio[1,2]**, G. M. Tovar[1,2], C. Gruber-Traub[2] *[1]Dept. of Functional Surfaces and Materials, *Fraunhofer Inst.e for Interfacial Engineering and Biotechnology IGB, Germany* *[2]Inst.e of Interfacial Process Engineering and Plasma Technology, Un. of Stuttgart, Germany*
15:30-15:45	**Cell biocompatibility, Trafficking, and Release of Fluorescent PLGA Nanoparticles for Nose to Brain Delivery (N2B-delivery)** **M. Rojas-Rodríguez[1]**, S. Akpinar[2,3], N. Günday-Türeli[2], A. E. Türeli[2], M. Schneider[3], M. Calamai[1,4] *[1]European Laboratory for Non-linear Spectroscopy, Italy* *[2]MyBiotech GmbH, Überherrn, Germany* *[3]Dept Pharmacy, Biopharmaceutics and Pharmaceutical Technology, Saarland Un., Germany.* *[4]Nat. Inst.e of Optics, CNR-INO, Italy*.
15:45-16:00	**Rational Design of Single-Domain Antibodies Targeting the Central Nervous System Neurite Outgrowth Inhibitor Nogo-A** **V. Roy Chowdhury[1]**, A. Röntgen[1], M. Greenig[1], Y. Méndez Gómez[1], M. Nowinska[1], S. Spiegel[2], R. Taylor[1], P. Sormanni[1], V. Pernet[2], M. E. Schwab[3], M. Vendruscolo[1] *[1] Centre for Misfolding Diseases, Yusuf Hamied Dept. of Chemistry, Un. of Cambridge, UK* *[2] Dept. for Biomedical Research, Un. Hospital Inselspital Bern, Un. of Bern, Switzerland* *[3] Dept. of Health Sci. and Technology, Inst.e for Regenerative Medicine, Un. of Zurich, Switzerland*
16:00-16:15	**Advanced imaging approaches for studying biopharmaceuticals and membrane proteins dynamics and their trafficking.** **A. Gomez-Navarro[1]**, V.R. Chowdhury[3], A. Röntgen[3], M. Vendruscolo[3], M. Calamai[1,2] *[1]LENS- European Laboratory for Non-Linear Spectroscopy, Un. of Florence, Sesto Fiorentino (Firenze), Italy* *[2]Nat. Inst.e of Optics - Nat. Research Council (CNR-INO), Sesto Fiorentino, Italy* *[3]Centre for Misfolding Diseases,Yusuf Hamied Dept. of Chemistry, Un. of Cambridge, UK*
16:15-16:30	**Photocrosslinked mucoadhesive hyaluronic acid hydrogels for transmucosal drug delivery** **S. Asamoah[1,2]**, M. Pravda[1], E. Šnejdrová[2] *[1]Contipro a.s., Dolní Dobrouč 401, 561 02 Dolní Dobrouč, Czech Republic* *[2]Dept. of Pharmaceutical Technology, Faculty of Pharmacy in Hradec Králové, Charles Un., Heyrovského 1203, 500 05 Hradec Králové, Czech Republic*
16:30-16:45	**Enzymatically crosslinked gelatin as a drug delivery system for the intranasal transmucosal pathway of active pharmaceutical ingredient** **A. M. Mihailescu**, C. Gruber-Traub *Dept. of Functional Surfaces and Materials, Fraunhofer Inst.e for Interfacial Engineering and Biotechnology IGB, Germany*
16:45-17:00	**Safe-by-Design Strategies for Intranasal Drug Delivery Systems: Machine Learning solutions to differentiate Epithelial Tissues via ATR FTIR Spectroscopy** **R. Topalian[1,2]**, L. Kavallaris[1], C. Mavoungou[1] *[1]Inst.e for App. Biotechnology, Biberach Un. of App. Sci., Germany* *[2]Ulm Un., Helmholtzstraße 16, 89081 Ulm, Germany*

Role of Fc receptors for transmucosal drug delivery of therapeutic antibodies

N. Ruggeri, D. Abdeldaim, I. Shrimo, M. Sickinger, K. Mayer, K. Schindowski
Institute for Applied Biotechnology, Biberach University of Applied Sciences, Biberach an der Riss, Germany

IgG antibodies are some of the most important biopharmaceutical molecules with a highly relevant market volume, but yet no suitable brain drug delivery strategies have been developed apart from intrathecal or intraventricular injections. Nose to brain delivery could be an alternative to deliver immunoglobulin G (IgG) to the brain and we observed previously Fc-mediated uptake of IgG in nasal mucosa. In the present we investigated the mechanisms, kinetics, dose-dependency and fate of IgG permeation through a primary epithelial cell model. We confirmed molecular interactions of IgGs with the neonatal Fc receptor (FcRn), but also Fc gamma receptors (FCGR) play an important role for transcytosis of IgG. Further, we observed that IgG uptake is limited, and too high doses results in excessive lysosomal degradation. Thus, intranasal drug delivery systems with controlled release may increase the bioavailability of transmucosally delivered IgGs.

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Spray-dried microparticles based on thiolated chitosan for nose-to-brain drug delivery

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As a biopolymer, chitosan exhibits significant potential in nose-to-brain drug delivery. Its mucoadhesive properties, swelling behavior, and ability to open tight junctions [1] make it an interesting option for controlled-release formulations in nose-to-brain drug delivery [2]. Moreover, the thiolation of chitosan amplifies its mucoadhesive properties and penetration enhancer ability [3], particularly attractive for the application as a nasal excipient [4]. In this work, we developed a synthesis strategy for L-cysteine chitosan, proving a high content of free thiol groups, related to better mucoadhesive properties [5]. The modified biopolymer was used as a matrix material for producing microparticles through spray drying, an easily scalable and widely spread technique for particle and powder formulations. Microparticles were obtained with a high yield and the free thiol number was tuned by changing the pH of the feeding solution to achieve different degrees of crosslinking.

References:

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Cell biocompatibility, Trafficking, and Release of Fluorescent PLGA Nanoparticles for Nose to Brain Delivery (N2B-delivery)

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In the last decade the use of nanotechnology in the medical field is growing. Nanoparticles (NPs) in particular, are promising in a wide range of applications such as diagnosis, tissue engineering, biomedical implants, and targeted drug delivery. Poly lactic-co-glycolic acid (PLGA), a biocompatible and biodegradable polymeric material, holds an outstanding position in the field of biomedicine. Yet, high-quality continuous manufacturing of these particles remains a challenge. Thus, we prepared blank or model-substance-loaded (Albumin-FITC and WGA488) fluorescent PLGA (Rhodamine-PLGA or PLGA) NPs by using the double emulsion method by a novel micro-spray-reactor (MSR) system. The MSR system relies on solvent/non-solvent mixing through spray and provides control over the fine particle production. In this study, we explore the biocompatibility of loaded NPs in living neuroblastoma cells, their uptake and trafficking, and the release kinetics of the encapsulated material. Furthermore, we demonstrate that the encapsulated product is functional after release using as a cargo WGA488 (a cell membrane marker). Notably these NPs are not internalized, a desired characteristic in the N2B-delivery application.

Rational Design of Single-Domain Antibodies Targeting the Central Nervous System Neurite Outgrowth Inhibitor Nogo-A

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Background: One of the most potent inhibitors of neurite growth and regeneration in the adult mammalian central nervous system (CNS) is the oligodendrocyte-derived membrane protein Nogo-A. Blocking its function *via* antibody promotes recovery in animal models of multiple sclerosis (MS), amyotrophic lateral sclerosis (ALS), spinal cord injury (SCI) and stroke, making it a promising therapeutic target. Single-domain antibodies, also called nanobodies, offer clinical and therapeutic advantages over full-length antibodies for the neutralisation of CNS targets such as Nogo-A because of their small size, CNS penetrance, similar target affinity, and ease of production. This study aims to develop nanobodies designed *in silico* to target Nogo-A for diagnostic or therapeutic purposes. *Methods:* We employed the cascade method (Sormanni *et al., PNAS,* 2015) to rationally design epitope-specific CDR3 loops that are grafted onto a pre-optimised human V_HH scaffold to create a panel of nanobodies. These designed nanobodies are screened for their thermostability, solubility, and binding affinity towards the target antigen to select the best candidate. *Results:* Computational and functional analyses of Nogo-A have led us to identify targetable epitopes, based on which, we designed a panel of CDR3 loops. The top-ranking candidates in terms of specificity, lack of promiscuity, and solubility have been grafted onto the nanobody scaffold. Initial round of stability testing and screening of epitope binding has yielded a promising candidate nanobody that binds to an epitope in human Nogo-A ectodomain. Determination of its target binding kinetics and studies to improve its binding efficacy are underway. *Conclusions:* This method of rational design of nanobodies can target almost any disordered epitope, even if weakly immunogenic. It holds the promise to significantly reduce the lead time of antibody development for Nogo-A detection and inhibition for CNS therapeutics.

Advanced imaging approaches for studying biopharmaceuticals and membrane proteins dynamics and their trafficking

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Neurological disorders affecting the central nervous system (CNS), such as multiple sclerosis, Alzheimer's, and Parkinson's diseases, afflict approximately 165 million individuals in Europe. These conditions cause considerable suffering among patients and families, while also placing strain on social systems. The intranasal route emerges as a promising approach to bypass the blood-brain barrier, thereby overcoming the limitations associated with current methods of oral and intravenous delivery of biopharmaceuticals to the CNS. Among the possible therapeutic options, nanocarriers can significantly increase drug delivery to the brain via olfactory and trigeminal pathways of the nasal route.
The field of biomedical nanotechnology requires a comprehensive understanding of novel nanomaterials and their interactions with biological systems. Literature highlights ambiguous cellular trafficking and interactions of nanomaterials, such as nanoparticles and nanobodies, with specific proteins. To tackle these challenges, Quantum dots (QDs) offer potential insights into biological events at the nanoscale. Here, single-quantum dot tracking is utilised to investigate the trafficking and interaction of nanomaterials with membrane proteins in cell cultures. Underlining the significance of these investigations in nano-bio interactions, our objective is to gather reproducible data essential for designing improved nanoformulations that elicit desired cell responses.
Keywords: intranasal delivery, Quantum dots, single-particle tracking and nano-bio interactions

Photocrosslinked mucoadhesive hyaluronic acid hydrogels for transmucosal drug delivery

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Nose to brain (N2B) route of application of active pharmaceutical ingredients (API) has emerged as an effective way of delivering API for the treatment of CNS-related ailments. It possesses the advantage of mitigating the highly invasive conventional application routes such as intrathecal, intracerebral, and intraventricular injection. However, the problem of mucocilliary clearance exists in the N2B application to be addressed. In this work, hyaluronic acid (HA) a known mucopolysaccharide is chemically modified with tyramine (TA) groups to overcome its susceptibility to enzymatic degradation and improve its mechanical properties via a two-step reaction and characterized via ^{1}H-NMR for the structure of the new derivative and SEC-MALLS for the determination of the molecular weight. The modified HA-TA provides photocrosslinkable hydrogels with riboflavin as a photoinitiator. Precursor solutions of HA-TA were characterized for mucoadhesion with contact angle measurement and rheology. Rheological experiments demonstrated the interpenetration and entanglement of HA-TA polymer-mucin chains exhibiting positive rheological synergism. Contact angle measurements demonstrated better wettability and adhesion of HA-TA solution to the model of mucosa surface in comparison to native hyaluronan solution. The hydrogels were evaluated for their gelation kinetics, viscoelastic properties and mucoadhesive properties. Finally, bovine serum albumin (BSA) was loaded into the hydrogel as a model drug which released 14 % of the total BSA loaded after seven (7) days. Our results demonstrate the feasibility of the use of photocrosslinked hyaluronic acid hydrogel as carrier for the controlled release of protein drugs while maintaining its mucoadhesive properties.

Enzymatically crosslinked gelatin as a drug delivery system for the intranasal transmucosal pathway of active pharmaceutical ingredient

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Brain diseases such as brain tumors, Alzheimer's, meningitis, and multiple sclerosis are increasing worldwide. The treatment of these diseases is challenging, as administering drugs to the brain and achieving a therapeutic concentration is limited by the blood-brain barrier (BBB). The intranasal route, or nose-to-brain path, has proven to be a promising strategy for administering drugs bypassing BBB.
Here, gelatin, mainly composed of collagen, was used as a carrier for drug delivery. Gelatin is a natural polymer with beneficial properties like biocompatibility, biodegradability, and the presence of exposed chemical groups that make it versatile. Gelatin was crosslinked enzymatically with microbial transglutaminase (mTG) in different combinations. mTG is known to be adhesive for different tissues such as cartilage or retina. This method has some relevant features like biocompatibility, controlled degradation and tunable properties by changing different parameters like the concentrations of gelatin or mTG or the temperature of the reaction. Cross-linked hydrogels obtained from a combination of gelatin and mTG were characterized. Rheology tests were performed to analyze viscosity (μ), gel point, storage (G') and loss modulus (G'') of the pre-gels to ensure their extrudability before the administration. Mucoadhesion was studied for the different combinations of hydrogels. To verify the properties of the samples, experiments were carried out to evaluate their swelling and degradability over a period of 14 days. The hydrogels were loaded with ciprofloxacin HCl as a model active pharmaceutical ingredient (API). Different concentrations of ciprofloxacin HCl were studied for the optimization of the drug release profile. To confirm the biocompatibility of the chosen combination, cytotoxicity tests were performed. **Keywords**: nose-to-brain, drug delivery, gelatin, mTG

Safe-by-Design Strategies for Intranasal Drug Delivery Systems: Machine Learning solutions to differentiate Epithelial Tissues via ATR FTIR Spectroscopy

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The development of intranasal drug delivery systems requires a precise understanding of the structure differentiation and related function of epithelial tissues, considering their different types and role, for targeted therapeutic interventions. Traditional bioanalytical methods are employed for their biochemical characterization and to study the pharmacological impact, of drugs. However, they often fail to distinguish subtle biochemical differences associated with their biostructural relevance, which underscores the need for more sophisticated analytical data tools.
Our optimization studies consist of Safe-by-Design models of intranasal drug delivery systems, being based on experimental outputs and Machine Learning (ML) enriched data-models. They aim at designing enhanced safety and efficacy profiles of therapeutic interventions when such drug delivery systems are used.
By developing ML models to analyze Attenuated Total Reflection Fourier Transform Infrared (ATR FTIR) spectroscopy data, this study achieves significant structural differentiation of epithelial tissues, a necessary step for the design of intranasal drug delivery systems tailored for specific therapeutic targets.
A complete dataset of ATR FTIR spectra from nasal olfactory, nasal respiratory and tracheal epithelial tissues was compiled. ML models were trained on this dataset, allowing feature extraction and optimization to enhance classification accuracy. Their performances were assessed based on accuracy, sensitivity, and specificity metrics. Optimized models were able to identify specific spectral signatures corresponding to each tissue type. These assignments not only outperformed traditional analysis techniques but also provided insights into the biochemical variances between the different tissues.
In conclusion, the innovative integration of ML models with ATR FTIR spectroscopy data analysis emerges as a novel and effective approach, improving the Safe-by-Design intranasal drug delivery systems efficacy.

Workshop on Bioelectronics 4 (NN24 & ISFOE24)

15:00-16:30	**Workshop on Bioelectronics 4 (NN24 & ISFOE24)** **(Timber Hall 1)** **Chair: C. Pitsalidis**
15:00-15:30 **INVITED**	**Combining SPR and Organic field effect detection in a low cost, high performance monitoring system for thin molecular layers deposition** D. Hatami[1], A. Spanu[2], **A. Bonfiglio[2]** *[1] Dept. of Electrical and Electronic Engineering, Un. of Cagliari Piazza d'Armi, Italy* *[2] Scuola Universitaria Superiore IUSS, Italy*
15:30-16:00 **INVITED**	**Conducting hydrogel electrodes for epidermal electronics and sensing** **A.M. Pappa** *Khalifa Un., Abu Dhabi, UAE*
16:00-16:15	**Combining reduced-graphene oxide transistor and CRISPR/Cas13a ribonucleic particles as a tool for amplification-free RNA detection** P. Guermonprez[1], T.A. Le[2], P. Nioche[3], E. Krejci[4], V.T. Thu[2], L. Renaud[5], S. Sanaur[6], B. Piro[1] *[1] Un. Paris Cité, ITODYS, CNRS, Paris, France* *[2] Un. of Science and Technology of Hanoi (USTH) and Academy of Science & Technology (VAST), Vietnam* *[3] INSERM U1124, Un. Paris Cité, Paris, France* *[4] CNRS, Un. Paris Cité, ENS Paris Saclay, France* *[5] Université de Lyon, Inst. des Nanotechnologies de Lyon, Université Lyon 1, France* *[6] Inst. Mines-Telecom, Mines Saint-Étienne, Dept. Flexible Electronics, France*
16:15-16:30	**Plasmonics-based strategy for concentration of analytes** **M.P.Carmo[1]**, D.Mack[2], D. J. Roth[1], F. J. Rodríguez-Fortuño[1], P.A.Huidobro[3], A.Rakovich[1] *[1] Physics Dept., King's College London, UK* *[2] Physics Dept., Imperial College London, UK* *[3] IFIMAC, Universidad Autónoma de Madrid, Spain*

INVITED TALK

Combining SPR and Organic field effect detection in a low cost, high performance monitoring system for thin molecular layers deposition

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An innovative monitoring system designed for the assessment of surface modification by thin molecular layers is here presented. The system uniquely combines Surface Plasmon Resonance (SPR) and electronic detection based on Organic Field-Effect Transistor (OFET) technology. At its core, the system features an Extended Gate OTFT (EG-OTFT) configuration that incorporates a nanostructured component specifically designed for surface plasmon resonant excitation. This device structure not only demonstrates the capability to reproducibly detect the layer-by-layer deposition of various polymers, similarly to traditional SPR, but also possesses the unique ability to differentiate between positively and negatively charged layers thanks to the detection ability of the EG-OTFT. This dual capability significantly enhances the system's monitoring potential. The versatility and improved sensitivity of this integrated, optical and electronic, detection approach represent a significant advancement in biosensing technology, providing a cost-effective, reliable and detailed analysis of surface modifications that are critical in various scientific and industrial fields, from biomedical diagnostics to environmental monitoring. This development paves the way for creating more accessible and efficient monitoring platforms that can meet the diverse needs of modern research and applications.

INVITED TALK

Conducting hydrogel electrodes for epidermal electronics and sensing

Anna-Maria Pappa

Department of Biomedical Engineering, Khalifa University of Science and Technology, Abu Dhabi, UAE

Traditional epidermal electrodes, typically made of silver/silver chloride (Ag/AgCl), have been widely used in various applications, including electrophysiological recordings and biosignal monitoring. However, they present limitations due to inherent material mismatches with the skin. This talk will summarize our recent efforts on developing tissue-mimicking materials based on conducting and stretchable hydrogels using a "one-pot" method. This approach involves the synthesis of a natural hydrogel, termed Golde, composed of abundant and eco-friendly components, including gelatin, chitosan, and glycerol. To enhance the properties of the hydrogels, we can simply mix them with conducting materials and pH indicators for high conductivity and colorimetric pH sensing. The fabrication is sustainable, as it employs environmentally friendly materials and processes, including compatibility with printing technologies. The resulting hydrogel electrodes have been tested in various epidermal electronics scenarios including ECG, and EMG outperforming commercial electrodes even when implemented in an all-flexible electrode setup.

Combining reduced-graphene oxide transistor and CRISPR/Cas13a ribonucleic particles as a tool for amplification-free RNA detection

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[6] *Institut Mines-Telecom, Mines Saint-Étienne, Departement of Flexible Electronics, France*

RNA detection and quantification are extremely useful to identify RNA virus infections, as illustrated by the recent pandemic caused by SARS-CoV-2. They are also used to monitor bacterial proliferation in water and food or after infection in humans or animals, or to monitor the evolution of diseases where miRNAs are produced. However, developing a highly sensitive and rapid pathogen-identifying method without PCR remains a deep-seated problem. Herein, we created a RNA sensing device termed CRISCOFET by incorporating CRISPR/Cas13a system into a reduced graphene oxide (rGO)-based field-effect transistor (FET) platform. This device enables timely and amplification-free detection of viral target RNA.

For the detection part, the transistor's channel is decorated with gold nanoparticles on which U-rich RNA sequences are covalently grafted. The sensing principle is based on the enzymatic cleavage of those U-rich RNA sequences when exposed to CRISPR/Cas13a complex: this hydrolysis event induces a p-doping with a positive shift of the rGO's Dirac point[1]. Using target and crRNA from the SARS-CoV-2 N-protein as model, the proposed CRISCOFET device shows a great ability to detect and quantify RNA with a linear response for concentrations from 75 ng. uL^{-1} down to 75.10^{-9} $ng.uL^{-1}$. Furthermore, this device is easily programmable: in order to detect different target RNAs, only the CRISPR recognition site has to be modified, thus maintaining the same enzymatic activity from Cas13a for all ribonucleic particles synthesized.

[1] Jiahao Li. Tandem Cas13a/crRNA-Mediated CRISPR-FET Biosensor: A One-for-All Check Station for Virus without Amplification, ACS Sensors 7, 9, 2680-2690 (2022)

Plasmonics-based strategy for concentration of analytes

M.P.Carmo[1], D.Mack[2], D. J. Roth[1], F. J. Rodríguez-Fortuño[1], P.A.Huidobro[3], A.Rakovich[1]

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Efficient manipulation and concentration of analytes are pivotal for advancements in sensing technologies and lab-on-a-chip systems. Traditional methods often face challenges due to range-of-action limitations, scalability issues, or power requirements. This work introduces a novel plasmonic-based approach utilizing a Brownian ratchet mechanism to overcome these obstacles. By employing arrays of asymmetrical plasmonic nanostructures, we demonstrate the capability of such structures to optically trap and directionally manipulate nanometer-sized dielectric spheres using low optical powers and over long distances. Specifically, plasmonic ratchets were fabricated using e-beam lithography and then activated by a chopped 980 nm CW laser. In this implementation, the ratchets were shown to rectify the random Brownian motion of model analytes (200 nm polystyrene spheres), achieving experimental transportation velocities of up to 2.4 μm/s at excitation powers as low as 0.785 kW/cm². This approach promises significant improvements in analytical sensitivity in life sciences applications.

Friday 5 July 2024

Workshop on Graphene & Other 2D NanoMaterials

09:30-11:00	**Workshop on Graphene & Other 2D NanoMaterials** **(Timber Hall 2)** **Chair: E. Capria**
09:30-10:00 **INVITED**	**The conundrum of Carbon nanodots: a chemical perspective** **M.Bartoli[1,2]**, A. Tagliaferro[2,3] *[1]Center for Sustainable Future Technologies, Italian Institute of Technology, Italy* *[2] Consorzio Interuniversitario Nazionale per la Scienza e Tecnologia dei Materiali (INSTM), Italy* *[3] Dept. of App. Science and Technology, Politecnico di Torino, Italy*
10:00-10:30 **INVITED**	**Tuning the optoelectronic properties of two-dimensional materials** G. Kourmoulakis[1,2], A. Michail[3,4], I. Paradisanos[1], X. Marie[5], M.M. Glazov[6], L. Covaci[7], E. Stratakis[1,8], K. Papagelis[4,9], J. Parthenios[4], **G. Kioseoglou[1,2]** *[1]Inst.e of Electronic Structure and Laser, FORTH, Heraklion, Greece* *[2]Dept. of Materials Science and Technology, Un. of Crete, Heraklion, Greece* *[3]Dept. of Physics, Un. of Patras, Patras, Greece* *[4]Inst.e of Chemical Engineering Sci., FORTH, Patras, Greece* *[5]Universite de Toulouse, INSA-CNRS-UPS, LPCNO, France* *[6]Ioffe Inst.e, St.-Petersburg, Russia* *[7]Un. of Antwerp, Belgium* *[8]Dept. of Physics, Un. of Crete, Greece* *[9]School of Physics, Dept. of Solid-State Physics, Aristotle Un. of Thessaloniki, Thessaloniki, Greece*
10:30-10:45	**Functional materials based on wood, carbon nanotubes, and graphene** **A. Lekawa-Raus[1]**, D. Lukawski[2] *[1]Centre for Advanced Materials and Technologies, CEZAMAT, Warsaw Un. of Technology, Warsaw, Poland* *[2]Faculty of Materials Engineering and Technical Physics, Poznan Un. of Technology, Poznan, Poland*

INVITED TALK

The conundrum of Carbon nanodots: a chemical perspective

M.Bartoli[1,2], A. Tagliaferro[2,3]

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Nanostructured materials have attracted a great deal of interest in recent years and the number of applications proposed for them has boomed. Their use in biological environment has become one of the 'hot' issues. Several applications have in fact been proposed, such as drug delivery, cancer therapy, localized heating and biological probes. All these uses are supported by scientific reports and papers that assess nanomaterials viabilities and outstanding properties. However, when the bridge from proof of concept to real world product needs to be crossed, as human beings are involved, requirements on material characterization become very stringent.

Without a thorough characterization, in fact, it is not possible to check nano particles reproducibility and hence assess that they will behave in the same way with respect to the desired application as well as biocompatibility.

In this talk we will focus on carbon dots, i.e. carbon based almost 0-d (size of a few nm) nanostructures. Carbon dots can be produced in different ways, even starting from natural derived chemicals like citric acid and urea. After a brief description of a few routes to produce carbon dots we will focus on their structural composition in order to establish strong correlation between chemical features and physiochemical properties.

INVITED TALK

Tuning the optoelectronic properties of two-dimensional materials

G. Kourmoulakis[1,2], A. Michail[3,4], I. Paradisanos[1], X. Marie[5], M.M. Glazov[6], L. Covaci[7], E. Stratakis[1,8], K. Papagelis[4,9], J. Parthenios[4], **G. Kioseoglou[1,2]**

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Monolayers of Transition Metal Dichalcogenides (TMDs) of MX_2 type (M=Mo or W and X=S or Se) exhibit promising potential for future 2D nanoelectronics. We'll pesent methods for controlling their optical and electronic characteristics through the enginneering of their dielectric environment, employing photochemical methods, and applying mechanical strain. We investigate WS_2 monolayers on pre-patterned Si/SiO_2 substrates with cylindrical wells of 3 μm in diameter, analyzing strained and suspended areas. Raman experiments quantify strain, revealing a 10-fold enhanced PL efficiency with strong neutral excitonic emission in suspended areas. TMD optoelectronic properties are chemically controlled by modulating the Fermi level using UV-assisted photochlorination processes in WS_2 [1,2] and WSe_2 [3] monolayers. Systematic shifts and relative intensities between charged and neutral excitons indicate a controllable decrease in e-density switching WSe_2 from n- to p-type semiconductor. Investigating isotropic, biaxial strain at room temperature on WS_2 monolayers shows a strong shift ~130 meV /% of strain in neutral exciton emission and a decrease in circular polarization degree [4]. The analysis reveals the interplay of energy and polarization relaxation channels, as well as variations in the exciton oscillator strength affecting the long-range exchange interactions.

[1] I. Demeridou, et al. 2D Mater. **6**, 015003 (2018), [2] I. Demeridou, et al. APL**118**, 123103 (2021), [3] E. Katsipoulaki, et al., 2D Mater. **10**, 045008 (2023), [4] G. Kourmoulakis, et al., APL**123**, 223103 (2023). This work was supported by the EU-funded DYNANSTY project, ID:101079179, under the Horizon Europe framework programme.

Functional materials based on wood, carbon nanotubes, and graphene

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The recent search for sustainable and low-carbon footprint materials has increased the interest of materials scientists in wood. Wood is a robust, porous, lightweight, and easily processable material. Simultaneously, it is natural, widely available, renewable, and biodegradable. It can be used as a raw material or turned into a wide range of composites and derivatives of varying properties. Enriching this carbon-based material and its composites and derivatives with carbon nanotubes (CNTs) and graphene can lead to the development of many novel applications, and significantly change the functionality and performance. Our earliest works have shown that wood can be coated with CNTs and graphene using standard printing and coating techniques, but interestingly, CNTs and graphene can also be deposited on wood without the use of binders (D. Łukawski et al. *Prog. Org. Coat*. 125, 23 (2018) &. *Compos. Part A*, 127, 105656 (2019)). Depending on the chosen technique of deposition and coating material we turned wood superhydrophobic and antistatic. Moreover, we have shown a range of electronic applications such as wood-based flood sensors, motion sensors, temperature sensors, integrated floor heaters or wood dryers. Further studies have shown that carbon nanomaterials can be easily integrated into wood binders and produce electroactive particleboards, which keep the international standards set for the reference composites (D. Łukawski et al. *Int. J. Adhes. Adhes*.132, (2024), 103678 & *Drewno* 62, 203 (2019). The most recent study considers the use of CNT-enriched wood sponges as medical electrodes. However, the combination of wood, CNTs and graphene can provide many more interesting solutions. Our recent reviews analyze current progress in this area and indicate directions for future development (D.Łukawski et al. *Wood. Sci. Tech* 57, 989 (2023) &. *Polymers* 14, 745 (2022)).

Workshop on Nanoparticles in Medicine

09:00-11:00	**Workshop on Nanoparticles in Medicine** **(Crystal Hall)** **Chair: Y. Missirlis**
09:00-09:30 **KEYNOTE**	**Technology for Bioelectronic Medicine** **G. Malliaras** *Dept. of Engineering, Un. of Cambridge, Cambridge, UK*
09:30-10:00 **INVITED**	**Calcium phosphates as drug delivery vehicles** **D. Loca[1,2]**, I. Kovrlija[1,2], O. Demir[1,2], A. Pylostomou[1,2], E. Pańczyszyn[3], M. Corazzari[3,4], J. Locs[1,2] *[1]Inst.e of Biomaterials and Bioengineering, Faculty of Natural Sci. and Technology, Riga Technical Un., Latvia.* *[2]Baltic Biomaterials Centre of Excellence, Headquarters at Riga Technical Un., Riga, Latvia.* *[3]Dept. of Health Science & Center for Translational Research on Autoimmune and Allergic Disease (CAAD), Un. of Piemonte Orientale, 28100 Novara, Italy* *[4]Interdisciplinary Research Center of Autoimmune Diseases (IRCAD), Un. of Piemonte Orientale, Novara, Italy*
10:00-10:15	**Silicon nanoneedles for long-term, sustained treatment of eye neovascularization** **Y.M. Paulus[1,2]**, V.P. Nguyen[1], J. Jeong[3], J. Lee[3], C.H. Lee[3,4,5] *[1]Dept. of Ophthalmology and Visual Sci., Un. of Michigan, MI, USA* *[2]Dept. of Biomedical Engineering, Un. of Michigan, MI, USA* *[3]School of Mechanical Engineering, Purdue Un., IN, USA* *[4]Weldon School of Biomedical Engineering, Purdue Un., USA* *[5]Dept. of Materials Engineering, Purdue Un., IN, USA*
10:15-10:30 **YRA** **CANDIDATE**	**Biocompatibility Assessment of Titanium Nitride Nanoparticles** **T. Odutola[1]**, N. Pliatsikas[1], S. Panos[1], I. Tsamesidis[2], S. Kassavetis[1], E. Kontonasaki[2], J.Arvanitidis[1], D. Christofilos[3], M. Tzitiridou[4], M. Gioti[1], P. Patsalas[1] *[1]Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece* *[2]School of Dentistry, Aristotle University of Thessaloniki, Greece* *[3]School of Chemical Engineering and Physics Laboratory, Faculty of Engineering, Aristotle University of Thessaloniki, Greece* *[4]Department of Midwifery, University Of Western Macedonia, Ptolemaida, Greece*
10:30-10:45	

KEYNOTE TALK

Technology for Bioelectronic Medicine

G. Malliaras
Department of Engineering, University of Cambridge, Cambridge, UK

Bioelectronic medicine provides a new means of addressing disease via the electrical stimulation of tissues: Deep brain stimulation, for example, has shown exceptional promise in the treatment of neurological and neuropsychiatric disorders, while stimulation of peripheral nerves is being explored to treat autoimmune disorders. To bring these technologies to patients at scale, however, significant challenges remain to be addressed. Key among these is our ability to establish stable and efficient interfaces between electronics and the human body. I will show examples of how this can be achieved using new organic electronic materials and devices engineered to communicate with the body and evolve with it.

INVITED TALK

Calcium phosphates as drug delivery vehicles

D. Loca[1,2], I. Kovrlija[1,2], O. Demir[1,2], A. Pylostomou[1,2], E. Pańczyszyn[3], M. Corazzari[3,4], J. Locs[1,2]
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[3]Department of Health Science & Center for Translational Research on Autoimmune and Allergic Disease (CAAD), University of Piemonte Orientale, Novara, Italy
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The study aimed to address the limitations of doxorubicin (DOX) as an anticancer therapy for osteosarcoma (OS), a predominant type of malignant skeletal tumors comprising 40% of bone tumors. While DOX is widely used, its effectiveness is often hindered by systemic toxicities. To mitigate toxicity, the study explored the use of calcium phosphates, specifically octacalcium phosphate (OCP), known for its unique structure suitable for controlled localized DOX delivery. Thus DOX-loaded OCP particles (pOCP) and OCP-based cements (cOCP) were synthesized, DOX release and its impact on osteosarcoma cells and MC3T3-E1 cells was investigated. **Methods**: α-TCP was used as a precursor for pOCP and cOCP synthesis and DOX was added *in situ* during synthesis. Characterization of OCP drug delivery systems (DDSs) included XRD, FTIR, and SEM analyses, while DOX release kinetics were determined via UV-VIS spectroscopy. Cytotoxicity against MG63 and MC3T3-E1 cells was assessed using CCK-8 and LDH assays, and apoptosis and ferroptosis induction by DOX combined with pOCP were evaluated in U2OS, MG63, and HOS cells using qRT-PCR and western blotting. **Conclusion**: Obtained results indicated the DOX incorporation into pOCP up to 2 wt%, while higher amounts hindered the OCP formation. It was found that DOX in cOCP affected the cement setting time and porosity, with both DOX-loaded cOCP/pOCP releasing the active substance for over 40 days. DOX+cOCP/pOCP reduced MG63 viability, while MC3T3-E1 cells continued to proliferate after 72 hours. Apoptosis was found as the primary cell death pathway upon pOCP contact. **Acknowledgement**: The authors acknowledge financial support from the EU's Horizon 2020 research and innovation programme under GA No. 857287 (BBCE) and GA No. 860462 (PREMUROSA).

Silicon nanoneedles for long-term, sustained treatment of eye neovascularization

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Macular degeneration affects more than 215 million people worldwide and is rapidly increasing with the aging population. Choroidal neovascularization (CNV) is the leading cause of vision loss and blindness in macular degeneration. Anti-vascular endothelial growth factor (VEGF) therapy such as bevacizumab (BEV) treats CNV, but this requires frequent (monthly) intra-eye injections and carry a risk of eye infection. To improve treatment efficiency, reduce treatment burden, and reduce side-effects and invasiveness, this study describes a novel CNV therapy using biodegradable silicon nanoneedles (SiNNs) fabricated on a tear-soluble contact lens.

Methods: The SiNNs were encapsulated with BEV (BEV@SiNNs) as drug carriers for long-term, sustained drug delivery. BEV@SiNNs were evaluated on a New Zealand rabbit CNV model (n = 7) after approval from the University of Michigan IACUC. To generate CNV, subretinal injection of Matrigel (20 µL) and VEGF (7.5 µL, 100 µg/mL) was performed using a 30G Hamilton needle. A contact lens was inserted subconjunctivally on the posterior sclera 3 days after CNV creation and monitored by color fundus photography, OCT, and fluorescein angiography (FA) before and at 1, 3, 7, 14, and 28 days and monthly for up to 12 months post-treatment.

Results: BEV@SiNNs resulted in long-term, sustained reduction in mean FA CNV leakage intensity for at least 1 year. There was a rapid 45% reduction in CNV within 1 week. CNV continued to gradually reduce further to an 80% reduction in CNV by 4 months that was persistent to 1 year. Control CNV did not have a significant change in CNV over 1 year. Rabbits were comfortable, and no complications occurred with treatment.

Conclusions: SiNNs are an efficient drug delivery platform technology for long-term sustained (at least 1 year) treatment of CNV in this clinically-relevant rabbit model.

Biocompatibility Assessment of Titanium Nitride Nanoparticles

T. Odutola[1], N. Pliatsikas[1], S. Panos[1], I. Tsamesidis[2], S. Kassavetis[1], E. Kontonasaki[2], J.Arvanitidis[1], D. Christofilos[3], M. Tzitiridou[4], M. Gioti[1], P. Patsalas[1]
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[4]Department of Midwifery, University Of Western Macedonia, Ptolemaida, Greece

Titanium Nitride NPs are a really promising plasmonic material for biomedicine. In contrast to Au and Ag, the traditional plasmonic materials, TiN has a higher melting point, and it is considered as a refractory material. Furthermore, by adjusting the Ti & N percentages, one could easily tune its localized surface plasmon resonance (LSPR) peaks, according to the desired application. These materials present LSPR peaks in between the biological window. Thus, they can be used as biomedical carriers. So, we used pulsed laser ablation (PLA) in liquids method to irradiate targets that were synthesized by unbalanced magnetron sputtering (UBMS). UBMS is a method that provides pure samples with well-controlled quantities. We had NPs produced in water by laser ablation in different wavelengths (355nm, 532nm & 1064nm), using the same laser power. We performed MTT assays to conclude whether our nanoparticles are biocompatible or not. Furthermore, we wanted to understand how the different laser wavelengths influence the samples' cytotoxicity. The nanoparticles were raw, without any shell-biofunctionalization. For the nanoparticles to be considered as biocompatible, the cells' vitality should be more than 70%. The MTT assays showed promising results, as the cells' vitality was 70% or more, a fact really important because our material is raw, meaning that after being biofunctionalized, its biocompatibility will be even higher. Concluding, in this work, we synthesized efficient nanoparticles that could be a promising precursor for biomedical applications, such as optical hyperthermia.

Workshop on Nanoparticles for Clinical Applications III

11:30-13:30	**Workshop on Nanoparticles for Clinical Applications III** **(Crystal Hall)** **Chair: I. Feitshans**
11:30-12:00	**Legal Frameworks for Reducing Maternal Mortality: Nanomedicine Meets the Greatest Challenge in Global Health Law** **Dr ilise Feitshans** *JD and ScM and DIR, (Chair of the Session) President-Elect Virginia Mountain Valley Lawyers Alliance and LLM Candidate Georgetown Un. Law Center*
12:00-12:15	**Nanomedicine: Technology challenges the old ways, but does it challenge traditional ethics?** **Cagri Zeybek Unsal** *Medical Ethics and History of Medicine- Bioethics Center, Hacettepe Un., Faculty of Medicine, Ankara, Türkiye*
12:15-12:45	**Nanomedicine Transforming Disability into Health** **Chrisa Vassara** *G. Gennimatas General Hospital Thessaloniki, Greece*
12:45-13:00	**You're Going to Court (and How You Could Have Avoided It) The Research Entrepreneur's Guide to Litigation Worldwide** **John S. Koehler** *Virginia Mountain/Valley Lawyers' Alliance, USA*
13:00-13:15	**Returning to Life: Nanomedicine Developments that May Upend Guardianship and End of Life Directives** **Hyatt Browning Shirkey** *Hyatt Browing Shirkey Law Firm & The Virginia Mountain Valley Lawyer Alliance* *Church Ave., S.W.Roanoke, Virginia, USA*
13:15-13:30	Discussion

Legal Frameworks for Reducing Maternal Mortality: Nanomedicine Meets the Greatest Challenge in Global Health Law

Dr ilise Feitshans

JD and ScM and DIR, (Chair of the Session) President-Elect Virginia Mountain Valley Lawyers Alliance and LLM Candidate Georgetown University Law Center

Until the time in the near future when machines will bear our human offspring, the questions surrounding the tragedy of maternal mortality, reflecting thousands of preventable deaths continue to plague humanity. People have been giving birth since humanity began, and children of all genders have their life, health and well-being undermined by maternal mortality, defined as: death of moms during pregnancy, delivery or soon after live birth. And while death cannot yet be avoided ultimately, given the state of our current technology, the reality that children need their moms in order to survive the early years of life remains nonetheless true. Nanomedicine offers opportunities for telehealth and exciting new tools to meet the grand challenge of helping moms survive pregnancy and keeping babies alive. This session explores how the global health law system is creating health protections for all, potentially embracing the unmet need to prevent maternal mortality. Universal health care offers the opportunity to tie a ribbon of cohesion around an inconsistent and wasteful patchwork of health care systems in order to protect moms and reduce maternal mortality, but whether it will do so remains an open question.

Nanomedicine: Technology challenges the old ways, but does it challenge traditional ethics?

Cagri Zeybek Unsal

Medical Ethics and History of Medicine- Bioethics Center, Hacettepe University, Faculty of Medicine Sıhhiye Campus, Ankara, Türkiye

Since there is close interaction between life sciences and engineering, sophisticated diagnostic and treatment methods have emerged. In particular, new techniques in nanomedicine arise new questions to the fore which need to be addressed in terms of traditional ethics and whether there is a need of a new form of ethics, especially the need to discuss the scope of informed consent. In this regard, when a cancer patient has not been informed of the possibility of preserving her eggs by freezing them prior to chemotherapy that removes or destroys her ovaries, it may be claimed that medical discretion to undertake his procedure without consent or without informing her about freezing her eggs exceeds the scope of standard informed consent. Whether the failure to inform her of this choice violates principles of informed consent, thereby rendering consent invalids a hot new area for litigation, nanomedicine regulation and reproductive health policy.

This dilemma represents but one example where nanotechnology offers opportunities for patients that they may not know about, raising the question whether there is a duty to inform patients of these options and to create a specific new discussion of unanticipated options that offer choices for patients, during the process of obtaining the patient's informed consent.

For this purpose, it becomes essential to question the applicability and adequacy of existing ethical approaches and principles in addressing the challenges posed by nanotechnologies in biomedicine. In this respect, this session explores the purposes and limits of informed consent and the role or duty of health care providers to ask patients about new developments rather than presuming they have made a choice with full knowledge of nanomedicine.

Nanomedicine Transforming Disability into Health

Chrisa Vassara
G. Gennimatas General Hospital Thessaloniki, Greece

Nanomedicine is a rapidly growing field that involves the use of nanotechnology for medical purposes. By utilizing materials at the nanoscale, researchers are able to create innovative solutions for diagnosing, treating, and preventing various diseases and conditions.One of the most exciting aspects of nanomedicine is its potential to transform disability into health. By developing targeted drug delivery systems, nanomedicine can deliver medications directly to the affected cells or tissues, minimizing side effects and improving treatment outcomes. This targeted approach is particularly beneficial for individuals with disabilities, as it can help manage symptoms and improve quality of life.Overall, nanomedicine has the potential to revolutionize the way we approach disability and health. By harnessing the power of nanotechnology, researchers are able to develop innovative solutions that can improve the lives of individuals with disabilities and ultimately transform their health outcomes.

You're Going to Court (and How You Could Have Avoided It) The Research Entrepreneur's Guide to Litigation Worldwide

John S. Koehler
Virginia Mountain/Valley Lawyers' Alliance, USA

Last year, I presented the thesis that researchers, especially those who wish to profit from their work, should view the attorney as an ally, not an advisory. While it is true that attorneys, especially those who work for the bureaucracies that regulate scientific research seem to be intent on explaining to researchers why they cannot do something, the truth is that an attorney's real job is to advise and advocate for someone who lacks the particular skills needed to deal with the regulatory and legal systems that impact their research and, more importantly, their ability to profit from the ideas.

The thesis last year reached the conclusion that most researchers reach the conclusion too late that consulting with an attorney should occur before, rather than when, a problem arises. This year, I will endeavour to explain why acting without legal counsel can lead to litigation that might easily have been avoided. Specifically, we will consider three topics that should concern all research entrepreneurs: the need to protect their right to their work product (intellectually property), the need to protect their rights with respect to financing, and the need to anticipate the potential liability for the use or misuse of their research and to indemnify against that liability.

Returning to Life: Nanomedicine Developments that May Upend Guardianship and End of Life Directives

Hyatt Browning Shirkey

Hyatt Browing Shirkey Law Firm & The Virginia Mountain Valley Lawyer Alliance

Church Ave., S.W.Roanoke, Virginia, USA

When nanomedicine offers new medical breakthroughs, such as the reduced impact of Parkinson's Disease explored by the Michael J Fox Foundation, patients who were perceived as perpetually ill with degenerative terminal diseases will have a new opportunity to live a highly functional life. Thanks to nanomedicines, that will very soon become available. Previously incapacitated people may get well. Yet the law and outdated legal documents may be unclear: what happens to directives and instructions for guardians or agents who never expected the patient to live without being sick?

This presentation explores key legal issues with possibly new outcomes: Can the guardian refuse such care? Is it ethically or legally wrong to refuse or permit such care? How can someone intervene to authorize care or end the guardianship? How do we know what the patient really wanted if we assume they did not know nanomedicines could make them well? This problem is not hypothetical: as directives are being written today, the possibility of recovery may not be included in the text of the patient care plan or underlying trust to fund such care. Nanomedicine breakthroughs will pose these real-life questions for people with Parkinsons disease in the next 3 to 5 years. Trusts and guardianship forming now probably don't foresee the patient becoming healthy, but the researchers at NANOTEXNOLOGY surely do! This session describes the changing role of guardians in light of these new discoveries not contemplated when patient protections were set up and offers practical approaches to anticipating these developments in nanomedicine.

Workshop on Nanocomposites

11:30-13:30	**Workshop on Nanocomposites** **(Timber Hall 1)** **Chair: D. Georgiadou**
11:30-12:00 **KEYNOTE**	**Heterogenous Integration of Superconductor With GaN Epitaxy** **A. Christou** *Un. of Maryland, USA*
12:00-12:30 **INVITED**	**Ultrafast photo-magnetic toggle switching without relying on heat in ferrimagnetic dielectrics** **A. Stupakiewicz** *Faculty of Physics, Un. of Bialystok, Poland*
12:30-12:45	**Dielectric behavior of stretchable silicone rubberbarium titanate composites** **A. Drymiskianaki[1,2]**, K. Katsara[2,3], A. Manousaki[2], Z. Viskadourakis[2] and G. Kenanakis[2] *[1] Dept. of Materials Science and Technology, Un. of Crete, Greece* *[2] Inst.e of Electronic Structure and Laser (IESL)-Foundation for Research and Technology-Hellas (FORTH),* *100 N. Plastira, Vassilika Vouton, Greece;* *[3] Dept. of Agriculture, Hellenic Mediterranean Un., Greece*
12:45-13:00	**Thermal scanning probe lithography accelerated.** **V. Theofylaktopoulos**, F. Könemann, S. Bonanni, K. Buddha, E. Cagin *Heidelberg Instruments Nano AG, Bändliweg 30, 8048 Zürich, Switzerland*
13:00-13:15	**Roll-to-Roll Processing of Silicate-based Nanocomposite Barrier Lacquers - Challenges and Chances** **S. Schiessl***, E. Kucukpinar *Fraunhofer Inst.e for Process Engineering and Packaging, Material Development, Freising, Germany*
13:15-13:30	**The Origin of Amphipathic Nature of Short and Thin Pristine Carbon Nanotubes—Fully Recyclable 1D Water-in-Oil Emulsion Stabilizers** A.W. Blacha[1], **K.Z. Milowska[2,3,4]**, M.C. Payne[2], H.F. Greer[5], A.P. Terzyk[6], E. Korczeniewski[6], A. Cyganiuk[6], S. Boncel[1] *[1]Faculty of Chemistry, Sil. Univ Technology, Poland* *[2]Cavendish Laboratory, Un. of Cambridge, UK* *[3]CIC nanoGUNE, Spain* *[4]Ikerbasque, Basque Foundation for Science, Spain* *[5]Yusuf Hamied Dept Chemistry, Univ. Cambridge, UK* *[6]Faculty of Chem, N. Copernicus Univ. Toruń, Poland*

Heterogenous Integration of Superconductor With GaN Epitaxy

A. Christou
Department of Materials Science and Engineering, University of Maryland, U.S.A.

The current state of GaN bulk crystal growth technology and GaN epitaxy lags behind the state of many of the compound semiconductor technologies especially in meeting the photonicr device requirements and power electronics requirements. ***This presentation reports the results of the UMD investigations on the characterization of defects in NbN superconducting epitaxial layers, doped and undoped leading to an understanding of the parameters which influence defect propagation*** from the substrate into the epilayer, as well as the results of our investigation of the electrical activity of defects in thin 10-100 nm NbN layers.

Epitaxial GaN and related nitride epitaxy such as NbN is required for achieving high speed power switching beyond 2 kV as well as for photonic sensing We have applied advanced defect spectroscopic techniques to NbN/GaN epi materials and test structures. Finally, the growth model for NbN on GaN is proposed based on the empirical observations.

Ultrafast photo-magnetic toggle switching without relying on heat in ferrimagnetic dielectrics

A. Stupakiewicz
Faculty of Physics, University of Bialystok, Poland

The mechanisms allowing to control state of matter with the help of ultrashort laser pulses is a highly intriguing and counter-intuitive topic in modern science. The main interest is opens up rich possibilities for non-volatile magnetic data storage technology. One of the most intriguing examples is the least-dissipative mechanisms of coherent photo-magnetic switching with orthogonal linear polarizations laser pulses in iron-cobalt garnet dielectrics [1]. The switching properties are vastly different, related to the crystal site hosting the excited Co-ions. As these ions are the source of the strong magnetic anisotropy in a garnet, their excitation between the crystal filed split states results in a coherent and ultrafast manipulation of spin-orbital interaction [2]. Here we demonstrate that the ultrafast laser excitation of iron-garnet causes toggle-switching with a train of identical laser pulses between two stable magnetic bit states [3]. This new regime of nonthermal toggle switching can be observed in an exceptionally broad temperature range. The control of magnetic anisotropy required for the toggle switching is accompanied by lower dissipations, than in the other mechanisms of laser-induced switching, but the dissipations and the switching-time are shown to be competing parameters. Additionally, we demonstrated that with femtosecond pulses it is possible to write and rewrite magnetic bits with a frequency of up to 50 GHz [3].

[1] A. Stupakiewicz, et al. *Nature* 542, 71-74 (2017).
[2] A. Stupakiewicz, et al. *Nature Comm.* 10, 612 (2019).
[3] T. Zalewski, L. Nowak, A. Stupakiewicz. *Phys.Rev.Appl* 21 (2024) and arXiv: 2311.10173.

Dielectric behavior of stretchable silicone rubberbarium titanate composites

A. Drymiskianaki[1,2], K. Katsara[2,3], A. Manousaki[2], Z. Viskadourakis[2] and G. Kenanakis[2]
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[3] Department of Agriculture, Hellenic Mediterranean University, Heraklion, Crete, Greece

Forming the backbone of flexible electronics, modern insulating materials necessitate not only high electrical insulation but also long-lasting qualities withstanding environmental stressors. Herein, elastomer composites, entailing silicone rubber and barium titanate, were fabricated via mechanical mixing suggesting a fast and uncomplicated method to produce flexible, highly dielectric materials with low cost. The impact of the filler loading on the polymer matrix was examined by means of their dielectric and mechanical properties. Dielectric permittivity measurements were conducted in the microwave regime, whereas uniaxial tensile tests were carried out for the study of mechanical properties. Furthermore, the potential correlation between the aforementioned quantities was investigated through the conduction of combined experiments; dielectric constant measurements were performed under the concurrent application of a constant tensile load. The case of potential dielectric fatigue due to cyclic mechanical load has also been examined. The experimental results indicate that barium titanate inclusions in silicone matrix significantly increase the dielectric constant, while, on the other hand, reduce the mechanical strength of the composites. According to the findings derived from combined experiments, the composites exhibit a nearly stable dielectric profile, despite the presence of mechanical deformations. This fact sets these composites as a possible candidate regarding their exposure on outdoor environmental conditions, where ambient mechanical vibrations pose an inevitable constraint. Consequently, mechanically mixed barium titanate-silicone elastomer composites could potentially become a cost-effective alternative to the ever-increasing field of insulating materials and flexible electronics.

Thermal scanning probe lithography accelerated

V. Theofylaktopoulos, F. Könemann, S. Bonanni, K. Buddha, E. Cagin
Heidelberg Instruments Nano AG, Bändliweg 30, Zürich, Switzerland

Thermal scanning probe lithography(tSPL) is a powerful technique for nanopatterning. The NanoFrazor is an instrument that uses tSPL for the simultaneous patterning and inspection of nanoscale structures as well as direct laser sublimation (DLS) for mix & match lithography to create nanodevices [1]. The technology has proven its value as an enabler of novel devices [2], as well as an asset for improving the performance of existing concepts [3]. It offers grayscale capabilities, and it can be placed in a glovebox to process sensitive materials.
In this talk, we will present tSPL and its applications in 2D devices, optics and photonics, and other applications based on thermal modification. In addition, work being done to enable higher throughput fabrication will be presented. From software allowing automated overlay to the first results with the multitip operation.

[1] S. T. Howell et al., Microsyst Nanoeng 6, 21 (2020).
[2] M. J. Skaug et al., Science. 359 (6383), 1505–1508 (2018).
[3] X. Zheng et al., Nature Electronics 2, 17-25 (2019).

Roll-to-Roll Processing of Silicate-based Nanocomposite Barrier Lacquers - Challenges and Chances

S. Schiessl, E. Kucukpinar

Fraunhofer Institute for Process Engineering and Packaging, Material Development, Freising, Germany

The integration of platelet-shaped montmorillonite nanoparticles to improve the oxygen barrier of polyvinyl-alcohol-based barrier layers is state-of-the-art. However, neither roll-to-roll coating processing of such nanocomposite barrier lacquers nor the effect of coating technique on the tortuous path effect has been extensively investigated. In the presented study, two different coating techniques, slot-die and reverse gravure, were used on a roll-to-roll pilot line to apply barrier lacquers comprising a polymeric matrix and montmorillonite. The liquid lacquers were analysed regarding viscosity at certain shear rates and their surface energy and the dried coating layers regarding oxygen barrier, surface morphology, and particle orientation. Low permeability coefficients delivering a high oxygen barrier of 0.14 and 0.12 ($cm^3(STP)\cdot\mu m)/(m^2\cdot d\cdot bar$) were achieved for the coating layers with slot-die and reverse gravure coating, respectively. It turned out that the properties of the composite barrier lacquer need to be adjusted to the coating technique to achieve high oxygen barrier performance. By tailoring the barrier lacquer formulation, a parallel orientation of the platelet-shaped montmorillonite particles can be achieved using both techniques. A low solid content of down to 3 wt% is preferable for the pre-metered slot-die coating, because it results in low agglomeration quantity in the coating layer. A high solid content of up to 9 wt% is preferable for the self-metered reverse gravure coating to assure a homogeneously coated layer.

The Origin of Amphipathic Nature of Short and Thin Pristine Carbon Nanotubes—Fully Recyclable 1D Water-in-Oil Emulsion Stabilizers

A.W. Blacha[1], **K.Z. Milowska[2,3,4]**, M.C. Payne[2], H.F. Greer[5], A.P. Terzyk[6], E. Korczeniewski[6], A. Cyganiuk[6], S. Boncel[1]

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[2]*Cavendish Laboratory, University of Cambridge, UK*

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[4]*Ikerbasque, Basque Foundation for Science, Bilbao, Spain*

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Short and thin pristine carbon nanotubes (CNTs) emerge as 1D emulsion stabilizers capable of replacing aquatoxic low-molecular surfactants. However, inconsistencies in understanding of water–solid interfaces for realistic CNTs hamper their individualization-driven functionalities, processability in benign media, and compatibility with a broad-scale of matrices. Pristine CNT processing based on water and inexpensive n-alkanes within a low energy regime would constitute an important step toward greener technologies. Therefore, structural CNT components are quantitatively assessed, placing various CNTs on the scale from hydrophobicity to hydrophilicity. This structural interweave can lead to amphipathicity enabling the formation of water-in-oil emulsions. Combining experiments with theoretical studies, CNTs and CNT emulsions are comprehensively characterized establishing descriptors of the emulsifying behavior of pristine and purified CNTs. They emerge as having hydrophilic open-ends, small number of oxygen–functionalized/vacancy surface areas, and hydrophobic sidewalls and full caps. The interplay of these regions allows short and thin CNTs to be utilized as fully recyclable 1D surfactants stabilizing water/oil emulsions which, as demonstrated, can be applied as paints for flexible conductive coatings. It is also shown how the amphipathic strength depends on CNT size, the pristine-to-oxidized/vacancy domains and the oil-to-water ratios.[1]
[1]Adv. Mater. Interfaces 2023, 2202407
depends on CNT size, the pristine-to-oxidized/vacancy domains and the oil-
to-water ratios.
[1]

Workshop on Latest Advances in Nanomedicine

15:00-17:00	**Workshop on Latest Advances in Nanomedicine** **(Crystal Hall)** **Chair: C. Gravalidis**
15:00-15:30 **INVITED**	**From the "organ-on-chip" to the "body-on-chip": Minuscule, but very efficient devices revolutionizing the medical field** **T. Mitsiadis** *Un. of Zurich, Inst.e of Oral Biology, Zurich, Switzerland*
15:30-16:00 **INVITED**	**Synthesis of functionalized nanoparticles and their antibacterial activity** **P. Das[1]**, M. Christodoulides[2], and A. G. Kanaras[1] *[1]School of Physics and Astronomy, Un. of Southampton, United Kingdom* *[2] School of Clinical and Experimental Sci., Un. of Southampton, UK*
16:00-16:30 **INVITED**	**Nanoparticles and Blood Mixing in Microfluidic Reactors using Computational Fluid Dynamics** **T. Karakasidis[1], E. Karvelas[1], G. Sofiadis[2], C. Liosis[3], I. Sarris[4]** *[1]Condensed Matter Physics Laboratory, Dept. of Physics, Un. of Thessaly, Greece* *[2]Hydromechanics and Environmental Engineering Laboratory, Dept. of Civil Engineering, Un. of Thessaly, Pedion Areos, 38334 Volos, Greece* *[3]Dept. of Biomedical Engineering, Un. of West Attica, 12241 Greece* *[4]Dept. of Mechanical Engineering, Un. of West Attica, 12241 Greece*
16:30-17:00 **INVITED**	**Information flow in cells, tissues and tissue engineering** **Y. Missirlis** *Uni. of Patras, Greece*
17:00-17:30	NN24 Closing Ceremony **Closing Remarks and Discussion** **Ceremony for NN24 Awards** **Farewell comments & End of NN24**

From the “organ-on-chip” to the “body-on-chip”: Minuscule, but very efficient devices revolutionizing the medical field

T. Mitsiadis

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Regenerative approaches combining signalling molecules and stem cells started to develop in almost all medical disciplines. Other emerging technologies such as tissue engineering, genomics, and imaging systems may help for obtaining faster, reliable advancements and outcomes in clinics. Single cell RNA sequencing analysis showed that a variety of stem cell populations process significant variability. Blood supply and innervation are also very important parameters for tissue repair. Attraction of blood vessels and neurons towards the injury or pathologic site is crucial for the function and survival of all organs and tissues of the body.

However, translation of results obtained in the laboratories into effective therapies in the clinics remains poor, highlighting the need for accurate human-emulation systems. 3D in vitro systems, such as the miniaturized “organ-on-chip” devices, successfully emulate human pathophysiological conditions and might be valuable tools for tissue regeneration purposes. “Organ-on-chip” devices have already been used in order to understand the interconnection of the various tissues (stem cells, nerves, vessels etc) and to study their responses upon bacterial attack. The above-mentioned technologies and the vascular and neuronal remodelling after the of tissues will be presented and discussed.

Synthesis of functionalized nanoparticles and their antibacterial activity

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In recent years, a variety of emerging nanomaterial-based approaches have been extensively studied as alternative therapeutics for the treatment of multi-drug resistant bacterial infections in both preclinical and clinical research. In this context, we have been developing functionalized inorganic nanoparticles that either exhibit inherent antibacterial activity or act as nanocarriers for targeted and responsive delivery of antibiotic agents. In the current study, we synthesized water-soluble noble metal nanoclusters coated with antibiotics and studied their antibacterial properties. We observed that the antibacterial activity of nanoclusters was significantly dependent on their composition, surface chemistry, and the bacterial genus. For example, silver nanoclusters are more efficient than gold nanoclusters in killing bacteria, P. aeruginosa. Furthermore, we synthesized highly biocompatible periodic mesoporous organosilica nanoparticles (nanoPMOs) with distinct physical and chemical properties such as uniform mesoporous structure and acidic pH-induced biodegradability. Surface engineered water dispersible nanoPMOs can be loaded with molecular antibiotics (rifampicin) or nano antibiotics (functionalized nanoclusters) into their pores efficiently. Their payload can be released in a controlled way because of their degradation in acidic pH 4.5 compared to physiological pH 7.4.

Nanoparticles and Blood Mixing in Microfluidic Reactors using Computational Fluid Dynamics

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Conventional cancer chemotherapy often causes severe side effects. However, magnetic driving of nanoparticles is a promising method to eliminate these effects by delivering targeted anticancer drugs or hyperthermia. The challenge lies in driving the nanoparticles to the desired cancer cell. This paper presents a numerical model that optimizes the driving of nanoparticles circulating in the blood via a magnetic field gradient. The study combines and extends optimization methods of mixing nanoparticles with blood and driving them along a desired path. The simulation uses Computational Fluid Dynamics (CFD) and Discrete Element Method (DEM). To drive nanoparticles along a pre-determined trajectory under various blood flow velocities in the cardiac cycle, the optimum magnetic intensity is evaluated each time using the covariance matrix adaptation evolution strategy (CMA-ES). The results reveal the influence of blood flow and the volume of nanocarriers in the magnetic driving process under natural conditions.

Acknowledgments.
T.K., G.S. acknowledge support by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the "2nd Call for H.F.R.I. Research Projects to Support Faculty Members and Researchers" (Project Number: 4584).
The authors would like to acknowledge the support of the Greek Research and & Technology Network (GRNET) for the computational time granted in the National HPC facility ARIS.

Information flow in cells, tissues and tissue engineering

Y. Missirlis
University of Patras, Greece

Life is sustained by information flow through all the "living" players, from the nano level to the whole organism and beyond. Information content in biology may be energy packets, physical or chemical signals, natural or artificial particles containing one or more messages and so on. The right flow of information is translated to physiological processes, while misinformation may lead to pathological conditions, whereby generating flow of dormant information packets (such as immunological responses). With the advent of Artificial Intelligence and Machine Learning techniques new areas of development, such as designing "intelligent" biomaterial structures, or extracellular niches are entering the experimental field of tissue engineering. The above issues will be discussed during the presentation.

Workshop on Nanocharacterization

15:00-17:00	**Workshop on Nanocharacterization** **(Timber Hall 1)** **Chair: M. Bartoli**
15:00-15:30 **INVITED**	**SOLARIS synchrotron: a state-of-the-art large-scale facility in CEE countries** **A.Maximenko**, M.Gołuński, M.Sikora, J.Szlachetko *SOLARIS Nat. Synchrotron Radiation Centre, Jagiellonian Un., Krakow, Poland*
15:30-15:45	**Carrier concentration effects on (Cd,Mn)Te QW's ODMR signal studied in the microscale** **Dydniański A.,** Lopion A., Raczynski M., Połczynska K.E., Kazimierczuk T., Pacuski W., Kossacki P. *Inst.e of Experimental Physics, Faculty of Physics, Faculty of Physics, Un. of Warsaw Poland*
15:45-16:00 **YRA** **CANDIDATE**	**Stabilizer Effects on Flow Synthesis of Iron Oxide Nanoparticles in Polyol Medium: Towards a Comprehensive Understanding of Formation Mechanisms** **L. Van Leuven[1]**, T. Vangijzegem[1], D. Stanicki[1], S. Laurent[1,2] *[1]General, Organic and Biomedical Chemistry Unit, NMR and Molecular Imaging Laboratory, Un. of Mons (UMONS), BELGIUM* *[2] Center for Microscopy and Molecular Imaging (CMMI), BELGIUM*
16:00-16:15 **YRA** **CANDIDATE**	**Molecular half-cages in the synthesis of intrinsically chiral anisotropic gold nanoparticles** **A. Le Hoang[1]**, N. Kowalska[1], F. Bandalewicz[1], W. Drożdż[2], A. Stefankiewicz[2], W. Lewandowski[1] *[1]Faculty of Chemistry, Un. of Warsaw, Poland* *[2]Faculty of Chemistry, Adam Mickiewicz Un., Poland*
16:15-16:30	**Ionic liquid/polar solvent carbon-based ionogel composites for electromagnetic interference shielding by microwave absorption.** **P. Al Malak[1,2]**, C. Vancaeyzeele[2], G. T. M. Nguyen[2], P.-H. Aubert[2], F. Vidal[2], C. Galindo[1], P. Bondavalli[1], C. Plesse[2] *[1]Thales Research & Technology, Palaiseau, France* *[2] Laboratory of Physiochemistry of Polymers and Interfaces (EA 2528), CY Cergy-Paris Un., France*
16:30-16:45 **YRA** **CANDIDATE**	**Colloidal nitride nanoparticles by Nanosecond Laser Ablation** **S. Panos[1]**, N. Pliatsikas[1], T. Odutola[1], S. Kassavetis[1], C. Papouli[1], J. Arvanitidis[1], D. Christofilos[2], M. Gioti[1], E. Pavlidou[1], P. Patsalas[1] *[1] Dept. of Physics, Aristotle Un. of Thessaloniki, Thessaloniki, Greece* *[2] School of Chemical Engineering and Physics Laboratory, Faculty of Engineering, Aristotle Un. of Thessaloniki, Thessaloniki, Greece*

SOLARIS synchrotron: a state-of-the-art large-scale facility in CEE countries

A.Maximenko, M.Gołuński, M.Sikora, J.Szlachetko
SOLARIS Natational Synchrotron Radiation Centre, Jagiellonian University, Krakow, Poland

The SOLARIS synchrotron is a third-generation light source operating at an electron energy of 1.5 GeV. It has been opened for users in 2018. Nowadays, it feeds six beamlines with intense collimated light in the spectral range from UV to hard X-rays, enabling experiments with multiple experimental techniques. At the PIRX beamline, users can exploit near edge X-ray absorption fine structure (NEXAFS) spectroscopy as well as structural and magnetic dichroism (XLD & XMCD). The main technique at the URANOS beamline is angle-resolved photoelectron spectroscopy (ARPES). PHELIX beamline offers two methods: ARPES and X-ray photoelectron spectroscopy (XPS). The DEMETER beamline hosts two end-stations: scanning transmission X-ray microscope (STXM) and photoemission electron microscope (PEEM). Among the recently opened compact beamlines, ASTRA is dedicated to X-ray absorption spectroscopy (XAS) in the tender and hard X-ray range, while POLYX is dedicated to X-ray microimaging and X-ray microspectroscopy in the energy range 4-15 keV. In mid 2024 the opening of the CIRI beamline for infrared spectroscopy and imaging is planned, while two other beamlines (SOLCRYS and SMAUG) are under construction. Last but not least, the SOLARIS Centre also offers access to cryo-electron microscopes of the latest generation: Titan Krios G3i and Glacios. The presentation of state-of-the-art research possibilities at the LEAPS photon infrastructures using the example of the SOLARIS synchrotron will be illustrated by selected experimental results. Special emphasis will be placed on XAS results and the information content they offer in the fields of nanoscience and nanotechnology.

Acknowledgements: Participation at the Nanotexnology 2024 is funded by the EU Horizon 2020 project LEAPS INNOV (no. 101004728). The EU Horizon2020 programme (952148-Sylinda) is also acknowledged.

Carrier concentration effects on (Cd,Mn)Te QW's ODMR signal studied in the microscale

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Optically Detected Magnetic Resonance (ODMR) is an effective technique for studying the local environment of paramagnetic ions in quantum wells (QWs). ODMR takes advantage of the selectivity provided by optical detection methods while maintaining the sensitivity of paramagnetic resonance. A common practice in optical studies of QWs is focusing the light with relatively low-NA lenses, which yields a large focal spot and relatively low resolution. Such an approach makes it easier to integrate the optical experiment with the microwave setup. In our studies, to get better access to local properties revealed in the optical spectrum, we employed μ-photoluminescence and μ-reflectance techniques, which allowed us to perform μ-ODMR experiments.

Using this new approach we investigate the correlation between local carrier gas density and ODMR signal. Our (Cd,Mn)Te/(Cd,Mg)Te quantum wells are intrinsically p-doped, with the hole gas derived from the structure's surface. Its local density is determined by measurement of the relative intensity between X^+ and X in reflectivity spectra. As a result of the presence of the hole gas, we observe a shift of the magnetic resonance towards lower magnetic fields (Knight shift) and acceleration of the spin-lattice relaxation time. We find that local fluctuations in carrier density are reflected in strong changes of ODMR signal monitored on the X^+ line, which can be exploited in future studies of low-dimensional semimagnetic nanostructures.

Stabilizer Effects on Flow Synthesis of Iron Oxide Nanoparticles in Polyol Medium: Towards a Comprehensive Understanding of Formation Mechanisms

L. Van Leuven[1], T. Vangijzegem[1], D. Stanicki[1], S. Laurent[1,2]
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Iron oxide nanoparticles (IONPs) are widely studied for their superparamagnetic properties, which make them suitable as contrast agents for MRI. While many synthetic routes have been described, one of the most popular is the thermal decomposition of organometallic compounds in polyol medium. The success of this process lies in its ability to produce IONPs with good control over their size, shape, and crystallinity. Polyols take advantage of several features such as high boiling point, reducing properties, as well as stabilizing properties enabling a control over the particle's growth during synthesis. In this work, tetraethylene glycol (TREG) was identified to be a suitable solvent for the flow synthesis of IONPs. By analogy to other conventional high temperature processes (i.e. thermal decomposition) and to modulate the particles' properties, the use of aminated and/or carboxylated oligoethyleneglycol stabilizers has been evaluated.
Starting from these experiments, a flow chemistry approach was applied to gain better control over the synthesis parameters, increase the scale-up potential and enhance safety of the process. After isolation and purification, the resulting batches were characterized by TEM, relaxometry and VSM in order to understand the influence of the stabilizers on the resulting properties and propose a particles' formation mechanism.

Molecular half-cages in the synthesis of intrinsically chiral anisotropic gold nanoparticles

A. Le Hoang[1], N. Kowalska[1], F. Bandalewicz[1], W. Drożdż[2], A. Stefankiewicz[2], W. Lewandowski[1]
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In recent years, the field of nanotechnology has seen an increase in interest in chiral nanoparticles, leading to numerous publications highlighting key advancements in enantiomer recognition, separation, chiral catalysis, biomedicine, and optoelectronics.

The current state of synthetic methods focuses mainly on the inducers of natural origin. Amino acids and peptides perform very well in this role providing reproducible syntheses with high colloidal stability. The problem with this approach is that such a narrow group of inducers limits the development of technology in terms of obtaining new morphologies of chiral nanoparticles and exploring new growth mechanisms of this type of nanomaterials. In our research, we tackle this problem by inducing chirality using synthetic compounds. We propose using the molecular half-cages as the chiral inducers. The key features of our structures are the multidentate nature of compounds (the presence of three cysteine moieties) and the presence of a modifiable central core unit.

As a result we obtained intrinsically chiral rod-like nanoparticles and have shown that the selected compounds can induce intrinsic chirality. Our research makes it possible not only to expand the range of chirality inducers but may also open the way to obtaining chiral materials with controllable and strong chiroptical properties.

Ionic liquid/polar solvent carbon-based ionogel composites for electromagnetic interference shielding by microwave absorption

P. Al Malak[1,2], C. Vancaeyzeele[2], G. T. M. Nguyen[2], P.-H. Aubert[2], F. Vidal[2], C. Galindo[1], P. Bondavalli[1], C. Plesse[2]

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Electromagnetic interference (EMI) presents a significant challenge in today's world due to the widespread adoption of electronic and telecommunication systems. Conventional EMI shielding relies on the reflection of EM waves by using metallic materials thanks to their electronic conductivity. Recently, polymers and polymeric composites, loaded with various fillers, have garnered significant interest for an EMI shielding based on absorption, thanks to the dielectric and/or magnetic properties of the fillers. However, the polymer matrices exhibit low dielectric losses, hence primarily serving a mechanical role and a dispersing medium for the fillers with minimal interaction with the EM waves. This study proposes the use of ionic liquids (ILs)-based polymers due to their high polarity. ILs are organic salts, molten at room temperature and composed purely of anions and cations. After investigation, their microwave loss characteristics revealed large ionic conductivities and dielectric loss factors, which can lead to EM loss through these two absorption mechanisms. Their integration into polymer matrices to form ionogels, which consist of immobilizing the IL within a polymer matrix, was studied. The combination of the ILs with a polar solvent increases the dielectric losses, particularly as the polar solvent itself exhibited high dielectric losses in the GHz region. Compared to bare IL ionogels, the addition of the polar solvent exhibited improved EM absorption and attenuation capabilities. Conversely, incorporating a CNT:Graphene mixture at a 4:1 ratio showed optimal EM absorption. Consequently, shielding effectiveness of over 20 dB (i.e over 99%) and up to 26 dB were obtained in the X (8.2-12 GHz) and Ku (12-18 GHz) bands with high absorption capabilities.

Colloidal nitride nanoparticles by Nanosecond Laser Ablation

S. Panos[1], N. Pliatsikas[1], T. Odutola[1], S. Kassavetis[1], C. Papouli[1], J. Arvanitidis[1], D. Christofilos[2], M. Gioti[1], E. Pavlidou[1], P. Patsalas[1]

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Nitrides are among the most prominent material families for novel nanotechnology applications and critical technological materials that revolutionized semiconductors & consumer electronics industry, and they are classified into two distinct sub-categories: i) III-nitride wide-gap semiconductors (such as GaN and AlN) and ii) Conducting nitrides of IIIb-Vb transition metals (such as TiN, ZrN, $Ti_{1-x}Sc_xN$, and $Ti_{1-x}Ta_xN$), which have recently gained importance as alternative plasmonic materials. Although the fabrication of nitrides in thin film form is well-known and controlled, the fabrication of high-quality nitride nanoparticles and the use of nitrides inks, which will pave the way of nitrides to the flexible electronics applications that is still an open issue. In this work we provide an eco-friendly approach for mass-producing nanomaterials with customized properties via the use of Pulsed Laser Ablation in Liquids (PLAL). The colloidal nanoparticles were fabricated through laser ablation of Titanium (TiN) thick coatings in liquids, using a nanosecond Nd:YAG pulsed laser at 355, 532 and 1064 nm in two different solvents. Morphology of produced TiN NPs have been evaluated by SEM. Stoichiometry and surface chemical bonding have been characterized with XPS, as well as their quality (qualitative defect proportion) have been analysed by Raman. Optical absorbance measurements were also performed to see their behaviour on the visible light.

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POSTER

WS1 Posters

	WS1 POSTER SESSION **Tuesday 2 July to Friday 5 July: Poster Display** **Thursday 4 (17:30-20:00): Poster Presentation**
P1-1 **YRA** **CANDIDATE**	**Tunable polarization degeneracy points in a perovskite-filled open cavity** Woyciechowska A.* [1], Kędziora M.[1], Opala A.[1,2], Sigurðsson H.[1,3], Król M.[1]., Mazur R.[4], Piecek W.[4], Szczytko J.[1], Piętka B.[1] *[1]Inst.e of Experimental Physics, Faculty of Physics, Un. of Warsaw, Poland* *[2]Inst.e of Physics, Polish Academy of Sci., Warsaw, Poland* *[3]Science Inst.e, Un. of Iceland, Reykjavik, Iceland* *[4]Faculty of New Technologies and Chemistry, Military Un. of Technology, Warsaw, Poland*
P1-2	**Photoelectrochemical characterisation of solar cell absorber materials** L. Mitchell, B. Griffin, D. Smith and L. Danos *Dept. of Chemistry, Lancaster Un., Lancaster, LA1 4YB, UK*
P1-3	**Efficient light harvesting in dye-polymer mixtures** S. Doyle, H. Chintakuntla, R. Manning and L. Danos *Dept. of Chemistry, Lancaster Un., Lancaster, LA1 4YB, UK*
P1-4	**Multiplication of laser repetition rate exploiting Fabry-Perot resonator** **G. Wlaź*, M. Kobecki, T. Jakubczyk, P. Kossacki** *Inst.e of Experimental Physics, Faculty of Physics, Un. of Warsaw, Poland*
P1-5	**Comparison of SPEs sensors based on various carbon nanostructure for monitoring of anticancer doxorubicin** A. Grozdanov[1], Perica Paunovik[1], Iva Dimitrievska[1] *University Ss Cyril and Methodius in Skopje, Faculty of Technology and Metallurgy, R.N. Macedonia*
P1-6 **YRA** **CANDIDATE**	**Nanofabrication of tailorable Titanium Nitride plasmonic nanostructures** P. Rampota, S. Panos, N. Pliatsikas, D. Tselekidou, P. Patsalas, S. Kassavetis *Nanotechnology Lab LTFN, Physics Dept., Aristotle Un. of Thessaloniki, Thessaloniki, GR-54124, Greece*

Tunable polarization degeneracy points in a perovskite-filled open cavity

Woyciechowska A.* [1], Kędziora M.[1], Opala A.[1,2], Sigurðsson H.[1,3], Król M.[1]., Mazur R.[4], Piecek W.[4], Szczytko J.[1], Piętka B.[1]

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The strong coupling between light and matter, achieved through manipulations of both the active material and the sample structure, enables the observation of a variety of nonlinear, topological, and non-Hermitian effects. A particularly intriguing system involves microcavities filled with quasi-2-dimensional perovskites, where stable excitons enable the manifestation of polariton effects at room temperature. The perovskite birefringence facilitates the generation of diabolical points as a degeneracy for two linearly polarized polariton modes. We expanded this framework by incorporating a birefringent [(4F-C6H4(CH2)2NH3)2PbI4], PEPI-F, in an open double cavity, which allowed us for the observation of non-Hermitian coupling between a polariton and an additional photon confined in air gap between the perovskite crystal and DBR. This strongly modified polariton dispersion reveals multiple inflection points. We observed subsequent regions of steep and flat dispersion, leading to a highly non-quadratic dispersion shape. When this complex behaviour is further juxtaposed with the birefringence of PEPI-F perovskite, it leads to unconventional diabolical points that appear along the dispersion. These diabolical points are repeated within a single mode pair and demonstrate a significant contribution to the circular polarization. Remarkably, these findings are accurately reproduced by the Berreman method, which relies on the anisotropic transfer matrix method, as well as by an analytical model employing synthetic Hamiltonians. Furthermore, manipulation of the thicknesses of perovskite and microcavities enables precise control over the locations of such degeneracy points. This provides a pathway to further explore the effects of non-Hermitian physics in polariton systems.

Photoelectrochemical characterisation of solar cell absorber materials

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There have been many photoelectrochemical studies into the electron transfer mechanism present in dye/quantum dot sensitised titanium dioxide electrodes,[1] but not a lot of research has been conducted into the non-radiative energy transfer mechanism in dye coated silicon wafers.[2] A three electrode photoelectrochemical cell can offer quick information into the suitability of a solar cell absorber material and avoid solid state junction and metal contact formation. This can provide further insight into the possible mechanism of silicon photosensitisation.[3-4] Cyclic voltammetry and photo-chronoamperometry was carried out on Si(111) n-type anodes constructed from thick wafers and thin (2μ) silicon on insulator (SOI) respectively. The surface of the anodes was examined with the presence of native oxide but also removing the oxide and chemically modifying the silicon surface via chlorination followed by methylation which has shown to increase the passivation of the silicon surface and significantly reduce electron-hole recombination. The successful passivation was confirmed with silicon photoluminescence which showed a significant enhancement on the near infrared silicon emission. The incident photon-to-current conversion efficiency (IPCE) vs incident wavelength was recorded for all the silicon anodes studied.

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Efficient light harvesting in dye-polymer mixtures

S. Doyle, H. Chintakuntla, R. Manning and L. Danos
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Light harvesting is the process by which the absorption ability of the photosynthetic reaction complex increases significantly via a series of excitation energy transfer steps from an array of pigments surrounding the reaction centre. A strong dipole-dipole interaction and a significant spectral overlap between the pigments are important for efficient non-radiative energy transfer before the excitation energy gets lost in other dissipative processes.[1] The key consideration in the design of light-harvesting structures is to maintain a close intermolecular separation for a high efficiency of excitation energy transfer while minimising self-quenching of fluorescence or non-radiative energy dissipation, which is common in dye containing solutions. The energy transfer from a donor to an acceptor depends strongly on the orientation and spectral properties of the supramolecular 'architecture' of the system in which this energy transfer takes place. In this presentation spin coated dye-polymer mixtures have been developed that can exhibit long range energy transfer with high donor to acceptor ratios. For this work, two different organic dyes (perylene/oxazine) have been prepared mixed in different ratios (1:1) up to (100:1). A perylene dye has been tested for efficient homo-energy transfer between the same molecular dyes with the aim to create a long exciton diffusion The dye-polymer mixtures are characterised with state-of-the-art steady state and time-resolved fluorescence spectroscopy.

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Multiplication of laser repetition rate exploiting Fabry-Perot resonator

G. Wlaź, M. Kobecki, T. Jakubczyk, P. Kossacki
Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Poland

High repetition rate train of laser pulses is a promising tool for optical manipulation of high frequency phenomena by accessing their resonant frequency in GHz range [1]. However, access to ultrafast GHz repetition rate lasers is currently limited due to their cost and technological complexity. One can multiply the repetition rate of widely available MHz lasers by implementing a Fabry-Perot resonator in the optical path. Tuning the distance between the mirrors of the resonator allow adjustment of the delay between the pulses and as a consequence multiplication the repetition rate of the laser. In this work we have analysed influence of the multiple reflections in the resonator on the duration of the 100 fs pulse by autocorrelation studies. Subsequently we have used range of mirrors in order to achieve best quality of the multiplied pulses. Future plans involve placing samples inside an open optical cavity to increase light-matter coupling with desired repetition rate.

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Comparison of SPEs sensors based on various carbon nanostructure for monitoring of anticancer doxorubicin

A. Grozdanov[1], Perica Paunovik[1], Iva Dimitrievska[1]
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Design of novel bio-nanosensors based on carbon nanostructures (G, CNTs, G-CNT hybrid) is facilitating a new research direction and it is very important task of many projects. In the present work, a promising application of bio-nanosensors based on Screen Printed Electrodes (SPE) with Graphene, MWCNT and MWCNT/PANI nanocomposites prepared by direct electro-polymerization method as well as inkjet and 3D printing were tested and compared for monitoring of anticancer drug Doxorubicin. Surface changes of the SPE-sensors, before and after cyclic voltammetry were followed by SEM. Polymer/CNTs interactions and their changes on the surface of SPE-sensors were studied by FTIR-ATR spectroscopy. The obtained results have confirmed polymer/CNs and CNs/drugs interactions and their characteristic band-shifting.

Nanofabrication of tailorable Titanium Nitride plasmonic nanostructures

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Nanotechnology Lab LTFN, Physics Department, Aristotle University of Thessaloniki, Thessaloniki, GR-54124, Greece

Transition metal nitrides are conductive ceramics with unique properties, such as substantial electronic conductivity, exceptionally high melting point, and tunable work function. Among them, Titanium Nitride (TiN) is a candidate for plasmonic applications (biosensors, catalysis, photochemistry, solar energy harvesting, and photo-detection). This work focuses on the fabrication of TiN nanostructures of varying sizes and shapes using NanoSphere Lithography (NSL), Reactive Magnetron Sputtering (RMS) and Highly Power Impulse Magnetron Sputtering (HIPIMS). The process involves three steps: (a) the formation of a two-dimensional photonic mask by applying a solution of colloidal polystyrene monodisperse (diameters d=552 and d=172 nm) via spin coating onto Si (001), glass and PET substrates (b) the deposition of TiN using different sputtering techniques to fabricate nanostructures of different sizes and shapes and (c) the removal of the mask to reveal the nanostructures on the substrate.
Throughout each step, various experimental parameters are examined that may affect the final nanostructure. For the step (a) the main goal is to develop a monolayer mask for large-scale lithography, considering factors such as spin-coating speed, surfactant usage, and substrate type. Additionally, the growth conditions of the sputtering techniques are investigated, analyzing parameters such as the reactive gas flow, deposition time, and target power After the lift-off of the nanospheres mask, the arrays of the highly ordered TiN nanostructures appear. Their morphology and the quality are evaluated using Atomic Force Microscopy (AFM), providing comprehensive insight into their characteristics at the microscale. UV-Vis Spectroscopy and NIR-Vis-UV Spectroscopic Ellipsometry were used to study the optical properties of the TiN nanostructures and to evaluate their optical / plasmonic response. We present the fabricaton of tailorable highly ordered TiN nanostructures by varying the thickness (controlled by deposition time), size (by using nanospheres with a diameter of 172 nm) and shape (by angular deposition) such as nanotriangles, nanorods, nanorod rings, and nanowire arrays.

WS2 Posters

	WS2 POSTER SESSION **Tuesday 2 July to Friday 5 July: Poster Display** **Thursday 4 (17:30-20:00): Poster Presentation**
P2-1	**Photocatalytic Activity of TiO2 Aerogels Prepared by Sol-Gel Synthesis and Different Drying Methods** J. Doneliene[1,2], E. Fataraite-Urboniene[2,3], S. Pakalka[1,2], J. Ulbikas[1,2] *[1]App. Research Inst.e for Prospective Technologies, Lithuania* *[2]JSC Modernios E-Technologijos, Lithuania* *[3]Kaunas Un. of Technology, Lithuania*
P2-2	**Green, eco-friendly reagents in the flotation of pyrite** P. Angelopoulos[1], G. Anastassakis[1], N. Kountouris[1], M. Taxiarchou[1] *[1] School of Mining and Metallurgical Engineering, Nat. Technical Un. of Athens (NTUA), 9 Heroon Polytechneiou Street, NTUA Zografou Campus, GR 15780, Greece*
P2-3	**Au NPs-coated ZrO_2 multilayer nanofibers as label-free SERS-active substrate for trace detection of analytes with varying sizes** J.-D. Liao[1, *], H. Lee[1], H.-P. Tsai[2, 3], W.-E. Fu[4] *[1]Dept. of Materials Science and Engineering, Nat. Cheng Kung Un., Tainan, Taiwan* *[2]Dept. of Pathology, Nat. Cheng Kung Un. Hospital, Tainan, Taiwan* *[3]Dept. of Medical Laboratory Science and Biotechnology, Nat. Cheng Kung Un., Tainan, Taiwan* *[4]Center for Measurement Standards, Industrial Technology Research Inst.e, Hsinchu, Taiwan*
P2-4	**Unveiling the Synergistic Effect of Nickel Phosphide/Nickel Oxide on Siloxene Nanosheets for Robust Lithium Sulfur Batteries** K. W. Seo[1], T. T. Nguyen[1], H. Song[1], N. H. Kim[1*], J. H. Lee[1,2*] *[1]Dept. of Nano convergence Engineering, Jeonbuk Nat. Un., Jeonju, Jeonbuk, 54896, Republic of Korea* *[2]Carbon Composite Research Center, Dept. of Polymer and Nano Science and Technology, Jeonbuk Nat. Un., Jeonju, Jeonbuk, 54896, Republic of Korea*
P2-5	**Atomic heterointerface Engineering of NiCoRuP Nanosheets-Coupled V_2CT_x Mxene for High-Efficiency Overall Water Electrolysis** D. Malhotra[1], D. T. Tran[1], Nam Hoon Kim[1*], Joong Hee Lee [1,2*] *[1]Dept. of Nano convergence Engineering, Jeonbuk Nat. Un., Jeonju, Jeonbuk, 54896, Republic of Korea.* *[2]Carbon Composite Research Center, Dept. of Polymer and Nano Science and Technology, Jeonbuk Nat. Un., Jeonju, Jeonbuk, 54896, Republic of Korea*
P2-6	**Nanocomposite membranes based on AB-PBI with embedded TiO_2 green synthesized particles – photocatalytic properties** H. Penchev[1], K. Zaharieva[2], I. Tsacheva[1], S. Dimova[1], O. Dimitrov[3] D. Stoyanova[4], Stambolova[4,] *[1]Inst.e of Polymers, Bulgarian Academy of Sci., "Acad. G. Bonchev" St., Bl.103A, 1113 Sofia, Bulgaria* *[2]Inst.e of Mineralogy and Crystallography "Acad. I. Kostov", Bulgarian Academy of Sci., "Acad. G. Bonchev" St., Bl. 107, 1113 Sofia, Bulgaria* *[3]Inst.e of Electrochemistry and Energy Systems "Acad. Evgeni Budevski", Bulgarian Academy of Sci., "Acad. G. Bonchev" St., Bl. 10, 1113 Sofia, Bulgaria* *[4]Inst.e of General and Inorganic Chemistry, Bulgarian Academy of Sci., "Acad. G. Bonchev" St., Bl. 11, 1113 Sofia, Bulgaria*
P2-7	**Preparation and photocatalytic activity of meta- Polybenzimidazole/green synthesized Zinc oxide hybrid nanocomposites** K. Zaharieva[1], S. Dimova[2], O. Dimitrov[3], H. Penchev[2] *[1]Inst.e of Mineralogy and Crystallography "Acad. I. Kostov", Bulgarian Academy of Sci., "Acad. G. Bonchev" St., Bl. 107, 1113 Sofia, Bulgaria* *[2]Inst.e of Polymers, Bulgarian Academy of Sci., "Acad. G. Bonchev" St., Bl.103A, 1113 Sofia, Bulgaria* *[3]Inst.e of Electrochemistry and Energy Systems, Bulgarian Academy of Sci., "Acad. G. Bonchev" St., Bl. 10, 1113 Sofia, Bulgaria*
P2-8	**Use of electrical impedance spectroscopy (EIS) for opal-based nanostructures identification** M. Cedeno Mata[1], A. Palomas[1], R. Bragos[1], J. Villar[2], M. Dominguez-Pumar[1], S. Bermejo[1] *[1]Dept. of Electrical Engineering, Polytechnic Un. of Catalonia, Jordi Girona 1-3, Spain* *[2]Dept. of Mathematics, Polytechnic Un. of Catalonia, Jordi Girona 1-3, Spain)*
P2-9	**Electrothermal study of nanostructured humidity sensor** A. Palomas Jimenez[1], M. Cedeno Mata[1], R. Bragos[1], M. Dominguez-Pumar[1], J. L. Villar[2], S. Bermejo[1] *[1]Dept. of Electrical Engineering, Polytechnic Un. of Catalonia, Jordi Girona 1-3, Spain*

	[2]Dept. of Mathematics, Polytechnic Un. of Catalonia, Jordi Girona 1-3, Spain
P2-10	**Comparison of Zn-doped mesoporous bioactive glasses produced via three different modifications of sol-gel synthesis** A. Beketova[1], R. Choudhary[1], I. Tsamesidis[2], K. Rubenis[1], V. Stepanova[1], K. Smits[1], G. K. Pouroutzidou[2], D. Loca[1], E. Kontonasaki[2], J. Locs[3] *[1]Riga Technical Un., Pulka 3, Riga, LV-1007, Latvia* *[2] Aristotle Un. of Thessaloniki, Greece* *[3] Baltic Biomaterials Centre of Excellence, Latvia*
P2-11	**Electrical and Optical Properties of Anodic Column-like WTi Oxide on the Glass** A. Hoha[1], U. Turavets[1], S. Granko[2], A. Pligovka[1] *[1]Research and Development Laboratory 4.10 "Nanotechnologies",* *Belarusian State Un. of Informatics and Radioelectronics, 6 Brovki Str., Minsk 220013, Republic of Belarus* *[2]Dept. of Micro- and Nanoelectronics, Belarusian State Un. of Informatics and Radioelectronics, 6 Brovki Str., Minsk 220013, Republic of Belarus*
P2-12	**Biomimetic Tarantula Hair-Inspired Washing Machine Filters for Enhanced Microplastics Capture** J.R. Kim *Advanced Textile R&D Dept., Korea Inst.e of Industrial Technology (KITECH), Ansan-si 15588*
P2-13	**Improving Indoor Air Quality: MIL-100(Fe) Growth on Polyacrylonitrile@TiO2 Nanofiber Webs for VOCs Adsorption and Photocatalytic effects** J. R. Kim *Advanced Textile R&D Dept., Korea Inst.e of Industrial Technology (KITECH), Ansan-si 15588*
P2-14	**Bioinspired structural coloration with melanin nanoparticles for architectural materials** W. Pajerski[1], A. Černoša[1], A. Gubenšek[1,2], V. Hribljan[1], A. Sandak[1,2,3] *[1] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia* *[2] Andrej Marušič Inst.e, Un. of Primorska, Titov trg 4, 6000 Koper, Slovenia* *[3] Faculty of Mathematics, Natural Sci. and Information Technologies, Un. of Primorska, Glagoljaška 8, 6000 Koper, Slovenia*
P2-15	**Nanoengineering of anodic aluminum oxide templates for photonic applications** U. Malecka, Gałan S., Pietrusińska K., Stefaniuk T. *Inst.e of Geophysics, Faculty of Physics, Un. of Warsaw, Poland*
P2-16	**Nanostructured Thin Films Fabricated by Anodizing of Three-Layer Systems** A. Hoha[1], U. Turavets[1], S. Zavadski[2], D. Golosov[2], S. Granko[3], A. Pligovka[1] *[1]Research and Development Laboratory 4.10 "Nanotechnologies", Belarusian State Un. of Informatics and Radioelectronics, 6 Brovki Str., Minsk 220013, Republic of Belarus* *[2]Center 2.1 "Ion Plasma Systems and Technologies", Belarusian State Un. of Informatics and Radioelectronics, 6 Brovki Str., Minsk 220013, Republic of Belarus* *[3]Dept. of Micro- and Nanoelectronics, Belarusian State Un. of Informatics and Radioelectronics,6 Brovki Str., Minsk 220013, Belarus*
P2-17	**Bismuth Nanowires Fabricated on Porous Al_2O_3 Assisted Niobia Arrays** Pligovka A.[1], Zavadski S.[2], Golosov D.[2] and Granko S.[3] *[1]Research and Development Laboratory 4.10 "Nanotechnologies", Belarusian State Un. of Informatics and Radioelectronics, 6 Brovki Str., Minsk 220013, Belarus* *[2]Center 2.1 "Ion Plasma Systems and Technologies", Belarusian State Un. of Informatics and Radioelectronics, 6 Brovki Str., Minsk 220013, Belarus* *[3]Dept. of Micro- and Nanoelectronics, Belarusian State Un. of Informatics and Radioelectronics, 6 Brovki Str., Minsk 220013, Belarus*
P2-18	**Detecting potential single photon emitters in C-doped GaN** J. Misiak[1], K. Kliczewska[1], P. Kulboka[1], N. Dalla[1], M. Kobecki[1], P. Kossacki[1], P. Prystawko[2], H. Turski[2], and T. Jakubczyk[1] *[1]Faculty of Physics, Un. of Warsaw, Warsaw, Poland* *[2]Inst.e of High Pressure Physics "Unipress", Polish Academy of Sci., 01-142, Warsaw*
P2-19	**Electrochemical Lead Sensing Based on Patterned Nanoclusters Made of a Mixture of PMMA and NTPH Ink Using Dip Pen Nanolithography** M. Zohar[1], K. K. Yadav[2], D. Shamir[3], H. Kornweitz[4], Y. Peled[3], and A. Burg[2] *[1]Electrical and Electronics Engineering, Shamoon College of Engineering, Be'er Sheva, Israel 56 Bialik St., Be'er Sheva, 8410802, Israel* *[2]Chemical Engineering, Shamoon College of Engineering, Be'er Sheva, Israel* *[3]Analytical Chemistry, NRCN, Be'er Sheva, Israel 4Chemical Sci. Dept., Ariel Un., Ariel, Israel*

P2-20	**High-efficiency All-Solid-State Sodium Battery Enabled by Novel Polyanionic Carbonophosphate-Based Electrolyte** H. Kim[1], S. Jena[1], D. T. Tran[1†], N. H. Kim[1], J. H. Lee[1,2†] *[1]Dept. of Nano Convergence Engineering, Jeonbuk Nat. Un., Jeonju-si, Jeollabuk-do, 54896, Republic of Korea.* *[2]Carbon Composite Research Center, Dept. of Polymer and Nano Science and Technology, Jeonbuk Nat. Un., Jeonju-si, Jeollabuk-do, 54896, Republic of Korea*
P2-21	**Core-shell Nanofiber Positrodes Derived by Na-Zn-HCF/$Ti_3C_2T_x$ for Flexible Sodium-ion Battery** Sehwi Park[1], Sambedan Jena[1], Duy Thanh Tran[1†], Nam Hoon Kim[1], Joong Hee Lee[1,2†] *[1]Dept. of Nano convergence Engineering, Jeonbuk Nat. Un., Jeonju-si, Jeollabuk-do, 54896, Republic of Korea.* *[2]Carbon Composite Research Center, Dept. of Polymer and Nano Science and Technology, Jeonbuk Nat. Un., Jeonju-si, Jeollabuk-do, 54896, Republic of Korea*
P2-22	**Magnetic Polaron States in Photoluminescent Carbon Dots Enable Hydrogen Peroxide Photoproduction** H. Kmentova[1], L. Zdrazil[1,2], S. Kment[1,2], R. Zboril[1,2] *[1]RCPTM/CATRIN, Palacky Un. Olomouc, Slechtitelu 27, 78371 Olomouc, Czech Republic [2]Nanotechnology Centre, VSB-TUO, 17. listopadu 2172/15, 70800 Ostrava, Czech Republic*
P2-23	**Synthesis of Nitrogen-doped Carbon Layer Encapsulated Iron Oxide/Graphene Decorated Hollow Carbon Nanofibers for High-performance Supercapacitor** OK-Kyung Park[1], Joong Hee Lee[1,2] *[1]Dept. of Nano Convergence Engineering, Jeonbuk Nat. Un., Jeonju-si, Jeollabuk-do, 54686, Republic of Korea* *[2]Carbon Composite Research Center, Dept. of Polymer and Nano Science and Technology, Jeonbuk Nat. Un., Jeonju-si, Jeollabuk-do, 54896, Republic of Korea*
P2-24	**Optical properties of Eu^{3+}-doped 13X luminescent zeolite for environment and sensing** A. Safonova [1], G. Mariotto[2], N. Daldosso[2], F. Enrichi[2] *[1]Dept. of Diagnostics and Public Health, Un. of Verona* *[2]Dept. of Engineering for Innovation Medicine, Un. of Verona, Strada le Grazie 15, Italy*
P2-25	**Anelasticity of Nanocomposites of Multiwalled Carbon Nanotubes and Polymers, SiO_2** A. Onanko[1], D. Charnyi, Y. Onanko, O. Dmytrenko, M. Kulish, T. Pinchuk-Rugal, M. Yatsiuk, E. Matselyuk, A. Gaponov, L. Kurochka, P. Il'in, S. Marysyk *Physical Dept., Kyiv Nat. Un., Volodymyrs'ka str., 64/13, Kyiv, 01601, Ukraine*
P2-26	**Improving Nanoparticle Stability and Performance with Multidentate Surfactants** M. Giustra[1], B. Novati[1], F. Arrigoni[1], S. Garbujo[1], A. Colombo[1], L. Bertini[1], L. De Gioia[1], M. Colombo[1] and D. Prosperi[1] *[1]Dept. of Biotechnology and Bioscience, Un. of Milano-Bicocca, Milano, Italy*
P2-27	**Thermochromic $V_{1-x}Re_xO_2$ thin films for smart windows** B. Polyakov, T. Tsebriienko, J. Butikova, E. Butanovs, T. Safiulins, J. Purans *Inst.e of Solid State Physics, Un. of Latvia, Kengaraga 8, LV-1063 Riga, Latvia*
P2-28	**Photocurrent studies of epitaxial $MoSe_2$ multilayers** Kuna M., Raczyński M., Pacuski W., Kossacki P., *Faculty of Physics, Inst.e of Experimental Physics, Un. of Warsaw, Poland*
P2-29	**Hexagonal Moiré patterns in nylon mesh nanoporous structures: computational and experimental study** E.M. Papia[1,2], V. Constantoudis[2,3], D. Nioras[4], E. Gogolides[2,3] *[1.] Dept. of Physics, School of Science, Un. of 15784 Greece* *[2.] Inst.e of Nanoscience and Nanotechnology, NCSR Demokritos, Agia Paraskevi, 15341, Greece* *[3.] Nanometrisis p.c., Agia Paraskevi, 15341, Greece* *[4.] Physics Dept., Nat. Technical Un. of Zografou Campus, Greece*
P2-30	**Phase change behavior of Poly(vinylidene fluoride) and PVDF with ZnO nanoparticle composite thin films monitoring by Micro-Raman spectroscopy** M. Purica[1], F. Comanescu[1], V. Dediu[1] *[1] Inst.e for Research and Development in Microtechnologies – IMT Bucharest, 126A Erou Iancu Nicolae Street, R-077190, Voluntari, Ilfov, Romania*
P2-31	**Synthesis and characterization of Carbon Dots (CDs)-$CuFe_2O_4$ nanohybrid material as an adsorbent for the removal of Congo Red azo dye from water** A. Zourou[1], A. Ntziouni[1], T. Roman[2,3], C. Tampaxis[4], T. Steriotis[4], G. Gkouzia[5], L. Alff[5], D. E. Sanchez[6], M. Terrones[6,7,8], K. V. Kordatos[1] *[1]School of Chemical Engineering, Nat. Technical Un. of Zographou Campus, 15772, Greece* *[2]Nat. Inst.e of Research & Development for Technical Physics, Iasi, 700050, Romania* *[3]Integrated Center of Environmental Science Studies in the North Eastern Region, "Alexandru Ioan Cuza" Un. of Iasi, Iasi, 700517, Romania* *[4]Inst.e of Nanoscience and Nanotechnology, NCSR "Demokritos", Agia Paraskevi, 15310, Greece*

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P2-32	**Shining a Light on Innovation: Harnessing Core-Shell Nanostructures for Enhanced Photocatalytic Applications** I. Kitsou[1], A. A. Alivisatou[1], M. Papageorgiou[1], N. Demetzos[1], E. Roussi[1], P. Gkomoza[1], D. Katerinopoulou[2], Ch. Charalampidis[2], A. Stoumpidi[2], V. Binas [2,3], G. Kiriakidis[2], A. Tsetsekou[1] [1]*School Of Mining and Metallurgical Engineering, Nat. Technical Un. of Iroon Polytechniou 9 str. GR15773 Zografou Campus, Greece.* [2]*PCN Materials IKE, Craftsmen Industrial Park of Heraklion (VIOPAN) in Anopolis, Hersonissos,70008, Crete, Greece* [3]*School of Chemistry, Aristotle Un. of Thessaloniki, 54124, Thessaloniki, Greece*
P2-33	**Effect of Silicon Precursor on Physicochemical Properties of Doped Mesoporous Silica-Based Nanoparticles MCM-41 Type** G. K. Pouroutzidou[1,2], D. Gkiliopoulos[3], K. Tsachouridis[4], K. S. Triantafyllidis[3], A. D. Anastasiou[4], and E. Kontonasaki[2] [1] *School of Physics, Aristotle Un. of Thessaloniki, Thessaloniki, Greece* [2] *School of Dentistry, Aristotle Un. of Thessaloniki, Thessaloniki, Greece;* [3] *School of Chemistry, Aristotle Un. of Thessaloniki, Thessaloniki, Greece;* [4] *Dept. of Chemical Engineering and Analytical Science, Un. of Manchester, Manchester M1 3AL, UK*
P2-34	**Innovative fabrication of metal oxide nanoparticles by Laser Ablation in solvents** E. Karkadaki, S. Panos, N. Pliatsikas, S. Kassavetis, P. Patsalas *Dept. of Physics, Aristotle Un. of Thessaloniki, GR-54124 Thessaloniki, Greece*
P2-35	**Development of Hall measurements in nanomaterials** E. Koutantou[1,2], G. Veisakis[2], G. Makris[2], D. Kosmidis[2] and G. Deligeorgis[2,1] [1] *Physics Dpt, Un. of Crete, 71203 Heraklion, Greece* [2] *Institute of Electronic Structure and Laser (IESL), Foundation for Research and Technology Hellas (FORTH), 70013 Heraklion, Greece*
P2-36	**Poly(maleic anhydride-*alt*-styrene) film modified with amino acid and divinylsulfone: Immobilized covalently multipoint laccase enzyme** M. Urzúa[1], N. González[1], J.M. Blamey[2], V. Guixé[3], R. Fernández-Lafuente[4], J.M Lázaro-Martínez[5], V. Villalobos1 [1]*Departament of Chemistry, Faculty of Sci. Un. of Chile Las Palmeras N°3425.Ñuñoa Santiago Chile.* [2]*Departament of Biology, Faculty of Chemistry and Biology, Un. of Santiago, Av. Libertador Bernardo O'Higgins Nº 3363 Estación Central Santiago, Chile* [3]*Departament of Biology, Faculty of Sci. Un. of Chile Las Palmeras N°3425.Ñuñoa Santiago Chile.* [4]*Dept. of Biocatalysis, Institute of Catalysis, CSIC, Campus Un. Autónoma,28049 Madrid, Spain* [5]*Dept. of Chemistry Sci. Faculty of Pharmacy and Biochemistry, Institute of Chemistry and Drug Metabolism, Un. of Buenos Aires. Argentina*
P2-37	**Enhancement of Antifouling Properties in Polymeric Films via Hyperbranched Polymer Functionalization** V. Villalobos[1], N. González[1], J.M. Lazaro[2], M. Urzúa[1]. [1]*Dept. of Chemistry, Sci. Faculty, Un. of Chile.Las Palmeras 3425, Ñuñoa, Santiago, R.M., Chile.* [2] *Dept. of Chemical Sci. Faculty of Pharmacy and Biochemistry, Institute of Chemistry and Drug Metabolism, Un. of Buenos Aires. Argentina*
P2-38	**Fabrication and characterization of FeCo/Cu multilayered nanowires** R. Grigore[1,2], E. Matei[2], C. Bran[3], V. Kuncser[2], G. Schinteie[2], C. Ghica[2], I. Enculescu[2] [1]*Faculty of Physics, Un. of Bucharest, 077125 Magurele, Ilfov, Romania* [2]*National Institute of Materials Physics, Atomistilor 405A, 077125 Magurele, Ilfov, Romania* [3]*Instituto de Nanociencia y Materiales de Aragón (INMA-CSIC), C/ Mariano Esquillor, s/n, Campus Río Ebro - 50018 Zaragoza, Spain*

Photocatalytic Activity of TiO2 Aerogels Prepared by Sol-Gel Synthesis and Different Drying Methods

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Titanium dioxide (TiO_2) aerogels are a fascinating 3D nanostructure of interconnected networks due to their advantageous features, such as high chemical stability, low toxicity, high specific surface area, low cost, etc. Understanding the influence of calcination temperature on the structure of TiO_2 aerogel is crucial, as its results on the crystal structure of synthesized material, determine photocatalytic activity and other properties of titanium dioxide as well.
The sol-gel method and different drying conditions (subcritical (400 and 800 mbar) and ambient at 80°C) were applied to synthesize high porosity, large specific surface area, and cost-effective TiO_2 aerogel. TiO_2 aerogels were prepared applying the acid (HNO_3)-catalysed sol-gel method and subcritical drying by using titanium isopropoxide (TIP) as titanium precursor, HNO_3, ethanol, and distilled water. The molar ratio of initial materials was nTIP : $nHNO_3$: nEtOH : nH_2O = 1:0.08:21:7.35. After drying obtained aerogel was additionally thermally treated at T=500°C temperature. Methods of XRD, STA, UV-vis were used to compare the properties of synthesized TiO_2 aerogels.
For samples calcinated at a temperature of 500°C it was found the formed crystalline anatase phase and the average size of crystallites was about 18 nm. The photocatalytic activity of synthesized TiO_2 powders was evaluated according to the methylene blue solution colour changes under light irradiation.

Green, eco-friendly reagents in the flotation of pyrite

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The environmental impact of the mineral flotation process is under consideration as it involves the use of toxic chemicals, which implicants can be dramatic because of the fact that froth flotation is among the most massively applied separation processes of the mineral processing industry. Under these circumstances, the use of biodegradable and environmentally friendly reagents has gained widespread international attention.
Pyrite is the most widespread occurring sulfide mineral, occurring in association with other sulfide minerals and coal, and is usually removed as gangue mineral through the froth flotation process since it is readily floatable with various types of collectors. Here, we present an overview of recent developments on the use of green chemicals in the flotation of pyrite, not only on the collectors, but also on the depressants and frothers, with a focus on performance comparison in comparison to conventional chemicals.

Au NPs-coated ZrO_2 multilayer nanofibers as label-free SERS-active substrate for trace detection of analytes with varying sizes

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Label-free surface-enhanced Raman spectroscopy (SERS) methods have great potential for detecting analytes of various sizes and dimensions with high sensitivity and size-matched selectivity. To reduce the influence of interfering substances, SERS-active substrates were designed by coating Au NPs on ZrO_2 multilayer nanofibers (Au NPs/fZrO_2) and referencing with Au NPs embedded on ZrO_2 nano-bowl (Au NPs/pZrO_2). Detection efficiency studies were performed on small pesticide molecules and live SARS-CoV-2 virus variants, as well as three interfering substances. The results show that the fibrous structure of Au NPs/fZrO_2 can effectively wet the sample and detect larger target molecules, thus improving efficiency by reducing unwanted molecules in the SERS signal. Au NPs/fZrO_2 showed similar ability to detect pesticide molecules and virus variants at trace levels as Au NPs/pZrO_2. The performance of the substrate is attributed to the optimization of four key factors, including the SERS-active nanostructured substrate, the appropriate Raman laser wavelength and power related to its sensing effect, the size and dimensions of the analyte, and the presence of interfering substance. Subsequent interactions between these factors can influence the resulting SERS measurements. It exhibits stronger peak intensity and more unique SERS peaks assigned to the variants. Thus, differences in substrate morphology affect the generation of hotspots and the distance between analyte and hotspots. These findings are expected to develop a SERS-based label-free method for trace detection of various virus particles by filtering out solution molecules and shortening the effective distance be-tween virus particles and Au NPs hotspot(s) on ZrO_2 multilayer nanofibers, the detection efficiency is significantly improved.

Unveiling the Synergistic Effect of Nickel Phosphide/Nickel Oxide on Siloxene Nanosheets for Robust Lithium Sulfur Batteries

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Recently, the demand for high specific capacity and excellent energy density energy storage system that could replace the state-of-the-art Li-ion batteries is an urgently task. Lithium-sulfur (Li-S) batteries are rising as one of the most promising energy storage systems with high theoretical specific capacity, outstanding energy density, and low cost. However, the low electrical conductivity of sulfur and final discharge product (Li_2S_2/Li_2S) as well as the shuttling effect of high-order polysulfide, could reduce the sulfur utilization and stability of batteries. To deal with this problem, we designed the heterostructure of Ni_2P/NiO that was uniformly grown on 2D siloxene nanosheets (Ni_2P/NiO@SLXs) by an in-situ growing and followed with a partial phosphidization process. The hierarchical nanostructure was employed as the cathode for Li-S batteries. Getting benefit from the excellent catalytic activity for intermediated polysulfide conversion reaction and the strong adsorption ability, the Ni_2P/NiO@SLXs/S cathode exhibited the outperformed specific capacity with excellent cycling stability. Even at a high sulfur loading and lean electrolyte condition, the as-assembled Li-S battery presented superior electrochemical performance, demonstrating the practical application possibility. This present work suggested a facile and low-cost approach to develop a novel hierarchical nanostructure sulfur host that could be potential for future commercialization of Li-S batteries.

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Atomic heterointerface Engineering of NiCoRuP Nanosheets-Coupled V_2CT_x Mxene for High-Efficiency Overall Water Electrolysis

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Water splitting is an uphill thermodynamic process that is regarded as an attractive way to realize hydrogen economy via renewable production of hydrogen fuel. The state-of art electrolyzer comprises platinum (Pt)-based cathode and ruthenium (Ru)/iridium (Ir)-based anode catalyst caused by their excellent performance; however, the expensiveness and scarcity limit their industrial-scale long-term application. Transition metal phosphides has gained significant interest due to their long-term durability, inexpensiveness, alongside the fascinating electrochemical activity due to the presence of electronegative P atom that could withdraw electrons from neighbouring metals. Furthermore, the heteroatom doping could favourably tailor the catalytic activities of transition metal phosphides and offers more exposed active sites by creating lattice defects. As one class of promising candidate, V_2CT_x MXene owing to its superior electrical conductivity, multiple vanadium oxidation states, could promote the rapid charge transfer between the two-dimensional NiCoRu nanosheets and V_2CT_x support. Taking these thoughts into consideration, we have designed a bi-functional catalyst based on the Ru doped nickel cobalt phosphide@ V_2C (NiCoRuP@V_2C) nano-architecture that offers low overpotential of 127 mV for HER and 430 mV for OER at 50 mA cm^{-2}. This study has contributed towards facile and scalable development of novel electrocatalyst to produce H_2 at low cost and high efficiency.

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Nanocomposite membranes based on AB-PBI with embedded TiO_2 green synthesized particles – photocatalytic properties

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Novel AB-Polybenzimidazole/TiO_2 nanocomposite membranes were prepared by green chemistry synthetic approach. Modified Eaton's reagent (methansulfonic acid/P_2O_5) was used as both reaction media for microwave assisted synthesis of AB-PBI and as efficient dispersant of partially agglomerated titan dioxide powders. Composite membranes with 100 μm thickness were prepared by film casting approach with subsequent anti-solvent inversion in order to obtain porous composite membranes with high sorption capacity. The maximum TiO_2 filler content achieved was 20 wt.%. TiO_2. Titania particles were green synthesized (using *Mentha Spicata* aqueous extract) by hydrothermal activation (150°C and 180°C), followed by thermal treatment at 400°C.For comparison, sample with embedded TiO_2 without plant extract was prepared (sol-gel TiO_2). The various methods such as Powder X-ray diffraction analysis, Fourier-transform infrared spectroscopy, scanning electron microscopy and thermogravimetric analyses, were used to study the phase composition, structure, morphology and thermal behaviour of synthesized nanocomposite membranes. The photocatalytic ability of prepared PBI/TiO_2 membranes was studied for degradation of 5 ppm Reactive Black 5 dye as model pollutant at pH= 3 under UV-light. The photocatalytic results established that the higher degree of degradation after 180 minutes of Reactive Black 5 dye was achieved using the PBI/green synthesizedTiO_2 membranes photocatalyst (70%) in comparison with PBI/sol-gel TiO_2 (46%), respectively. The composite membranes based on PBI with green synthesized TiO_2 hydrothermally treated at 180°C possess higher photocatalytic efficiency (70%) about degradation of Reactive Black 5 than that membrane containing conventional TiO_2 particles, obtained at 150°C (58%).

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Preparation and photocatalytic activity of meta- Polybenzimidazole/green synthesized Zinc oxide hybrid nanocomposites

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Novel meta-PBI/ZnO micro- and nanocomposite powders with up to 30 wt. % ZnO content were prepared by two general approaches i) direct mixing of m-PBI/DMAc solution with concentrated dispersions of commercial micronized ZnO or laboratory synthesized ZnO NPs dispersed in organic solvent with subsequent ionogenic gelation of the mixed polymer dispersion and ii) in situ ZnO NPs formation within PBI matrix with the use of alkali-ethanol PBI solution and $Zn(NO_3)_2.6H_2O$ precursor salt. The zinc oxide nanopowders were obtained by green synthesis using plant extract of Vaccinium vitis-idaea L. and further used in preparation of hybrid nanocomposite materials. The phase composition, structure, morphology and thermal behavior of synthesized PBI/ZnO nanocomposites were investigated by Powder X-ray diffraction analysis, Fourier-transform infrared spectroscopy, scanning electron microscopy and thermogravimetric analyses. The photocatalytic behavior of prepared PBI/ZnO nanocomposite powders was studied in the reaction of degradation of Malachite Green dye (5 ppm) from aqueous solutions under UV light. The PBI/green synthesized ZnO demonstrated higher photocatalytic activity in Malachite Green dye degradation (99 %) after 120 minutes UV irradiation.

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Use of electrical impedance spectroscopy (EIS) for opal-based nanostructures identification

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Opal and inverse-opal structures are widely used to fabricate humidity and gas sensors. Therefore, ensuring the correct fabrication of these structures is relevant since it has a direct impact on their sensing performance. This work introduces the application of Electrochemical Impedance Spectroscopy (EIS) for the characterization and identification of opal-based micro and nanostructures. Three different structures based on micro and nanoparticles of polystyrene (PS) and alumina (Al2O3) layers have been characterized. The first structure consists of a mixture of PS spherical particles of 500 nm and 5 um in diameter. The second structure is based on the first structure, with an Al2O3 layer of 360nm enveloping the particles. Finally, for the fabrication of the last structure, the PS micro and nanoparticles have been calcined, and an additional Al2O3 layer of 450nm is deposited, leading to an inverse-opal structure. The EIS measurements show that the fabricated opalbased structures possess their own distinctive impedance spectra. Therefore, the obtained results show that each structural modification stimulates alterations in the impedance spectra. These results are attributed to changes in: (i) the space occupied by air, PS, or the Al2O3 layer, which modifies the effective epsilon parameter of the structure, and (ii) the available free charges in the structure. EIS results have been compared with the ones obtained through scanning electron microscopy (SEM). The comparison reveals a correlation between the resulting morphology from the SEM and the EIS spectra, validating that the EIS spectra alterations can be attributed to structural modifications. This finding suggests the potential capability of the EIS characterization technique for identifying structure modifications in a real-time and more cost-effective and non-destructive way, thereby facilitating the fabrication process and evidencing the dispensable role of the SEM method.

Electrothermal study of nanostructured humidity sensor

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One of the functionalities of inverse opal structures is to use them as humidity sensors. These humidity sensors are accompanied by a structure that allows heating them to achieve a sensing response as stable as possible throughout their lifespan. In this work, a device consisting of electrodes capable of both measuring and heating is shown, along with an alumina (Al_2O_3) nano-voided structure to help in humidity measurement. This work introduces its theoretical and experimental analysis. The theoretical study demonstrates the currenttemperature relationship of two different electrode size. It also presents the energy required to reach those temperatures. Finally, simulations, using Comsol Multiphysics, were conducted to predict the temperature the Al_2O_3 nano-voided sensing layer would reach for specific electrode temperatures. The experimental part consists of qualitatively and quantitative analysis that reveals the temperature reached by the electrodes with a specific current excitation, using measurement tools such as a thermocouple and a thermal camera. A comparison between the studies carried out related with the electrodes has validated the simulations. These findings reveal the effectiveness of the studied structure as a double-functionality electrode over cost-effective substrates, thereby proposing a humidity sensor that possesses low consumption as well as the capability of recovering its sensing response. This work introduces an effective approach for humidity sensing applications based on cost-effective and simple design.

Comparison of Zn-doped mesoporous bioactive glasses produced via three different modifications of sol-gel synthesis

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Bioactive glasses with mesoporous structure (MSNs) have potential applications in bone tissue regeneration and local drug delivery. Inclusion of Zn in minor doses into their composition could additionally provide anti-inflammatory, anti-bacterial and angiogenic properties. The aim of this investigation was to synthesize Zn-MSNs with three-different modifications of sol-gel method and to compare their physicochemical, morphological properties and hemocompatibility. **Materials and Methods.** Mesoporous Ca/Zn-doped silicate nanopowders (MS-Z1, MS-Z2, MS-Z3) in the composition of 70SiO2-25CaO-5ZnO (in % mol) were synthesized using three different modifications of sol-gel method. Their phase composition and morphology were characterized by XRD and SEM/EDS, and surface area was measured by BET. Hemolytic activity of different concentrations (0.06-1 mg/ ml) of MSNs was evaluated spectrophotometrically (540 nm) after 24h of incubation with human erythrocytes (hRBCs). **Results** The synthesized Zn-MSNs were primarily composed of amorphous phase and possessed homogeneous shape, their size varied from 50 to 500 nm. BET analysis revealed large surface area in range of 176-726 m2/g. Two of the tested materials (MS-Z1 and MS-Z2) presented no hemolysis at the tested concentrations, while MS-Z3 appeared to be hemolytic. **Conclusions** Three different variations of sol-gel method were successfully applied for Zn-MSNs synthesis. Their different physicochemical characteristics had an impact on their hemocompatibility, finding that merits further investigation. **Acknowledgements.** The research has been funded by RegrOssBio (HORIZON-MSCA-2022-PF-01-01) GA 101106882 project. The authors also acknowledge the access to the infrastructure and expertise of the Balic Biomaterials Centre of Excellence (BBCE, GA No.857287).

Electrical and Optical Properties of Anodic Column-like WTi Oxide on the Glass

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Titania and tungsta are widely used in micro and nanoelectronics, photonics and optics devices. An alloy based on these two metals is widely used in microelectronics in standard processes. Therefore, the study of the electronic and optical properties of this material is a relevant study.Two types of films were obtained by anodizing a two-layer Al/WTi on glass: transparent WTi oxide by one step Al/WTi anodizing and column-like WTi oxide by two step anodizing. Morphology, C–V characteristic, sheet resistance, optical characteristic were investigated. Transparent WTi oxide was formed by one step anodizing technique in 0.4 M oxalic solution at constant voltage 37 V the duration of anodizing was 5 h. Anodic alumina was removed by selective etching. Two step approach include the same first step (duration of anodizing was 50 min) and then anodizing treatment were reanodized in an electrolyte borate solution by raising the voltage to 380 V. The tops of WTi oxide column were open by selective etching of anodic alumina for Ni contact pad deposition. Sheet resistance of transparent WTi oxide was 3.8 MOhms·□$^{-1}$ just after anodizing treatment. The sheet resistance of transparent WTi oxide alumina free decrease to 1.5 kOhms·□$^{-1}$. The transparence of WTi oxide was 60 %. After being in ambient conditions for 20 d sheet resistance has consistently increase to 2.2 kOhms·□$^{-1}$, further resistance changes were negligible. C–V characteristic of column-like WTi oxide have a non-linear and non-symmetrical character in the range from –0.5 to +1,5 V. An increase in the voltage causes a breakdown. Transparent WTi oxide can be used as transport layers in perovskite solar cells. The column-like WTi oxide can be used as a memristor.

Biomimetic Tarantula Hair-Inspired Washing Machine Filters for Enhanced Microplastics Capture

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Aquatic environments are being polluted by microplastics primarily originating from the washing 24 of synthetic textiles. Microfibers (MF), which are microplastics in synthetic fibers, are consistently 25 introduced into the environment with each domestic laundry cycle. To address this issue, we 26 developed a specialized MF capture "barbed filter" (BF) by transforming PET monofilaments of 27 different diameters (0.4, 0.6, and 0.8 mm) into structures that closely resemble the characteristics 28 of tarantula urticating hairs. BFs feature sharp barbs that effectively capture and retain microfibers 29 of diverse lengths, surpassing the performance of conventional control filters. The BFs had a 30 retention efficiency of 88–91%, while the CFs had an efficiency of 79–86%. Our findings revealed 31 that the barbed filter significantly outperformed the conventional control filter in capturing 32 microfibers due to its smaller pore size, shorter pore distance, and unique filter shape. This design 33 not only enhances the surface area and friction, facilitating microfibril strong entrapment but also 34 minimizes the probability of microfibril passage through the filter. This research offers a promising 35 solution for reducing microfibril release from laundry and textile industrial wastewater. The 36 implementation of BFs in real life has the potential to significantly reduce microplastic pollution 37 and promote a cleaner and more sustainable environment.

Improving Indoor Air Quality: MIL-100(Fe) Growth on Polyacrylonitrile@TiO2 Nanofiber Webs for VOCs Adsorption and Photocatalytic effects

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In light of rapid industrialization and urban expansion, the pressing issue of environmental pollution, particularly concerning indoor air quality, calls for innovative solutions. Volatile organic compounds (VOCs), pervasive indoor pollutants, pose significant health risks, necessitating effective adsorption and removal methods. In response, we propose a pioneering approach to develop a versatile air filter membrane capable of both toluene adsorption and photocatalytic degradation under varying light conditions, making it ideal for self-cleaning applications.
This study details the successful fabrication of the air filter membrane, emphasizing the in-situ growth of MIL-100(Fe) particles on PAN nanofibers loaded with TiO2 nanoparticles to create the PTF membrane. With an impressive 98% toluene adsorption efficiency and a higher toluene capacity of 383.94 mg g-1, the PTF membrane surpasses its counterparts. Notably, its design enables functionality under diverse light sources, showcasing significant photocatalytic degradation efficiencies of 62.3%, 71.3%, and 80.2% under UV, visible, and combined UV-visible light, respectively, owing to its reduced bandgap and enhanced light absorption capabilities. Furthermore, the regeneration cycle of the PTF membrane demonstrates minimal efficiency loss, ensuring long-term performance. This innovative approach offers a straightforward and environmentally friendly technique for producing MOF-based photocatalytic filters tailored for indoor VOC purification systems. The developed PTF membrane exhibits exceptional stability and durability, promising versatile applications across residential, automotive, commercial, and industrial settings. By advancing efforts to improve and maintain air quality, this research holds the potential to foster a healthier and more sustainable environment.

Bioinspired structural coloration with melanin nanoparticles for architectural materials

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Structural coloration, inspired by natural phenomena, has great potential for revolutionizing architectural materials and design. By harnessing bioinspired approaches and nanotechnology, the integration of structural coloration into architectural substrates is explored, aiming for sustainability by reducing reliance on chemical dyes and colorants. Our interdisciplinary research focuses on the synthesis and optimization of melanin nanoparticles, ranging in size from 50 to 200 nm, as key components in achieving structural coloration for coatings dedicated to commonly used architectural materials such as wood, concrete, plastic, and steel. Various deposition methods, including sonochemical, deep-coating, and airbrushing, are investigated to realize vibrant structural colors with precision and efficiency.
Beyond conventional materials, our exploration shifts towards Engineered Living Materials (ELMs), extending to assessing the biocompatibility of the synthesized nanoparticles with fungi, particularly *Aureobasidium pullulans*, the non-pathogenic fungus acting as a main active ingredient of a living coating system for architectural materials. The nature of interactions between this fungus and synthesized melanin nanoparticles is crucial for developing engineered living systems with the desired color design.
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Nanoengineering of anodic aluminum oxide templates for photonic applications

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Over the past decade, the development of various nanofabrication techniques has made the use of nanostructures in photonics more widespread and resulted in significant improvement in the functionality of materials and devices. Among the different fabrication approaches anodization stands out as one the most promising methods allowing for the fabrication of high-quality nanostructures, uniform over a large area. During this self-organizing process, an ordered array of sub-100 nm pores can be produced with controllable pore diameter, periodicity, internal structure and density distribution. Typically, after fabrication porous aluminum oxide films are used as templates and are further functionalized or filled with other materials. In such form, they have been successfully used in biosensing, optoelectronic devices, microelectronics, or drug delivery systems. In our work, we focused on studying the complex interplay between the different anodizing parameters such as current, voltage, electrolyte type and concentration, temperature and time on the shape of nanopores and their arrangement. In our investigation, we followed two different optimization paths. In the first, we achieved well-oriented, column-like pores with minimal tortuosity value. Such template can be further filled with plasmonic material like gold or ITO and used to construct nanorod metamaterial optical components. The second optimization path was to develop a strongly branched structures with a high degree of porosity. In the future we intend to use it as a scaffold for polymer materials in radiative cooling applications. The morphology of the fabricated final anodic aluminum oxide structures was characterised using the SEM microscope and the optical properties were studied using the ellipsometry technique.

Nanostructured Thin Films Fabricated by Anodizing of Three-Layer Systems

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Great interest in such unique nanostructured thin films oxides is caused by their widespread use in different electronic devises. In this work, the peculiarities of formation, morphology and composition of nanostructured thin films created by anodizing of Al/Ti/Nb and Al/Hf/Nb systems deposited on silicon substrate in aqueous solutions of malonic and orthophosphoric acids followed by reanodizing in borate electrolyte have been investigated. The thin films were formed by anodizing the Al/Hf/Nb and Al/Ti/Nb in 0.6 M malonic solution at constant current density 6 $mA \cdot cm^{-2}$ and 0.2 M phosphoric acid aqueous solution at constant voltage 100 V, until the aluminum was fully oxidized. Than all systems were reanodized in 0.5 M boric acid and 0.05 M sodium tetraborate electrolyte in a potentiodynamic mode by raising the voltage to 250 V for Al/Hf/Nb and 400 V for Al/Ti/Nb. SEM shows the anodized systems is an array of oxide columns and upper layer of mesoporous Ti oxide. All columns consist of islands, legs, and heads. The height of columns is 690 and 650 nm respectively. EDX analysis of hafnium-niobium oxide showed: Al, Hf, Nb, silicon of the substrate and oxygen as the result of anodizing. Similar results are for titanium-niobium oxide: the response of the silicon substrate is visible, the presence of all elements that were part of the initial three-layer system (Al, Ti, Nb), as well as oxygen. Anodizing of three-layer systems is just beginning to develop and holds great promise. Anodic thin films from three-layer systems can be used for resistors, capacitors, sensors, semiconductors and other electronic devices have been obtained using anodizing.

Bismuth Nanowires Fabricated on Porous Al_2O_3 Assisted Niobia Arrays

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The field of nanotechnology related to the formation and the study of Bi nanowires, is currently attracting great interest. This is due to their applicability in the fabrication of various micro- and nanoelectronics devices: pH electrodes, sensors, potential applications, etc., as well as their unique properties different from their bulk counterparts. One of the optimal methods of formation of bismuth nanowires is electrochemical deposition into the Al_2O_3 pores. The base of the pores in such a method should consist of a well-conducting material. Most of the methods of creating such Al_2O_3 are expensive and difficult to realize. One approach is to create niobia in the pore base by anodizing. In this work, anodic niobia nanowire assisted electrodeposition of Bi arrays. Niobia nanowires have been obtained by porous Al_2O_3 assisted potenciostaticlly 250 V anodizing of Al/Nb (1500/200 nm) layers in 0.2 M tartaric solition. Bismuth was potentiostatically 0.28 V electrodeposited inside Al_2O_3 pores onto the surface of niobia nanowires in solution 0.13 M $BiCl_3$, 1.2 M NaCl and 1 M HCl. Removal of porous Al_2O_3 in 50% orthophosphoric solution. Microgemetry, composition and electrophysical properties were investigated. SEM and optical studies showed non-uniform distribution of nanowires in the microscale. However, the electrophysical characteristics at different contact sites were commensurate. This indicates a high uniformity in the macroscale. The dimensions of the niobia nanowires were 535 nm height and 120 nm dia. The size of the grouped Bi arrays was 2 μm height and 600 nm diameter. The positive character of the temperature coefficient of resistance characterizes the arrays as materials with predominant metallic conductivity. The results obtained lay scientific foundations for the creation of electronic devices based on nanostructured arrays of Bi nanowires on niobia surfaces.

Detecting potential single photon emitters in C-doped GaN

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Semiconductors like GaN have recently been explored as potential platforms for on-chip integrated photonics. Atomic defects in GaN have also been lately confirmed as a source of single-photons in the visible and infrared spectral range, which maintain strong emission in the zero-phonon-line up to room-temperature [1, 2].

By employing a method based on photoluminescence mapping, we can determine the physical location of these emitters, thus detemininig emitter surface density. Our setup paired with a custom data analysis program allows for attaining precise maps of emitters' distribution on a probe's surface. The method should allow us to determine the impact of C-doping on density of emitters and their PL intensity.

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Electrochemical Lead Sensing Based on Patterned Nanoclusters Made of a Mixture of PMMA and NTPH Ink Using Dip Pen Nanolithography

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One of the most important necessities for human existence is access to drinking water that is free from any form of contamination. Ground drinking water is contaminated with heavy metals as a result of industrialization. The impurities present in water before purification are of utmost importance. Electrochemical methods have proven their significance in online sensing of heavy metals in water. In certain situations, particularly in the detection of Pb(II), the limit of detection (LoD) is relatively high and needs to be reduced. Dip-pen nanolithography (DPN) is a potential solution to address the LoD issue. DPN can accurately create patterns of nanoclusters with ligands that can bind heavy metals in water to enable sensing. The nanoclusters patterned on the electrode surface are defined as the meta-chemical surface (MCS), which shares similarities with metasurfaces. MCSs are nanoclusters with periodic patterns, where one or more of their patterned elements have nanoscale dimensions. The chemical characteristics of MCSs can be enhanced compared to their bulk form. Utilizing a small quantity of ink, the patterned MCS can produce highly sensitive nanoclusters with a high surface area-to-volume ratio. By utilizing this cutting-edge MCS on a Pt electrode, we developed an MCS-based electrode for heavy metal detection. Nitrilotris-methylene-tri phosphonic acid (NTPH) mixed with poly-methyl methacrylate (PMMA) and acetonitrile was utilized as ink for making MCS using DPN. The detection sensitivity is significantly enhanced by using the as-patterned nanoclusters, and this approach shows promise in detecting ultra-low concentrations of lead (II), which is an urgent requirement in water quality monitoring. Moreover, it provides a cost-effective and accessible solution. Using DPN to create MSC electrodes, we could identify 0.49 ppb Pb (II) when MCSs were patterned on a Pt electrode surface.

High-efficiency All-Solid-State Sodium Battery Enabled by Novel Polyanionic Carbonophosphate-Based Electrolyte

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Commercializing all-solid-state sodium batteries (ASSSBs) is still a distant dream due to lack of affordable solid electrolyte options that are easy to fabricate and offer high ionic conductivity. Although sodium-based polyanionic carbonophosphate family compounds have been reported as suitable intercalation-type cathodes, their feasibility as solid electrolytes (SE) are yet to be explored. In this regard, we report the fabrication of a magnesium-based sodium carbonophosphate, which is chemically similar to bradleyite, a naturally occurring mineral, through a conventional hydrothermal route. By optimizing the room temperature pressure-induced sintering parameters, molecular arrangements favourable for Na coordination environment for conduction are obtained along with robust mechanical properties. Additionally, the layered polyanionic framework offers simultaneous Na (de)intercalation, reversible Na plating/stripping, and Na|SE interface stability. The proposed work will pave way for the development of low-cost ASSSBs that can withstand long-term cycling at higher currents with overall battery safety.

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Core-shell Nanofiber Positrodes Derived by Na-Zn-HCF/$Ti_3C_2T_x$ for Flexible Sodium-ion Battery

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Flexible sodium-ion pouch batteries have garnered significant attention for affordable next generation wearable electronics. Our present work focuses on developing a novel positrode for these flexible pouch batteries, comprising electrospun polyacrylonitrile-based core-shell nanofibers infused with sodium zinc hexacyanoferrate nanocubes and $Ti_3C_2T_x$ MXene nanosheets. By leveraging a core-shell electrospun architecture (nanocubes core fibers and nanosheets shell fibers), we maximize (de)sodiation capacities, leading to enhanced energy and power densities. Additionally, we incorporate PEDOT:PSS as molecular bridges between core and shell fibers, facilitating rapid electronic and ionic kinetics while improving mechanical stability during deformation. Our composite nanofiber positrode exhibits a reversible charge capacity of 62.21 $mAh \cdot g^{-1}$ in pristine condition and 60.32 $mAh \cdot g^{-1}$ in 180° bent condition with coulombic efficiency maintained above 98%. This innovative electrode architecture not only matches the energy density of lithium-ion counterparts but also surpasses them in mechanical durability under bending stresses at low cost. This proposed methodology addresses critical challenges in flexible battery research, promising high-performance power sources for portable and wearable electronics.

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Magnetic Polaron States in Photoluminescent Carbon Dots Enable Hydrogen Peroxide Photoproduction

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Photoactivation of aspartic acid-based carbon dots (Asp-CDs) induced the generation of spin separated species including electron/hole (e^-/h^+) polarons and spin-coupled triplet states, as uniquely confirmed by the light-induced electron paramagnetic resonance spectroscopy. The relative population of the e^-/h^+ pairs and triplet species was found to be dependent on the solvent polarity, featuring a substantial stabilization of the triplet state in non-polar environment (benzene). The formation of the spin separated states in Asp-CDs enabled the photoproduction of hydrogen peroxide from water and water/2-propanol mixture *via* water oxidation reaction. The photocatalytic activity of Asp-CDs was studied in water and water/2-propanol mixture at room temperature and under air atmosphere. Asp-CDs dispersed in water were able to generate H_2O_2 with reaction rates of 140 µmol g^{-1} h^{-1}, and 52 µmol g^{-1} h^{-1} under UV light (365 nm) or under 1 sun irradiation, respectively. The H_2O_2 production rates were further enhanced by addition of 2-propanol to the reaction mixture, reaching the values of 240 µmol g^{-1} h^{-1} and 120 µmol g^{-1} h^{-1}. The time-dependent profiles of H_2O_2 photoproduction by Asp-CDs under UV light and 1 sun revealed that the H_2O_2 concentration was sustained even after several hours of irradiation. To uncover the reaction pathway of the H_2O_2 formation by Asp-CDs, photocatalytic activities of Asp-CDs in water/2-propanol mixture under air, O_2, and N_2 atmospheres were studied. Interestingly, the reaction rate remained constant even upon changing the reaction environment, validating that H_2O_2 was formed through water oxidation reaction (WOR) rather than through reduction of oxygen. This finding was consistent with the EPR analysis, which showed that long-lived holes were more surface exposed than electrons located at the core of the particle, thus more profound to react and enabling the photocatalytic oxidation of water to H_2O_2.

Synthesis of Nitrogen-doped Carbon Layer Encapsulated Iron Oxide/Graphene Decorated Hollow Carbon Nanofibers for High-performance Supercapacitor

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The iron oxide nanoparticles (NPs) anchored hollow carbon nanofibers (H-CNF) are in the spotlight as an electrode material for supercapacitors due to their good charge absorption-desorption properties, and excellent electron transport properties. However, the weak bonding force between the H-CNF and FeO NPs and the reaggregation of FeO NPs can reduce the overall performance and durability of the electrode, which limits their widespread application in commercial energy devices. Recent studies reported an encapsulation method by heteroatom-doped graphitic carbon layer to fix FeO NPs on the H-CNF surface without the binder materials. However, the scalable and cost-effective fabrication processes to employ the FeO/G/H-CNF as electrode materials at the real industrial level remain a not solved serious technical issues. Therefore, in this study, we suggest the effective and scalable synthesis approach of FeO@graphene/H-CNF encapsulated by a nitrogen-doped graphitic carbon layer through the thermal conversion process using a nitrogen atom-containing polymer precursor. The encapsulated nitrogen-doped carbon layer (NG) and anchored FeO@Graphene on the H-CNF surface provided an effective way to improve the performance of electrodes with good durability. Consequently, the fabricated NG@FeO@G/H-CNF revealed a higher specific capacitance of 466.3 F g^{-1} (@ 0.5 A g^{-1}) with good cycling stability compared to H-CNF. These results suggested that the NG@FeO@G/H-CNF could be a potential electrode material to enhance the properties of the supercapacitors.

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Optical properties of Eu^{3+}-doped 13X luminescent zeolite for environment and sensing

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Zeolites are minerals with a network structure consisting of aluminum-silicon oxides. They have a large surface area, making them excellent materials for absorbing gases and liquids, as well as pharmaceuticals, pesticides, and industrial pollutants. Moreover, the porous crystalline nature of zeolites allows a homogeneous dispersion of luminescent species, which could add sensing functionality to the material. In this context, Eu3+ ions present clear and identifiable photoluminescence narrow lines and long lifetimes [1] and can be easily introduced in the network by ion-exchange in solution. Our main objective is to prepare a highly porous and optically effective material. Experiments were conducted with zeolite 13X doped with varying concentrations of Europium and annealed at 400°C to maximize the luminescent emission while preserving the porosity of the material.

The luminescent properties of these materials can be used to create more efficient and durable light sources in LED displays and other lighting devices [2]. Optimization of the synthesis process supported by a detailed optical characterization will be presented.

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Anelasticity of Nanocomposites of Multiwalled Carbon Nanotubes and Polymers, SiO_2

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Improving Nanoparticle Stability and Performance with Multidentate Surfactants

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Nanoparticles need to exhibit specific features customized for their intended application, maintaining consistent characteristics across different batches under study. Ensuring monodispersity and colloidal stability is essential, particularly for metal or metal oxide nanoparticles, necessitating the use of surface stabilizers to prevent aggregation. This study tackles the issue of functionalizing surfactant-coated inorganic nanoparticles for biomedical applications, which is often hindered by the presence of excess unbound surfactant. Limitations in bioconjugation stem from the equilibrium between free molecules and those bound to nanoparticle surfaces, which can impact both in vitro and in vivo biocompatibility.

Testing conventional surfactants such as monothiolated polyethylene glycol and amphiphilic polymers, like dodecylamine-grafted-poly(isobutylene-alt-maleic-anhydride), revealed insufficient affinity. This led to the loss of colloidal stability as excess surfactant was removed. Conversely, newly introduced multidentate surfactants demonstrated high avidity, excelling in maintaining stability and suggesting enhancements in various nanoparticle applications. The introduction of these polymers addresses biocompatibility issues within the human system, where excessive stabilizing ligands post-inorganic nanoparticle synthesis exceed tolerable levels. Consequently, the removal of excess surfactant becomes necessary, otherwise destabilizing the samples.

By adjusting the polymer backbone, nanoparticles can be tailored for specific applications. Precisely, the introduction of 4-aminothiophenol as a dangling group enables the creation of highly stable SERS colloidal probes in the diagnostic field.

Thermochromic $V_{1-x}Re_xO_2$ thin films for smart windows

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Vanadium dioxide (VO_2) is a thermochromic material prospective for smart windows, which undergoes a reversible semiconductor-metal phase transition at a critical temperature of 68 ℃. However, the VO_2 transition temperature should be decreased to a value close to room temperature. To solve the problems of decreasing transition temperature, VO_2 doping with different elements can be used. However, vanadium substitution dopants in VO_2 differently affects the temperatures of structural transitions and optical properties depending on the valence of the doping element. The doping of VO_2 with Re is of particular interest because Re can adopt valence states between +4 and +7 in the octahedral oxygen surrounding. However, so far only a few works are known devoted to the synthesis of $V_{1-x}Re_xO_2$ crystals, and to the best of our knowledge no works on $V_{1-x}Re_xO_2$ thermochromic films.

The $V_{1-x}Re_xO_2$ (x=0-0.5 or 0-50%) films were fabricated by co-sputtering of metallic V and Re thin layer (100 nm) on quartz substrates by DC magnetron, and following 10 min annealing 400º C in ambient atmosphere. The $V_{1-x}Re_xO_2$ films were characterized by XRD, XPS, while phase switching studied by temperature dependent ellipsometry measurements and optical transmittance spectroscopy. These measurements reveal significant phase switching temperature decrease for Re amount 2-5%, while at higher Re content phase transition was not observed in temperature range 0-100 º C. **Acknowledgments:** This work is carried out within the framework of Horizon Europe project “Smart Windows for Zero Energy Buildings” (SWEB).

Photocurrent studies of epitaxial $MoSe_2$ multilayers

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The molybdenum diselenide ($MoSe_2$) layers grown by molecular beam epitaxy (MBE) achieved recently optical quality comparable to the best exfoliated monolayers. However despite of very sharp excitonic transitions both in photoluminescence and in absorption, they exhibit surprisingly short photoluminescence times.

The purpose of this study was to investigate the carrier dynamics by means of photocurrent in $MoSe_2$ multilayer grown on isolating sapphire substrate. The photocurrent was measured as a function of the energy of monochromatic illuminating beam modulated at different frequencies. The ultrafast time dynamics is revealed by measurement of two-pulse illumination performed with femtosecond laser ant two beams of tuneable relative delay. Surprisingly, we find that the strongest and dominant photocurrent signal is due to heating of the sample, which results in tiny reduction of the sample resistivity. Nevertheless even such thermal signal reproduces well absorbance of the semiconductor layer with such characteristic features as band edge and absorption enhancement related to exciton complexes. The detailed analysis of the temporal profiles reflects detailed heat transport in the structure.

Hexagonal Moiré patterns in nylon mesh nanoporous structures: computational and experimental study

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Moiré patterns, resulting from the superposition of two or more periodic structures, have garnered attention for their potential applications in various fields. Recently, hexagonal Moiré patterns were associated with graphene applications since it was shown that slight changes in the rotation angle between two grapheme lattices can have dramatic changes in total conductivity. In this study, we explore the utilization of Moiré patterns in nanoporous structures of hexagonal nylon mesh used for fog water harvesting, following analytical and computational approaches and compare their output with experimental results. Computational modelling techniques are applied to simulate the behaviour of the hexagonal Moiré membranes under varying angles of rotation and positioning, while an appropriate formula is derived analytically to describe the influence of the number of meshes. The two approaches are compared on the basis of Shadow Coefficient (SC) which is a parameter quantifying the coverage of the studied material and directly related to membrane performance in water collection efficiency. Furthermore, our analysis reveals the intricate relationship between pore size distribution and angle rotations, as well as the positioning of the meshes. The findings are compared against analogous analysis of images of the experimental set-up. Our results not only provide insights into the fundamental mechanisms governing hexagonal moiré pattern formation, but also offer the possibility of practical guidance for optimizing fog water collection systems through tailored mesh design and arrangement.

Phase change behavior of Poly(vinylidene fluoride) and PVDF with ZnO nanoparticle composite thin films monitoring by Micro-Raman spectroscopy

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Poly(vinylidene flouride),PVDF polymer, exhibits four polymorph crystalline phases (no-polar α, polar β, γ and δ), that are defined by the conformation of the polymer chains and crystalline structure. β- and γ-PDVF thin films due to their physical properties such as piezoelectricity, ferroelectricity and pyroelectricity have attracted attention for their potential applications in flexible electronics,in sensors, actuators, energy harvesting, MEMS. We report the results regarding the polymorphism and the evolution of the temperature-dependent phase transitions of PVDF and the PVDF–ZnO composite investigated using an experimental set–up consisting of a high resolution micro-Raman spectrometer (HR 800, λ=633 nm) and a thermo-electric cell (DSC600) with optical access to the sample. DSC600 cells ensure a cooling/heating temperature variation speed of maximum 30 °C/min and a stability of 0.1 °C, with the possibility of establishing the desired profile of temperature-duration depending on the nature of the sample to be analyzed. Samples were prepared using commercial PVDF powder (SIGMA-ALDRICH) dissolved in a mixture of 50%, N-dimethylformamide (DMF 99.5%) and 50% acetone to a PVDF solution with a concentration of 5 wt.% by stirring for 30 minutes and place under vacuum for 30 minutes for degassing. Two types of thin layers (~ 200 µm thickness) were prepared by casting: thin layer of PVDF and PVDF-ZnO composite layer containing ZnO nanoparticles with a diameter of 50 nm in a concentration of 1 wt.%. The analysis of the Raman spectra collected at various temperatures highlighted the phase transitions for the two types of samples and that the addition of ZnO nanoparticles in PVDF led to the strengthening of the beta-PVDF crystalline phase , which ensures the piezoelectric properties of the polymer.

Synthesis and characterization of Carbon Dots (CDs)-$CuFe_2O_4$ nanohybrid material as an adsorbent for the removal of Congo Red azo dye from water

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Nowadays, water quality encounters severe challenges due to the highly increasing population, industrialization and agricultural activities. Unfortunately, it is estimated that 80 % of the global industrial and municipal water is released into the environment without undergoing any treatment. Over the years, the scientific community has dedicated efforts to the successful removal of water pollutants through various methods. Among them, adsorption is the most popular due to its simplicity, high efficiency, low-cost, minimum energy requirement and absence of secondary waste production during the process. Herein, a carbon dots (CDs)-based hybrid material was developed as an adsorbent for the removal of Congo Red (CR) azo dye from water. CDs consist of either an amorphous or a crystalline carbon core surrounded by various surface functionalities (e.g. –OH, –COOH, –C=O, –C–O–C, etc.). They have been employed as adsorbents due to the surface functional groups abundance, and the ease of surface functionalization, which could be tailored to enhance selectivity towards specific pollutants. However, due to their high hydrophilicity, they cannot be easily separated from the solution after their utilization. Therefore, their combination with magnetic nanoparticles has been considered as an ideal option, as they could be easily retrieved by applying an external magnetic field. In this work, a CDs-$CuFe_2O_4$ nanohybrid material was successfully prepared through a solvothermal process and utilized as an adsorbent for the removal of CR dye from aqueous environment. The as-prepared material was characterized by various techniques, including XRD, micro-Raman, FT-IR, HR-TEM/EDS, N_2 porosimetry, and SQUID. Finally, its capability in the removal efficiency of CR dye was investigated at different initial CR concentrations, contact times and pH values via UV-Vis spectroscopy.

Shining a Light on Innovation: Harnessing Core-Shell Nanostructures for Enhanced Photocatalytic Applications

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This study presents the synthesis and characterization of a novel core-shell, organic/inorganic, photocatalytic nanostructure comprising a titanium dioxide (TiO_2) core with attached silver (Ag) nanospheres. The fabrication process involved synthesizing TiO_2 cores followed by a controlled deposition of Ag nanospheres through chemical modification of the cores with hyperbranched poly(ethylene)imine (HBPEI). HBPEI facilitated the synthesis, size regulation, and deposition of silver nanostructures onto the TiO2 substrate. The role of HBPEI in the stability and catalytic properties of the nanostructures was further examined by adding a final step to the procedure: the calcination of the samples. Structural analysis using transmission electron microscopy (TEM) revealed a well-defined core-shell architecture with a uniform distribution of Ag nanospheres on the TiO2 substrate. X-ray diffraction (XRD) analysis confirmed the crystalline nature of both TiO_2 and Ag phases within the nanostructure. The photocatalytic activity of the synthesized nanostructure was evaluated by studying the degradation of model organic pollutants, specifically 4-nitrophenol, methylene blue, as Gaseous (NOx) photocatalytic tests under simulated and direct solar irradiation. Remarkably, the core-shell nanostructure exhibited superior photocatalytic performance compared to pristine TiO_2, attributed to synergistic effects between the substrate (TiO_2) and the shell (Ag nanospheres).
This study not only provides insights into the synthesis and characterization of core-shell photocatalytic nanostructures but also underscores the potential of these materials for environmental remediation.

Effect of Silicon Precursor on Physicochemical Properties of Doped Mesoporous Silica-Based Nanoparticles MCM-41 Type

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The impact of silicon precursor on the physicochemical properties of mesoporous silica nanoparticles (MSNs) is crucial for optimizing their performance in biomedical applications. MSNs MCM-41 type are particularly valued for their large specific surface area and uniform pore structure. This study examines how different silicon precursors affect the properties of calcium (Ca) and cerium (Ce) doped MSNs, with a focus on enhancing their antibacterial and regenerative capabilities. Ca and Ce co-doped MSNs were synthesized using the sol-gel method with various silicon precursor amounts to evaluate the influence of the silicon precursor content on physicochemical properties. The modified synthesis aimed to result in well-defined spherical nanoparticles with an ordered mesoporous structure. Different silicon precursors significantly impacted the zeta potential, particle size, dispersion, porosity, and overall structure of the resulting nanoparticles. Optimal co-doped MSNs were amorphous and presented mesoporous structure, small particle size, negative surface charge, and the ability to form a crystalline apatite layer in Simulated Body Fluid, beneficial for bone tissue engineering. These findings highlight the importance of silicon precursor amount on the properties of doped MSNs. This study enhances targeted drug delivery systems using MCM-41 type mesoporous silica nanoparticles, paving the way for new treatments in bone regeneration.
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Innovative fabrication of metal oxide nanoparticles by Laser Ablation in solvents

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The fabrication of metal oxide (MO) nanoparticles (NPs) is highly desirable due to their unique optical, electrical and chemical properties and their wide range of applications, e.g. in solar cells, drug delivery, catalysis, sensors and optoelectronic devices. Zinc oxide (ZnO) NPs are used extensively in photocatalysis and as UV-blocking agents, while aluminum-doped zinc oxide (AZO) and indium-doped zinc oxide (IZO) are known for their applications in transparent conductive films and solar cells. Indium tin oxide (ITO) NPs are widely used in touch screens, flat panel displays and photovoltaic cells. The study aims at the production of ZnO, AZO, IZO and ITO NPs by laser ablation in liquids (LAL). LAL offers the great advantage of preserving the stoichiometry and structure of the target material, which is crucial for maintaining the intrinsic properties of the NPs. This method allows precise control of particle size and distribution, making it an excellent choice for the fabrication of NPs.
In this work, we present the methodology for the development of the MO NPs using nanosecond Nd:YAG pulsed laser to ablate MO bulk targets immersed in different solvents, including water, acetone, ethanol and isopropanol. The use of the different solvents aims to study their effects on the properties and stability of the synthesized NPs. By LAL process, we aim to develop high purity NPs with controlled properties The properties of the colloidal MO NPs , will be studied with various characterization techniques, such as Optical Transmission Spectroscopy, Atomic Force Microscopy, Dynamic light scattering to measure particle size distribution, and Raman spectroscopy to study molecular vibrations and structural information.

Development of Hall measurements in nanomaterials

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Nanomaterials are increasingly becoming a material of interest for electronic and electrical applications at the nanoscale. However, mobility, doping levels and carrier density measurements in nanomaterials do not necessarily obey the fundamental rules described in classical Hall measurements. Particularly in the case of nanowires such as Carbon nanotubes (CNTs), the ability to study doping effects is important and cannot be completed with the study of gated conductance as frequently done in the literature. We show a setup developed to automatically measure Hall mobility and we explore the correlation between conductance and the extracted values in CNT carpets deposited by different techniques.

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Poly(maleic anhydride-*alt*-styrene) film modified with amino acid and divinylsulfone: Immobilized covalently multipoint laccase enzyme

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Enzyme immobilization has become a target of interest, particularly in the development of bioprocesses, due to the advantages of immobilized enzyme respect soluble enzyme in industrial processes. An immobilized enzyme has the advantage of being reusable, a process of interest in biotechnological development.[1] The aim of this study is to covalently immobilize multipoint laccase enzyme on a poly(maleic anhydride-*alt*-styrene) film modified with L-glutamine and L-lysine and divinyl sulphone (DVS).The polymer films were obtained by spin coating on Si-wafer. The modified surface was characterized by AFM spectroscopy, zeta potential and contact angle measurements. The surface thickness was measured by Ex-Situ ellipsometry. After characterization of the polymeric films, the laccase enzyme is immobilized, for which a laccase enzyme solution was prepared. Subsequently, a drop of the solution is placed in contact with the polymeric film and left in agitation for one hour. Preliminary studies showed that the enzymatic activity of the laccase enzyme is dependent on the surface morphology, which is determined by the presence of spacer groups, DVS, and the type of amino acid present in the polymer side chain.

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Reference.

1.Green immobilization: Enhancing enzyme stability and reusability on eco-friendly support. Vesen Atiroğlu a b, Atheer Atiroğlu a b, Ahmed Atiroğlu c, Ali Sultan Al-Hajri d, Mahmut Özacar b eFood Chemistry. Volume 448, 1 August 2024, 138978

Enhancement of Antifouling Properties in Polymeric Films via Hyperbranched Polymer Functionalization

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The development of antifouling polymeric coatings has seen significant progress, but ensuring their long-term stability and durability remains a challenge.[1] This study aims to enhance the antifouling capacity and durability of polymeric nanofilms by functionalizing hyperbranched polyglycerol (HPG) with the copolymer poly(ethylene glycol)-poly(caprolactone) (mPEG-PCL). HPG's highly branched structure forms intramolecular cavities that enhance antifouling properties. Additionally, HPG boasts biocompatibility, thermal and oxidative stability, and an abundance of reactive sites that allow integrated mPEG-PCL through esterification reactions, resulting in homogeneous and stable surfaces that maintain antifouling properties over extended periods, thanks to the union with the PCL. On the other hand, polyethylene glycol (PEG) is widely known for its biocompatibility and its ability to form hydration layers that repel proteins and cells, thereby reducing contaminant adhesion. This approach enables the tuning of surface hydrophilicity and the assessment of how chemical modifications impact the stability and surface characteristics of the coating, including wettability, thickness, charge density, roughness, and morphology. The modification with mPEG-PCL is expected to significantly increase the surface hydrophilicity and enhance the antifouling capacity. This study could represent a significant step forward in creating more efficient and durable coatings for applications in water purification, biomedical devices, and industrial settings, addressing the challenges of stability and durability in antifouling polymeric coatings with an effective long-term solution.

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Fabrication and characterization of FeCo/Cu multilayered nanowires

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The synthesis of the FeCo/Cu nanowires through electrodeposition is of significant interest due to their potential applications in magnetic storage, sensing devices and spintronics. This study reports the fabrication of FeCo/Cu nanowires by electrochemical deposition using nanochanneled template method. The nanowires were deposited into the pores of anodic aluminium oxide (AAO) membranes, which were fabricated by hard anodization process using a 0.3 M oxalic acid and ethanol aqueous solution. Electrodeposition is a versatile and cost-effective technique that involves the reduction of metal ions from an electrolyte solution onto a conductive substrate under an applied electric current. In this case, the electrochemical deposition was carried out in a single-electrolyte bath using a three-electrode setup, in chronoamperometric mode, with a pulsed applied voltage, one corresponding to deposition of FeCo segments and another one of Cu segments. The resulting nanowires exhibit a multilayered structure with distinct FeCo and Cu segments. Structural characterization using scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX) and transmission electron microscopy (TEM) confirmed the morphology and composition of the synthesized nanostructures. The well-defined structure of the nanowires makes them suitable candidates for further functionalization and integration into nanoscale devices. The magnetic properties were also evaluated, showing promising results for high-density data storage and magnetic sensing applications. Furthermore, the ability to modify the properties of the FeCo/Cu nanowires by adjusting the electrochemical deposition parameters opens up new ways for their integration in various advanced technologies.

WS3 Posters

	WS3 POSTER SESSION **Tuesday 2 July to Friday 5 July: Poster Display** **Thursday 4 (17:30-20:00): Poster Presentation**
P3-1 **YRA CANDIDATE**	**Green synthesis of magnetic bio-MOFs for combined cancer therapy via magnetic hyperthermia and drug delivery** J. Barman[1], T. Pellegrino[2] *[1,2]Italian Inst.e of Technology, Via Morego, 30, Genoa, 16163, Italy* *[1]Un. of Genoa, Via Balbi, 5, Genoa, 16126, Italy*
P3-2	**The potential of Mg alloys with Nano/sub-micron structure to serve as bioabsorbable implants** **E. Aghion and A. Arnon** *Dept. of Materials Engineering, Ben-Gurion Un. of the Negev, Beer-Sheva, Israel*
P3-3	**Preparation and investigation of 52Mn labelled beta cyclodextrin derivative using positron emission tomography** I. Hajdu[1], I. Kalman-Szabo[1,2], L. A. Komor[1], I. Kertesz[1], Z. Kepes[1], G. Trencsenyi[1], *[1]Division of Nuclear Medicine and Translational Imaging, Medical Imaging Dept., Un. of Debrecen, Debrecen, Hungary* *[2]Gyula Petranyi Doctoral School of Allergy and Clinical Immunology, Un. of Debrecen, Debrecen, Hungary*
P3-4	**Multi-Drug Delivery System Based on Porous Fibers Grafted with Metal Organic Frameworks** J. Kim *Advanced Textile R&D Dept., Korea Inst.e of Industrial Technology (KITECH), Ansan-si 15588*
P3-5	**Rational control of magnetic and relaxation properties of magneto-plasmonic nanoparticles** Nistor M.*[1,2], Balan V.[1,3], Pui A.[2], Uritu C. M.[4], Stiufiuc R.-I.[1,5], Dragoi B. [1,2] *[1]Nanotechnology Laboratory, TRANSCEND Research Center, Regional Inst.e of Oncology, 2-4 General Henri Mathias Berthelot Street, 700483 Iași, Romania* *[2]Faculty of Chemistry, Alexandru Ioan Cuza Un. of Iași, 11 Carol I Boulevard, 700506 Iași, Romania* *[3] Biomedical Sci. Dept., Faculty of Medical Bioengineering, Grigore T. Popa Un. of Medicine and Pharmacy of Iasi, 9-13 Kogalniceanu Street, 700454 Iasi, Romania* *[4]Advanced Centre for Research-Development in Experimental Medicine, Grigore T. Popa Un. of Medicine and Pharmacy, 9-13 Mihail Kogalniceanu, 700259 Iasi, Romania* *[5]Dept. of Nanobiophysics, MedFuture Research Center for Advanced Medicine, "Iuliu Hatieganu" Un. of Medicine and Pharmacy, 4-6 Pasteur Street, 400337 Cluj-Napoca, Romania*
P3-6	**Development of Magnetic Layered Double Hydroxides - Iron Oxide hybrid materials with high potential for theranostic applications** Ibanescu A[1], Nistor M.[1,2], Balan V.[1,3], Grigoras M.[4], Stiufiuc R.-I.[1,5], Dragoi B.[1,2] *[1]Nanotechnology Laboratory, TRANSCEND Research Center, Regional Inst.e of Oncology, 2-4 General Henri Mathias Berthelot Street, 700483 Iași, Romania* *[2]Faculty of Chemistry, Alexandru Ioan Cuza Un. of Iași, 11 Carol I Boulevard, 700506 Iași, Romania* *[3]Dept. of Biomedical Sci., Faculty of Medical Bioengineering, "Grigore T. Popa" Un. of Medicine and Pharmacy, 9-13 Kogalniceanu Street, 700454 Iasi, Romania* *[4]Nat. Inst.e of Research and Development for Technical Physics, 700050, Iasi, Romania* *[5]Dept. of NanoBioPhysics, MedFuture Research Center for Advanced Medicine, Iuliu Hatieganu Un. of Medicine and Pharmacy, 4-6 Pasteur Street, 400337 Cluj-Napoca, Romania*
P3-7	**Temperature dependent morphologic and surface charge properties of Au plasmonic NPs and impact on RAMAN signal enhancement** Mairean C.-P.*[1,2], Olariu D.-I.[1,2], Dragoi B.[1,2], Stiufiuc, R.-I.[1,2,3] *[1]Nanotechnology Laboratory, TRANSCEND Research Center, Regional Inst.e of Oncology, 2-4 General Henri Mathias Berthelot Street, 700483 Iasi, Romania* *[2]Faculty of Chemistry, Alexandru Ioan Cuza Un. of Iasi, 11 Carol I Boulevard, 700506 Iasi, Romania* *[3]Dept. of NanoBioPhysics, MedFuture Research Center for Advanced Medicine, "Iuliu Hatieganu" Un. of Medicine and Pharmacy, 4-6 Pasteur Street, 400337 Cluj-Napoca, Romania*
P3-8	**Dynamic hydrogels based on selectively functionalized polysaccharides for anticancer controlled drug delivery** Duceac I.A.*[1,2], Stiufiuc R.I.[2,3], Dragoi B.[2,4], Coseri S.[1] *[1]Polyaddition and Photochemistry Dept., "Petru Poni" Inst.e of Macromolecular Chemistry, 700487 Iasi, Romania*

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P3-9	**Comparative Study of Silver and Copper Nanoparticles Synthesized from Cistus Ladanifer Extract: Physicochemical Study and Biological Activities** Chaikali C.[*1], Stola N.[1], Strataki A.[1], Lampropoulou P.[2], Papoulis D.[2], Lamari F.[1], Avgoustakis K.[1] and Hatziantoniou S.[1] *[1]Dept. of Pharmacy, Un. of Patras, Patras GR-26504, Greece* *[2]Dept. of Geology, Un. of Patras, Patras GR-26504, Greece*
P3-10	**Unveiling the Potential of Photothermal Therapy: NIR-797-Loaded PLGA Nanoparticles for Enhanced Cancer Treatment** Borlan R.*[1], Tudor M.[1], Soritau O.[2], Florea A.[3], Astilean S.[1,4], Focsan M.[1,4] *[1] Nanobiophotonics and Laser Microspectroscopy Centre, Interdisciplinary Research Inst.e on Bio-Nano-Sci., Babes-Bolyai Un., 42 Treboniu Laurian Street, Cluj-Napoca, Romania* *[2] Dept. of Radiobiology and Tumor Biology, Oncology Inst.e Prof. Dr. Ion Chiricuta, 34-36 Republicii Street, Cluj-Napoca, Romania* *[3] Dept. of Cell and Molecular Biology, Faculty of Medicine, Iuliu Hatieganu Un. of Medicine and Pharmacy, 8 Victor Babes Street, Cluj-Napoca, Romania* *[4] Biomolecular Physics Dept., Faculty of Physics, Babes-Bolyai Un., 1 Mihail Kogalniceanu Street, Cluj-Napoca, Romania*
P3-11	**Tailored Therapeutics: BSA-Coated SPIONs Grafted with Curcumin for Advanced Cancer Therapy** Lapusan R.*[1,2], Borlan R.[1], Balmus A.[2], Muntean M.[3], Focsan M.[1,2] *[1] Nanobiophotonics and Laser Microspectroscopy Centre, Interdisciplinary Research Inst.e on Bio-Nano-Sci., Babes-Bolyai Un., 42 Treboniu Laurian Street, Cluj-Napoca, Romania* *[2] Biomolecular Physics Dept., Faculty of Physics, Babes-Bolyai Un., 1 Mihail Kogalniceanu Street, Cluj-Napoca, Romania* *[3] Dept. of Cell and Molecular Biology, Faculty of Medicine, Iuliu Hatieganu Un. of Medicine and Pharmacy, 8 Victor Babes Street, Cluj-Napoca, Romania*
P3-12	**Laser induced photothermal effect of anisotropic nanoparticles for oncologic therapy: Preliminary results** Novati B.*[1], Giustra M.[1], De Vita E.[2], Salvioni L.[1], Bianconi F.[3], Lo Presti D.[3,4], Gizzi A.[3], Iadicicco A.[2], Massaroni C.[3,4], Schena E.[3,4], Campopiano S.[2], Prosperi D.[1] *[1]Dept. of Biotechnology and Bioscience, Un. of Milano Bicocca, Milan, Italy* *[2]Dept. of Engineering, Un. of Naples "Parthenope", Naples, Italy* *[3]Research Unit of Measurements and Biomedical Instrumentation, Dept. of Engineering, Università Campus Bio-Medico di Roma, Roma, Italy* *[4]Fondazione Policlinico Universitario Campus Bio-Medico, Roma, Italy*
P3-13	**Advanced Freeze-Dried Hydrogel Films for Combatting Bacterial Infections in Chronic Wounds** E. Cerna, J. Brtnikova[1], B. Lipovy[2], Z. Fohlerova[1,3], L. Vacek[4], L. Vojtova[1] *Advanced Biomaterials, Central European Inst.e of Technology, Brno Un. of Technology, Purkynova 656/123, Brno, Czech Republic[1], Dept. of Burns and Plastic Surgery, Un. Hospital Brno and Faculty of Medicine, Masaryk Un., Jihlavska 20, Brno, Czech Republic[2], Faculty of Electrician Engineering and Communications, Brno Un. of Technology, Technicka 10, Brno, Czech Republic[3], Dept. of Microbiology, St. Anne's Hospital Brno and Faculty of Medicine, Masaryk Un., Pekarska 53, Brno, Czech Republic[4]*
P3-14	**Synthetic Hydrogels as Cartilage Models for Biomimetic Tribological Testing** I. Chamradova[1], K. Lysakova[1], D. Rebenda[2,3], P. Cipek[2], M. Vrbka[2], L. Vojtova[1] *Advanced Biomaterials, Central European Inst.e of Technology, Brno Un. of Technology, Purkynova 656/123, Brno, Czech Republic[1], Faculty of Mechanical Engineering, Brno Un. of Technology, Technicka 2896/2, Brno, Czech Republic[2], Footware Research Centre Un. Inst.e, Tomas Bata Un. in Zlin, Nad Ovcirnou IV 3685, Zlin, Czech Republic[3]*
P3-15	**A Comparative Study on Physicochemical Properties and In Vitro Biocompatibility of Sr-Substituted and Sr Ranelate-Loaded Hydroxyapatite Nanoparticles** L.Stipniece[1,2], A. Ramata-Stunda[3], J. Vecstaudza[1,2], I. Kreicberga[1,2], D. Livkisa[3], A. Rubina[1,2], A. Sceglovs[1,2], K. Salma-Ancane[1,2] *[1] Rudolfs Cimdins Riga Biomaterials Innovations and Development Centre of RTU, Inst.e of General Chemical Engineering, Faculty of Materials Science and App. Chemistry, Riga Technical Un., Latvia* *[2] Baltic Biomaterials Centre of Excellence, Headquarters at Riga Technical Un., Riga, Latvia* *[3]Dept. of Microbiology and Biotechnology, Faculty of Biology, Un. of Latvia, Jelgavas St. 1, Riga, LV-1004, Latvia*
P3-16	**Smart Albumin-Based Nanoparticle Delivery System for the Treatment of Infected Burn Wounds**

	V. Polakova[1], Z. Fohlerova[1], Jan Pribyl[2], Radka Oborilova[2], Simon Klimovic[2], L. Vojtova[1] *[1]CEITEC BUT, Central European Inst.e of Technology, Advanced biomaterials, Brno Un. of Technology* *[2]CEITEC MUNI, Central European Inst.e of Technology, Nanobiotechnology Core Facility, Masaryk Un., Purkynova 123, 621 00 Brno, Czech Republic*
P3-17	**Antibiotic and silver loaded hydroxyapatite for bone tissue healing** S.I. Buştiucel, G. Ciobanu *Faculty of Chemical Engineering and Environmental Protection "Cristofor Simionescu", „Gheorghe Asachi" Technical Un. of Iaşi, 73 Prof. Dimitrie Mangeron Bvd., Iaşi, 700050, Romania*
P3-18	**Detecting potential single photon emitters in C-doped GaN** J. Misiak[1], K. Kliczewska[1], P. Kulboka[1], N. Dalla[1], M. Kobecki[1], P. Kossacki[1], P. Prystawko[2], H. Turski[2], and T. Jakubczyk[1] *[1]Faculty of Physics, Un. of Warsaw, Warsaw, Poland* *[2]Inst.e of High Pressure Physics "Unipress", Polish Academy of Sci., 01-142, Warsaw*
P3-19	**Zinc / Manganese Doped Iron Oxide Nanoparticles to Control Radical Generation and Magnetic Hyperthermia** Morales O. M.*[1,2,3,4], Lima Jr. E.[2], Vasquez, M.[2] and Goya R. G.[3,4] *[1]Balseiro Inst.e, Bariloche Atomic Centre, Bustillo Av. 9500, 8400 S. C. de Bariloche, Argentina* *[2]Nanoscience and Nanotechnology Inst.e, CNEA, CONICET, CAB, Bustillo Av. 9500, 8400 Bariloche, Argentina* *[3]Un. of Zaragoza, Condensed Matter Dept., C/ Pedro Cerbuna 12, 50009 Zaragoza, Spain* *[4]Aragon Nanoscience and Materials Inst.e, CSIC-UNIZAR, C/Mariana Esquillos S/N, 50018 Zaragoza, Spain*
P3-20 YRA CANDIDATE	**Development and Preclinical Validation of Curcumin Nanoparticles and biofunctionalized Curcumin Nanoparticles for targeted delivery of antithrombotic and antiinflammation factors towards the Atherosclerosis treatment** K. Meliopoulou[1], K. Tsimenidis[2], A. Orfanos[2], A. Laskarakis[1], S. Logothetidis[1,2], V. Karagkiozaki[2] *[1] Nanotechnology Lab LTFN, Physics Department, Aristotle University of Thessaloniki, Greece* *[2] BL Nanobiomed P.C., 20th Km Thessaloniki – Tagarades Road, Thessaloniki, Greece*
P3-21	**Co-Creation Aid Kit 4.0 (CoCreAid) Cooperation partnerships in higher education** A. Sendemir[1,5], E. Tunali Caliskan[2], Ö. Andic Cakir[3,5], F. Sarsar[4], T. Dogan[5] *[1]Department of Bioengineering, Faculty of Engineering, Ege University, Izmir, Türkiye* *[2]Department of Economics, Faculty of Economics and Administrative Sciences, Ege University, Izmir, Türkiye* *[3]Department of Civil Engineering, Faculty of Engineering, Ege University, Izmir, Türkiye* *[4]Department of Computer and Instructional Technologies Education, Faculty of Education, Ege University, Izmir, Türkiye* *[5]Department of Materials Science and Engineering, Graduate School of Natural and Applied Sciences, Ege University, Izmir, Türkiye*

Green synthesis of magnetic bio-MOFs for combined cancer therapy via magnetic hyperthermia and drug delivery

J. Barman[1], T. Pellegrino[2]
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Magnetic nanoparticles such as iron-oxide nanoparticles (IONPs) with metal-organic frameworks (MOFs) can be excellent candidates for a combined nano-therapeutic system for killing cancer cells via magnetic hyperthermia and drug treatment. However, traditional methods for synthesizing iron-oxide nanoparticles generally utilize chemical reagents that produce bi-products, which can lead to several toxicological concerns such as accumulation in the tissues, inflammatory responses, etc. In case of MOFs, organic linkers are one of the main concerns, which generally consist of sulfonates, phosphonates, imidazolates, carboxylates, amines, and phenolates. Therefore, the idea of the study is to move towards a greener way to synthesize iron-oxide nanoparticles by microwave (MW)-assisted method by using green solvents and precursors and the use of biological MOFs, typically known as bio-MOFs. Bio-MOFs have gained significant attention in recent years due to their biocompatibility, enhanced stability, sustainability, structural functionality as they are prepared by biologically derived endogenous organic ligands such as amino acids, proteins, nucleobases, saccharides, and porphyrins. MW-assisted synthesis of IONPs offers cost-effectiveness, fast synthesis, reduced energy consumption, large-scale production, good magnetic properties, with various opportunities for controlling size, shape, and surface properties. These magnetic nanoparticles could be directly coordinated with the biological molecules as an organic linker to form a core-shell nanostructure. These core-shell nanostructures can be further utilized to carry anti-cancerous drugs such as doxorubicin which can be released only upon magnetic induction. The heat generated through this process can release the loaded drug and, in turn, kill the cancer cells in synergy with the toxic effects of direct heat damage induced by magnetic hyperthermia.

The potential of Mg alloys with Nano/sub-micron structure to serve as bioabsorbable implants

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The inherent advantage of Mg alloys as bioabsorbable implant materials for orthopaedics and cardiovascular applications, mainly related to their excellent biocompatibility and their natural capability to dissolved in physiological environment. However, their dissolution is accompanied with the evolution of hydrogen gas that can promote the danger of gas embolism. Hance the size of the implant should be minimized to limit the production of hydrogen gas. To address this requirement the mechanical properties of the Mg implants in terms of strength and ductility should be significantly increased.

The aim of this study was to evaluate the prospects of Mg alloys with Nano/sub-micron structure that may poses superior mechanical properties for innovated biodegradable implants. This was demonstrated on a Mg-3%Al-1%Zn alloy using optical and high-resolution electronic microscopy (HRSEM and TEM), tension test, corrosion resistance measurements and electrochemical analysis by potentiodynamic polarization in simulated physiological environment in the form of PBS solution. In addition, the stress corrosion resistance was examined in terms of slow strain rate testing (SSRT). The obtained results clearly exhibit the superior strength of the tested alloy compared to its conventional counterpart wrought alloy.

Preparation and investigation of 52Mn labelled beta cyclodextrin derivative using positron emission tomography

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The number of malignant diseases is increasing worldwide, therefor there is increasing interest in the development of sensitive imaging procedures that are excellent for the detection of functional neoplastic changes. Cyclodextrins are truncated conical or toroidal polymers composed of cyclic oligosaccharides. Our previously published results prove that certain cyclodextrin derivatives, such as random-methylated-beta-cyclodextrin (RAMEB), show a high affinity towards complex formation with prostaglandin E2 (PGE2) expressed by tumours. The aim of our studies is to synthesize a Manganese-52-labeled DOTAGA-randomly methylated beta-cyclodextrin (^{52}Mn-DOTAGA-RAMEB) and investigate its tumour-targeting properties. ^{52}Mn is a radionuclide with a long half-life, which is suitable for monitoring the radiopharmaceutical accumulated in the tumour for several hours. ^{52}Mn radioisotope was produced in a GE PETtrace cyclotron with 16 MeV beam on Chromium target. DOTAGA-RAMEB was labelled with ^{52}Mn, and the radiochemical purity (RCP%), and in vitro, in vivo stability was determined. After intravenous injection of ^{52}Mn-DOTAGA-RAMEB the tumour accumulation was monitored in vivo by PET and ex vivo by gamma counter in BxPC-3 PGE2 positive tumour-bearing mice. The radiochemical purity of the newly synthesized ^{52}Mn-DOTAGA-RAMEB was higher than 98%, the molar activity was over 15 GBq/µmol. Our results demonstrates that the accumulation of ^{52}Mn-DOTAGA-RAMEB in BxPC3 tumours and the tumour-to-muscle ratios were significantly ($p \leq 0.01$) higher than other organs and tissues, moreover the tumour accumulation was more than 10-fold higher than the background. This study was supported by János Bolyai Research Scholarship of the Hungarian Academy of Sciences (bo_328_21). and the ÚNKP-23-5 new national excellence program of ministry for culture and innovation.

Multi-Drug Delivery System Based on Porous Fibers Grafted with Metal Organic Frameworks

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Metal-organic frameworks (MOFs) have emerged as promising materials for various applications due to their exceptional tunability and high surface area. In recent years, the integration of MOFs with fibers has gained significant attention in the field of drug delivery systems. The combination of MOFs and fibers offers a unique platform for controlled release, targeted therapy, and enhanced drug stability, ultimately revolutionizing the field of therapeutics. Moreover, researchers have explored the application of dual drug delivery using porous fibers with MOFs in various therapeutic areas, including cancer therapy, antimicrobial treatments, and regenerative medicine. These studies have demonstrated the potential of these systems to overcome drug resistance, reduce side effects, and enhance treatment efficacy by delivering multiple drugs simultaneously.
In this study, we developed porous poly(caprolactone) (PCL) fibers through liquid-liquid phase separation, and then ZIF-8 was grown on the porous PLA fiber through in-situ synthesis. These carriers were investigated the relationship among pore formation, physical properties, and antibacterial activities of the fibers for identifying their potential as drug delivery carriers. Studies have focused on optimizing the synthesis techniques to achieve uniform ZIF67 coatings on the surface of porous PCL fibers.
Overall, the research on dual drug delivery using porous fibers with ZIF-8 highlights the potential of these drug carrier systems in achieving controlled release, synergistic effects, and improved antibacterial outcomes. Further advancements in the synthesis techniques, optimization of drug ratios, and comprehensive understanding of the in vivo behavior are crucial to translate these innovative systems into clinical applications and address the challenges associated with their practical implementation.

Rational control of magnetic and relaxation properties of magneto-plasmonic nanoparticles

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Superparamagnetic behavior and relaxation properties of metallic nanoparticles (NPs) are of utmost importance for MRI application. Herein, we synthesized a superparamagnetic iron oxide NP coated with biocompatible F127 Pluronic surfactant via coprecipitation method. Doping of F127-magnetite with Co in various amounts (1, 5, and 10%) or decorating the pure magnetite with Au were strategically approached to rationally tune the magnetic and relaxation properties. Samples were prepared by coprecipitation at 65°C and pH 14. Au decorated F127@Fe_3O_4 was prepared by grafting *via* reduction of $HAuCl_4$ in citrate solution (0.36 % Au). XRD showed the formation of spinel structure for all samples while for Au@F127@Fe_3O_4 the coexistence of both metallic Au and Fe_3O_4 phases with a crystallite size of 14 nm. DLS measurements revealed a hydrodynamic size of 127 nm for F127@Fe_3O_4 and respectively 187, 206 and 525 nm for 1, 5, and 10% Co-F127@Fe_3O_4. Decoration of magnetic core with Au resulted in a population of NPs with an average hydrodynamic size of 177 nm. All samples exhibited very good magnetic properties with values of magnetization in the range of 46.5 and 58 emu/g for F127-Fe_3O_4 and Co-F127@Fe_3O_4. The presence of Au improved the magnetic properties, a value of 79 emu/g being measured for this sample. Relativity measured in agarose phantoms on a 1T apparatus revealed that all samples are mainly T2 contrast agents with transversal relativities depending on the concentration of Co. Interestingly, the presence of Au increased twice the value of r_2, indicating a direct correlation between magnetic and T2 relaxation properties.

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Development of Magnetic Layered Double Hydroxides - Iron Oxide hybrid materials with high potential for theranostic applications

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Controlling magnetic properties of metallic nanoparticles (NPs) is of high interest for many medical applications, such as drug release, hyperthermia, imaging. In this work, Layered Double Hydroxide (LDH) - iron oxide materials were investigated in view of developing hybrid NPs with both magnetic properties and ability of incorporating drugs for theranostic purposes. At this stage, Mg-Al-LDH were synthesized by coprecipitation at low saturation in the presence of various amounts of F127-Fe_3O_4 NPs (Mg^{2+}/ F127-Fe_3O_4 at 1/x, w/w, where x = 0.025, 0.05, 0.1, 0.2, 0.5) synthesized in our group. XRD showed the presence of both crystalline phases, that is, LDH and magnetic NPs with the crystallite size of magnetic NPs in the range of 4 - 10 nm. Coexistence of the two phases was confirmed by typical vibrations bands in FTIR spectra. TEM images displayed NPs with mixed morphologies between spherical and hexagonal irrespective of the amount of magnetite. Yet, improved dispersion of hybrid NPs was noticed with the increase of magnetite in the sample. Indeed, DLS revealed hydrodynamic size of the hybrid NPs ranging from 436 to 203 nm as the amount of magnetite increased in the sample. The field-dependent magnetic measurements of pure magnetite and hybrid NPs showed superparamagnetic behavior of 58.63 emu/g for F127-Fe_3O_4. The presence of the non-magnetic component (Mg-Al LDH) lowered the magnetization value in line with the amount of LDH in the samples. Therefore, values in the range of 51.77 to 3.58 emu/g were obtained for LDH-Fe_3O_4 with the mass ratio of 1/0.5 to 1/0.025. The results revealed that the synthesized hybrid NPs exhibit the appropriate magnetic properties for imaging and therapy of cancer, investigations in this sense being ongoing in our group.

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Temperature dependent morphologic and surface charge properties of Au plasmonic NPs and impact on RAMAN signal enhancement

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Despite recent advances in developing new plasmonic substrates for SERS applications, synthesizing Au-based plasmonic nanoparticles (NPs) is a continuous topic of interest. The aim is to have advanced control of their physico-chemical properties, such as composition, morphology, and size distribution, which can be tuned by a rational control at the synthesis stage. Herein, we aimed to control those properties by changing one of the critical parameters of the synthesis, that is, temperature. To reach this goal, Au NPs colloids were synthesized by a chemical method, using $HAuCl_4$ and a short-chain PEG200 solution as Au precursors and reducing agent. In the first protocol, $HAuCl_4$ and short-chain PEG200 aqueous solutions were mixed at room temperature (RT) and stirred for 24 h while for the second protocol, $HAuCl_4$ solution was added to a preheated PEG solution at 85°C and kept for 10 min. Both syntheses were performed at constant pH 10 using a 1% NaOH solution. The obtained samples were characterized by UV-Vis, DLS, Zeta potential, and TEM. SPR_{max} at 525 nm was obtained for both samples. The results revealed a slight influence of the temperature on the size, with larger NPs being obtained at 85°C. Zeta potentials of -36 and -29 mV for the samples synthesized at RT and 85°C, respectively, were measured. TEM images displayed quasi-spherical NPs for both samples. Yet, those prepared at RT are more dispersed and unpurified with a few anisotropic NPs while the sample obtained at 85°C is made of sphere-like NPs gathered in large agglomerates. Their plasmonic properties have been analysed by means of SERS experiments performed on solid plasmonic substrates synthesized using the here-proposed nanoparticles as main building blocks, using an NIR excitation laser.

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Dynamic hydrogels based on selectively functionalized polysaccharides for anticancer controlled drug delivery

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Dynamic hydrogels are polymeric networks with labile, reversible bonds. Such systems can be obtained using physical or chemical interactions, which can break and reform. This allows for macroscopic advantages, namely injectability and self-healing. This behavior is particularly suitable for local delivery of drugs or cells and the design of complex architectures using 3D printing.

In this study we opted for hydrogels based on a water-soluble chitosan derivative for creating dynamic networks with other polysaccharides bearing carboxylic or aldehyde groups. We performed selective periodate oxidation with protocols adapted for each of the selected polysaccharides (i.e., pullulan, starch, alginate and gellan) for the control of subsequent material structure and properties. Depending on the polymer choice, the networks were crosslinked through hydrogen bonds, ionic interactions and covalent, imine bonds. FTIR and NMR spectroscopy were used for an in-depth analysis of the derivatives and the resulting hydrogels. Microscopy images offered information concerning the porous structure. The swelling capacity, injectability, gelation, in vitro stability, and loading capacity of drugs and nanoparticles were assessed. The results indicated that the formulations are injectable, with gelation speed and viscosity highly dependent on the composition. A higher aldehyde content led to a higher crosslinking density, an internal morphology with smaller pores and a lower swelling capacity. The loading capacity is governed by both network parameters and polysaccharide nature. Therefore, alginate and gellan exhibited a different loading and release behavior then pullulan and starch, impacted more by the polymer relaxation and ionic interactions then solute diffusion.

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Comparative Study of Silver and Copper Nanoparticles Synthesized from Cistus Ladanifer Extract: Physicochemical Study and Biological Activities

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This study presents a comparative investigation of copper (Cu) and silver (Ag) nanoparticles (NPs) synthesized using Cistus Ladanifer L. essential oil, focusing on their synthesis, physicochemical properties, and biological activities. Green synthesis methods utilizing plant extracts offer environmentally benign routes for nanoparticle fabrication, garnering increasing interest in different areas.

The synthesis process is thoroughly examined, considering parameters such as reactant concentration and volume ratio, reaction time, temperature and pH to elucidate their influence on nanoparticle characteristics. Physicochemical characterization includes size, polydispersity index (PDI), and zeta potential measurements, providing insights into nanoparticle stability and colloidal behaviour. Confirmation of NP formation is achieved using UV/Vis spectroscopy and X-ray diffraction (XRD), while dynamic light scattering (DLS) verifies their size and zeta potential. Transmission electron microscopy (TEM) is employed to reveal the morphology and crystal form of the NPs, supported by selected area electron diffraction (SAED) patterns and XRD results. Stability studies over a period of 60 days assess the suitability of the nanoparticles for cosmetic and pharmaceutical formulations. Biological activities of Cu and Ag NPs are comprehensively evaluated, including antioxidant and antimicrobial properties. The antioxidant capacity is determined using the DPPH method.

By systemically comparing Cu and Ag nanoparticles synthesized from C. Ladanifer essential oil, this study advances our understanding of green synthesis methodologies and their implications on nanoparticle properties and functionalities of NPs synthesized using different metal precursor. The findings offer valuable insights for the development of tailored nanomaterials with diverse applications in pharmaceutics and cosmetics.

Unveiling the Potential of Photothermal Therapy: NIR-797-Loaded PLGA Nanoparticles for Enhanced Cancer Treatment

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The relentless rise in global cancer incidence necessitates novel approaches to combat this epidemic. Melanoma, a deadly skin cancer, underscores the urgency for improved therapies. Despite advancements, metastatic melanoma survival rates remain dismal, prompting the need for innovative strategies.

Introducing poly(lactide-co-glycolide acid) (PLGA) nanoparticles (NPs) loaded with NIR molecules (NIR-797) for cancer photothermal therapy (PTT), our study commences with in-solution photothermal studies, showcasing the efficient conversion of NIR-797-loaded PLGA NPs into hyperthermic agents, with a photothermal conversion efficiency of 30.5%. Subsequent validation in murine models demonstrates the efficacy of NIR-797-loaded PLGA NPs in inducing targeted tumor hyperthermia. *In vivo* thermal imaging conducted 4 hours post-administration of the NIR-797–loaded PLGA NPs reveals temperature changes during an 8-minute exposure to an 808 nm medical laser. This approach achieves mild hyperthermia with temperatures below 45°C, effectively mitigating damage to surrounding healthy tissue. Histological analysis reveals early apoptosis and increased immune cell infiltration compared to controls. Transmission electron microscopy (TEM) imaging elucidated cellular structural changes post-PTT, including mitochondrial elongation and cytoplasmic vacuolization, confirming cell death induction. Notably, imaging from irradiated zones demonstrated targeted therapeutic effects.

Our findings underscore the promise of NIR-797-loaded PLGA NPs combined with NIR irradiation as effective photothermal agents. By providing insights from both in-solution and in vivo studies, our research advances cancer treatment modalities, presenting promising avenues for clinical translation.

Tailored Therapeutics: BSA-Coated SPIONs Grafted with Curcumin for Advanced Cancer Therapy

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Cancer claims 9.6 million lives annually, underscoring the urgency for innovative therapies. Nanotechnology revolutionizes cancer treatment with precise targeting and enhanced biocompatibility, overcoming challenges of conventional methods. Superparamagnetic iron oxide nanoparticles (SPIONs) represent a cornerstone in biomedical research, owing to their facile synthesis, versatility, and superparamagnetic properties. They hold immense promise across various medical applications, including MRI contrast enhancement, photothermal therapy, and targeted delivery. Integration of these modalities transforms SPIONs into theranostic agents, capable of both diagnosis and treatment. In our study, we developed biocompatible SPIONs with enhanced multimodal therapy capabilities. Using an adapted precipitation method, we synthesized SPION with a mean diameter of 6.3 ± 1.4 nm, and a zeta potential of 31.6 ± 2.6 mV. To facilitate surface functionalization for the attachment of therapeutic agents, we coated SPIONs with a protein, i.e., BSA, using a two-step adapted protocol. The successful functionalization of the SPION with BSA was confirmed through TEM imaging, revealing a final diameter of 66.8 ± 9.2 nm, and zeta potential measurements, indicating a zeta potential of -63.7 ± 1.8 mV. Further, we grafted the BSA-coated SPIONs with curcumin, leveraging its dual functionality as both a photosensitizer and an antioxidant, enhancing the nanoparticles' therapeutic potential for targeted cancer treatment. We confirmed the grafting of curcumin onto BSA-coated SPION agents through UV-Vis and fluorescence spectroscopy analyses. Additionally, the BSA-coated SPION agents were embedded in phantoms, and dark-field and fluorescence microscopy were utilized for their examination. In vitro assays were conducted on cancer cells to assess the viability of the BSA-coated SPION agents

Laser induced photothermal effect of anisotropic nanoparticles for oncologic therapy: Preliminary results

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In recent years, metallic nanoparticles have garnered significant interest in the biomedical field, emerging as optimal nanotechnologies to support and enhance the efficiency of hyperthermia treatments for oncology. Based on their physicochemical properties, once accumulated at the tumor site, metallic nanoparticles can be activated by external energy sources, such as lasers, to generate heat in a controlled manner. Depending on the temperature reached at the tumor site, cells can undergo different biological mechanisms: the activation of the innate immune response, between 42.5°C and 43°C (Oncologic Hyperthermia), and cell apoptosis, above 50°C (Thermal Ablation Treatments, TATs).

The research has focused on optimizing experimental parameters related to the synthesis of gold nanorods and silver/gold alloy nanocages for the modulation of nanoparticle size and optical properties. Subsequently, the photothermal response of colloidal nanoparticles was evaluated by measuring the temperature variation resulting from the excitation of surface plasmons through 1064 nm laser radiation (Nd:Yag Laser).

In this manner, we were able to understand the different ability of nanoparticles with varying optical properties to convert light radiation into heat, and to identify the best candidate for the biomedical application.

Cell viability demonstarted the biocompatibility of the colloidal solution, and cell internalization was studied by cellular microcopy. In the future, the presented nanoparticles will be tested in *ex vivo* organs to confirm the obtained results. Ultimately, this research lays the groundwork for future advances in personalized medicine based on the use of nanotechnologies for the treatment of solid tumors through hyperthermia.

Advanced Freeze-Dried Hydrogel Films for Combatting Bacterial Infections in Chronic Wounds

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Infected chronic wounds affected by antibiotic-resistant bacteria are a significant global healthcare problem, leading to prolonged patient suffering, increased healthcare costs, and morbidity rates, which demand innovative solutions. This work presents a novel approach using antiseptic-coated gum Karaya/PVA hydrogel films to combat resistant bacterial infections. The freeze-dried films integrate antimicrobial agent within a biocompatible matrix, offering sustained release and prolonged efficacy. The freeze-drying process facilitates the fabrication of the hydrogel films and enables crosslinking within the hydrogel matrix enhancing the mechanical strength and stability of the films, making them more resilient to physical stresses encountered during wound management. Key analyses include hydrogel degradation and mechanical strength, antimicrobial agent release, cytotoxicity, and antibacterial testing. These tests confirm the film's ability to absorb exudates, maintain stability in the hydrated state for up to 30 days, withstand physical stresses needed for easy handling, exhibit biocompatibility and sufficient antimicrobial activity to suppress and eliminate bacterial infection. In conclusion, this technology presents a promising strategy for managing infected chronic wounds, enhancing wound healing, and alleviating the global healthcare burden.

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Synthetic Hydrogels as Cartilage Models for Biomimetic Tribological Testing

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Synthetic hydrogels offer a versatile platform for biomimetic testing, allowing researchers to recreate the complexity of biological systems in vitro and gain insights into various physiological processes, disease mechanisms, and potential therapeutic interventions. To study the biotribological behavior of model joints, a cartilage model was created from synthetic hydrogel based on 2-hydroxyethylmethacrylate (HEMA). By understanding the tribological properties of these hydrogels, it is possible to design HEMA hydrogels for artificial joint replacements that mimic the lubrication mechanisms and frictional response of natural synovial joints. The investigation of the frictional behavior of the model joints under various contact configurations and loading conditions, similar to those observed in natural articular cartilage, was applied and studied.

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A Comparative Study on Physicochemical Properties and In Vitro Biocompatibility of Sr-Substituted and Sr Ranelate-Loaded Hydroxyapatite Nanoparticles

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Synthetic hydroxyapatite nanoparticles (nHAp) possess compositional and structural similarities to those of bone minerals and play a key role in bone regenerative medicine. Functionalization of calcium phosphate biomaterials with Sr, *i.e.*, bone extracellular matrix trace element, has been proven to be an effective biomaterial-based strategy for promoting osteogenesis *in vitro* and *in vivo*. Functionalizing nHAp with Sr^{2+} ions or strontium ranelate (SrRAN) can provide favorable bone tissue regeneration by locally delivering bioactive molecules to the bone defect microenvironment. Moreover, administering an antiosteoporotic drug, SrRAN, directly into site-specific bone defects could significantly reduce the necessary drug dosage and the risk of possible side effects. Our study evaluated the impact of the Sr source (Sr^{2+} ions and SrRAN) used to functionalize nHAp by wet precipitation on its *in vitro* cellular activities. The systematic comparison of physicochemical properties, *in vitro* Sr^{2+} and Ca^{2+} ion release, and their effect on *in vitro* cellular activities of the developed Sr-functionalized nHAp was performed. The ion release tests in TRIS-HCl demonstrated a 21-day slow and continuous release of the Sr^{2+} and Ca^{2+} ions from both Sr-substituted nHAp and SrRAN-loaded HAp. Also, SrRAN and Sr^{2+} ion release kinetics were evaluated in DMEM to understand their correlation with *in vitro* cellular effects in the same time frame. Relatively low concentration (up to 2 wt %) of Sr in the nHAp led to an increase in the alkaline phosphatase activity in preosteoblasts and expression of collagen I and osteocalcin in osteoblasts, demonstrating their ability to boost bone formation.

Smart Albumin-Based Nanoparticle Delivery System for the Treatment of Infected Burn Wounds

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Infected burn wounds pose a major challenge in regenerative medicine due to their long healing times, pain, and other health risks like sepsis. The failure of traditional antibiotics against resistant bacteria has led to a focus on developing materials suitable for antibacterial nanoparticle on wound site delivery. However, research on pH-responsive delivery systems for the alkaline conditions of infected wounds is limited. The development of "smart delivery systems" with unique properties (e.g., external stimuli responsiveness) is critical to overcome these issues.
Addressing this, our goal was to develop a smart, biocompatible albumin-based hydrogel. It leverages the pH shift to alkaline region, caused by presence of infection in burns, as a stimulus for quicker swelling and antibacterial nanoparticle release. Second was to ensure easy and less painful experience for the patient. Therefore, we aimed to develop sprayable material.
The gelation mechanism of this hydrogel is based on carbodiimide crosslinking. Final hydrogel can be applied on wound site by spray, after combining two liquid parts, gelation occurs within 20 minutes. Within this study the effect of glycerol and urea, to improve mechanical properties, was studied. Swelling/degradation kinetics were evaluated according to changes in hydrogel volume in real time using QCM-D in different pH and temperature.

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Antibiotic and silver loaded hydroxyapatite for bone tissue healing

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For a very large number of people, especially elderly people, the life quality is greatly affected by health problems related to the bone defects caused by trauma or some diseases. In restorative medicine, to solve the problems that occur at the level of the bone structure, in addition to biological bone grafts, implants made of synthetic biomaterials that try to imitate the bone structure are used. Among them, bioceramic materials are widely used, and this is because they have excellent biocompatibility and mechanical properties suitable for their clinical use in orthopedics and dentistry. A problem that can arise after the implantation of a biomaterial in a bone structure is the appearance of bacterial infections. Therefore, it is extremely important that the bioceramic implant also has an antibacterial function to prevent or treat a possible infection associated with the bone implant. In recent years, a series of studies have been carried out regarding the creation of bioceramics that incorporate antibiotic-type active principles, precisely to induce antibacterial activity of the implant. In our study, to achieve antibacterial aims, hydroxyapatite scaffolds doped with silver ions were prepared for long-term release of antibacterial ions. In addition, an antibiotic (amoxicillin) was introduced into the apatitic bioceramic to act quickly on pathogenic bacteria that could develop on the implant. The porous scaffolds were obtained by the phase inversion process and were characterized by XRD, SEM and EDX methods. In vitro drug release of amoxicillin and silver ions indicated that these hybrid biomaterials can provide a prolonged release of bioactive agents in physiological conditions. The results suggested that these biomaterials with antibacterial function may be of use for the regeneration of bone defects and bone tissue healing.

Detecting potential single photon emitters in C-doped GaN

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Semiconductors like GaN have recently been explored as potential platforms for on-chip integrated photonics. Atomic defects in GaN have also been lately confirmed as a source of single-photons in the visible and infrared spectral range, which maintain strong emission in the zero-phonon-line up to room-temperature [1, 2].

By employing a method based on photoluminescence mapping, we can determine the physical location of these emitters, thus detemininig emitter surface density. Our setup paired with a custom data analysis program allows for attaining precise maps of emitters' distribution on a probe's surface. The method should allow us to determine the impact of C-doping on density of emitters and their PL intensity.

[1] A. M. Berhane et al.,. Bright Room-Temperature Single-Photon Emission from Defects in Gallium Nitride. Advanced Materials 29, 1605092 (2017).
[2]Y. Geng, J. Luo, p. u. Deurzen, Len, Huili, Xing, D. Jena, G. D. Fuchs, and F. Rana, Decoherence by Optical Phonons in GaN Defect Single-Photon Emitters, 2206.12636 (2023).

Zinc / Manganese Doped Iron Oxide Nanoparticles to Control Radical Generation and Magnetic Hyperthermia

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Magnetic nanoparticles based on iron oxides (IONPs) are widely studied for biomedical applications and their use is approved by the main regulatory agencies in certain applications. In particular, its magnetic properties play a fundamental role in potential biomedical developments e.g. treatment for retinal detachment, neuroregeneration, magnetic hyperthermia. On the other hand, the chemistry of IONPs gives them the ability to decompose hydrogen peroxide (H_2O_2) through heterogeneous Fenton-like reactions, producing reactive species. Depending on the application, the production of reactive species could be beneficial or, conversely, detrimental. It has been observed that it is possible to modify the catalytic activity of IONPs by replacing iron with other 3d metals (MFe2O4 where M is a transition metal) and also tune their magnetic properties. In this work we synthesize 23(2) and 15(1) nm nanoparticles of zinc and manganese ferrite, respectively, in order to modify the generation of radicals while maintaining equally favorable properties for their application in magnetic hyperthermia treatments. The oxidation state of zinc is 2+, reducing the catalytic activity of conventional magnetite, while manganese presents oxidation states from 1+ to 7+, conferring a complex reactivity with other substances. This allows the use of IONPs to be directed according to the application. The IONPs were tested in their most restricted condition to generate heat under the influence of an alternating magnetic field by fixing them in paraffin, demonstrating in both cases their equivalent capacity to achieve hyperthermia conditions.

Development and Preclinical Validation of Curcumin Nanoparticles and biofunctionalized Curcumin Nanoparticles for targeted delivery of antithrombotic and antiinflammation factors towards the Atherosclerosis treatment

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Cardiovascular diseases are among the leading causes of death worldwide. Curcumin, a powerful compound found in Curcuma longa, has demonstrated significant anti-atherosclerotic effects due to its anti-inflammatory and antioxidant properties. To reduce curcumin's hydrophobicity, we developed curcumin-loaded poly (lactic-co-glycolic acid) nanoparticles (Cur-NPs) as a drug delivery system. These Cur-NPs were prepared using the nanoprecipitation method and characterized using various techniques such as DLS, AFM, SEM, and FT-IR. In vitro characterization showed that the nanoparticles had mean particle sizes ranging from 150 nm to 200 nm and a polydispersity index of 0.2 to 0.4. Cytotoxicity tests on the L929 cell line indicated that Cur-NPs had low cytotoxic effects compared to control cells, and cell viability was not affected by the nanoparticles. Additionally, we investigated apoptosis and anti-inflamation and biofunctionalization in the presence and absence of Cur-NPs. This study aims to examine how formulation factors influence the physicochemical properties of nanoparticles using the nanoprecipitation technique, with the goal of optimizing the formulation for further biological applications in treating atherosclerosis.

Co-Creation Aid Kit 4.0 (CoCreAid) Cooperation partnerships in higher education

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Cooperation and R&D activities between civil society organizations and higher education institutions come to the fore and are of great importance. Current research has shown that digital environments can increase the efficiency and effectiveness of co-creation projects while reducing project costs. However, entrepreneurship in the digital field has been neglected to date and for this reason, there have been deficiencies in digital co-creation between higher education institutions and civil society organizations.

In this context, the 'CoCreAid Kit 4.0' project, funded by the European Union, is being developed to create an easy-to-use digital platform for co-creation projects between higher education institutions and civil society organizations, thus contributing to the success of such projects. This project also aims to encourage co-creation collaborations in rural areas. Initial investigations confirmed that there are obstacles to digital co-creation, such as lack of digital literacy, hardware or software problems, lack of communication in digital collaboration, etc. In addition, it was observed that despite the existence of many digital platforms, there is a lack of knowledge on how to use these platforms. The research revealed that there is a high need for a platform that acts as a knowledge base about existing digital platforms and digital co-creation methods. In this direction, CoCreAid Kit 4.0, which serves as a user platform that brings together existing co-creation platforms and methods, has been developed. The developed guides will attract the attention of more academics, NGOs and citizens, and enable them to use CoCreAid Kit 4.0 and scale the project to the European level.

WS4 Posters

	Biosensors & Bioelectronics (Common POSTER Session in ISFOE24 & NN24) **Tuesday 2 to Thursday 4 July: Poster Display & Presentations** **Thursday 4 July (17:00-20:00): Poster Presentation**
P4-1	**Fabrication of label-free immunoprobe for monkeypox A29 detection using one-step electrodeposited molybdenum oxide-graphene quantum rods** Murugesan Chandran[1], Kyusik Yun[1], Jongsung Kim[2], Chang-Hyun Jang[3] *[1]Department of Bionanotechnology, Gachon University, Gyeonggi-do 13120, Republic of Korea* *[2]Department of Chemical & Biological Engineering, Gachon University, Republic of Korea* *[3]Department of Chemistry, Gachon University, Gyeonggi-do 13120, Republic of Korea*
P4-2	**Effective Self-Assembled Multilayer-Based Electrode Passivation for Operationally Stable Electrolyte-Gated Transistor Biosensors** Young-Geun Ha *Department of Chemistry, Kyonggi Uiversity, Suwon, Gyeonggi-Do, Republic of Korea*
P4-3	**Single-Nanoparticle-Based Digital SERS Sensor for Accurate, Quantitative, and Simultaneous Detection of Various Disease Biomarkers** Eun-Ah You[1], Jae-Eul Shim[1], Young Jun Kim[1], Eunil Hahm[1], Jong-Ho Choe[2], and Ahruem Baek[1] *[1] Korea Research Inst.e of Standards and Science (Division of Biomedical Metrology), Republic of Korea* *[2] Korea University (Department of Physics) Seoul 02841, Republic of Korea*
P4-4	**Glucose Sensing Based on Glucose Oxidase Meta-Chemical Surface (MCS) Electrode Fabricated Using Dip-Pen Nanolithography** M. Zohar[1], D. Shamir[2], A. Burg[3] *[1] Electrical and Electronics Engineering, Shamoon College of Engineering, Be'er Sheva, Israel* *[2] Analytical Chemistry, NRCN, Be'er Sheva, Israel* *[3] Chemical Engineering, Shamoon College of Engineering, Be'er Sheva, Israel*
P4-5	**Comparison of SPEs sensors based on various carbon nanostructure for monitoring of anticancer doxorubicin** A. Grozdanov[1], Perica Paunovik[1], Iva Dimitrievska[1] *University Ss Cyril and Methodius in Skopje, Faculty of Technology and Metallurgy, R.N. Macedonia*
P4-6	**Anodic Niobia and Tantala Nanocolumn-like Surface Functionalization for Click Coupling** B. Ranishenka[1], A. Hoha[2], A. Poznyak[2], V. Shmanai[1], A. Pligovka[2] *[1]Inst.e of Physical Organic Chemistry, Nat. Academy of Sciences of Belarus, Belarus* *[2]Research and Development Laboratory 4.10 "Nanotechnologies", Belarusian State University of Informatics and Radioelectronics, 6 Brovki Str., 220013 Minsk, Belarus*
P4-7	**Innovative gold nanoparticles-based biosensors for point of care (POC) pathogen detection** Colombo A.[1], Giustra M.[1], Salvioni L.[1], Tomaino G.[1],Barbieri L.[1], Colombo M.[1] *NanoBioLab, Department of Biotechnology and Bioscience, University of Milano-Bicocca, Italy*
P4-8	***In vitro* culture platform based on electroconductive BSA/PEDOT:PSS hydrogel** Z. Fohlerova, V. Polakova *Central European Inst.e of Technology, Purkynova 123, 612 00 Brno, Czech Republic*
P4-9 **YRA** **CANDIDATE**	**Multifunctional Wireless BTO@PEDOT Core@shell Nanobioelectronic Systems for Cancer Therapy** C. F. Jones[1,2], Frederico Castelo Ferreira[1,2], Paola Sanjuan- Alberte[1,2],Teresa Esteves[1,2] *[1]Department of Bioengineering, Inst.e for Bioengineering and Biosciences, Inst.o Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisbon, Portugal* *[2]Associate Laboratory i4HB—Inst.e for Health and Bioeconomy, Inst.o Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisbon, Portugal*
P4-10	**Calibration and Characterization of Biohybrid Catheters integrating organic transistor-based strain sensors** U. Mahmood[1], G. Casula[1], A. Bartolucci[2], P. Cosseddu[1], L. Ricotti[2], L. Vannozzi[2], S. Lai[1] *[1]Department of Electrical and Electronic Engineering, University of Cagliari, Piazza d'Armi, 09123 Cagliari,Italy* *[2]The Biorobotic Inst.e, Scuola di Studi Superiori Sant'Anna, Viale Rinaldo Piaggio 34, 56025 Pontedera, Italy*
P4-11	**A textile-based filtering antenna for wearable applications** A. K Stavrakis, G. M. Stojanović *Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*
P4-12	**Bio-functionalization and characterization of flexible printed electrochemical biosensors for detection of D-Glucose** A. Batsi[1], V. Karagkiozaki[2], K. Tsimenidis[2], A. Orfanos[2], S. Logothetidis[1,2] *[1] Nanotechnology Lab LTFN, Aristotle University of Thessaloniki, Thessaloniki Greece*

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P4-13	**Safe-by-Design of DNA origami based biosensors - moving towards safer nano-innovations** J. Voglhuber-Höller, S. Resch, S. Tahiraj, M. Reinfelds, JK. Scheper, A. Falk *BioNanoNet Forschungsgesellschaft mbH (BNN), Kaiser-Josef-Platz 9, 8010 Graz, AUSTRIA*

Fabrication of label-free immunoprobe for monkeypox A29 detection using one-step electrodeposited molybdenum oxide-graphene quantum rods

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Monkeypox is a zoonotic viral infection caused by the monkeypox virus (MPXV), which belongs to the Poxviridae family of the Orthopoxvirus (OPXV) genus. Monkeypox is transmitted from animals to humans and humans to humans; therefore, the accurate and early detection of MPXV is crucial for reducing mortality. From 1 January 2022 to 31 October 2023 a total of 91,788 cases were confirmed by the World Health Organization (WHO) and 116 countries have reported a total of 167 deaths. A graphene-based material called graphene quantum rods (GQRs) was synthesized and confirmed using high-resolution transmission electron microscopy and atomic force microscopy. One-pot electrodeposition of MoO_3-GQRs composite on carbon fiber paper (CFP) and antibody A29 (Ab-A29) modified immunoprobe used to detect the MPXV protein (A29P). The mechanisms of the antigen and antibody interaction were examined by X-ray photoelectron spectroscopy and differential pulse voltammetry (DPV) was used to detect the MPXV A29P. DPV analysis showed a wide linear range of detection from 0.5 nM to 1000 nM, a detection limit of 0.52 nM, and a sensitivity of 4.51 µA in PBS. The prepared immunoprobe was used to analyze A29P in serum samples without reducing electrode sensitivity. Prepared paper-based Ab-A29/MoO_3-GQRs composite electrode can be a promising candidate for clinical analysis of A29P antigen with high sensitivity and selectivity.

Effective Self-Assembled Multilayer-Based Electrode Passivation for Operationally Stable Electrolyte-Gated Transistor Biosensors

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This presentation introduces a novel electrode passivation technique for transistor-based biosensors to enhance their stability and reproducibility in aqueous environments. By employing a self-assembled multilayer (SAML) approach, involving layers of 1,10-decanedithiol, vinyl-polyhedral oligomeric silsesquioxane, and octadecanethiol, the method ensures efficient insulation and operational consistency for electrolyte-gated transistor (EGT) biosensors. Unlike single-layer passivated EGTs, which are prone to short circuits, SAML-protected EGTs demonstrate sustained functionality in phosphate-buffered saline (PBS) across multiple tests. This passivation strategy is particularly effective in the ultrasensitive detection of Tau protein, a key Alzheimer's disease biomarker, using a specific DNA aptamer in low ionic strength PBS to overcome charge screening effects. The SAML-passivated EGT biosensor achieves reliable Tau protein quantification over a broad concentration range, far exceeding clinical requirements. This advancement not only benefits stable and reproducible biosensing but also holds potential for broader applications in biomedical devices and bioelectronics within aqueous or physiological environment.

Single-Nanoparticle-Based Digital SERS Sensor for Accurate, Quantitative, and Simultaneous Detection of Various Disease Biomarkers

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To achieve an accurate and quantitative determination of disease biomarkers and early diagnosis of diseases, it is crucially important to develop a highly sensitive and reliable detection tool for various biomarkers. Here, we present an ultrasensitive and reliable single nanoparticle-based digital surface-enhanced Raman spectroscopy (SERS) sensor for the accurate and quantitative detection of various disease biomarkers. In particular, we develop bumpy core-shell Au nanoprobe-based sensing platform with single nanoparticle-based digital SERS analysis for the accurate and quantitative detection of multiple biomarkers, including the biomarkers of infectious and neurodegenerative diseases. For all the multiple biomarkers of infectious and neurodegenerative diseases, this NP-based digital SERS sensor shows an excellent performance with a limit of detection lower than 1 fM and a wider detection range covering 7 orders of magnitude. Consequently, the performance of the NP-based digital SERS sensor far outperforms the conventional enzyme-linked immunosorbent assays for the identical target analytes. In addition, this presented SERS sensor allows for the quantitative and simultaneous detection of multiple biomarkers with distinct labels in biofluids as well as clinical applicability. Therefore, the NP-based digital SERS sensor can be widely and effectively applied to the ultrasensitive and quantitative detection of multiple biomarkers for the accurate and reliable diagnosis of various diseases.

Glucose Sensing Based on Glucose Oxidase Meta-Chemical Surface (MCS) Electrode Fabricated Using Dip-Pen Nanolithography

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Extensive research has been carried out to enhance the creation of cost-effective, user-friendly, and high-performing sensors that play a crucial role in the food and pharmaceutical sectors, particularly for detecting glucose levels. Electrochemistry-based sensors and biosensors are widely used today. In this research, a new method employing dip-pen nanolithography (DPN) was introduced to create nanoclusters of glucose oxidase mixed with PMMA to form efficient electrodes to achieve improved detection sensitivity. This approach demonstrated the ability to detect $\sim 1\times10^{-9}$M of glucose, which is a significant improvement compared to current glucose sensors. Using the DPN technique, we were able to create a Meta-Chemical Surface (MCS), a precise pattern of consistent clusters that contained very small amounts of the active GOD enzyme. The Micrux gold electrode was used as the base for fabricating the patterned working electrode, where we used the NLP2000 platform to execute the patterning process. We were able to strictly regulate the sizes and number of the active nanoclusters and the spacing between adjacent nanoclusters in both the x and y directions (L_x, L_y) through the use of the NLP2000 platform. We have shown that it is feasible to employ DPN for the creation of sensors on diverse electrode surfaces that are patterned with different active species. These patterned electrodes are particularly useful in applications that necessitate a low limit of detection value or when an expensive active species is required. We conducted a comparison between the coated electrodes and the suggested electrode with the MCS working electrode, where the glucose concentration values in the solutions were known.

Comparison of SPEs sensors based on various carbon nanostructure for monitoring of anticancer doxorubicin

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Design of novel bio-nanosensors based on carbon nanostructures (G, CNTs, G-CNT hybrid) is facilitating a new research direction and it is very important task of many projects. In the present work, a promising application of bio-nanosensors based on Screen Printed Electrodes (SPE) with Graphene, MWCNT and MWCNT/PANI nanocomposites prepared by direct electro-polymerization method as well as inkjet and 3D printing were tested and compared for monitoring of anticancer drug Doxorubicin. Surface changes of the SPE-sensors, before and after cyclic voltammetry were followed by SEM. Polymer/CNTs interactions and their changes on the surface of SPE-sensors were studied by FTIR-ATR spectroscopy. The obtained results have confirmed polymer/CNs and CNs/drugs interactions and their characteristic band-shifting.

Anodic Niobia and Tantala Nanocolumn-like Surface Functionalization for Click Coupling

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The field of nanotechnology related to the formation and the study of Bi nanowires, is currently attracting great interest. This is due to their applicability in the fabrication of various micro- and nanoelectronics devices: pH electrodes, sensors, potential applications, etc., as well as their unique properties different from their bulk counterparts. One of the optimal methods of formation of bismuth nanowires is electrochemical deposition into the Al_2O_3 pores. The base of the pores in such a method should consist of a well-conducting material. Most of the methods of creating such Al_2O_3 are expensive and difficult to realize. One approach is to create niobia in the pore base by anodizing. In this work, anodic niobia nanowire assisted electrodeposition of Bi arrays. Niobia nanowires have been obtained by porous Al_2O_3 assisted potenciostaticlly 250 V anodizing of Al/Nb (1500/200 nm) layers in 0.2 M tartaric solition. Bismuth was potentiostatically 0.28 V electrodeposited inside Al_2O_3 pores onto the surface of niobia nanowires in solution 0.13 M $BiCl_3$, 1.2 M NaCl and 1 M HCl. Removal of porous Al_2O_3 in 50% orthophosphoric solution. Microgemetry, composition and electrophysical properties were investigated. SEM and optical studies showed non-uniform distribution of nanowires in the microscale. However, the electrophysical characteristics at different contact sites were commensurate. This indicates a high uniformity in the macroscale. The dimensions of the niobia nanowires were 535 nm height and 120 nm dia. The size of the grouped Bi arrays was 2 μm height and 600 nm diameter. The positive character of the temperature coefficient of resistance characterizes the arrays as materials with predominant metallic conductivity. The results obtained lay scientific foundations for the creation of electronic devices based on nanostructured arrays of Bi nanowires on niobia surfaces.

Innovative gold nanoparticles-based biosensors for point of care (POC) pathogen detection

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The constant exposure of humans to environmental microbes facilitates the interconnection between micro- and macro-organisms. In this context, hospitals are environments of special interest as they are frequented by both healthy and sick people, where antibiotics are widely utilized and cleaning rates are high. These factors contribute to the development of a unique microbiota characterized by the presence of pathogens, multidrug-resistant bacteria, and harmless common species.
In traditional conditions, pathogen detection is carried out using complex equipment frequently found in centralized laboratories, mostly employing molecular and microbiology-based methods. In recent decades, biosensors and related signal-processing systems have been extensively studied and created.
The advancement of nanotechnology has led to the development of submicron-sized nanobiosensors due to their low sample requirements, speedy analysis, onsite detection, and sturdy nature. Among the nanotechnologies employed for pathogen detection, gold nanoparticles (AuNPs) are the most widely used in this research field. AuNP surfaces can be easily functionalized with a wide range of molecules, including antibodies. Moreover, AuNPs present unique optical properties, such as their distinctive plasmonic band, which imparts a bright-red colour to AuNP solutions, and their extremely high extinction coefficient, making AuNPs detectable by the naked eye.
These properties could be exploited by the specific binding of the target analyte with the NPs, causing a visible change in the colour of the solution due to the loss of the characteristic plasmon band.

In vitro culture platform based on electroconductive BSA/PEDOT:PSS hydrogel

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The development of conductive hydrogel-based platforms combined with optics for studying cardiomyocytes and their interactions *in vitro* is of a great attention. Complementing the use of these platforms with computer modeling represents an innovative and unique approach for studying cardiac cellular electrophysiology and pathophysiology. The conductive hydrogel is prepared from natural bovine serum albumin (BSA) and conducting PEDOT:PSS polymer. The work involves preparation of hydrogels with desired mechanico-electrical properties, physico-chemical characterization of hydrogel and biocompatibility to cardiac cells. The preliminary results shows that BSA/PEDOT:PSS creates the optically transparent hydrogel with Young modulus and ionic conductivity about 20 kPa and 10^{-4} S·m, respectively. The hydrogel also shows good adhesion and non-toxicity to cardiac HL-1 cells. The proposed novel in vitro culture platforms can be used to study phenomena previously undiscoverable with electrically insulating cell culture substrates.

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Multifunctional Wireless BTO@PEDOT Core@shell Nanobioelectronic Systems for Cancer Therapy

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Cancer cells exhibit unique bioelectrical properties, such as depolarized cell membranes, yet therapeutic strategies exploiting these are still lacking. Herein, we merge a nanobioelectronic system comprising a piezoelectric barium titanate nanoparticle core and a conducting poly(3,4-ethylenedioxythiophene) shell (BTO@PEDOT NPs) with cancer cells to modulate bioelectricity. We show that the BTO@PEDOT NPs act as a nanoantenna, transducing a mechanical input provided by external ultrasound (US) stimulation into an electrical output, capable of interfering with the bioelectronic circuitry of the human breast cancer cell lines, MCF-7 and MDA-MB-231. Upon a 2min30s US stimulation, the viability of MCF-7 and MDA-MB-231 treated with 200 ug mL^{-1} BTO@PEDOT NPs reduced significantly to 31% and 24%, respectively, while healthy human mammary fibroblasts were unaffected by the treatment (94% viability). The treatment induced membrane polarization, leading to higher levels of reactive oxygen species (ROS) and increased intracellular calcium, while also promoting apoptosis and disrupting proliferative states in cancers' cell cycle. These findings underscore the potential of nanobioelectronic systems as an emerging and promising strategy for cancer intervention with no impact on healthy cells.

Calibration and Characterization of Biohybrid Catheters integrating organic transistor-based strain sensors

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Biohybrid catheters are innovative medical devices that incorporate biological components into passive catheters to improve their functioning, in particular as regards their movement ability in anatomically difficult areas of the human body. Integrating advanced sensing technologies into catheter design enables real-time monitoring and feedback during medical procedures, providing valuable information about catheter positioning, tissue interfaces and physiological responses. This abstract investigates the integration of flexible sensors on a catheter tip, focusing in particular on its calibration with an applied deformation mimicking the one induced by the biohybrid actuator. First, sensor structure is discussed. The device is an organic transistor-based strain sensor fabricated by inkjet printing over ultra-thin su strates. The final thickness of the device is only 2 micrometers, thus making it suitable for integration on catheter tips by lamination. The definition of a calibration platform and protocol is then reported. 3D-printed supports are precisely built to secure the catheter during testing, ensuring stability and uniformity throughout the calibration procedure. During calibration, mechanical deformation is applied to one end of the catheter, inducing a displacement in the tip. Simultaneously, electrical characterization is performed in order to derive the extent of the sensor response as a function of applied deformation. The combination of 3D printing for the calibration platform and analysis of electrical characterization during catheter deformation by applied mechanical force allows defining its performances and thus its suitability for vivo applications, providing enhanced precision and efficiency in medical applications like drug delivery. This assure the sensor-enhanced catheter's capability to bend at desirable angles and reach specific parts of the human body for medication procedures.

A textile-based filtering antenna for wearable applications

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In the last decade, a significant rise of mobile and portable devices is observed, owing primarily to the Internet of Things. As most of such devices need to effectively communicate wirelessly, not only novel antennas have surfaced, but also a need for co-design parts of the RF front end. That is because by co-designing at least two of its three elements, which are an antenna, a filter and an amplifier, usually the passive ones, warrants a better matching, and lower losses in transmission or reception, while oftentimes, the resulting geometry is also decreased. In our work, we propose for the first time a filtering antenna entirely fabricated using textiles, which relies on the co-design of a split ring resonator filter with one of its elements substituted by a patch antenna. This approach allows great conformity with use cases such as integration on garments, while its operating frequencies are in popular parts of the electromagnetic spectrum, used for wireless communication (5G band).

Bio-functionalization and characterization of flexible printed electrochemical biosensors for detection of D-Glucose

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Diabetes is a disease that affect many people worldwide, as a consequence of our living habits. Therefore, a daily and constant monitoring of glucose levels is needed for preventing more serious complications. This work addresses this need by developing a bio-functionalization process for the detection of D-Glucose by an electrochemical biosensor. Its' biofunctionalization was made by using glucose oxidase as the enzyme and glutaraldehyde solution for the immobilization of it and Prussian Blue as the mediator. A detailed research was made for Prussian Blue, especially the materials used for its synthesis and the conditions for that process such us the temperature and time needed for the stabilization. Moreover, the appropriate amount of enzyme that should be used and the usage of BSA protein and Nafion in the enzyme membrane were examined. The effectiveness of the biofunctionalization procedure was investigated by cyclic voltammetry and square wave voltammetry and the materials properties by UV-Vis. Finally, a calibration curve was made for the case of different glucose concentrations. All these contributed to understand the electrochemical reactions that take place in the device, and to further enhance its functionality by using new materials to detect different substances.

Safe-by-Design of DNA origami based biosensors - moving towards safer nano-innovations

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Continued efforts in R&D are put into the development of nano-enabled biosensor applications. However, the potential, actual or perceived risks that might accompany nanotechnology, are paralleled by elevated expectations for safety control. DeDNAed aims to develop a sensor platform that allows for advanced sensitivity and versatility using surface enhanced Raman spectroscopy (SERS), via the precise controlling of element positioning by DNA origami. Alongside the technical development of the sensor, BNN generated a tailored Safe-by-Design (SbD) concept, taking into account potential hazards and risks. Implementing SbD in early innovation stages can mitigate late failures by eliminating hazards and issues before they become real risks. In a tiered approach we examined first the inherent properties of individual biosensor components (consisting of the DNA origami, biological recognition elements (bioREs), gold nanoparticles (AuNPs) and a carrier substrate) as well as used chemicals/materials used for processing and production. Information was gathered through questionnaires and laboratory visits. Due to the early innovation stage, the uncertainty of information remained high for a portion of the components and processes, which leads to a potential overestimation of hazard/risk scoring. Partially, read across with similar products enabled enhanced information gathering. Used chemicals and materials were grouped based on their hazard classifications and the most hazardous have been suggested to be considered for replacement. In conclusion, hotspots have been highlighted and areas where further investigations are needed have been pin pointed to be able to confidently assess hazard and risk levels. Continuing SbD implementation along further development stages will enable the DeDNAed biosensor to be suitable for launch in regard to safety aspects.

I3D Posters

	Workshop on Artificial Intelligence, Machine Learning, Intelligent Manufacturing and Automation **Tuesday 2 to Thursday 4 July: Poster Display & Presentations** **Thursday 4 July (17:00-20:00): Poster Presentation**
I3D-1 **YRA CANDIDATE**	**Isocyanate-free urethanediol itaconates as biobased liquid monomers in photopolymerization-based 3D printing** R. Carmenini, C. Spanu, E. Locatelli, L. Sambri, M. Comes Franchini* and M. Maturi* *Department of Industrial Chemistry "Toso Montanari", University of Bologna, Viale Risorgimento 4, 40136 Bologna, Italy*
I3D-2	**Lightweight mineral particles/ABS composite filaments for Fused Filament Fabrication (FFF); physical and mechanical properties, and printability** P. Angelopoulos[1], N. Kountouris[1], Z. Viskadourakis[2], A. Skaropoulou[1], C. Panagiotopoulou[1], A. Peppas[1], G. Kenanakis[2]. M. Taxiarchou[1] *[1] Laboratory of Metallurgy, School of Mining and Metallurgical Engineering, National Technical University of Athens (NTUA), Greece* *[2] Institute of Electronic Structure and Laser, Foundation for Research & Technology-Hellas, N. Plastira 100, Heraklion, Crete, GR 70013, Greece*
I3D-3	**Tandem FFF Printing using High-Load Composite Polymeric Filaments for Rapid Manufacturing of Dielectric and Electrochemical Energy Storage Devices** A. Tiliakos[1,2], R.-Valentin Răbuga[1], G.-Rainer Gillich[2] *[1] National R&D Institute for Cryogenic and Isotopic Technologies (ICSI), ICSI Energy Department, Rm. Vâlcea, 240050, Romania* *[2] Babeș-Bolyai University, Department of Engineering Science, Centre for Vibrodiagnostics for Equipment Testing and Automation (CVDTEA), Cluj-Napoca, 400084, Romania*
I3D-4 **YRA CANDIDATE**	**Functionalized red emitting carbon dots as fluorescent additives for 3D printing photopolymerization** S. Maturi,[a] A. Baschieri,[b] E. Locatelli,[a] M. Comes Franchini[a] and L. Sambri[a] *a) Department of Industrial Chemistry "Toso Montanari", University of Bologna, via P. Gobetti 85, Bologna, 40129, Italy* *b) ISOF, CNR, via P. Gobetti 101, Bologna, 40129, Italy*
I3D-5	**Bipolar Plates for Hydrogen Fuel Cells Manufactured by Fused Filament Fabrication using High-Load Metal-Polymer Composites** A. Tiliakos[1,2], R.-V. Răbuga[1], G.-Rainer Gillich[2] *[1] National R&D Institute for Cryogenic and Isotopic Technologies (ICSI), ICSI Energy Department, Rm. Vâlcea, 240050, Romania* *[2] Babeș-Bolyai University, Department of Engineering Science, Centre for Vibrodiagnostics for Equipment Testing and Automation (CVDTEA), Cluj-Napoca, 400084, Romania*
I3D-6	**Extending the Aerodynamic Shape Optimization of a Solar Car to 3D Printing** G. Tzionas[1], An. Moissiadis[1], N. Ntinas[2], I. Tzionas[1] *[1]Department of Mechanical Engineering, International Hellenic University, Serres, Greece* *[2]Department of Mechanical Engineering, University of Western Macedonia, Kozani, Greece*
I3D-7	**3D printed materials for healing of bone defects** J. Frankova[1], R. Novotna[1], R. Novotny[1], J. Janusz[2] and A. Jabłoński[2], I. Rajzer[2] *[1]Department of Medical Chemistry and Biochemistry, Hnevotinska 3, Palacky University Olomouc, 775 15, Czech Republic* *[2] Faculty of Mechanical Engineering and Computer Science, University of Bielsko-Biala, Willowa 2, 43-309 Poland*
I3D-8	**Advanced 3D collagen-based scaffolds enriched with vasculogenic compound for enhanced vascularization and wound healing** D. Izsak[1], V. Pavliňáková[1], Z. Fohlerová[1], T. Szotkowská[2], M. Buchtová[2], L. Vojtová[1] *[1]CEITEC BUT, Central European Institute of Technology, Brno University of Technoogy, Czech Republic* *[2]Institute of Animal Physiology and Genetics, The Czech Academie of Science, Czech Republic*
I3D-9	**Finite Element Analysis and Topology Optimization of Additive Manufactured Orthodontic Twin Brackets for Enhanced Performance and Mass Reduction** T. Profitiliotis[1], N. Kladovasilakis[1,2], E. M. Pechlivani[1], D. Tzetzis[1] *[1] Digital Manufacturing and Materials Characterization Laboratory, School of Science and Technology, International Hellenic University, Thessaloniki, 57001, Greece* *[2] Center for Research and Technology Hellas, Information Technologies Institute, 57001 Thessaloniki, Greece*

I3D-10	**Development and Numerical Evaluation of a Topologically Optimized Helmet with Advanced Architected Materials** N. Kladovasilakis [1,2], K. Tsongas[2], E.M. Pechlivani[1], D. Tzetzis *[1]Center for Research and Technology Hellas, Information Technologies Institute, 57001 Thessaloniki, Greece* *[2]Digital Manufacturing and Materials Characterization Laboratory, School of Science and Technology, International Hellenic University, Thessaloniki, 57001, Greece*
I3D-11	**A refractometry sensor for the detection of pathogens in bioreactor samples** M. Chatzipetrou[1], E. Damianidou[2], M. Dimadi[2], A. Bokski[3], E. Schreuder[3], A. Klinakis[2] and I. Zergioti[1] *[1]School of Applied Mathematics and Physical Sciences, National Technical University of Athens, Zografou 15780, Greece.* *[2] PhosPrint P. C. Lefkippos Technology Park, NCSR Demokritos, Patriarchou Grigoriou 5' & Neapoleos 27, 15341, Agia Paraskevh, Athens, Greece.* *[3] LioniX International B.V., Hengelosestraat 500, 7521 AN Enschede, The Netherlands*
I3D-12	**Multilayer laser printing of cells with hydrogels.** S. Elezoglou[1], A. Hatziapostolou[2], A. Chalari[3], A. Rufino[4], C. Chandrinou[1], C. Custodio[4], A. Klinakis[3,5], and I. Zergioti[1,5] *[1]National Technical University of Athens, School of Applied Mathematical and Physical Sciences, Athens, Greece* *[2]Department of Naval Architecture, School of Engineering, University of West Attica, Athens, Greece* *[3]Biomedical Research Foundation of the Academy of Athens, Athens, Greece* *[4]Metatissue Edifício Central, PCI · Creative Science Park Aveiro Region, Via do Conhecimento, 3830-352 Ílhavo, Portugal* *[5]PhosPrint P.C., Attika Technology Park Lefkippos, Agia Paraskevi, Athens, Greece*
I3D-13 **YRA CANDIDATE**	**Surrogate model for exciton-polariton condensation** K. Kuba[1], M. Matuszewski[2,3], B. Piętka[1], A.Opala[1,2] *[1] Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Poland* *[2] Institute of Physics, Polish Academy of Sciences, Aleja Lotników 32/46, PL-02-668 Warsaw, Poland* *[3] Center for Theoretical Physics, Polish Academy of Sciences Aleja Lotników 32/46, 02-668 Warsaw, Poland*
I3D-14	**Compensating for Errors in a Gas Sensor Array Using Machine Learning and a Custom Laboratory Test System** F. Gerhát, M. Mičjan, V. Režo *Institute of Electronics and Photonics, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology in Bratislava, Slovak Republic*
I3D-15	**High Secure Process Automation Frameworkto Improve Production Quality and Scalability** A. Takaluoma[1], Janne Rosberg[2] *Offcode Oy, Finland*
I3D-16	**From CHADA to CHAMEO:** **A reference system for characterisation data management** **O. M. Roscioni[1], G. Goldbeck[1], P. Del Nostro[1], D. Toti[1]** *1 Goldbeck Consulting LTD, CB4 0WS Cambridge, United Kingdom.*

Isocyanate-free urethanediol itaconates as biobased liquid monomers in photopolymerization-based 3D printing

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Nowadays, most of the commercial resins for VP are composed of (meth)acrylated urethanes, as they are cheap and provide good mechanical properties to the thermosets produced by their photocuring. However, such urethanes are still produced using toxic and polluting isocyanates, even if alternative pathways exploiting cyclic carbonates and biobased amines are arising. Unfortunately, the use of biobased amines and carbonates to produce (meth)acrylate urethanes often lead to the formation of solid products that display poor solubility in the liquid components of photocurable resins. In this work, we describe the synthesis of fully biobased diurethanediols using a biobased diamine and bioderived carbonates functionalized with itaconic acid moieties that are liquid at room temperature and that can be efficiently formulated with (meth)acrylic and itaconic acid-based formulations for VP leading to 3D printed materials with good mechanical properties, comparable to those of commercially available non-biobased alternatives. In fact, depending on the resin formulations, the addition of diurethanediols diitaconates led to the obtainment of 3D printed materials with elastic moduli as high as 1 GPa, and tensile strengths over 30 MPa, and biobased contents as high as 90 wt.%. These products may serve as candidates for the replacement of isocyanate-based components with the aim of increasing the sustainability of resins' manufacturing for VP.

Lightweight mineral particles/ABS composite filaments for Fused Filament Fabrication (FFF); physical and mechanical properties, and printability

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Lightweight mineral granules are attractive fillers in composites because of their tiny size, light weight, inertness, incombustibility and low cost, while can improve the rheological characteristics of the parental polymer. Such properties are of great importance in 3D printing. FFF constitutes the most common and massively applied 3D printing process. The incorporation of an inorganic filler in the polymeric filament is of interest because of its potential economic and environmental benefits, as well as the improvement of the printability. The article presents the production of ABS/lightweight glassy mineral fillers composite formed in filament, and its use in FFF printing. Fillers' grades of different diameter and density have been produced applying sophisticated thermal treatment of the minerals, and subsequently were used for the production of the composite filaments through melt extrusion. Composite filaments were used for the printing of dogbone samples, which were subjected to physical and mechanical characterization and morphological observation to assess the printability of the composite filaments and determine the optimum filler in terms of the size and density.

Tandem FFF Printing using High-Load Composite Polymeric Filaments for Rapid Manufacturing of Dielectric and Electrochemical Energy Storage Devices

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Additive manufacturing (AM) is continuously gaining momentum as a disruptive technology, with the global industry experiencing drastic transformations in product design and manufacturing practices. However, there is still a pronounced disparity in capital costs between high-end and low-end AM technology types, for example between Selective Laser Melting (SLM) or Sintering (SLS) and Fused Filament Fabrication (FFF) installations, reflected in the quality of produced parts and their availability from a financial perspective to the end user. Certainly, depending on the choice of printable materials, expensive installations have been the main (and sometimes only) option, for example SLM in the case of metal processing. Nevertheless, the variability of polymer-based filament materials coupled with low capital costs have recently started opening new horizons for the simplest FFF technologies. In our work, we employ composite polymeric filaments with high loadings of additive particles, ranging from metal and ceramic/glass particles to carbon nanotubes (CNTs), carbon fibres (CFs), and graphene, for the rapid manufacturing of dielectric and electrochemical energy storage devices at a scale pertinent to the resolution allowed by FFF. To accelerate and simplify the manufacturing process, composite materials with compatible thermo-mechanical and rheological properties are chosen for tandem FFF extrusion, accommodating both classical and intricate form factors for energy storage devices. Depending on the material, the corresponding post-processing treatment is applied, for example thermal or microwave debinding and sintering in the case of metal-polymer or glass/ceramic-polymer composites. We are presenting here our first results in realizing modular dielectric capacitors and supercapacitors by such methods.

Functionalized red emitting carbon dots as fluorescent additives for 3D printing photopolymerization

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Early discovered in 2004, carbon dots (CDs) are currently considered as rising stars in the universe of carbon nanoparticles owing to their excellent luminescent properties, low toxicity, high biocompatibility and photostability, and to the possibility of surface functionalization. Currently, CDs have found application in a wide variety of fields, from sensing to catalysis, from energy to biomedical applications, among other. Notably, carbon dots exhibiting good optical properties in the therapeutic windows, i.e. absorption and emission in the red to NIR region, are nowadays extremely important for efficient bioimaging and even phototherapy. Moreover, owing to the increasing demand for new smart materials, CDs have great potentiality in the use as additives for the development of advanced functional materials for applications in the most innovative production techniques. In this framework, 3D-printing is one of the most recent techniques which is undergoing on a fast and exponential growth in the last years, since its approach is fast, cheap, and versatile and allow us to create a 3D model on a 3D design software and to transfer it into a real physical object potentially with no limits in terms of geometry, details, dimensions, and accuracy. We addressed our attention to the use of biocompatible and highly fluorescent additives such as carbon dots (CDs). Herein, we report the synthesis of functionalized red emitting carbon dots and their use as additives to resins with different mechanical properties to demonstrate the possibility to print 3D object with red emission properties for potential applications in implantable objects.

Bipolar Plates for Hydrogen Fuel Cells Manufactured by Fused Filament Fabrication using High-Load Metal-Polymer Composites

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Bipolar plates are key components of proton exchange membrane, alkaline, and solid oxide fuel cells and electrolyzers for hydrogen energy. They are machined with complex flow fields and channels to distribute gaseous fuel, evacuate moisture, and conduct electricity between cells when assembled in stack formation. Traditional manufacturing methods used in producing metallic bipolar plates, such as stamping and hydroforming, have the disadvantage of compromised planarity due to stress introduction. On the other hand, presswork tooling is time-consuming and uneconomical, especially during prototyping, and chemical etching, while being a highly efficient and cost-effective method, has inherent limitations pertaining to the thickness of the processable material and thus the accessible geometries. In our work, we attempt to overcome these obstacles while maintaining production costs at minimum by employing basic additive manufacturing methods (Fused Filament Fabrication, FFF) using composite polymeric filaments that incorporate the as yet highest load in metal content: for the materials tested at this stage, copper particles at 90wt% with a PLA-based binder. This scalable and cost-effective process is completed by thermal and/or microwave debinding and sintering at high temperature, and results in an all-solid-metal bipolar plate with serpentine channel geometry and conductivity that reaches 99% IACS.

Extending the Aerodynamic Shape Optimization of a Solar Car to 3D Printing

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The aim of this work was to investigate the extension of the aerodynamic shape optimization of two solar car 3D printed CAD geometries. The two CAD geometries were obtained after aerodynamic shape optimization using computational fluid dynamic analysis software. After the aerodynamic shape optimization completion, the effort proceeded to investigate the extension of optimization by 3D printing the two solar car CAD geometries, initial and optimized. Optimization criteria for printing the two 3D models were time (min), weight (gr), energy (kWh) with consequence the final cost (€). The two solar car 3D models were printed on a 1:1 scale in relation to the CAD geometries. CAD geometries were prepared by using the software called UltiMaker Cura 5.6.0. Each CAD geometry, split up in the same way, in six individual pieces created due to a predetermined allowed printing area. To be able to compare the 3D printed models, each piece was printed exactly in the same way in terms of positioning method and the use of the auxiliary support material. The printer model used is Creality 3D Printer Ender 3 Pro using PLA material EVO by NEEMA 3D. The results of the two 3D printing models in terms of time, weight and energy, verified the initial hypothesis to extend the aerodynamic shape optimization to 3D printing as well. Specifically, the 3D printing time of the optimized geometry compared to that of the initial geometry was reduced by 3.96%. Also, the optimized geometry mass of the 3D printed model was 4.98% lighter. The energy consumed on printing the optimized 3D model was reduced by 3.94%. Finally, 3D printing total cost of these two models reduced, from the original to the optimized, by 4.87%.

3D printed materials for healing of bone defects

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In the medical domain, 3D printing applications have extended to a wide range of type tissues e.g. bone, join, vascular tissue or neuronal tissue. Bone is a complex tissue composed of several types of cells and a matrix that includes organic (collagen I, proteoglycans and glycoproteins) and inorganic materials (hydroxyapatite, calcium phosphate). The cells involved in bone formation and maintenance include osteoblasts, osteocytes and osteoclasts (1). Immature osteoblasts produce specific proteins alkaline phosphatase, collagen I, osteopontin and etc. (2). By combining different biomaterials, both natural and synthetic, cells and biologically active agents, it could create complex three-dimensional structures that resemble target tissues (3). In our study we prepared 3D printed polycaprolactone materials (PCL) combine with graphene oxide (GO), β- tricalcium phosphate (β-TCP) and hydroxyapatite (HAp) with the final concentration 0.5%. The preparation and biocompatibility of these samples will be discussed.

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Advanced 3D collagen-based scaffolds enriched with vasculogenic compound for enhanced vascularization and wound healing

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Skin serves as a protective barrier for the human body against toxins and microbes in the environment. The presence of biomaterials at a wound site plays a crucial role in influencing the production of the skin's extracellular matrix (ECM). This research focuses on protein-based biomaterials designed to mimic the ECM and regulate biomechanical processes at the cellular level, including cell migration, proliferation, and differentiation. In this study, porous 3D collagen scaffolds were prepared by using the freeze-drying method. To investigate the effect of additives, the scaffolds were modified with chitosan followed by crosslinking using carbodiimide crosslinking agents. Subsequently, varying concentrations of a pro-angiogenic bioactive substance were incorporated into the scaffolds to enhance the production of vascular endothelial growth factor in fibroblast cells and to improve dermal wound healing. Physicochemical characterization of the prepared carriers involved techniques such as scanning electron microscopy to assess morphology and pore size. The release of pro-angiogenic molecules from the scaffolds was monitored through UV-VIS analysis. Furthermore, cytotoxicity assessments were conducted in-vitro using mouse fibroblasts, while neovascularization studies were performed in ovo using chicken embryos. This comprehensive approach not only elucidates the potential of protein-based biomaterials in wound healing but also highlights the importance of tailored scaffold design for promoting effective tissue regeneration.

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Finite Element Analysis and Topology Optimization of Additive Manufactured Orthodontic Twin Brackets for Enhanced Performance and Mass Reduction

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Integrating the advanced computational technique of topology optimization with the precision capabilities of additive manufacturing presents a transformative approach to engineering design, enabling the creation of highly efficient, structurally optimized components that were previously unattainable with traditional manufacturing methods. This study focuses on this approach, specifically investigating the mechanical behavior of orthodontic twin brackets made from five different materials: Aluminum Oxide (Al_2O_3), Ferritic Stainless Steel, AISI Type 316L Stainless Steel, Titanium (Ti-6Al-4V), and Co-Cr alloy. Finite element analysis (FEA) was performed on 3D models of a standard twin bracket design, simulating a torque of 3000 gm-mm (0.0294 N-m) applied by a 0.6 x 0.6-mm archwire. The FEA results indicated that only the Ti-6Al-4V and Co-Cr brackets met the minimum factor of safety requirement (>1) for the applied torque, with safety factors of 1.85 and 1.89, respectively. Topology optimization was then applied to both the Ti-6Al-4V and Co-Cr bracket models to minimize mass, while maintaining a safety factor above 1.25. Both the optimized Ti-6Al-4V and Co-Cr designs, which were subsequently additive manufactured, achieved a 46% mass reduction compared to the original brackets. Although the maximum stress and minimum safety factor decreased in the optimized designs, the values remained more favourable than those of the other three materials evaluated. Both the optimized Ti-6Al-4V and Co-Cr brackets demonstrated promising potential for withstanding the required torque levels with reduced material usage.

Development and Numerical Evaluation of a Topologically Optimized Helmet with Advanced Architected Materials

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Main sports activities have a high probability of causing injury with variable severity, thus in many cases, protective equipment, such as helmets, kneecaps, etc., are required. Of all possible injuries, head injuries are the most crucial as they reveal the most severe cases. Hence, in the last decades, the scientific interest has been focused on establishing head injury criteria and improving the helmet design with the ultimate goal of the reduction of injury probability and increasing the athlete's performance. In this context, the current study aims to develop a lightweight sports helmet with increased safety performance utilizing topology optimization processes and advanced architected materials. In detail, the design of a conventional helmet was developed and modified applying in specific regions advanced architected materials, such as triply periodic minimal surfaces (TPMS) and hybrid structures, with functionally graded configurations to produce sandwich-like structures capable of absorbing mechanical energy from impacts. The developed helmet's designs were numerically evaluated through dynamic finite element analyses (FEA) simulating the helmet's impact on a wall with a specific velocity. Through these analyses, the plastic deformation of the designed helmets was observed coupled with the stress concentration contours. Furthermore, the results of FEAs were utilized in order to calculate the values of the Head Injury Criterion (HIC). Finally, the developed topologically optimized helmet design with the hybrid lattice structure revealed increased energy absorption reaching a HIC of 1618 improved by around 14% compared to the conventional design configuration.

A refractometry sensor for the detection of pathogens in bioreactor samples

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Photonic integrated biosensors, utilizing silicon-nitride waveguides, present high sensitivity and compatibility with large-scale production and integration into optofluidic devices. Furthermore, their implementation of advanced miniaturization and integration techniques not only reduces costs but also enhances the versatility of these systems. In this article, we present a refractometry sensor based on asymmetric Mach Zender interferometers for the detection of pathogens on bioreactor samples. To this aim, a passive photonic chip with 8 aMZI sensors will be presented and used for the multiplex analysis of such analytes, with the use of antibodies as biorecognition elements. Site-selective conjugation strategy is used to ensure that antibodies are attached in a controlled manner, preserving their orientation and bioreactivity. Towards this goal, we have modified silicon nitride (Si3N4) surfaces with epoxy-terminated silane (3-Glycidyloxypropyl)trimethoxysilane (GOPTs). Subsequently, for achieving the maximum recognition capacity of biosensor and guarantee the long-term stability of antibodies, proteins A/G have been used to selectively absorb the Fc region of antibodies thus achieving their immobilization in such a way that leaves their antigen binding region facing upwards. The spotting of the antibody onto the functionalized surfaces was achieved with the use of laser-induced forward transfer (LIFT) technique that aids towards uniform antibody coverage on the sensor surface, improving sensitivity and reliability. Finally, the sensors will be validated with prototype bioreactor samples for the detection of gram-positive and gram-negative bacteria.

Multilayer laser printing of cells with hydrogels.

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The impact of laser on life sciences has been increased significantly in recent years. Specifically, bioprinting is a rapidly expanding additive manufacturing process, which offers a great potential for the fabrication of living tissue by precise printing of cells and biomaterials in a variety of substrates. This technique can imitate native tissue functions, with a great potential in regenerative medicine. Between the main bioprinting techniques, Laser Induced Forward Transfer (LIFT) offers the highest degree of spatial resolution, accurate and controlled deposition of bioinks and post-printing cell viability. In this study, a variety of cell-laden bioinks are printed mixed with different biomaterials, utilizing a Nd:YAG laser source at 532 nm wavelength. All bioinks were characterized using a rheometer-on a-chip. Human and mice derived smooth muscle cells and urothelial cells are deposited in a layer-by-layer manner on top of, or inside scaffolds made from biomaterial called Platelet Lysates methacrylated (PLMA) from Metatissue. A fully covered layer with cells is fabricated by using the proper printing pattern in less than a second. To investigate the transfer dynamics, a high-speed camera has been integrated in the LIFT set-up, enabling the monitoring of the immobilization phenomenon within ECM (this time BME diluted with DMEM was utilized) and for the proper selection of the laser parameters (repetition rate, laser fluence, spot – spot distance). In parallel, the dynamics between laser and bioinks has been examined, to examine the morphological characteristics of the printed jets in relation to the laser parameters. Hence, the morphological characteristics of the cell-laden jets, are examined in detail, during the printing process (i.e jet dimensions and impact velocities). In addition, controlled immobilization of cells in any desired depth inside ECM, was investigated. It has been showed that, as the laser fluence increases, cells are deposited at different depths, reaching almost 3mm. Concerning the multilayer printing with PLMA and cells, the final grafts were successfully constructed, containing both smooth muscle cells and urothelial cells. Proper markers were utilized showing cells expression in them, validating their proliferation and differentiation. This study highlights the unique advantages of LIFT bioprinting to develop highly controlled building structures and paves the way for the fabrication of ex vivo tissues.

Surrogate model for exciton-polariton condensation

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The surrogate model is an engineering technique approximating a desired result using an equivalent mathematical model. It is useful when the system response cannot be easily measured or calculated. In our work, we use a surrogate model to reproduce the Gross-Pitaevskii equation (GPE) results. The GPE is essential for describing exciton-polariton condensates in the mean-field approximation. However, the numerical integration of the GPE can be time-consuming. Therefore, surrogate models can be used as an alternative to sophisticated numerical calculations, thus reducing the computational resources required.Consequently, the development of surrogate models becomes essential, especially for the optimisation of novel photonic devices employing exciton-polariton condensates. Therefore, our theoretical work explores surrogate models based on Fourier Neural Operators (FNOs). Neural operators are well-known in deep machine learning architectures and are used to learn the mapping between different function domains. The advantage of neural operators is that the output function can be evaluated at any discretisation, making the method highly useful. In preliminary research, we have obtained promising results showing that FNO can identify the nonlinearity of exciton-polariton condensation as a function of pump intensity. The application of the FNO surrogate model can accelerate the research on exciton-polariton neuromorphic devices.

Compensating for Errors in a Gas Sensor Array Using Machine Learning and a Custom Laboratory Test System

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Toxic gases, such as NO_x, SO_2 and CO, have known negative effects on human health. Their concentration in urban environments is actively monitored using reference measurement stations which are very precise, but also bulky and expensive. The possibility of using low-cost electronic gas sensors for air quality monitoring is currently being researched. The main drawbacks of these sensors are low sensitivity at low concentrations, cross-sensitivity to other gases and sensitivity to atmospheric conditions, such as relative humidity and temperature. These effects can be compensated by measuring and characterizing the sensor response in various operating conditions. Current research often does this by collocating the sensor with an existing reference measurement station. In this study, an array of cross-sensitive gas sensors for air quality monitoring is assembled, using commercially available electrochemical gas sensors. A custom laboratory test system for gas mixing and conditioning is constructed. This system is then used to measure the sensor array's response to varying gas composition and relative humidity. Measurements are used to characterize the array using statistical methods and methods based on machine learning. Finally, the laboratory test system's usefulness for future research of new gas sensor materials and technology is discussed.

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High Secure Process Automation Framework to Improve Production Quality and Scalability

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Modern manufacturing processes are getting more complex. At commissioning, but also often during operation they may require application specific customized calibration. The different process modules and automation algorithms are delivered by different vendors. Often these vendors may be competitors and the information leak between may seen as a risk and all information is not necessary shared. As a result the process overall performance may suffer. Secondly, while having parallel similar processes, a small (application specific) differences on calibrations and at differently optimized algorithms, will eventually make them all individual. During time, the identical process lines may specialise only to specific applications. This again, limits the scalability of the whole production site.On this poster we present thoughts of: How the process component (vendor) specific calibration data may be separated from process/product data; how different data is assigned safely to their owners; how specific process responsibilities may delegated to 3rd parties (process specialists), how to do this securely and how this may done remotely. As result this opens a business for continuous development of process modules, on-demand process optimization and enables easy way to copy functionalities between parallel processes, and increase the performance and scalability of the production sites.

From CHADA to CHAMEO:

A reference system for characterisation data management

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The CHAMEO (CHaracterisation MEthodology Ontology) has been developed to provide a machine-readable and actionable version of the CHADA (Characterisation Data) template, a common format for documenting materials characterisation experiments. CHAMEO includes all terms and metadata of CHADA in a unified, EMMO-based semantic model that provides context and meaning. CHAMEO has been applied to areas ranging from nanomechanical characterisation (nanoindentation, FIB-DIC) (e.g. of coatings) to partial discharge testing of batteries and has been designed from CHADA concepts gathered from domain experts, encompassing various activities in the characterisation process such as sample preparation, inspection, calibration, measurement, and data analysis. It also details the experiment workflow, laboratory and operator information, sample properties, hardware, and data types (raw, primary, secondary, characterisation properties). CHAMEO's modular approach allows for the development of technique or application-specific ontologies by specialising its constructs. This modularity ensures interoperability across different characterisation techniques. The CHAMEO ontology has achieved a perfect FAIR score, validating its efficacy in creating harmonised, machine-readable documentation for characterisation experiments. CHAMEO stands as a comprehensive reference ontology for materials characterisation, providing curated metadata and harmonised documentation. It fosters a common data space, facilitating queries across various sub-disciplines and contributing to the interoperability and standardisation in materials characterisation. The CHAMEO ontology can be found at:

https://github.com/emmo-repo/domain-characterisation-methodology. This project has received funding from the EU-H2020 under GA No 952869 (NanoMECommons).

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