2024
NANOCON®

ABSTRACTS

16th International Conference on Nanomaterials - Research & Application

October 16 - 18, 2024
Orea Congress Hotel Brno, Czech Republic, EU

Tanger
RCPTM
Regional Centre of Advanced Technologies and Materials
CATRIN
Czech Advanced Technology and Research Institute
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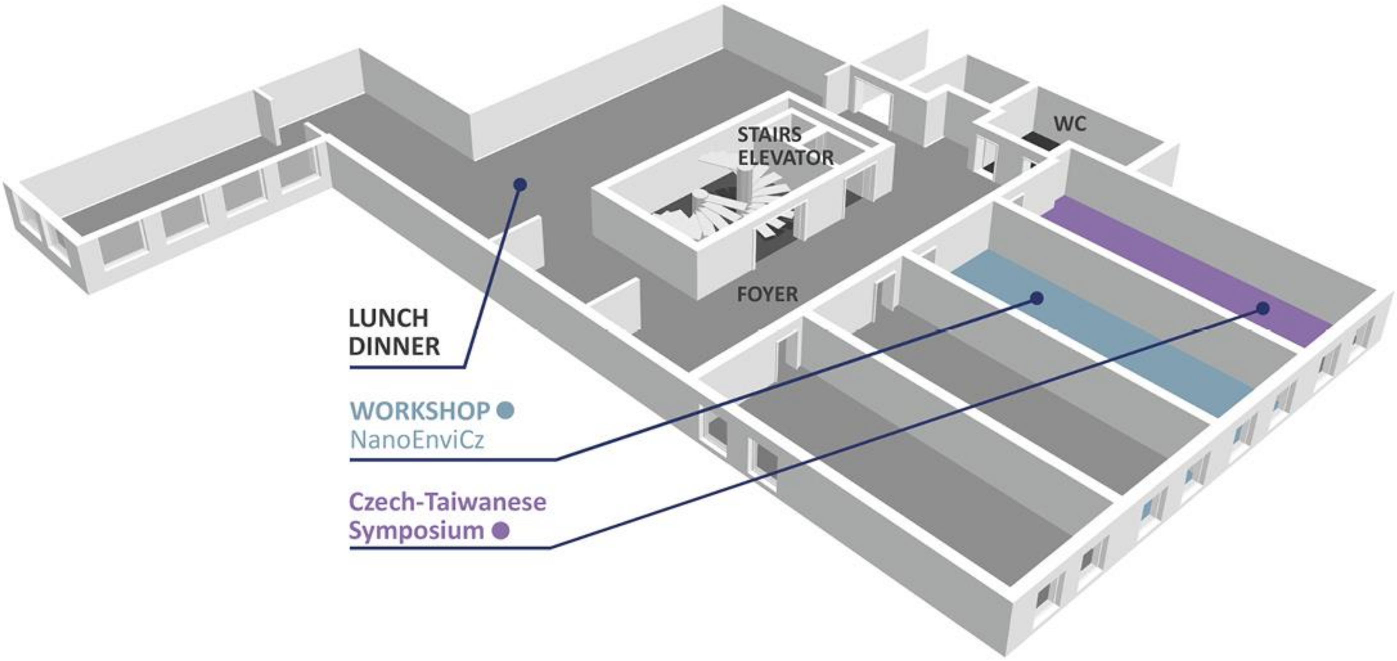
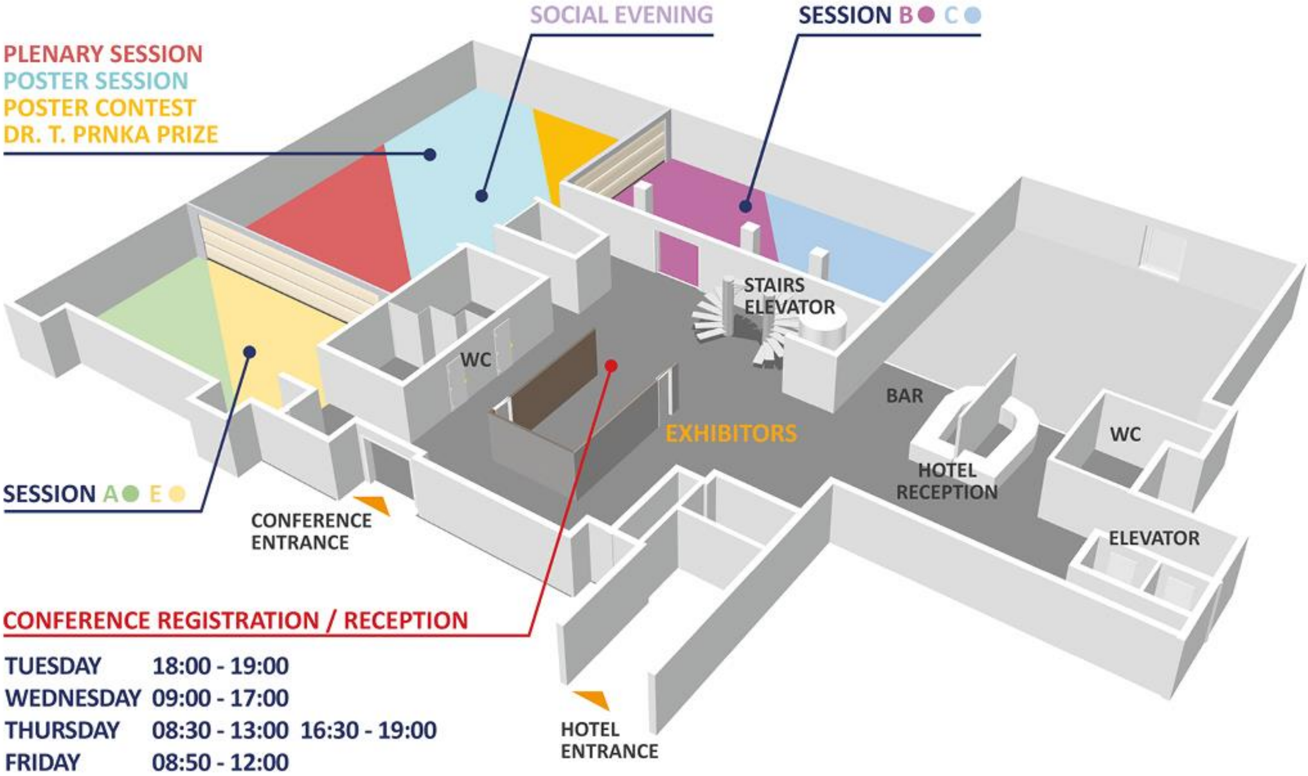
NANOCON

FLOORPLAN

FIRST FLOOR



GROUND FLOOR



TUESDAY	18:00 - 19:00	
WEDNESDAY	09:00 - 17:00	
THURSDAY	08:30 - 13:00	16:30 - 19:00
FRIDAY	08:50 - 12:00	

TANGER Ltd.

The Czech Society for New Materials and Technologies
CATRIN - Regional Centre of Advanced Technologies and Materials

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NANOCON 2024 - Abstracts
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Welcome from the Chairlady

For the sixteenth time it is my great pleasure to welcome you on behalf of the organizing and program committees to the NANOCON 2024 international scientific conference focused on fascinating world of nanomaterials and nanotechnologies and on its limitless possibilities. This year marks **65 years** since the American physicist and Nobel Prize laureate **Richard Feynman introduce the concept of nanotechnology** in his famous lecture entitled “There’s Plenty of Room at the Bottom”. Since that time nanoscience breakthroughs in almost every field of science and nanotechnologies make our life easier.

Nanotechnologies contribute to almost every field of science, including physics, materials science, chemistry, biology, computer science, and engineering. In only a few decades, **nanotechnology and nanoscience have become of fundamental importance to industrial applications and medicine**. Targeted drug delivery systems using nanoparticles improve the precision and effectiveness of cancer treatments. Nanoscale imaging agents enable earlier and more accurate disease diagnosis. Nanomaterials are being used to build a new generation of solar cells or hydrogen storage systems capable of delivering clean energy. New materials, like 2D materials, are successfully used for electronic components, nanocatalysts for efficient pollution control and wastewater treatment, nanomaterial-based filtration systems for water purification. We can admire novel nanocomposites with enhanced properties, such as increased strength and conductivity, or a huge progress in the development of nanoscale robots capable of performing tasks at the molecular level…

Also, this year the NANOCON provides the opportunity to present advances in target-oriented nanotechnology research. The opening **plenary talk** of Professor Iván Morá-Seró from the Institute of Advanced Materials (INAM), University Jaume I (Spain) will outline amazing properties of halide perovskite nanoparticles, which revolutionized the photovoltaic field in the last decade. Professor Bengt Fadeel from the Karolinska Institutet (Sweden) in his plenary talk will turn our attention to the potential hazards of engineered nanomaterials for human health.

I hope that more than **70 next lectures and 110 posters** dedicated to preparation of nanoparticles, characterization of their properties, applications of nanomaterials and nanotechnologies in various industries and sectors, will attract your attention. You are invited also to the **Czech-Taiwanese Symposium** on Thursday afternoon (17/10, 2-5 p.m.), where research directions and results of mutual collaboration will be presented. And I believe that you will also be interested in the **offer of scientific technologies, equipment or nanomaterials** to be presented in the conference stands by several companies.

On behalf of the organisers – the conference company Tanger, the Czech Society for New Materials and Technology and the Czech Advanced Technology and Research Institute (CATRIN) and its Regional Centre of Advanced Technologies and Materials (RCPTM) at the Palacky University Olomouc – I wish you pleasant time spent at the NANOCON´24 enriching you by new knowledge and contacts and inspiring you to new discoveries.

Sincerely,

Jiřina Shrbená Váňová

Chairlady of the Program Committee of NANOCON´24

Time	TUESDAY, Oct 15	WEDNESDAY, October 16	THURSDAY, October 17	FRIDAY, October 18
8:00			REGISTRATION 8:30 - 13:00, 16:30 - 19:00	REGISTRATION 8:50 - 12:00
9:00		REGISTRATION 9:00 - 17:00	**A** (9:00 - 10:45) **B** (9:00 - 10:45)	**E** (9:00 - 10:30) **B** (9:00 - 10:30)
10:00		**CONFERENCE OPENING** **PLENARY SESSION** (10:30 - 12:00)	COFFEE BREAK 10:45 - 11:15	COFFEE BREAK 10:30 - 10:50 **E** (10:50 - 12:20)
11:00			**E** (11:15 - 12:45) **B** (11:15 - 13:00)	
12:00		LUNCH 11:30 - 13:30		**CONFERENCE FINAL CEREMONY** **Best Lecture Award (12:20)**
13:00		**A** (13:00 - 14:45) **C** (13:00 - 14:45)	LUNCH 12:00 - 14:00	LUNCH 12:00 - 13:30
14:00		COFFEE BREAK 14:45 - 15:05	**Czech-Taiwanese Symposium** (First floor) (14:00 - 17:00) **WORKSHOP NanoEnviCz** (First floor) (14:00 - 16:00)	
15:00		**A** (15:05 - 16:35) **C** (15:05 - 16:35)		
16:00		COFFEE BREAK 16:35 - 16:55	COFFEE BREAK 16:30 - 17:00	
17:00		**A** (16:55 - 18:25) **C** (16:55 - 17:55)	**POSTER SESSION** (17:00 - 19:00)	
18:00	REGISTRATION 18:00 - 19:00			
19:00		BREAK	**BEST POSTER CONTEST (19:00)**	
20:00		SOCIAL EVENING - hotel restaurant 20:00 - 23:00	DINNER 19:00 - 22:00	

CONTENT

PLENARY SESSION

SESSION A - E

SESSION A - NANOMATERIALS FOR ELECTRONIC, MAGNETIC AND OPTIC APPLICATIONS. CARBON NANOSTRUCTURES, QUANTUM DOTS

Preparation Of Nanomaterials/2D Materials

Preparation of Nanomaterials/Physics of Surfaces

Preparation of Nanomaterials/Nanoenergy/Nanosensing

Preparation of Nanomaterials/Nanoelectronics/Nanoalloys

SESSION B - INDUSTRIAL AND ENVIRONMENTAL APPLICATIONS OF NANOMATERIALS

Industrial Applications/Catalysis

Environmental Applications

Industrial Applications

SESSION C - BIONANOTECHNOLOGY, NANOMATERIALS IN MEDICINE

Bio Applications/Nanomedicine

Bio Applications/Biosensing

Bio Aplications/Nanotoxicity/Nanosafety

SESSION E - ADVANCED METHODS OF PREPARATION AND CHARACTERIZATION OF NANOMATERIALS

Nanocharacterization - Metrology

Nanocharacterization - Technics

Standardization/Nanocharacterization - Techniques

WORKSHOP NANOENVICZ

CZECH-TAIWANESE SYMPOSIUM

POSTER SESSION (A - E)

POSTER SESSION A

Nanocomposites

Nanoelectronics

2D Nanostructures

Films/Layers

Magnetic, Metal and Oxidic Nanomaterials & Other Nanostructures

POSTER SESSION B

Industrial Applications - Nanofibres, Thin Films, Layers, Catalysis

Industrial Applications - in Construction, Energy Production, in Consumer and Other Industries

Environmental Applications

POSTER SESSION C

Nanomedicine: Diagnostics and Therapy

Nanomedicine: Diagnostics and Therapy/Drug Delivery Systems

Nanomedicine: Biosensing

Nanomedicine: Tissue Engineering and Implants

Microbiology and Others

POSTER SESSION D

Health, Toxicity, Environmental Challenges, Safety

POSTER SESSION E

Advanced Methods of Preparation and Characterization of Nanomaterials

Advanced Methods of Preparation and Characterization of Nanomaterials: Films/Nanolayeres

Advanced Methods of Preparation and Characterization of Nanomaterials: Membranes/Nanofibres/Nanocomposites

Metrology/Progress in STM/AFM Applications

PLENARY SESSION

Chairman, Chairlady

Prof. Dr. Radek ZBORIL	Palacký University in Olomouc, CATRIN-RCPTM, Czech Republic, EU
M.Sc. Jirina SHRBENA	Inova Pro Ltd., Prague, Czech Republic, EU

MORA-SERÓ Iván ***Universitat Jaume I, Castelló, Spain, EU***

***** INVITED LECTURE *****

Halide Perovskite Nanoparticles for Optoelectronic and Photocatalytic Applications **PS1**

Halide perovskite solar cells have revolutionized the photovoltaic field in the last decade, due to their outstanding optoelectronic properties, causing that currently the research with these materials widespread to different optoelectronic and photocatalytic fields. The great success of halide perovskites boosted also the interest on perovskite nanoparticles (PNPs). PNPs are also generating a huge interest as relative easy preparation methods yield to photoluminescence quantum yield (PLQY) close to unity. Here we show the application of PNPs on light emitting diodes (LEDs), providing narrow electroluminescence (EL) peak, purer colors, and versatility to tune the emitting color. In this talk, I discuss different strategies to increase the performance, considering both the external quantum efficiency (EQE) and stability), but also the reproducibility. After an intensive work in perovskite LEDs field, it has been a huge improvement in the performance of these devices, however, the two main drawbacks of this system, the use of hazardous Pb and the long term stability, still to be open questions that have not been fully addressed. In addition, in this talk we will show the application of inorganic perovskite NP in the photocatalytic and photoelectrochemical degradation of Organic compounds, highlighting the potentiality to drive both oxidation and reduction reactions. However, their use in most of the practical applications is limited due to the instability of the perovskite nanocrystals in polar environments. We will also discuss about the preparation of non-encapsulated CsPbX3 nanocrystals dispersed in fully alcohol environments, with outstanding stability through surface defect passivation strategy.

FADEEL Bengt ***Karolinska Institutet, Institute of Environmental Medicine, Stockholm, Sweden, EU***

***** INVITED LECTURE *****

Nanotoxicology: the Potential Hazards of Engineered Nanomaterials for Human Health **PS2**

Engineered nanomaterials interface and interact with biological systems and this could be harnessed for biomedical applications such as drug delivery or imaging. On the other hand, nanomaterials may also cause unexpected or unwanted effects on human health. The present lecture will provide an overview of studies on the potential hazards of engineered nanomaterials with emphasis on the effects on the immune system. We will focus, in particular, on recent work on two-dimensional (2D) materials including graphene-based materials, transition metal dichalcogenides, and transition metal carbides and nitrides (MXenes). We will discuss the activation of the inflammasome, a multiprotein complex that serves as a key sentinel of the immune system. We will also address the biodegradation and/or biotransformation of 2D materials in living systems, and related studies on carbon nanotubes will be highlighted. Overall, a better understanding of the biological interactions of 2D materials and other nanomaterials will aid in the prediction of potential toxicities and may enable the prevention of adverse effects of nanomaterials on human health through the promotion of safe-by-design approaches. Further reading: Fadeel B, Keller AA. Nanosafety: a perspective on nano-bio interactions. Small. 2024 Apr 10. doi: 10.1002/smll.202310540. [Epub ahead of print]; Fadeel B, Kostarelos K. Grouping all carbon nanotubes into a single substance category is scientifically unjustified. Nat Nanotechnol. 2020;15(3):164; Peng G, Fadeel B. Understanding the bidirectional interactions between two-dimensional materials, microorganisms, and the immune system. Adv Drug Deliv Rev. 2022;188:114422.

SESSION A - E

SESSION A

NANOMATERIALS FOR ELECTRONIC, MAGNETIC AND OPTIC APPLICATIONS. CARBON NANOSTRUCTURES, QUANTUM DOTS

Chairmen

Prof. Dr. Eduard HULICIUS	Institute of Physics of the CAS, Czech Republic, EU
Assoc. Prof. Dr. Martin KALBAC	J. Heyrovsky Institute of Physical Chemistry of the CAS, Czech Republic, EU

Preparation of Nanomaterials/2D Materials

STRATAKIS Emmanuel ***Foundation for Research & Technology Hellas, IESL, Heraklion, Greece, EU***

***** INVITED LECTURE *****

Pulsed Laser Assisted Generation of 2D Materials and Diagnostics A1

This presentation will focus on the application of advanced ultrafast laser-based techniques for the synthesis and diagnostics of 2D materials and their nanoelectronic device components. Specifically, the pulsed laser assisted fabrication of transparent graphene electrodes and interlayers for photovoltaic devices, is demonstrated. Furthermore, we present a fast, non-destructive and roll-to-roll compatible photochemical method for the doping of graphene and transition metal dichalcogenide (TMD) crystals. In the second part, we present an all-optical, non-invasive ultrafast laser-scanning microscopy method to resolve the crystallographic imperfections of atomically thin TMD nanocrystals, via experimentally probing and theoretically interpreting their nonlinear optical properties. In particular, we show that polarization resolved second harmonic generation (PSHG) imaging reveals with high-precision a pixel-by-pixel mapping of the armchair orientations on a CVD-grown TMD sample. This allows us to measure the mean orientational average of armchair angle distributions from specific regions of interest and consequently to define the standard deviation of these distributions as a crystal quality factor. Furthermore, the same method can be used to optically identify the twist angle in stacked layers of different armchair orientation. We envisage our methodology as a new tool for the discovery of new phenomena in twisted 2D layers employed in the future nanoelectronic devices.

SLANÝ Jan ***VSB - Technical University Ostrava, Ostrava, Czech Republic, EU***

Use of Carbon Nanostructures for Sensor Preparation **A2**

Graphene oxide is a carbonaceous material that has unique physicochemical properties (specific surface area, pollution resistance, conductivity, high mechanical strength) and can be produced in large quantities with relative ease. It is a material formed by the oxidation of graphene, which can be further modified with, for example, ascorbic acid to form reduced graphene oxide (rGO), or with hydrogen peroxide to form holey graphene oxide (HGO). The application of graphene oxide and its modifications in processes leads to improved sensitivity, electrocatalytic behaviour and reduced fouling. Thus, a kampron, which is an electronic component with graphene oxide derivatives fabricated using 3D printing technology, has been experimentally prepared with the advantage of applications in various fields - physical, chemical and biological. Graphene oxide in the form of filaments will be used for 3D printing. Thus, in several stages, the action in the physical domain (pressure), chemical domain (gases and vapours) and biological domain (gases exhaled from the lungs) will be investigated. The changes caused by the investigated influences on the sensors are reflected by a change in the voltage on the sensor. This paper focuses on the first stage of the research, i.e. the fabrication and verification of reactivity of sensors printed in a single layer, which are similar to conventional comb or spiral sensors. The next stages of the research will focus on the investigation of sensors arranged in multiple layers, with the final stage involving the preparation of sensors with complex spatial shapes, while higher sensitivity is also expected.

Co-authors: ***HÖLZEL Jaroslav, KLOUDA Karel, ROUPCOVÁ Petra***

MUKHERJEE Aniket ***CEITEC, Brno University of Technology, Brno, Czech Republic, EU***

Discovering Fluorescent Carbon Nanoparticles Present in Amine Plasma Polymer Films **A3**

Amine plasma polymer (PP) films are thin coatings created through the plasma polymerization of amine-containing monomers or from the mixture of nitrogen-containing and hydrocarbon gases. They can be prepared under various plasma conditions with varying nitrogen content, functional groups, and cross-linking. They have shown potential applications in biomolecule immobilization for biosensors or improved cell viability in tissue engineering. Previously, we have investigated the bioapplication of such films deposited from a mixture of cyclopropylamine and argon in a low-pressure (50 Pa) radio frequency plasma discharge. Generally, amine PPs are considered amorphous, but our recent discovery revealed that they might contain crystalline domains. We proved it for the film deposited at 30 W in the pulsed mode because of its partial solubility in water (around 18% of the film thickness was reduced after immersion in water for 216 hrs) that enabled the extraction of the crystalline particles from the film. The extract contained particles with a 5-15 nm diameter determined by dynamic light scattering and atomic force microscopy. High-resolution transmission electron microscopy proved that the nanoparticles are graphitic. The fluorescence spectra of these particles revealed excitation-dependent emission for excitation wavelengths from 300 to 500 nm. When the human monocyte cells (THP 1) were cultivated on the partially soluble amine PP film, they had a higher fluorescence signal than the corresponding control plates of THP 1. Thus, we concluded that the cells uptake the particles.

Co-authors: ***JANU Lucie, PEREZ GOMEZ Jennifer. I, BARTOSIKOVA Jana, MEDALOVA Jirina, PIZUROVA Nada, NECAS David, ZAJICKOVA Lenka***

Collaboration: ***Faculty of science, Masaryk University, Brno, Czech Republic, EU***

OKHAY Olena ***University of Aveiro, TEMA, Aveiro, Portugal, EU***

Graphene-Based Electrodes Made by Different Methods for Supercapacitor Applications **A4**

In people's daily life, energy storage is one of the most important topics of scientific research today [1] due to the use of small-size batteries in watches, phones, computers, and large supercapacitors / batteries in cars, etc. Reduced graphene oxide (rGO) is a promising material for improving the structural and electrochemical properties of capacitive electrodes of energy storage devices [2]. In addition, the rGO aerogel, which is lightweight and can exhibit a large surface area, is a more promising material for energy storage compared to the dense rGO membranes obtained by vacuum filtration. At the same time, the process of preparing rGO, as well as composite materials based on rGO, plays a significant role in the final characteristics of the material and the device. Dense free-standing rGO electrodes obtained by vacuum filtration are compared with composite electrodes made from rGO powder or aerorgel on a different substrate. ACKNOWLEDGEMENT: O.O. thanks for support the projects PTDC/EME-REN/1497/2021 “Power Phoenix Battery - A Full Solid State Grid-scale Storage Solution”; UIDB/00481/2020 and UIDP/00481/2020 - Fundaç~ao para a Ci^encia e a Tecnologia, DOI 10.54499/UIDB/00481/2020 (https://doi.org/10.54499/UIDB/00481/2020) and DOI 10.54499/UIDP/00481/2020 (https://doi.org/10.54499/UIDP/00481/2020); CENTRO-01-0145-FEDER-022083 - Centro Portugal Regional Operational Programme (Centro2020), under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund. REFERENCES: [1] J. Mitali, S. Dhinakaran, A.A. Mohamad, Energy Storage and Saving, 1, 166-216, (2022); [2] S.M. Mousavi, S. A. Hashemi, M.Y. Kalashgrani, A.Gholami, M. Binazadeh, W.-H. Chiang, M.M. Rahman, Sustainable Energy Fuels, 7, 5176-5197 (2023)

Co-authors: ***YANG Tao, TKACH Alexander***

Collaboration: ***LASI - Intelligent Systems Associate Laboratory, Guimaraes, Portugal, EU; CICECO - Aveiro Institute of Materials, Department of Materials and Ceramic Engineering, University of Aveiro, Aveiro, Portugal, EU***

KYLIÁN Ondřej *Charles University, Prague, Czech Republic, EU*

Plasma Polymer Nanoparticles Produced by a Gas Aggregation Source A5

Plasma polymers, i.e., macromolecular solids created during a passage of molecular fragments or precursors through a plasma, represent a unique class of materials with a broad range of applications. Although these materials are traditionally prepared in the form of thin films, our recent studies proved the possibility of producing also plasma polymer nanoparticles. This may be achieved using gas aggregation sources based on a magnetron sputtering of a polymeric target. In these sources, plasma polymer nanoparticles are formed due to the spontaneous gas-phase nucleation of sputtered molecular fragments in the aggregation chamber at increased pressure (~ 100 Pa). As reviewed in this study, this approach is applicable to produce various types of plasma polymer nanoparticles with tailor-made sizes, shapes or chemical compositions by variation of the deposition conditions (i.e., target material, working gas composition, aggregation pressure, applied power, etc.). However, a new phenomenon unique to nanoparticle deposition must also be accounted for: the re-bouncing of nanoparticles from a substrate caused by their relatively high speed upon landing on a substrate and their mechanical properties. As shown, this adverse effect may be overcome either by the adjustment of the pressure in the deposition chamber or by the use of a suitable structured substrate. ACKNOWLEDGEMENTS: This work was supported by grant 24-12197S from the Czech Science Foundation.

Co-authors: **ŠKORVÁNKOVÁ Kateřina, SOLAŘ Pavel**

BOAHENE Stephen *Czech Technical University in Prague, Prague, Czech Republic, EU*

Novel Acid-Assisted Polymerization Technique for Synthesis of Polyaniline Films at Room Temperature: Morphological Study and Supercapacitor Applications A6

This study presents a novel technique for polymerizing aniline (monomer) to form Polyaniline (PANI) films. PANI films were prepared via acid-assisted polymerization with concentrated formic acid in the presence of ethanol and ammonium peroxydisulfate (APS) at room temperature. Using this method, two PANI films were prepared with different APS ratios (10:1 for PANI 1 and 5:1 for PANI 2). After the synthesis, PANI was deposited on glassy carbon (GC) electrode to form PANI/GC heterostructures. We investigated the morphologies of the PANI films using SEM measurements, which revealed distinct structures: a nanofibrillar porous structure for PANI 1 and a densely packed arrangement for PANI 2. The electrochemical performance of the fabricated PANI/GC electrodes was evaluated using a three-electrode cell configuration in the scan rates ranging from 10 mV/s to 100 mV/s. Data analysis indicates that the morphology of the PANI structure significantly influenced the oxidation/reduction characteristics, which were modulated with GC characteristics. The PANI 1 /GC heterostructure exhibited a specific capacitance of 160 F/g, while this value increased to 407 for the PANI 2/GC. This study highlights the role of PANI structure and conductive support, providing valuable insights for the development of advanced energy storage materials.

Co-authors: ***AUBRECHTOVÁ DRAGOUNOVÁ Kateřina, POTOCKÝ Štěpán, TOMŠÍK Elena, KROMKA Alexander***

Collaboration: ***Institute of Physics of the CAS, Prague, Czech Republic, EU; Institute of Macromolecular Chemistry of the CAS, Prague, Czech Republic, EU***

Preparation of Nanomaterials/Physics of Surfaces

FRIÁK Martin ***Institute of Physics of Materials of the CAS, Brno, Czech Republic, EU***

Quantum-mechanical Study of the Impact of Thermal Vibrations on the Stability of the FeSn2 Intermetallics A7

We have performed a combined theoretical and experimental study of FeSn2 intermetallics. We were motivated by a scarcity of published data as well as previous theoretical calculations of the antiferromagnetic (AFM) state of FeSn2, when this compound was found mechanically unstable due to imaginary-frequency phonons, i.e., effectively denying the existence of FeSn2. Addressing both mechanical and thermodynamic stability within density-functional theory (DFT) calculations, we focused on the AFM state as well as the ferromagnetic (FM) state of FeSn2, which were both considered in earlier experiments. In contrast to the previous calculations, we found the AFM FeSn2 state mechanically stable (no imaginary-frequency phonons). The same is true for the FM state, which possesses a slightly higher energy than the AFM state. The mechanical stability allowed for assessing the thermodynamic properties within both harmonic approximations as well as computationally much more demanding quasi-harmonic approximation. Interestingly, while the static-lattice formation energy of AFM FeSn2 is negative and, therefore, the compound is predicted stable with respect to the decomposition into elemental end-members, phonon-related contributions have a destabilizing impact at low temperatures. Our calculations were complemented by experimental characterization of Fe-Sn samples and the experimental FeSn2 lattice parameters were found in excellent agreement with theoretical values. ACKNOWLEDGEMENTS: M.F., P.Č., P.R., O.S., D.F., Š.M. and A.M. acknowledge the Czech Science Foundation for the financial support received under Project No. 22-05801S. We also acknowledge computational resources provided by the Ministry of Education, Youth and Sports of the Czech Republic under the Projects e-INFRA CZ (ID:90254) at the IT4Innovations National Supercomputing Center and e-Infrastruktura CZ (e-INFRA LM2018140) at the MetaCentrum as well as CERIT Scientific Cloud, all provided within the program Projects of Large Research, Development and Innovations Infrastructures.

Co-authors: ***ČÍPEK Petr[1,2], ROUPCOVÁ Pavla[1], SCHNEEWEISS Oldřich[1], PAVLŮ Jana[2], FINK Dominika[3], MSALLAMOVÁ Šárka[3], MICHALCOVÁ Alena[3]***

Collaboration: ***[2]Department of Chemistry, Faculty of Science, Masaryk University, Brno, Czech Republic, EU; [3]Department of Metals and Corrosion Engineering, University of Chemistry and Technology in Prague, Czech Republic, EU***

PINCHUK Nataliia ***Karlstad University, Karlstad, Sweden, EU***

Influence of Al Content on Crystal Structure and Morphology of PVD Coatings Ti1-xAlxN A8

Ternary nitride coatings ($Ti_{1-x}Al_xN$) were synthesized by varying the aluminum content, and their crystal structures and morphologies were analyzed. The $Ti_{1-x}Al_xN$ coatings were deposited on cemented carbide substrates under pulsed bias conditions of -30 V, -60 V, and - 300 V (duty cycle 10%) with different compositions. Additionally, a series of samples were deposited with a -300 V pulsed bias, but with a duty cycle of 20%. The chamber pressure was at 4.5 Pa (N_2) for all samples. XRD analysis showed that the crystal structure of $Ti_{1-x}Al_xN$ coatings transitioned from a NaCl-type (cubic structure; c-) to a wurtzite-type (hexagonal structure; h-) as the aluminum content increased to X=0.6-0.7. All coatings have a columnar structure. The pulsed bias resulted in a rough surface. The profilometer measurements showed an increase in surface roughness (Sa) from 0.16 µm to approximately 0.26 µm as the aluminum content increased, likely due to 3D growth as columnar grains reached the coating surface. However, increasing the duty cycle to 20% reduced the roughness (Sa ≈ 0.15-0.16 µm), and this roughness remained nearly constant with increasing Al content.

Co-authors: ***ANDERSSON Jon, JOHANSSON-JÖESAAR Mats, M'SAOUBI Rachid, NILSSON Mikael, KRAKHMALEV Pavel***

ABBAS Ghulam ***Czech Technical University in Prague, Prague, Czech Republic, EU***

Effect of oleic-ligands on Electronic Interaction of CsPbBr3 Nanocrystals with ZnO Surface Facettes: Computational Study **A9**

Scintillators transform high-energy ionizing radiation into the easily detected photons. Semiconductor CsPbBr3-like (CPB) aggregates with narrow bandgap (about 2.5 eV) possess very fast (hundreds of picoseconds) and strong free exciton luminescence (green at the nanoscale). CPB grown on ZnO microrods showed improved photoluminescence by an order of magnitude. Calculations by density functional theory (DFT) methods could be used to understand and predict the properties of the CPB nanocrystals on ZnO surfaces. Thus, in this study the behavior of the CPB nanocrystals on the surface of ZnO, considering polar and non-polar surfaces was investigated by DFT methods. We designed model of nanoscale slabs of ZnO and CPB clusters with oleic ligands (OA, OAm) of 155 atoms in overall size. We employed force field molecular dynamics (FFMD) and density functional tight binding simulations (DFTB). The results of polar surfaces (Zn-face ([0001] or O-face $[000\bar{1}]$) surfaces and non-polar surfaces ($(10\bar{1}0)$ and $(11\bar{2}0)$ oriented) were compared. We observed that interparticle charge transfer barrier exists due to the steric hindrance when the CPB are furnished with unoptimized surfaces or ligands configurations, leading to inefficient interparticle energy transfer and limited photocatalytic performance. We show that properly designed ligands enable the exciton wave function to extend into the interfacial region, leading to a significant electron density redistribution at the ligand-CPB interface. Influence of specific properties of particular ZnO surface facettes is also presented and discussed.

Co-authors: ***UKRAINTSEV Egor, REZEK Bohuslav***

STEHLÍK Štěpán ***Institute of Physics of the CAS, Prague, Czech Republic, EU***

Exploring the Interplay between Zeta Potential and Surface Characteristics of Hydrogenated Diamond Surfaces **A10**

The zeta potential of a surface is an important property that determines the electrostatic interactions between a material surface and the surrounding environment. A distinctive and incompletely understood phenomenon is the positive zeta potential observed when hydrogenated diamond nanoparticles (nanodiamonds; NDs) are introduced to water. In contrast, the zeta potential of the hydrogenated single-crystalline diamond surface was reported to be negative at close-to-neutral pH [1]. The Kelvin probe is used to measure surface potential, which provides another important surface characteristic related to the work function of a material. A more profound comprehension of the interrelationship between zeta and surface potentials may bring a more complete understanding of material surface properties. The present study investigates and compares the zeta and surface potentials of hydrogenated diamond surfaces with a different topology, nanoparticles and nanocrystalline diamond (NCD) layers. The hydrogenated detonation NDs were obtained by annealing in the hydrogen gas at 500-1000°C. The NCD layers were grown on silicon substrates via plasma-enhanced chemical vapor deposition and subsequently exposed to hydrogen or oxygen plasma to ensure hydrogen or oxygen surface terminations, respectively. The results demonstrate that the NDs zeta potential, determined by the electrophoretic light scattering technique, is consistently positive across the entire hydrogenation temperature range. Furthermore, a strong correlation is observed between the zeta and surface potential, as measured by the Kelvin probe. In contrast, the zeta potential of hydrogenated NCD layers, measured by the streaming potential technique, was negative in the slightly acidic to basic pH ranges with an isoelectric point below pH = 3 and its correlation with the Kelvin probe was less obvious. Finally, we discuss possible material and methodological factors that could contribute to the observed discrepancies in zeta potential, such as sp2 carbon or structural defects, and propose new approaches to understand these phenomena better. REFERENCES: [1] A. Härtl, J.A. Garrido, S. Nowy, R. Zimmermann, C. Werner, D. Horinek, R. Netz, M. Stutzmann, The Ion Sensitivity of Surface Conductive Single Crystalline Diamond, J. Am. Chem. Soc. 129 (2007) 1287-1292. https://doi.org/10.1021/ja066543b.

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Collaboration: ***DataPhysics Instruments GmbH, Filderstadt, Germany, EU***

HOUEL Julien ***Université Claude Bernard Lyon 1, Lyon, France, EU***

Spectroscopy of Single CdSe/CdZnS Quantum Dots in Tunable-Bandgap MAPbX3 (X=Cl, Br) Thin-Films at T = 4K **A11**

We have developed CdSe/CdZnS colloidal quantum dots (QDs) within perovskite (MAPbX3 (X=Cl, Br)) thin film matrices using a soft-chemistry method [1,2]. At room temperature (300 K), we successfully demonstrated single-photon emission from a single CdSe/CdZnS QD-in-perovskite hybrid through antibunching measurements, confirming that the quantum yield remained largely unaffected by the soft-chemistry process. At cryogenic temperatures (4 K), we identified two spatially-dependent emission mechanisms (down to the micrometer scale) within the MAPbBr3 matrix: direct excitonic recombination and long-lived shallow trap emission, following a truncated 2D Förster resonant transfer model [3]. After a halide exchange process (replacing Br with Cl) on MAPbBr3 thin films doped with CdSe/CdZnS QDs, we obtained QDs within MAPbClxBr3-x tunable bandgap materials. At 4 K, we could optically address single QDs, achieving state-of-the-art narrow emission linewidths and deterministic single charge control of individual QDs in MAPbCl3 matrices through an optical gate. These findings pave the way for the development of QD-in-perovskite field-effect devices for single-photon applications, based on soft chemistry processes with CdSe/CdZnS colloidal QDs. REFERENCES: [1] J. Baronnier et. al., Nanoscale 14, 5769-5781 (2022); [2] J. Baronnier et. al., Phys. Chem. Chem. Phys. 23, 22750-22759 (2021); [3] J. Baronnier et al., Nanomaterials 13, 2376 (2023).

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Experimental Simulation of Changes in Nanomaterial Optoelectronic Properties - the Case of MoOX Polyoxomolybdate Clusters **A12**

Non-stoichiometric molybdenum oxides emerged as potent tools in optoelectronics, providing tunable optical properties and energy-conversion capabilities at very favorable cost. In our previous work, we reported the possibility to control the optoelectronic properties by changing temperature during an original short microwave-assisted synthesis. The changes in optical properties were not caused by varying size or shape of produced nanoparticles, but through modulation of their chemical structure confirmed by Fourier-transform infrared spectroscopy. We understand this process as defect engineering of oxygen vacancies in MoOX structure. In this work, it is further explored by energy-resolved electrochemical impedance spectroscopy (ER-EIS), by means of UV-vis-NIR and imaging confocal Raman spectroscopy complemented by X-ray photoelectron spectroscopy (XPS). We observed changes in density of electronic states by applying ER-EIS and prove subsequent modification of optical properties during the process. The optical and Raman response is compared to different MoOX clusters prepared by either microwave-assisted synthesis or previously reported liquid-phase exfoliation method. Our results highlight the potential in preparation of tailored MoOX structures with desired optical response but also point out a possibly adverse phenomena which could interfere with the optoelectronical performance of such a device. This knowledge contributes to development of new polyoxomolybdate-based materials in various applications including photothermal therapy, microelectronics or energy conversion and storage. ACKNOWLEDGEMENT: This work was supported by the Slovak Research and Development Agency contract No. APVV-20-0485, SK-FR-22-0012 and by the Slovak Grant Agency for Science under contract No. VEGA 2/0117/22.

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Preparation of Nanomaterials/Nanoenergy/Nanosensing

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***** COMMERCIAL PRESENTATION *****

Towards High-speed 3D Nanofabrication A13

Two-Photon Lithography (TPL) represents one of the most promising nanofabrication technologies for manufacturing highly precise and complex three-dimensional objects. Although TPL offers significant potential in both laboratory and industrial applications, achieving a substantial increase in writing speed while maintaining high accuracy still remains challenging. In this context, an advanced TPL platform is presented, utilizing a combination of an inertia-free acousto-optic scanner (AOD) and a flying stage to significantly accelerate the writing process. With our approach, utilizing the AOD system, we demonstrate the possibility of achieving very high fabrication speeds on the order of several 10^6 voxels/s while maintaining high resolution. To validate our AOD-enabled TPL system, we present examples of printing on several objects from the fields of micro-optics, mechanical metamaterials, and bioscaffolds that confirm achieved writing speed and resolution. The presented results show that our method provides a promising solution for high-speed 3D nanofabrication across various application areas and beyond laboratory use.

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BURYI Maksym ***Institute of Plasma Physics of the CAS, Prague, Czech Republic, EU***

Influence of Er Doping Level and Post-Growth Treatment on Luminescence Properties of ZnO Nano- and Microrods A14

The popularity of the nanosystems containing zinc oxide (ZnO) is rapidly raising. Therefore, ZnO-based nanostructures appear on top of the world-wide R&D. In particular, wide bandgap reaching value of about 3.3-3.5 eV, high exciton binding energy of about 60 meV and fast timing of luminescence (decay time is ~400-500 ps in the case of excitonic emission) make it attractive for the time-of-flight (TOF) applications like TOF positron emission tomography, especially in combination with other materials such as $CsPbBr_3$. Another scientific and industrial branch where ZnO and/or $CsPbBr_3$ can find use is renewable sources of energy like solar cells. It is known that luminescence as well as charge carriers transport can be moderated by doping with different ions and/or post-growth treatment including annealing in different atmospheres and exposure to plasma. Doping with erbium, annealing in air and separate hydrogen plasma treatment are the efficient tools for the ZnO properties moderation. However, there is lack of information about simultaneous doping with Er at higher concentrations (1-30%) and hydrogen plasma treatment, especially when combined with the preceding annealing in air. Therefore, the aim of the current work is to address these important points in order to improve the efficiency of luminescence processes inside ZnO nano- and microrod. ACKNOWLEDGEMENTS: The financial support of the Czech Science Foundation project No. 24-12872S and the program “Strategy AV 21” of the Czech Academy of Sciences, specifically work package VP 27 Sustainable Energy (Renewable energy resources and distributed energy systems) are gratefully acknowledged.

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TURCSÁNYI Árpád

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Utilization of Protein-Stabilized Bimetallic Nanoclusters for the Detection of Kynurenine Pathway Molecules

A15

In recent years, there is a growing interest in the rapid and selective sensing of neurotransmitters such as kynurenine-type molecules. Neurotransmitters from the kynurenine pathway can be involved in many pathological processes in the immune and nervous systems in a concentration-dependent manner. Fluorescence sensing is a simple and effective method compared to complicated instrumental techniques, and utilizing metallic nanoclusters with good fluorescence properties can be an alternative to quantum dots or fluorescent dyes. The aim of our research was to prepare bimetallic silver/gold nanoclusters as fluorescent probes for the identification of kynurenine pathway molecules. Human apo-transferrin and γ-globulin were used as reducing and stabilizing agents, and synthesis parameters (e.g. silver to gold ratio, temperature) were optimized to achieve high fluorescence and kinetic stability. The prepared nanoclusters were characterized using instrumental techniques to determine their size, metal content, oxidation state and protein secondary structure, furthermore their behavior in high ionic strength environments and at different pH (1-13) was also investigated. Subsequently the nanoclusters were tested with different kynurenine pathway molecules to check their selectivity, and the interaction with the selected molecules were studied to determine the reaction kinetics. In the case of γ-globulin-stabilized bimetallic nanoclusters, the effect of the introduced silver atoms on colloidal, optical and sensing characteristics were determined. ACKNOWLEDGEMENT: Project no TKP2021-EGA-32 has been implemented with the support provided by the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund, financed under the TKP2021-EGA funding scheme.

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Optoelectronic Properties Of CsPbBr3/ZnO Nanocomposite Structures

A16

There are two perspective materials which are planned to be combined as a composite for efficient and ultrafast radiation conversion in scintillator detectors, perovskites and zinc oxide. Perovskites are optically active materials with high light-absorption coefficients, intrinsic defect tolerance, and size-tunable optoelectronic properties. Zinc oxide (ZnO) is a direct bandgap semiconductor that has gained significant importance in optical, electrical, and optoelectronic applications. Prior works indicate that increased photoluminescence yield and electron transport may be achieved in such composite systems [Journal of Luminescence 239 (2021) 118396]. In this work, we study the structural and electronic properties of nanocomposite structure of CsPbBr3 (CPB) nanocrystals on different ZnO substrates: 0001-Zn face and 0001-O face with polar surfaces, 1010 and 1120 with non-polar surfaces. The material structure was characterized by scanning electron microscopy (SEM) in the secondary (SE) and backscattered (BSE) electron mode. Nanocomposite work function (WF) and time-resolved surface photovoltage (SPV) were studied by scanning Kelvin Probe (SKP) in the dark and under a solar simulator or UV illumination. Confocal photoluminescence (PL) micro-spectroscopy was used to characterize PL emission spectra and their spatially resolved maps. SEM images and PL maps showed different distribution, shape and agglomeration of the CPB nanocrystals on the different ZnO substrates. Uniform film with well-defined CPB microcrystals grew on polar 0001 Zn-face surface, showing also clearly resolvable crystals in the PL maps. Smaller cubic CPB crystallites were observed on non-polar 1010 ZnO surface, exhibiting diffuse PL maps. PL and SEM analyses showed an overall weak CPB adhesion and localized CPB crystals and PL spots on ZnO with both polar O-face and non-polar 1120 surface. These differences were also manifested in the CPB/ZnO optoelectronic properties. The work function of the bare reference ZnO samples was around 4.7 eV. After CPB deposition, the WF increased between 4.79 to 5.34 eV depending on the ZnO orientation. SPV was generally positive from 30 to 430 mV, thus, holes were generated (or transported) to the CPB. The exception was again the 0001 Zn-face surface, where CPB crystals exhibited negative SPV -40 to -70 mV, i.e. electrons being concentrated on CPB. CPB PL peak remained between 525 - 527 nm (with ZnO PL suppressed in the composite) whereas its intensity changed significantly depending on ZnO crystal orientation. Obviously both the ZnO surface polarity and surface chemistry are controlling the CPB growth and opto-electronic properties on ZnO crystal planes. This may be crucial for prospective nanoscintillator detector applications. Authors gratefully acknowledge the financial support from the Czech Science Foundation project No. 24-12872S and the program "Strategy AV 21" of the Czech Academy of Sciences, specifically work package VP 27 (Renewable energy resources and distributed energy systems).

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Self-assembled Monolayers as Hole Selective Contacts for Perovskite Solar Cells: Experiment Versus Simulations A17

Recent advances in the performance of perovskite solar cells (PSCs) have been strongly linked to advancements in interfacial engineering and the development of charge-selective contact. Self-assembled monolayers (SAMs) play an important role in inverted PSCs due to their distinctive and versatile ability to manipulate chemical and physical interface properties. Here we compared the dipole moments of (2-(9H-carbazol-9-yl)ethyl)phosphonic acid (2PACz), (4-(3,6-Dimethyl-9H-carbazol-9-yl)butyl)phosphonic acid (Me-4PACz), (4-(3,6-Dimethoxy-9H-carbazol-9-yl)butyl)phosphonic acid (MeO-4PACz), and (2-(3,7-Dibromo-10H-phenothiazin-10-yl)ethyl)phosphonic acid (Br-2EPT) molecules and their impact on the energy conversion of PSC devices. Additionally, we simulated the dipole moment and surface charge effect device behavior to support our hypothesis. Finally, we observed that the fill factor behavior in both devices and simulations exhibited a similar trend, which correlated with the dipole moment of SAMs.

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Molecular Approach to Engineer Surface and Interface of Perovskite Solar Cells and Self-Powered Photodetectors A18

Optimization of the surface and interface properties of hybrid perovskite optoelectronic devices is crucial for achieving both high performance and long-term stability. In this presentation, I would like to outline a number of straightforward and promising molecular engineering for enhancing the performance and stability of perovskite solar cells (PeSC) and self-powered perovskite photodetectors (PePD). Particularly, through optical simulation based on fast computing system, rational design of optimal device architecture for high-performance all-perovskite tandem solar cells is manifested. In addition, I will talk about how to lean on the experience in molecular engineering to realize high-performance and ultra-stable self-powered PePD, with specific focus on the development of novel multi-functional low band-gap polymer DPP-CNTVT. Finally, I will showcase an innovative perovskite-based energy harvesting system that is particularly suitable for use under shadow conditions, offering great potential as a new solution for energy scavenging in a variety of application scenarios. Our findings offer valuable insights for the development of high-performance and long-term stable PeSC and self-powered PePD, marking a significant milestone in these fields and representing a major step towards the practical application of these emerging technologies.

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Preparation of Nanomaterials/Nanoelectronics/Nanoalloys

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***** INVITED LECTURE *****

Enhancing Photocatalytic Efficiency Through Spin-polarized Semiconductor Materials A19

The quest to imbue semiconductor materials with magnetic properties has been a topic of significant interest over the past two decades. Traditionally, research has focused on applying magnetic semiconductors to spintronic devices. However, semiconductors also play a crucial role as catalysts. Recently, there has been growing interest in whether magnetic semiconductor catalysts can enhance their catalytic efficiency through the application of magnetic fields. The key to developing such materials lies not in the magnitude of their magnetism but in whether doping or defect engineering can induce spin-polarized energy bands in the semiconductor [1]. If spin-polarized energy bands can be created, it opens the possibility of using magnetic fields to control spin and, consequently, the absorption of light or the transition of photoelectrons. This has potential applications in spintronic optoelectronic devices or photocatalysts. Our work begins with ZnO nanowires, studying the effects of surface modification or doping with Co layers on their spin-polarized energy bands [2]. We apply this understanding to enhance the photocatalytic efficiency under magnetic fields. Similarly, we have demonstrated that doping manganese cations (Mn2+) into CsPbBr3 halide perovskite nanoplates can significantly boost photocatalytic CO2 reduction reaction efficiencies when an external magnetic field is applied, attributed to the creation of spin-polarized electrons after Mn doping [3]. Our results show that manipulating spin-polarized electrons in photocatalytic semiconductors is an effective strategy to enhance photocatalytic efficiencies. This approach has the potential to bring new opportunities in future optoelectronic, energy, and biomedical applications through the spin polarization engineering of semiconductor energy bands. REFERENCE: [1] K. Ando, Science 312, 1883 (2006); [2] J. X. Lin, J. Thaomonpun, V. Thongpool, W. J. Chen, C. H. Huang, S. J. Sun, Z. Remeš, Y. T. Tseng, Y. F. Liao, H. S. Hsu, , ACS Appl. Mater. Interfaces, 13, 19, 23173 (2021); [3] C. C. Lin, T. R. Liu, S. R. Lin, K. M. Boopathi, C. H. Chiang, W. Y. Tzeng, W. H. Chang Chien, H. S. Hsu, C. W. Luo, H. Y. Tsai, H. A. Chen, P. C. Kuo, J. Shiue, J. W. Chiou, W. F. Pong, C. C. Chen, and C. W. Chen, J. Am. Chem. Soc. 144, 34, 15718-15726 (2022).

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Single Rare-Earth Adatom Magnets as Atomic-Scale Magnetic Memory A20

Single atom magnets offer the possibility of magnetic information storage in the most fundamental unit of matter. Rare-earth atom adsorption on suitable surfaces is a viable pathway for creating atomic scale magnetic memories. The strongly localized 4f electrons of RE show a very limited degree of covalency and preserve well-defined integer occupation with their electronic configuration controlled by the ligand environment. Recent XAS and XMCD experiments for Dy adatoms on MgO/Ag(001) thin films reveal strong dependence of the Dy adatom electronic and magnetic character on supporting MgO layer thickness [1]. We investigate the electronic structure and magnetism of individual Dy atom adsorbed on the MgO(001) substrate using the combination of DFT with the Hubbard-I approximation to the Anderson impurity model (DFT+U(HIA)) [2]. The divalent Dy[2+] adatom is found. Quantum tunneling leads to formation of the ground state with an in-plane orientation of the magnetic moment. It explains experimentally observed absence of remanent magnetization, and the butterfly-type magnetic hysteresis loop in Dy adatom on the top of MgO(001) substrate [1]. The XAS and XMCD spectra are calculated in a good agreement with the experimental data. Our studies can provide a viable route for further investigation and prediction of the rare-earth single atom magnets. We acknowledge partial support provided by the GACR grant No. 24-11992S, and EU-MSMT project TERAFIT - CZ.02.01.01/00/22_008/0004594. REFERENCES: [1] F. Donati et al., Nano Lett. 21, 8266 (2021); [2] A. Shick, E. Belsch, A. Lichtenstein, Phys. Rev. B 108, L180408 (2023).

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Nanostructuring of Boron-Doped Diamond Electrodes for Advanced High-Performance Electrochemical Supercapacitors **A21**

This study presents innovative approaches to fabricating and utilizing nanostructured boron-doped diamond (BDD) electrodes for electrochemical applications, particularly supercapacitors. Three distinct methods are explored: molten salt thermal etching (MSTE), Au mask-assisted reactive ion etching (RIE), and the RIE process combined with silicon micro-pyramids. The MSTE technique, applied at moderate temperatures (450 °C) throughout the electrode bulk, fabricates nanoporous BDD electrodes with increased electrochemically active surface area, exhibiting up to 50-fold higher capacitance compared to pristine BDDE. The Au mask-assisted RIE method produces vertically aligned nanorods, with diameters controlled by the initial thickness of the Au mask. These nanostructured BDD electrodes demonstrate improved electron transfer kinetics and 80% capacitance retention after 2000 cycles. Finally, the combined RIE process with Si micro-pyramids yields hierarchically structured BDD electrodes comprising both nano- and micro-morphologies, further enhancing capacitance (53.7 mF/cm2) and 95.5% retention after 5000 cycles. These fabrication approaches demonstrate the potential of nanostructured BDD electrodes in advancing miniaturized supercapacitors and other electrochemical applications, offering a combination of durability, high efficiency, and versatile performance across various potentials.

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JOHN David *Institute of Physics of the CAS, Prague, Czech Republic, EU*

Optical Properties of Lu3Al5O12:Ce(Er) Nanocrystals **A22**

Lutetium aluminum garnet (LuAG) is the crystal well known for extraordinary useful for building highly efficient laser devices or ionizing radiation detectors. To design the most favorable physical properties, different dopants and synthesis methods are constantly developed, primarily focused on advantages of single-crystals. However, downscaling of the luminescent materials to nanosize also creates additional benefits of increased surface to volume ratio and thus, the efficiency of luminescence can be improved. Therefore, the aim of this work is to compare influence of Ce and Er doping on optical properties of LuAG nanogarnets. Synergy of methods like X-ray diffraction (XRD), Raman, photoluminescence (PL) and photothermal deflection spectroscopies (PDS) were applied to the newly synthesized LuAG:Ce(Er) nanopowders. In particular, the pure LuAG shows only negligible PL around 625 and 650 nm originating from accidental defects. The LuAG:Ce nanocrystals emits at 450 and 650 nm. The former wavelength corresponds to the cerium typical 5d-4f transition. LuAG:Er has 5 peaks in infrared PL spectrum around 1460, 1530, 1580, 1620 and 1660 nm which are commonly known Er3+ transitions between Stark levels. According to XRD, the materials are pure phase garnets. ACKNOWLEDGEMENTS: The work was supported by Ministry of Education, Youth and Sports of Czech Republic (MEYS) Danube project 8X23025 and the program “Strategy AV 21” of the Czech Academy of Sciences, specifically work package VP 27 Sustainable Energy (Renewable energy resources and distributed energy systems). The financial support of the Leading Agency National Science Centre - Czech Science Foundation project No. 24-14580L is gratefully acknowledged.

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HULICIUS Eduard *Institute of Physics of the CAS, Prague, Czech Republic, EU*

Gan Based Wires for Detectors and Scintillators **A23**

GaN based structures from nanoscale to micron scale (quantum wires - nanorods -- micropillars) are widely used in many applications. Here we focus on detectors and scintillators with a view to water photocatalysis. Their preparation is based on epitaxial growth, mainly Molecular Beam Epitaxy and MetalOrganic Vapor Phase Epitaxy (MOVPE). Here we explain the advantages of MOVPE. As the most prominent application, 1−3 µm high core-shell micropillars grown on a periodic mask were studied in the past decade for new-generation LEDs. Several groups reported that overgrowth of their pencil-shaped multiple InGaN/GaN quantum well (MQW) surfaces with p-doped GaN formed LEDs with several advantages over the planar design [1]. The aim of our future work is to develop a new type of scintillator structure based on GaN micropillars containing MQW heterostructures in core-shell geometry. This structure will take advantage of nonpolar orientation of QWs resulting in better overlap of electron hole wave function, increased efficiency of blue/UV luminescence and fast decay time. Published results of the time-resolved X-ray excited optical PL showing $\tau \approx 0.14$ ns [2].

The advantage of our suggested concept is also lower dislocation density in nanopillars and higher effective thickness. We suppose that the following technologies and structures will be developed: • Growth of micropillars with minimal length of 3 µm. • Growth of core-shell structure with InGaN/GaN MQW and luminescence in the blue or UV regions. • The scintillator structure has expected PL decay time below 5 ns with sufficient RL efficiency in comparison to standard bulk or previously demonstrated MQW scintillators. REFERENCES: [1] C. G. Bryce et al., Quantum Well Engineering in InGaN/GaN Core-Shell Nanorod Structures, J. Phys. D. Appl. Phys. 50, 42LT01 (2017); [2] J. Segura-Ruiz et al., Spatially and Time-Resolved Carrier Dynamics in Core-Shell InGaN/GaN Multiple-Quantum Wells on GaN Wire, Nano Lett. 21, 9494 (2021).

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SERS-active and Recyclable Nb2O5/Au Platforms Fabricated by Magnetron Sputtering Combined with Thermal Treatment A24

Due to their unique physicochemical properties, metal/metal oxide (Me/MeO) nanomaterials are gaining increasing attention in the scientific community. One possible and promising application field of such materials is their use as platforms for surface-enhanced Raman spectroscopy (SERS). In this case, the SERS activity is predominantly due to the plasmonic metals, while the presence of a metal-oxide may provide the possibility to clean once-used platforms by UV-induced photodegradation of analyte hence lowering the costs of SERS detection. Because of this, various methods to produce Me/MeO nanomaterials have been developed in the past decade. Among them, especially those based on different plasma-based techniques seem advantageous as they are compatible with the demand for a time- and cost-effective green way of producing materials. This study aims to explore and test the possibility of producing Au/Nb2O5 heterogeneous coatings by magnetron sputter deposition combined with a thermal treatment. As demonstrated, this approach makes it possible, under appropriate fabrication conditions, to achieve a high SERS activity with a detection limit of 10-7 M for methylene blue, and at the same time also UV-induced re-cyclability of formed Au/Nb2O5 coatings. ACKNOWLEDGEMENTS: This work was supported by the grant GAČR 22-16667S from the Grant Agency of the Czech Republic.

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SESSION B

INDUSTRIAL AND ENVIRONMENTAL APPLICATIONS OF NANOMATERIALS

Chairmen

Prof. Dr. Radek ZBOŘIL	Palacký University in Olomouc, CATRIN-RCPTM, Czech Republic, EU
Prof. Dr. Miroslav ČERNÍK	Technical University of Liberec, Czech Republic, EU
Prof. Dr. Miloslav PEKAŘ	Brno University of Technology, Czech Republic, EU
Dr. Jan MACÁK	CEITEC BUT / University of Pardubice, Czech Republic, EU

Industrial Applications/Catalysis

ALTOMARE Marco ***University of Twente, Enschede, Netherlands, EU***

***** INVITED LECTURE *****

Dewetted Nanoparticles as Catalysts for Electro- and Photo- catalysis **B1**

Metal nanoparticles on conductive or semiconductor surfaces are of wide scientific and technological interest. They find application as catalysts in electro- and photo-catalytic reactions, or in plasmonics and sensing, among other areas. A straightforward and versatile, yet underexplored, way to produce supported metal particles is “solid-state dewetting” [1], that is, the heat-induced agglomeration of thin metal films into defined nanoparticles well-attached onto a support. In this talk, I will discuss the use of solid-state dewetting to control key properties of catalyst nanoparticles (size, composition, and structure) formed on electrodes and photocatalytic layers [2]. I will show how to enable nanoscale effects such as metal-support interactions to boost the catalyst performance in electrocatalytic reactions (e.g., hydrogen evolution) [3], and how tuning the catalyst composition affects catalyst stability and activity in photocatalysis [4,5]. In addition, I will show how dewetting can be steered to produce model nanocatalysts composed of ensembles of spatially-separated and uniformly-oriented metal nanoparticles with defined exposed facets [6]. REFERENCES: [1] C.V. Thompson, Annu. Rev. Mater. Res. 2012, 42, 399; [2] M. Altomare et al., Chem. Sci. 2016, 7, 6865; [3] S. Harsha et al., Adv. Funct. Mater. 2024, 2403628; [4] D. Spanu et al., ACS Catal. 2020, 10, 15, 8293; [5] D. Spanu et al., ACS Catal. 2018, 8, 6, 5298; [6] R.K. Sharma et al., 2023 Meet. Abstr. MA2023-02 2059.

MACÁK Jan — *University of Pardubice, Pardubice, Czech Republic, EU*

Atomic Layer Deposition of Noble Metal Nanoparticles for Catalytic Applications B2

Platinum group metals such as Pt, Ru, Pd, Ir, etc., have superior performance for various catalytic applications [1]. Due to their scarcity, efforts were being made to reduce the mass/loading or replace these noble metals. Atomic Layer Deposition (ALD) is one among the best technique to facilitate lowering of loading mass on a support of interest [2,3]. Due to the governing surface energy variations between noble metals and support surfaces, the growth initiates as nanoparticles (NP) and with a further increase in ALD cycles the agglomeration among NP's dominates over the individual NP size increase, thus developing thin films of relatively higher thickness. For electrocatalytic applications, it is important to choose the right substrates. Among available substrates, carbon papers and titania nanotube layers are best choices considering their physio-chemical properties, availability and low costs incurred. The uniform decoration of these substrates by NPs of catalysts proved to be highly efficient in electrocatalysis, as shown in our recent papers [4-6]. The presentation will introduce and describe the synthesis of different noble metal NPs by ALD on important substrates. It will also include the corresponding physical and electrochemical characterization and encouraging results obtained in electrocatalysis. REFERENCES:[1] Huang, Z. F. et al. Advanced Energy Materials vol. 7 (2017) 1700544; [2] Yoo, J. E. et al. Electrochem. commun. 86, (2018) 6; [3] Anitha, V. C. et al. J. Catal. 365, (2018) 86; [4] Sitaramanjaneya M. Thalluri & Macak, J. M. Small (2023) 2300974; [5] B. Bawab et al., Electrochim. Acta 429 (2022) 141044; [6] B. Bawab et al. CEJ 485 (2024) 148959

Collaboration: ***Brno University of Technology***

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Photocatalytic Hydrogen Evolution Activity of Anatase-Brookite Nanoparticles Modified With Rare Earth Metals (Gd, Lu, Tm, Tb, Pr) B3

Rare earth elements (Gd, Lu, Tm, Tb, Pr) modification effects on two-phased TiO2 (anatase-brookite) were analyzed. The powders were synthesized by a one-step hydrothermal method. The phase composition, crystalline size and shape of samples were studied by X-ray powder diffraction, transmission, scanning electron microscopies and energy-dispersive X-ray spectroscopy. The decreasing of crystallite size and increasing of lattice strain due to the modification were confirmed by the Scherrer, modified Scherrer, Williamson-Hall, Size-strain plot (SSP) and Halder-Wagner methods. The textural characteristics of the samples were determined from N2 adsorption-desorption isotherms using the methods of Brunauer-Emmet-Teller and Barret-Joiner-Halenda and revealed their mesoporous structure. UV-Vis diffuse reflectance spectra of the modified samples showed a blue shift compared to the unmodified sample. The values of band gap energy of the modified powders increased due to a phenomenon of quantum confinement or size quantization. The modification with rare earth elements improved the photocatalytic activity of anatase-brookite composite in the reaction of hydrogen evolution, which is ascribed to physico-chemical properties.

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Dielectric and Thermal Conductive Properties of Ti3C2Tx MXene / nanocellulose Based Substrates for Flexible Organic Electronics B4

Green renewable biopolymers have attained extensive attention recently in advanced electronics and wearable sensing devices to decrease the cost and, above all, to replace nonbiodegradable dielectric thermoplastic polymers (e.g. BOPP and PVDF) while retaining device's flexibility and boosting their recyclability. Among them, nanocellulose has gained particular attention due to its inherent biocompatibility, biodegradability, and cost-effectiveness. Nanocellulose consists of linear cellulose chains of repeating ß-D-glucopyranose units, covalently connected through b-1,4 glycosidic bonds, which symmetrical molecular structure with dipole moments of C-H and C-OH bands generate a strong polarity, and yield differently semi-crystalline structures by intra- and intermolecular hydrogen bonds between adjacent glucose groups, all beneficial for dielectric properties. Herein, films were prepared from native (CNF) and carboxylated (TCNF) cellulose nanofibrils, with and without the addition of thermally conductive multi-layered Ti3C2Tx MXene, to examine the impact of polar (-OH, -COOH) surface groups on the film morphological, moisturizing, dielectric (permittivity, loss, and AC conductivity), and thermal dissipation properties as function of temperature (0 to 100°C). The electrostatic repulsion and hydrogen bonding interaction between the hydrophilic surface/terminal groups on CNF/TCNF and MXene was shown to render their self-assembly distribution and organization into morphologically differently structured films, and, consequently, different properties. ACKNOWLEDGMENTS: This work was supported by the Slovenian Research and Innovation Agency (Project no. J2-3053 and Programmes no. P2-0424 and P1-0125).

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Synthesis of High Surface Area Cu/SiO2 Nanofiber Catalysts for Non-Oxidative Ethanol Dehydrogenation B5

Amidst growing concerns over the environmental impact of petroleum-based industries and their contribution to global ecological challenges, there is a pressing need for sustainable alternatives in chemical synthesis. This study addresses this imperative by exploring an innovative catalytic approach for the eco-friendly production of acetaldehyde from ethanol, a crucial chemical feedstock. Catalysts utilized so far perform poorly due to their low stability. Supported copper nanoparticles at higher temperatures suffer from the rapid deactivation caused by nanoparticles sintering and reduction of active sites by coking. To address this issue, the advanced copper nanoparticle-decorated nanofibers (107 nm in diameter) with outstanding surfacer area (700 m2 g-1) were synthesized and tested, showing enhanced stability to benchmark (Aerosil 300 SiO2/Cu). Two approaches were compared for copper catalyst preparation, i.e., dry impregnation and one-pot synthesis. Remarkably, the dry-impregnated DI-9.4 sample at 325 °C after 100 h remained at over 66 % of ethanol conversion with 99 % selectivity to acetaldehyde (acetaldehyde productivity: 3.09 g g h-1) compared to benchmark catalyst dropped to 40 % of ethanol conversion. These findings highlight the potential of the superior morphological advantage of electrospun SiO2 nanofibers as efficient catalysts. ACKNOWLEDGEMENTS: This work was supported by the project Quantum materials for applications in sustainable technologies (QM4ST), funded as project No. CZ.02.01.01/00/22_008/0004572 by P JAK, call Excellent Research.

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Silver Nanowire Coated Poplar-Pet Conductive Nonwoven Fabrics for Pressure Sensing Applications B6

This study demonstrates the use of needle-punched nonwoven fabrics of poplar seed fiber and polyester fiber blends in sensor applications. For this purpose, the surfaces of the produced fabrics were functionalized by coating them with silver nanowires (AgNWs). AgNWs were synthesized according to the polyol method and then coated onto the nonwoven fabrics through dip coating process. Surface morphology is characterized by scanning electron microscopy (SEM), and the analysis revealed a uniform coating on the fabric surface. Measurement of electrical surface resistance of treated fabrics confirmed that the presence of silver nanowires significantly improved the electrical conductivity. The capacitor structure was fabricated as a sandwich via placing a stretchable sealing film (Parafilm®) between two conductive nonwoven samples. Variation in the relative capacitance as a result of loading and unloading was observed. Poplar blended nonwoven fabrics exhibited great potential to be used as capacitive sensors to measure variable weight pressures. By virtue of its biodegradability, availability and light-weight solution, bio-waste poplar fibers offer a novel application for developing wearable and flexible tactile sensors.

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Environmental Applications

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Centrifugally Spun Hematite Hollow Fibers For Photocatalytic CO2 Reduction and H2 Evolution B7

A new synthetic approach for hematite (Fe2O3) nanofibers was developed using a centrifugal spinning process followed by a two-step annealing treatment. Initially, the spinning solution was prepared with two different iron precursors and polyvinylpyrrolidone (PVP). These fibers were then subjected to a two-step high-temperature annealing process with optimized profiles to convert them into hollow hematite (α-Fe2O3) nanofibers. Comprehensive characterization of both the as-spun and annealed fibers was performed using scanning electron microscopy (SEM), X-ray diffractometry (XRD), X-ray photoelectron spectroscopy (XPS), Raman spectroscopy, and textural analyses. The photocatalytic performance of the hematite fibers was evaluated under UV light illumination for the photocatalytic carbon dioxide reduction and hydrogen production. The resulting hematite fibers exhibited very good photoactivity compared to the commercial TiO2-P25 photocatalyst. Due to their hollow structure, and excellent photocatalytic activity, these nanofibers show great potential for future photocatalytic applications.

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Nanoarchitectonics as a Tool for Designing Nanorobots for Environmental Remediation B8

Nanorobots, self-propelled autonomous nanomachines, can perform desired tasks in bio-applications, medical fields, and environmental remediation, among others. In the latter, nanorobots have been introduced as powerful tools due to their efficiency and great versatility [1]. To apply nanorobots in environmental remediation, their design must be customized to enable propulsion capabilities while providing efficient task accomplishement, such as pollutant sensing, capture, removal, transport, degradation, or chemical conversion. In this regard, it is highly advantageous to fabricate nanorobots by applying the principles of nanoarchitectonics [2,3]. Nanoarchitectonics studies the assembly and self-assembly abilities on the molecular and atomic levels and their influence on the properties of resulting nanomaterials. Using nanoarchitectonics, affinity of nanorobots toward pollutants can be tuned while enabling efficient propulsion in a specific environment. Additionally, catalytic abilities can be provided to degrade pollutants in the 'on-the-fly' mode. This talk will introduce approaches toward designing nanorobots for environmental remediation by applying the principles of nanoarchitectonics. The decoration with nanoscaled materials, such as magnetic nanoparticles and their influence on catalytic properties will be discussed. Moving to the molecular level, the influence of hydrogen bonding on the resulting properties of the nanorobots will be presented. Finally, nanorobots with decorations on the atomic scale will be introduced. This work was supported by JSPS KAKENHI Grant Number 24KF0086. REFERENCES: [1] A. Jancik-Prochazkova et al. ACS Appl. Mater. Interfaces 2022, 14, 45545-45552; [2] A. Jancik-Prochazkova et al. ACS Nano 2022, 17, 146-156; [3] A. Jancik-Prochazkova et al. Adv. Funct. Mater. 2024, 2402567.

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Development of Multifunctional Micro/nanostructures for Environmental Remediation B9

Wastewater treatment is a global challenge 1, and photocatalysis offers a promising solution. This technique harnesses light and catalysts to break down pollutants in water, making it simpler and more sustainable than traditional methods 2. The key to photocatalysis lies in the generation of reactive oxygen species (ROS) by the photocatalyst. These highly reactive molecules, including hydroxyl radicals (OH•), superoxide anion radicals ($O_2•^-$), and singlet oxygen ($^1O_2$), break down pollutants into harmless components 3. Recent research focuses on molybdenum disulfide (MoS2), a special material with properties ideal for generating ROS. MoS2's layered structure boasts active sites, particularly at its edges, where molybdenum atoms bond with unsaturated sulfur atoms. These edge sites readily trap light-generated electrons, initiating a cascade of reactions that ultimately produce ROS 3. In this work, different new photocatalysts combining MoS2 with silicon based materials (mesoporous silica or integrating np silicon junctions) are explored for wastewater treatment. Different synthesis methods and MoS2 phases are being explored to optimize the number and distribution of these active edge sites, maximizing ROS production 4. Additionally, co-catalysts are used to further enhance ROS generation and minimize the recombination of these reactive species 2. The effectiveness of these photocatalysts is tested against common pollutants like dyes and antibiotics. REFERENCES: [1] United Nations, 2023, https://www.un.org/sustainabledevelopment/water-and-sanitation/; [2] Sinar Mashuri, S.I.; Ibrahim, M.L.; Kasim, M.F.; Mastuli, M.S.; Rashid, U.; Abdullah, A.H.; Islam, A.; Asikin Mijan, N.; Tan, Y.H.; Mansir, N.; et al. Photocatalysis for Organic Wastewater Treatment: From the Basis to Current Challenges for Society. Catalysts 2020, 10, 1260; [3] Rahman, A.; Jennings, J. R.; Tan, A. L.; Khan, M. M. Molybdenum disulfide-based nanomaterials for visible-light-induced photocatalysis. ACS Omega 2022, 7 (26), 22089-22110; [4] L. Zhou et al. Morphology/phase-dependent MoS2 nanostructures for high-efficiency electrochemical activity. J Alloy Compd 2020, 818.

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Cascade Catalytic Transformation of Furfural to Biofuel Molecules B10

The conversion of biomass platform chemicals, such as furfural (FFA) and levulinic acid (LA), into biofuels like furfural ether and γ-valerolactone (GVL) is highly significant. In this research, a nanoporous inorganic-organic Zr-phosphonate catalyst (ZrNPO3) was developed and utilized to selectively produce GVL through the catalytic transfer hydrogenation of LA. This catalyst, which features both acidic and basic sites, was also employed to generate biofuels like GVL and furfuryl ether under mild reaction conditions via cascade furfural transformation. The selectivity for GVL was further improved by using phosphotungstic acid@ZrNPO3. The study incorporated catalytic optimization, poisoning studies, and detailed physicochemical characterization to gain insights into the structure-activity relationship and reaction mechanism. The exceptional activity of the catalyst was attributed to the synergistic presence of Lewis acidic and basic sites. Developing a single catalyst capable of the one-pot tandem conversion of FFA to GVL represents a significant innovation for both catalysis researchers and the biofuel industry.

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Nano Twist and Shout: Chiral Nanoantennas Making Water Splitting Cool B11

In the last several years, spin polarization of electrons has been reported as a promising method of improving oxygen evolution reaction (OER). Here, we report the development of a system of novel nanoantennas with a chiral lock for plasmon-assisted water splitting. The chiral nanoantennas were prepared via a thin mesoporous gold film, on which a dielectric spacer containing a chiral substance (L- or D-tryptophan) was deposited and a thin layer of platinum was sputtered. The resulting samples were characterized at each step of their preparation using modern analytical methods, such as AFM, SEM-EDX, XRD, XPS, UV-Vis and Raman spectroscopy. It is hypothesized that electron spin polarization suppresses the formation of hydrogen peroxide and promote the formation of the ground state O2 triplet during OER. This was confirmed via electrochemical measurements, particularly using linear sweep voltammetry and chronoamperometry in two regimes - with and without illumination. During the experiments, we found a correlation between the OER efficiency and the presence of chiral substances in the dielectric spacer. Practical measurements are consistent even after numerous repetitions, implying their accuracy. Finally, based on these results, a theoretical working principle of this system was proposed. ACKNOWLEDGEMENT This work was supported by the GACR under project 23-08509S.

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Evaluating the Stability of Silver Nanowire Coated Poplar Nonwovens Under Washing Conditions B12

Poplar fibers, known for their high cellulose content and hollow structure, are primarily discarded as waste in the wood industry despite the tree's abundance. Recent advancements have enabled the utilization of poplar fibers in the textile industry, specifically in the production of nonwoven fabrics. This study explores the potential of valorizing poplar fibers by functionalizing them with silver nanowires (AgNWs) for technical applications. The focus is on enhancing the durability of conductive poplar nonwovens against washing procedures. Initially, silver nanowires were synthesized via the NaCl-mediated polyol method and subsequently coated onto a blend of poplar and polyester (PET) nonwoven fabric. The conductive fabric samples underwent a series of washing cycles to assess their durability. Post-washing analyses included morphological characterization and conductivity measurements to evaluate the performance and resilience of the coatings. This study provides insights into the wash durability of conductive poplar nonwovens, contributing to their potential application in electronic wearables, where compliance and comfort are critical.

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Composite Zeolite Granules Coated with Hydrated Manganese Dioxide Nanoparticles for Heavy Metal Stabilization in contaminated soils B13

The increase in human activities has resulted in higher levels of heavy metals in the environment, particularly in soils, raising the risk of these metals entering the food chain. Using chemical stabilization/solidification with mineral amendments from reactive minerals and organic materials is considered a highly promising modern technique for soil remediation. This method decreases the bioavailability of heavy metals (HM) by converting contaminants into less soluble or mobile forms. Zeolites are known to be effective for HM stabilization in soils. However, due to the reversible nature of ion exchange processes with zeolites, modifications are needed to improve contaminant fixation. One method is to add functional groups to the zeolite surface that can form strong physical-chemical interaction with heavy metal ions. This study examines the synthesis and application of composite zeolite granules coated with hydrated manganese dioxide nanoparticles as an efficient soil amendment for stabilizing heavy metals/metalloids such as cadmium, lead, zinc, copper, and arsenic. The zeolite granules were created through a controlled coating process, where hydrated manganese dioxide nanoparticles were deposited onto the zeolite matrix (clinoptilolite tuff, Sokirnitsya deposit, Ukraine). The granules were characterized using various analytical techniques to confirm the successful incorporation of manganese dioxide nanoparticles into the zeolite matrix and the maintenance of the structural integrity of the composites. Subsequent experiments evaluated the effectiveness of the composite zeolite granules in stabilising heavy metals in contaminated soil (Přibram, Czech Republic). The results showed that the composite zeolite granules significantly reduced the concentrations of cadmium, lead, zinc and copper in the soil, thereby reducing the bioavailability and mobility of these heavy metals. The improved stabilisation of composite granules compared to zeolite granules was attributed to the stronger reactive interaction between the hydrated manganese dioxide nanoparticles and HM.

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Industrial Applications

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***** INVITED LECTURE *****

Engineering Aspects of the PEM Fuel Cell Electrode Construction **B14**

In the PEM fuel cells technology research and development, like it is a case of most of the systems, significant attention is being paid by the research community to development of the novel, more efficient and less costly materials. Often is, however, neglected optimal application of such materials in the systems working under real conditions. Here different aspects need to be considered, like homogeneity of the local quantities distribution, sufficient accessibility of the reactants at the reaction sites etc. PEM fuel cells are using gaseous reactants (typically hydrogen and oxygen), generating water as a product. Gaseous reactants pose challenge to the electrochemical processes. It is because they are characterized by a relatively low volumetric density. At the same time, they are electrically insulating. To overcome these problems and to ensure high intensity of the electrode reactions, structure of the entire setup involving the electrodes, polymer electrolyte membrane and flow and electric charge distributors, needs to be highly optimized. The target of this contribution is to address selected aspects of the PEM fuel cells electrodes production, as well as aspects of their combination with the flow and charge distributors.

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Solar Upconversion for Photocatalysis **B15**

The production of green hydrogen, i.e. strictly from renewable resources, has become a worldwide global issue. The most advanced method is the electrolysis of water using electricity from a de-carbonated source. Another method is the dissociation of water by photocatalysis. Photocatalysis seems pivotal because it combines a simpler energy conversion scheme and systems whose photons-to-hydrogen conversion efficiency is close to unity. However, these efficiencies are only obtained in the absorption range of the photocatalysts which is often very limited and generally in the UV range. The efficiency, under solar irradiation, is solely constrained by the small fraction of useful light for photocatalysis (a few percent) and not anymore by the photocatalyst itself. Converting this unused light (~95%) into light adapted to the photocatalyst's absorption is the route to obtain competitive efficiencies compared to the electrolysis process. Upconversion is in this regard an interesting approach to harvest sunlight from IR and visible and thus enhance the overall solar to hydrogen conversion of photocatalyst. Through careful synthetic approaches we have developped Infrared to UV upconversion particles that in combination with classic photocatalysts (TiO2) can allow a significant improvement of the photocatalytic efficiency under solar irradiation.

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Self-Propelled Micro/nanomotors and Pumps by Ion-Exchange **B16**

The development of micro/nanostructures, which can move in a fluid environment in a controlled and autonomous way while performing specific tasks, is one of the present challenges of nanoscience and nanotechnology. In this context, many self-powered devices have been developed either as motors in a free-standing configuration (swimmers) or immobilized on a substrate (pumps). Among them, motors that are self-propelled by catalytic reactions have attracted a lot of attention. However, most of these devices are triggered by toxic chemicals, which prevents their applicability in various contexts, or cannot work at high salt concentrations. Therefore, new propulsion mechanisms, materials or safe chemicals need to be explored to overcome such limitations. Ion exchange is one of the most interesting processes occurring at the interface between aqueous solutions and polymers endowed with sulfonic groups, such as the well-known Nafion1. When exchanged ions possess varying diffusion coefficients, this process generates local electric fields that can be utilized to propel fluid motion1,2. In this study, we demonstrate the design and fabrication of self-propelling micro/nanoswimmers and pumps based on Nafion, powered by ion exchange and fueled by salts. These Nafion micromachines are created through different lithographic techniques (colloidal, stencil, photo or electron beam lithographies) shaping Nafion into asymmetric structures3,4. The resulting micro/nanoswimmers exhibit fascinating collective motion in water driven by the interplay of their self-generated chemical/electric fields and their capability to pump surrounding matter towards them. The pumping activity of the micro/nanoswimmers induces the formation of growing mobile clusters, whose velocity increases with size. Such dynamic structures are able to trap nearby micro/nano-objects while purifying the liquid, which acts both as the transport media and as fuel3,4. This phenomenon holds promise for potential applications in water remediation currently under development. References [1] M. J. Esplandiu, D. Reguera, and J. Fraxedas, Soft Matter, 16 (2020) 3717. [2] M. J. Esplandiu, K. Zhang, J. Fraxedas, B. Sepulveda, and D. Reguera, Acc. Chem. Res., 51 (2018) 1921 [3] M. J. Esplandiu, D. Reguera, D. Romero-Guzman, A. M. Gallardo-Moreno, and J. Fraxedas, Nat. Commun. 13 (2022) 2812. [4] J. Fraxedas, D. Reguera, M. J. Esplandiu, Faraday discussions, 249 (2024) 424.

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TEKCIN Meltem *ITU, Istanbul, Turkey*

High Performance Flexible Capacitive Pressure Sensor for Wearable Technologies B17

Flexible capacitive pressure sensors have applications in a wide variety of fields, especially soft robotics, bioelectronics, wearable devices and healthcare applications. In this study, a capacitive pressure sensor has been designed and fabricated using silver, nickel, and carbon nanoparticle conductive inks. Pad printing method was used to print nanoparticle inks on a polyamide-based taffeta label fabric. Capacitive pressure sensor underwent testing through three methodologies; these are pressing different fingers on the sensor surface, dropping water on the sensor and applying bending-relaxation process to the pressure sensor to determine sensor performance measuring capacitance variations. The capacitance of the fabricated pressure sensor changed according to the type of finger pressed and the number of water droplets dropped. As the amount of water droplets and the force of the pressed finger increase, the capacitance changes in the printed sensor also increase. On the other hand, there was no significant change in the capacitance values of the sensor after the bending-relaxation application. This shows that the proposed flexible pressure sensor can be used in wearable electronics, human-robot interactions, pressure mapping or detection of finger touch.

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NEBIPAŞAGIL Esma Nur *ITU, Istanbul, Turkey*

Innovative Textile-Based Force Sensor B18

In this study, a flexible force sensor with silver and carbon mixed conductive nanoparticles was designed and tested for use in the robotics field. Conductive inks composed of Ag:C nanoparticles were printed on polyamide-based taffeta label fabric by pad printing method in order to fabricate a capacitive force sensor. The sensitivity of this capacitive sensor structure was tested and evaluated by loading different weights. The results showed that as the concentration of carbon nanoparticles in the conductive ink increases, a decrease in capacitive energy loading is observed. Hence, the production of a capacitive force sensor form was carried out with the appropriate number of printing layers and Ag:C concentration. The focus of research lies in the discovery and development of durable flexible force sensors for motion tracking in robotic applications.

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SESSION C

BIONANOTECHNOLOGY, NANOMATERIALS IN MEDICINE

Chairmen

Prof. Dr. Anton FOJTÍK	Czech Technical University in Prague, Czech Republic, EU
Prof. Dr. Jiří HOMOLA	Institute of Photonics and Electronics of the CAS, Czech Republic, EU
Prof. Dr. Bohuslav REZEK	Czech Technical University in Prague, Czech Republic, EU

Bio Applications/Nanomedicine

PAMUŁA Elżbieta ***AGH University of Krakow, Cracow, Poland, EU***

***** INVITED LECTURE *****

Inhalable Drug Delivery Systems for the Treatment of Lung Diseases C1

Active pharmaceutical ingreadients (APIs) to treat lung diseases, e.g. cancer, acute infections, chronic obstructive pulmunary disease (COPD), are usually administered via typical enteral or parenteral routes, although the lungs can be directly targeted through the airways. Thus, by using inhalable formulations, it is possible to obtain much higher concentration of APIs directly at required site and reduce their amounts distributed systemically [1]. In our group, we developed inhalable stimuli-sensitive drug carriers that are intended to improve the efficacy of lung cancer therapy through guided accumulation directly at the tumour site and controlled API release triggered by an alternating magnetic field resulting in a local increase in temperature [2]. Such carriers are in the form of solid lipid microparticles composed of fatty acids, superparamagnetic iron oxide nanoparticles (SPIONs) and paclitaxel [3]. Recently, we have been working on polymer drug delivery systems of antibiotics and quorum sensing inhibitors for the treatment of bacterial infections in patients with COPD exacerbations [4]. Such systems are based on fast-degrading polyanhydride microparticles loaded with antibiotics (e.g., azithromycin, tobramycin, gentamycin) and quorum-sensing inhibitors (e.g., curcumin, linolenic acid). The microparticles are designed to ensure an appropriate size for inhalation, degrade within a few days, and release drug cargo, which is capable of killing bacteria causing COPD exacerbations and preventing biofilm formation. The system is cytocompatible with lung epithelial cells, as shown by in vitro and ex vivo tests. ACKNOWLEDGMENTS: This study was supported by the NCN (project No 2019/35/B/ST5/01103) and partly by the Program „Excellence initiative - research university" for the AGH University of Krakow. REFERENCES: [1] K. Knap, et al, Regenerative Biomaterials, 2023, 10, rbac099; [2] K. Reczyńska, et al, Nanomaterials, 2020, 10(6), art. no. 1076; [3] K. Reczyńska et al, Materials Science and Engineering C, 2020, 111, 110801; [4] K. Kwiecień, et al, Engineering of Biomaterials, 2021, 162, 7-12; [5] K. Knap, et al, Biomaterials Advances, 2023, 153, art. no. 213540.

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Ultrathin TiO2 ALD Coatings Enhance Properties of Biomaterials Used in Implantology C2

Various TiO2 nanostructured surfaces are generally recognized as excellent biocompatible materials. Anodic TiO2 nanotube (TNT) layers have emerged as extremely suitable and effective substrates for surface modification of various materials used in biomedical applications, especially TiAlV alloy. Recently, we compared the biological effect of ultrathin

TiO2 coatings, achieved by various numbers of Atomic Layer Deposition (ALD) cycles, on planar and nanotubular surfaces. We demonstrated that ultrathin TiO2 ALD coatings on TNT layers enhanced cell adhesion, growth, and proliferation [1]. Furthermore, we found that 1 cycle of TiO2 ALD coating shaded the impurities of F- and V-based species in tested TiAlV alloys while preserving the original structure and morphology. ALD modification makes tested materials suitable candidates for bone and dental implants [2]. For the first time, single-cell adhesion to modified TNT layers using the ALD method was studied by bio-Atomic Force Microscopy [3]. REFERENCES: [1] Motola, M., Capek, J. et al., ACS Applied Bio Materials (2020); [2] Capek, J., Sepúlveda, M. et al., ACS Applied Materials & Interfaces (2024); [3] Baishya, K., Vrchovecka, K. et al., Applied Surface Science Advances (2023).

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Repeated Exposure of Escherichia Coli to Sub-Lethal Concentrations of ZnO Nanoparticles — C3

Nanoparticles (NPs) were initially considered a promising solution to combat antibiotic-resistant bacteria (10.1039/D4PM00032C). However, recent findings show that bacteria can develop resistance to NPs (10.3389/fmicb.2023.1102615), necessitating a deeper exploration of this phenomenon. We investigated the potential for resistance development in Escherichia coli (E. coli) when repeatedly exposed to sublethal concentrations of zinc oxide (ZnO) nanoparticles (200 nm, 6% aluminum-doped, Sigma Aldrich) over an extended period. Real-time bacteria growth curves were studied in reverse spin bioreactors, with and without visible light illumination alongside sub-lethal concentrations of ZnO NPs, using an established setup and protocol for highly reproducible experiments (10.37904/nanocon.2023.4813). The experiment involved more than 10 re-exposure cycles, where surviving cells from previous exposures were re-exposed to the same growth conditions. Growth parameters, including lag and log phase lengths, and maximum growth rate, were analyzed. Colony-forming unit (CFU) concentrations and colony morphology were examined after each exposure. Furthermore, bacteria from selected exposure steps underwent minimum inhibitory concentration (MIC) testing and scanning electron microscopy (SEM) analysis. The results revealed a consistent and specific bacterial response to ZnO NPs and antimicrobial activity enhancement under illumination. Notably, cells exposed to both ZnO NPs and illumination exhibited the longest lag and log phases, the lowest maximum growth rate, and the lowest final optical density (OD) over all exposure steps, with a marked decline in CFUs and increase in log phase length during repeated exposures. In contrast, cells exposed solely to ZnO NPs did not show significant deviations from control groups. The size and shape of bacteria exposed to ZnO NPs and illumination were similar to that of the control and cannot explain the reduction in OD observed during growth. Additionally, there was no reactive oxygen species (ROS, e.g. H2O2) detected from liquid that contained illuminated ZnO NPs, making it highly unlikely that the photoactivation of ZnO is the main factor of the heightened antimicrobial activity of illuminated ZnO. On the other hand, significant differences were observed in cell envelopes after illumination, which could point to the previously described changes in cell membranes, including changes in membrane integrity or ion pump activity (10.3390/antibiotics10030341), under illumination. This may in turn lead to a higher permeability of the cellular membrane towards ZnO NPs, or lower the ability of cells to expel zinc ions, resulting in heightened antimicrobial capacity.

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Control of Nanoscale Molecular Assembly ZnO Surface Atoms and Dipoles — C4

Nanoscale chemical modification and interaction of semiconductor surfaces with organic molecules in gases and solutions is key to many many modern applications from electronic sensors to catalysis and energy conversion. In our work, we investigate at the nanoscale the effect of surface atomic configurations and surface dipole orientation on two polar (Zn-face, O-face) and two non-polar ZnO monocrystalline slabs on several types of application relevant biomolecules (bovine serum albumin - BSA, aminoacids - AA, and thiorphan). We employ atomic force microscopy with molecular resolution to characterize morphology and adhesion of adsorbed molecular assemblies on these ZnO diverse surfaces. The experimental data are correlated with atomistic computations based on DFTB and Force Field MD methods. The theoretical and experimental results show pronounced differences in each case. BSA adsorbed on ZnO in mono-molecular layers (2-10 nm), arrangement and adhesion of which is controlled by the surface chemistry. Even some chemical bonds are formed spontaneously, via interaction with AA residues, except for O-faced ZnO surface that is rather repelling to BSA. Thiorphan on the other hand tends to form 4 nm or 25 nm nanodots on polar surfaces and rigid 2D-like layers and islands (stacking by 4 nm) on non-polar ZnO surfaces. The simulations prove that it is the effect of electrostatic dipole orientation, not of surface chemistry. Similar effect is observed also for magnetized surfaces with spin up and spin down orientation. These findings may help elucidate many prior studies of ZnO properties and effects in biological environments as well as design new applications.

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TOF-SIMS Analysis of the Antibodies Orientation in Biomolecular Nanolayers on Silicon C5

Surface immobilization of the IgG antibody, which is used as a detection element in immunosensors, requires a special attention. Since this molecule has an Y shape with antigen binding sites located on two Fab arms, its orientation (flat-on, side-on, and vertical: tail-on and head-on) determines the assay efficiency [1,2]. Therefore, it is of utmost interest to examine and control the dominant orientation of surface-immobilized antibodies which depends on the pH of the adsorption solution, the amount Γ of antibody adsorbed, and other factors. However, the IgG orientation is most commonly inferred from indirect methods, prone to high uncertainty. In contrast, antibody orientation can be resolved with TOF-SIMS mass spectrometry, because of the technique sensitivity to the outermost nanometer region of adsorbed proteins and discrimination of the IgG domains (Fc and Fab) with different amino acid composition, enhanced by a multivariate Principal Component Analysis. This method is, however, limited to comparative analysis between samples that hindering an absolute determination of the dominant orientation on the particular surface. In this work, we present the novel approach of surface density dependent studies of antibody orientation with TOF-SIMS and PCA, which allows for direct tracking of orientation changes induced by the increasing molecules surface amount and for an accurate evaluation of the dominant orientation by estimation of share of molecules with head-on and tail-on alignment (fFc fraction) [2,3]. We examined the surface density dependent orientation of antibodies immobilized on silane-modified silicon by physical adsorption (APTES layer) and covalent coupling (APTES layer activated with glutaraldehyde APTES/GA). In particular, differences in dominant vertical orientations are revealed and discussed in terms of relevant molecule-molecule and molecule-surface interactions. Moreover, the impact of the pH of the IgG solution on the dominant vertical orientation of the antibodies immobilized on APTES and APTES/GA is determined and expressed by the fFc fraction. It is shown that under particular pH conditions the dominant antibody orientation can by significantly improved to be close to the ideal tail-on alignment through electrostatic molecules-surface interactions [4]. REFERENCES: [1] Gajos, Katarzyna et al., Applied Surface Science, 594, 153439 (2022); [2] Gajos, Katarzyna et al., Applied Surface Science, 518, 146269 (2020); [3] Gajos, Katarzyna et al., Molecules, 27, 3672 (2022); [4] Gajos, Katarzyna et al., Appl. Surf. Sci., 656, 159644 (2024).

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Free-radical Rich Amine Plasma Polymer Thin Films for Bioapplications C6

Plasma polymerization of thin film coatings is an effective method for modifying synthetic materials that lack optimal bioapplication properties. Amine plasma polymers (PPs) capable of stable binding with biomolecules and enhanced cell adhesion are suitable for designing biomaterials. Their properties can be tuned concerning the surface charge (from strongly positive to slightly negative) and reactivity for covalent bond formation. The presence of free radicals can explain part of their properties. Therefore, it is essential to investigate their formation for different plasma polymerization conditions, namely radio frequency power absorbed by the discharge in the deposition gas mixture (argon and cyclopropylamine vapors). Electron paramagnetic resonance revealed a significant concentration of free radicals for higher power, attributed to the higher ion energy flux towards the growing PP film. The concentration of free radicals in PPs decreased exponentially over time due to their recombination at the surface or even in the bulk, as they can diffuse through the material. Nevertheless, even after three months, the spin density in PPs remained at 60% of the initial concentration. The amount and kinetics of radicals in the amine PPs and their other chemical properties were correlated to the cell-surface interactions and kinetics of protein immobilization determined by measurements with quartz crystal microbalance sensors.

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Bio Applications/Biosensing

SCHWARZOVÁ-PECKOVÁ Karolina Charles University, Prague, Czech Republic, EU

***** INVITED LECTURE *****

Structured Diamond Surfaces for Development of Electrochemical Biosensors C7

Structuring conductive diamond surfaces with boron doped diamond as the most popular variant is a challenging task due to the complexities of diamond growth procedure and the inherent properties of the material (hardness, chemical inertness). However, structuring may enhance proclivity to anchor (bio)molecules, increase sensitivity and lower limits of detection in electroanalytical applications or facilitate growth of human neural cells [1-3]. In this contribution, results of our continuous research in the field of engineering BDD surfaces will be presented for: 1) supported and free-standing porous BDD layers for batch and flow-through electrochemical cells, 2) IR laser-processed polycrystalline and chem-mechanically polished BDD layers [3], leading to micrometer-scale spot-structuring of the surface and controlled introduction of sp2 carbon [4], 3) single-crystal BDD layers nanostructured with spherical cavities, achieved via microwave plasma chemical vapor deposition in the presence of silica nanosphere templates. To address advantages of these novel BDD varieties, their physico-chemical properties and prospective applications will be demonstrated via the electrochemical detection of neurotransmitters in batch and flow-through arrangements or the assessment of DNA adsorption. ACKNOWLEDGEMENTS: The work is supported by the Czech Science Foundation (project GACR 23-05688S) and by EU (project SenDiSo: CZ.02.01.01/00/22008/0004596). REFERENCES: [1] J. Krůšek, I. Dittert, T. Smejkalová, M. Kořínek, K. Gottfriedová, H. Freislebenová, E. Neuhöferová, L. Klimša, S. Sedláková, A. Taylor, V. Mortet, V. Petrák, V. Benson, V. Petráková, Phys. Status Solidi B 256 (2019) 1800424. [2] M. Zelenský, J. Fischer, S. Baluchová, L. Klimša, J. Kopeček, M. Vondráček, L. Fekete, J. Eidenschink, F.-M. Matysik, S. Mandal, O.A. Williams, M. Hromadová, V. Mortet, K. Schwarzová-Pecková, A. Taylor, Carbon 203 (2023) 363-376. [3] J. Hrabovsky, M. Zelensky, J. Sladek, M. Zukerstein, J. Fischer, K. Schwarzova-Peckova, A. Taylor, M. Veis, S. Mandal, O.A. Williams, N.M. Bulgakova, Applied Surface Science 639 (2023) 158268J.

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Upconversion Nanoparticle-Based Dot-Blot Immunoassay for Quantitative Biomarker Detection C8

Even though immunoassays are considered the gold standard among bioanalytical methods, conventional immunoassay labels often possess disadvantages, e.g., low stability and sensitivity in the case of enzymes or photobleaching in the case of fluorophores. To address these drawbacks, new nanomaterial-based labels are being studied (1). Photon-upconversion nanoparticles (UCNPs) are lanthanide-doped nanocrystals exhibiting anti-Stokes emission, enabling low assay background due to the reduction of autofluorescence and light scattering (2). Our work focused on the development of a dot-blot immunoassay with UCNPs as detection labels. First, UCNPs were synthesized, and their surface was modified with a PEG-based linker to achieve hydrophilicity and low levels of non-specific interactions. This was followed by the conjugation with streptavidin, preparing a sensitive biorecognition element. Human serum albumin was chosen as a model biomarker for immunoassay optimizations. Each assay step was optimized to achieve the highest signal-to-background ratios and, consequently, the lowest detection limits (LOD). After that, the assay was successfully adjusted to detect other clinically important biomarkers, prostate-specific antigen as a prostate cancer biomarker and cardiac troponin as a biomarker of myocardial infarction. Achieved LODs were 0.24 ng/mL for HSA, 0.62 ng/mL for troponin, and 9.4 pg/mL for PSA. The obtained data showed that dot-blots with UCNP labels can become an alternative to conventional microtiter plate assays (MTP). Conventionally, dot-blots lack the sensitivity of the MTP assays and are mainly used for the semi-quantitative detection of analytes. Due to the outstanding performance of UCNPs as labels, it is possible to transform dot blots into a reliable quantitative detection platform for the detection of low-abundance biomarkers. (1) Farka Z, Juřík T, Kovář D, Trnková L, Skládal P. Nanoparticle-Based Immunochemical Biosensors and Assays: Recent Advances and Challenges. Chem Rev. 2017;117(15):9973-10042. (2) Hlaváček A, Farka Z, Mickert MJ, Kostiv U, Brandmeier JC, Horák D, et al. Bioconjugates of photon-upconversion nanoparticles for cancer biomarker detection and imaging. Nat Protoc. 2022;17(4):1028-72.

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The Behavior of Fluorescence Quenching of Two-Photon Active Sensors Based on Biocompatible Quantum Dots for Ferric Ions Detection C9

Although cadmium-based quantum dots (QDs) exhibit superior optical properties, their potential applications are significantly limited due to the high risk of toxic cadmium ion release. Therefore, there is a strong demand for the development of non-toxic alternatives. In this study, we focused on two classes of cadmium-free nanomaterials: carbon nanodots (CNDs) and molybdenum disulfide (MoS_2) QDs. These materials not only offer desirable optical properties but also exhibit low toxicity, good biocompatibility, and excellent water dispersibility, making them attractive candidates for a wide range of applications, including heavy metal ion sensing. We explored the capability of both label-free CNDs and MoS_2 QDs to function as fluorescence quenching-based sensors for Fe^{3+} ions, with a focus on the less extensively studied nonlinear optical properties in an expanded spectral range of wavelengths. Utilizing tunable femtosecond laser pulses for the two-photon induced luminescence technique, we optimized the excitation wavelength in the near-infrared region to achieve maximum of two-photon brightness. Additionally, we performed temperature-dependent measurements to elucidate the potential mechanisms underlying the observed quenching effects under one- and two-photon excitation conditions. The results confirm that both CNDs and MoS_2 QDs exhibit significant fluorescence quenching in the presence of Fe^{3+} ions, demonstrating their potential as sensitive and selective two-photon active sensors suitable for applications in e.g. environmental systems. ACKNOWLEDGEMENTS: We acknowledge support from the National Science Centre, Poland under Grant no. UMO-2018/30/E/ST5/00718.

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Nitrogen-Doped Carbon Quantum Dots for Enhanced Bacteria Growth and Biosensing Signals C10

Due to the ever-increasing threat of Antimicrobial resistance (AMR) to human health globally, there is a constant need for novel strategies for rapid detection and identification of live bacteria. Amongst these technologies, quantum dots with their unique tuneable optical properties are small enough to traverse the bacteria membrane and become activated upon interaction with light of suitable energy even after internalisation without, crucially, causing bacteria death. We observed pronounced differences in the growth profiles of bacteria (E. coli) when cultured in the presence of carbon quantum dots (CQD), nitrogen-doped CQD (N-CQD) or iron/nitrogen co-doped CQD (Fe/N-CQD). Bacteria growth was not inhibited even during exposure to relatively high concentrations (1.5 mg/mL). Bacteria exposed to CQD and Fe/N-CQD had comparable growth profiles to the untreated bacteria. Interestingly, we observed enhanced maximum growth rate, shortened lag phase, and higher final optical density for bacteria exposed to the highest concentration of N-CQD. Pre-illumination of the colloid using solar simulated light prior to the addition of bacteria resulted in further enhancement of the effect. All these effects decreased towards lower N-CQD concentrations. Moreover, photoluminescence of N-CQD with bacteria was more pronounced than that of CQD and Fe/N-CQD, possibly because of localisation around the bacteria surface as observed using scanning electron microscopy. Absorbance measurements of colloidal CQD, N-CQD and Fe/N-CQD confirmed long-term stability (5 days). Such a material has potential use for incorporation into rapid diagnostic systems for bacteria detection in liquid with minimal cytotoxic complications for the environment.

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Computational Analysis of Plasmonic Enhancements and Resonance Shifts in Metal-Diamond Nanoparticle Complexes C11

Nanodiamonds (NDs) and metal nanoparticles (NPs) are widely investigated for their diverse applications, from biomedicine to industry, due to their unique properties at the nanoscale. In this work, the effect of surface plasmon resonance for different nanostructures (i.e. clusters and dimers of gold, silver and diamond nanoparticles) were studied theoretically by using the Finite Element Method (FEM) in COMSOL Multiphysics with the RF module. We analyzed the extinction cross section spectra and electric field enhancement maps for varying parameters (interparticle distance, size and surrounding medium) of nanoparticle clusters including dimers and larger aggregates with diamond at their core. This study aims to provide a comprehensive understanding of the plasmonic behavior in mixed nanoparticle systems. Our findings shows that electric field enhancement and the resonance wavelength is affected by interparticle distance, nanoparticle size, the surrounding medium and the presence of diamond nanoparticles at the center of the cluster. For instance, the resonance wavelength changes from 532 nm to 544 nm as the interparticle distance decreases from 5 nm to 1 nm for a nanodimer with a 20 nm gold NP and 50 nm diamond NP in water. The introduction of diamond NP at the center of the Au and Ag nanoparticle clusters and varying the number of NPs in the system significantly affect the electric field enhancement, its localization, and resonance wavelengths from original 520 nm (Au NP) or 380 nm (Ag NP). The results underscore the critical role of nanoparticle geometry and composition in tailoring plasmonic properties, highlighting their potential applications in nanophotonic devices, thermal therapy, and sensing technologies.

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Bio Aplications/Nanotoxicity/Nanosafety

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***** INVITED LECTURE *****

Reducing Health Risks of Nanoparticles from Mobile Sources: Much Accomplished, But Still a Long Path Ahead C12

Emissions from mobile sources, released directly in streets at breathing level, are one of the major sources of air pollution in many urban areas. Air pollution, in turn, is one of the gravest environmental hazards, causing premature death of millions of people worldwide. Particles from high temperature processes, primarily carbonaceous particles from engine exhaust and metallic particles from friction brakes, contain semi-volatile organic compounds and metals, and are on the order of units to tens nm diameter. Such small particles have been reported to deposit efficiently in lung alveoli and to penetrate into bloodstream, and to travel along the olfactory nerve to the brain, causing or contributing to a range of acute and chronic illnesses. The toxicity attributed to exhaust particles can be reduced by oxidation catalysts and particle filters, yet despite their massive introduction, our air is far from clean. Brake wear nanoparticles can be reduced by improved friction materials, electrodynamic braking and sensible driving style. As in nearly all categories of emissions sources, small percentage of not properly operating devices contributes a large part of total emissions, highlighting the importance of appropriate design, manufacture, calibration, maintenance and usage. High variability of emissions over time and among sources, particle dispersion and physical and chemical processes cause nanoparticle distribution in the air to vary with both location and time. As of yet, there is no reliable, cheap, simple nanoparticle sensor for general public use. Despite considerable improvements mainly in the technology, nanoparticles in our air remain a considerable challenge.

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ONDRAŠÍK František ***VSB - Technical University Ostrava, Ostrava, Czech Republic, EU***

Potential Environmental Impacts of Using Specific Types of Water for Firefighting Purposes **C13**

The availability of water for firefighters is a key factor in ensuring fire safety in the area. That is why natural and artificial water sources can be used without limitations, according to the Water Act. In recent years, the idea of using alternative water sources, in particular treated wastewater and rainwater, has also been discussed. The rainfall over the last three decades has been more localised but much more intense, which led to a crisis situation where long-term water scarcity is alternated with an immediate surplus. Rescue services then deal with cases where, although there is sufficient water in a natural stream, it is not available for pumping equipment due to unsuitable terrain. One option is to use treated wastewater from sewage treatment plants, where there is a constant supply of sufficient water for pumping and access is provided by paved roads. For this reason, water samples were collected from open fire ponds, closed fire ponds, WWTP outfall, open watercourse and closed watercourse. The aim of this paper is thus to perform ecotoxicological tests on samples mentioned in accordance with the European standard ISO 11348-3:2007 Water quality - Determination of the inhibitory effect of water samples on the light emission of Vibrio Fischeri (Luminiscent bacteria test) and Czech legislation (Law No. 541/2020 Coll., Waste Act and Decree No. 8/2021 Coll., Waste Catalogue), to determine whether this water is ecotoxicologically safe to use in firefighting.

Co-authors: ***SLANÝ Jan, KROČOVÁ Šárka***

FUCIKOVA Anna ***Charles University, Prague, Czech Republic, EU***

Protein Corona on Nanoparticles: What Do We Know So Far? **C14**

The variety of nanostructures surrounding us today is enormous. The use of nanomaterials is very extensive because of the unique properties of nanoparticles (NPs) arising from their nanometre dimensions. When NPs enter a cell or a living organism, biomolecules adhere to their surface and form a so-called protein corona. This affects not only the entry of NPs into the cell but also the overall toxicity of NPs and their fate in the cell. The secondary toxicity of NPs is caused by the interaction of molecules on their surface, which greatly limits their use in medicine and pharmacy. These interactions between NPs and the biological environment have so far been studied by outdated indirect ensemble methods. Our approach plans to examine individual NPs and is focused on the rate of protein corona formation and its stability by studying individual anchored nanoparticles under liquid using modified atomic force microscopy.

SESSION E

ADVANCED METHODS OF PREPARATION AND CHARACTERIZATION OF NANOMATERIALS

Chairmen

Dr. Petr KLAPETEK	Czech Metrology Institute, Czech Republic, EU
Dr. Oldřich SCHNEEWEISS	Institute of Physics of Materials of the CAS, Czech Republic, EU
Dr. Michael SOLAR	Czech Technical University in Prague, Czech Republic, EU

Nanocharacterization - Metrology

SCHITTER Georg ***TU Wien, Wien, Austria, EU***

***** INVITED LECTURE *****

Charge Measurements in Liquid and Device Characterization up to 90 GHz by AFM-based Techniques E1

Atomic force microscopes (AFM) enable characterization of surfaces at nanometer resolution, including the topography as well as electrical properties, such as surface charges, where in KPFM a feedback applies a DC-offset for measuring the local surface charges. However, this DC-bias may cause limitations for imaging in aqueous solutions as well as in electronic applications. Recently various novel electrical AFM measurement modes have been developed that enable operation without DC-bias voltage. In AC-KPFM multiple AC-signals are applied to the AFM tip that enable compensation-based surface potential measurements in aqueous solutions. An extension towards simultaneous excitation of the AFM tip electrically as well as mechanically results in a heterodyne detection that renders the measurement independent of the lift-height, reduces influence of the cantilever cone structure, and results in a better spatial resolution and measurement accuracy. In AC-EFM an amplitude-modulated signal in the MHz-range is applied to the AFM tip that additionally enables surface potential measurements in solutions of high ionic concentration. In a second step a new AFM system is developed for measurements at radio-frequencies (RF) up to several GHz, which converts the AFM into a RF-probing station on the sub-micrometer scale. This allows characterization of integrated circuits directly on the device during operation and is demonstrated by measurement of the voltage distribution in active RF-devices. This AFM-based system in combination with a vector-network-analyzer and a conventional probing station enables characterization of RF-circuits during operation directly on the device and wafer-level at frequencies up to 90 GHz with sub-micrometer spatial resolution.

Co-authors: ***POIK Mathias, HACKL Thomas***

AGARWAL Akanksha ***Czech Technical University in Prague, Prague, Czech Republic, EU***

Thickness-Dependent Evolution of Trion and Excitonic Emission in MoS2 Grown by Atmospheric Pressure CVD E2

Transition Metal Dichalcogenides have attracted immense interest due to their unique properties and potential applications in electrical and optoelectronic devices. Among these, MoS2 has drawn great attention due to its indirect to direct bandgap transition at 1.9 eV exhibiting extremely high excitonic photoluminescence in the visible range. In this work, we synthesized MoS2 on Si/SiO2 substrate using a single-step atmospheric pressure chemical vapor deposition process. We successfully obtained mono- to few-layer MoS2 films. The thickness dependence of the as-grown MoS2 layers was analyzed from the peak energy difference (Δ) between the in-plane (E2g) and out-of-plane (A1g) phonon modes in the Raman spectra (Δ value of 19 cm-1 for monolayer; 22 - 26 cm-1 for few layers; and > 26 cm-1 for bulk). Additionally, Raman analysis also allowed us to correlate the layer thickness with photoluminescence spectra. Analyses of the photoluminescence spectra reveal that the excitonic peak in MoS2 is red-shifted from mono- to few-layer MoS2 by approx. 0.04 eV. Moreover, we also observed thickness-dependent trion peak energy at room temperature. These findings provide insights into the relationship between layer thickness and quasi-particle excitations, which are useful for MoS2 based optoelectronic applications.

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SERES László

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Novel Approaches to Monitoring the Formation of Self-assembled Colloids Composed of Cationic Surfactants and Alginate Polysaccharide

E3

In actual work, the self-assembly process of low molecular weight (240 kDa) alginate (Alg) polysaccharide with cationic surfactants from the family of trimetylammonium bromide (TAB) derivatives was examined at wide polysaccharide/surfactant molar ratio range through the interpretation of the formation of non-aggregated colloidal complexes. Firstly, the critical micelle concentration (cmc) values of the investigated TAB surfactants with different chain length (C12-C18) were determined and published for the first time in phosphate buffer solution. In addition to the applied conventional measurement procedures like calorimetry, tensiometry, light scattering and equilibrium dialysis, the applicability of streaming potential technique was also demonstrated for the first time for these types of systems to gain a deeper insight into the formation process of the complexes built up by biocompatible polysaccharides and cationic surfactants. With the interpretation of the change of the streaming potential curves as a function of surfactant concentration it was clearly highlighted that both the individual and cooperative binding process of the surfactants can be clearly identified which process is followed by the aggregation of the polysaccharide-surfactant colloidal complexes and the formation of surfactant micelles in the bulk dispersion. Moreover, surfactant dependent studies revealed that the presence of the polysaccharide impacts the characteristics of the longer the chain length surfactants more than that of shorter ones. ACKNOWLEDGEMENT: Project no TKP2021-EGA-32 has been implemented with the support provided by the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund, financed under the TKP2021-EGA funding scheme.

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***** COMMERCIAL PRESENTATION *****

Analysis of Buried Interfaces for Device Technology by Soft and Hard X-ray Photoemission

E4

Due to its accuracy and reliability in determining nm-thick overlayers on Si, XPS has been utilized as a metrology technique for many years. It has become more challenging to perform surface sensitive XPS with a soft X-ray source because the interfaces of interest are frequently hidden beneath metal electrodes or oxide layers. Higher energy X-ray probe beams have made it possible to gather photoelectron signals from further deep in the material thanks to the development of lab-based hard X-ray spectrometers (HAXPES). New options for routine application for the qualification of the procedures and components utilized in technologically significant devices are thus made available. In this talk, we will discuss the current state of the art and possible future directions for integrating hard X-ray photoelectron spectroscopy (HAXPES) and soft X-ray photoelectron spectroscopy (XPS) in the study of semiconductors and nanoelectronics. We'll discuss the benefits of employing Hard X-ray sources on a lab-based high throughput fully automated spectrometer. This includes analysis of buried interfaces, such as electronic layers below a surface capping layer, and compositional studies in the bulk of materials and interfaces below the sampling depth of soft X-rays. Reduced surface contamination's impact on the photoelectron signal is another benefit of deeper sampling. For precisely the same reason, a deeper sample depth of the Cr source enables one to explore past the potential depth of ion sputtering-induced damage. Another crucial benefit is eliminating the overlap between Auger and major photoemission peaks. This is particularly important for transistor devices based on GaN technology, for which quantification using XPS is impossible due to the overlap between Ga Auger peaks and N 1s photoelectron peaks. Thin films of various types are critical components of modern microelectronic products. Conducting films form the interconnect layers in all chips, and dielectric films provide electrical insulation. Angle-resolved or angle-dependent XPS and HAXPES(ADXPS/ADHAXPES) is a powerful, non-destructive method that provides a quantitative chemical composition depth profile for thin film structures with thicknesses within the XPS sampling depth - under 5-10 nm for an Al K alpha soft X-ray source and ~15-30nm for a Cr K alpha hard X-ray source. We will describe the use of the software StrataPHI for metrological applications in devices to estimate the structure of thin-film stacks from angle-dependent and spectral XPS and HAXPES data.

Co-authors: ***MANN J., BIDERMAN N., ARTYUSHKOVA K.***

Nanocharacterization - Technics

RÜMMELI Mark H. ***VSB - Technical University of Ostrava, Ostrava, Czech Republic, EU***

***** INVITED LECTURE *****

Towards Atom Precise Synthesis and Engineering with Electron Microscopes E6

In this presentation I will highlight the different areas of research I am involved with. The areas I will introduce are the synthesis of nano-materials, nano-bio studies, nano-materials in ion insertion batteries and finally electron beam materials science. A common aspect of much of the work is to explore ways to correlate structure - property relationships, for example, the chiral dependence of single wall carbon nanotubes with respect to their electrical properties or biological cell response with respect to nanomaterial type, size and morphology. A key feature of my research is to develop a transmission electron microscope (TEM) into an atomic-scale laboratory to fabricate, modify and characterize samples so that crucial structure property studies and synthesis studies can be conducted in high spatial resolution and high temporal resolution. Thus, the core of this presentation will look at a variety of electron beam driven chemical reactions and electron beam engineering techniques in which we can fabricate and manipulate nano-materials at the atomic level.

VÁCLAVIK Richard ***Masaryk University, Brno, Czech Republic, EU***

Advanced Methods for Measuring Mechanical Properties of Nanocomposite Plasma Polymers Using Nanoindentation **E7**

The presented work focuses on advanced nanoindentation techniques for measuring the mechanical properties of thin films with complex topography and structure. Advanced nanoindentation techniques were applied to nano-composite thin films with a plasma polymer structure. These films were deposited on silicon substrates in a capacitively coupled radiofrequency discharge from a mixture of monomer hexamethyldisiloxane (HMDSO) and oxygen as the carrier gas. The power supply of the CCP and the flow rates of both HMDSO and oxygen were chosen to grow thin films under dusty plasma conditions. The deposition time was in the range of tens of minutes to achieve sufficient thicknesses (1-15 micrometers) and suppress the influence of the substrate. To select suitable places for individual nanoindentation tests, surface topography was visualized via indentation tip scanning, and the distribution of mechanical properties was acquired via high-speed mechanical property mapping beforehand. This approach allows distinguishing between the matrix and dust particles and performing targeted measurements at specific locations. To obtain extensive information about the mechanical properties, the studied samples underwent measurements by various indentation methods, such as nanoscale dynamic mechanical analysis (nanoDMA) with different oscillation frequencies, loading profiles, loading rates, and other parameters. Partial unloading tests were performed to obtain a depth profile of mechanical properties, with variations in the duration of individual segments, loading/unloading rates, and other indentation parameters. Additionally, creep tests were conducted to analyze the viscoelastic properties of the studied materials at various locations on the sample and using different indentation parameters such as loading/unloading profiles and the duration of the creep segment. ACKNOWLEDGEMENTS: This research has been supported by projects LM2018097 and LM2023039 funded by the Ministry of Education, Youth and Sports of the Czech Republic and by Czech Science Foundation under project GA23-06263S.

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Quantification of Boron Concentration in Diamond Electrodes and Its Impact on Electrochemical Stability Window **E8**

This study presents a comprehensive characterization approach to gain deeper insights into the relationship between boron concentration, film quality, and electrochemical performance of boron-doped diamond electrodes. Advanced methodologies were employed to precisely detect and quantify boron concentration in diamond films grown as a function of Trimethylborane (TMB) in the feed gas mixture of methane and hydrogen. Surface and bulk, chemical, and electronic analytic techniques were utilized to accurately quantify boron content and its incorporation into diamond films over a wide range from 10E+15 to 10E+21 cm-3. The surface morphologies were investigated by scanning electron microscopy that has revealed a microcrystalline nature, with an inverse correlation between average grain size and increasing boron contents. Moreover, the crystallinity was confirmed by grazing incident X-ray diffraction results with the presence of (111) and (220) peaks. X-ray Photoelectron Spectroscopy, sensitive to a depth of max. 10 nm, demonstrated a linear increase in atomic percentage B (~1%) with increasing TMB. As well as linear dependence was found by Nuclear Reaction Analysis, which revealed concentrations from 10E+18 to 10E+21 cm-3 over the whole film bulk. Finally, Hall effect measurements identified electrically active carrier concentrations within the range of 10E+17 to 10E+21 cm-2. The practical significance of controllable B concentration was demonstrated through a comprehensive study on the dependence of the electrochemical stability window (ESW), which showed a maximum ESW of 3.5 V for a boron concentration of 10E+17 cm-2 as confirmed by Hall measurements.

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AFM and MD Simulations Analyses of [7]-helicene Assembly on ZnO Polar and Non-polar Facets E9

Despite the importance of [7]-helicene as a small chiral molecule, its interactions with zinc oxide (ZnO) nanomaterials that are prospective in photocatalysis have not yet been sufficiently explored. Here the impact of surface polarity of different ZnO facets on P/M-[7]-helicene adsorption is studied both experimentally by atomic force microscope (AFM) and theoretically by force field molecular dynamics (FFMD) and density functional tight binding simulations (DFTB). Nonpolar ZnO surfaces cause self-assembly into layered nanoislands with characteristic 4 nm layer thickness. Polar O-faced ZnO surface causes the formation of similar nanoislands, while polar Zn-faced ZnO surface is practically clean with few circular objects. Theoretical simulations show the impact of surface dipole electric field orientation and magnitude, surface chemistry and solution on helicene self-assembly. The results thus also show a way for controlling the assembly of [7]-helicene and other molecular nanomaterials for diverse applications.

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ŠEC Karel ***Nicolet CZ, Prague, Czech Republic, EU***

***** COMMERCIAL PRESENTATION *****

New Advances in s-SNOM: Optical and Chemical Characterization of Nanomaterials E10

Scattering-type Scanning Near-field Optical Microscopy (s-SNOM) is a scanning probe approach to optical microscopy and spectroscopy bypassing the ubiquitous diffraction limit of light to achieve a spatial resolution below 10 nanometer. s-SNOM employs the strong confinement of light at the apex of a sharp metallic AFM tip to create a nanoscale optical hot-spot. Analyzing the scattered light from the tip enables the extraction of the optical properties (absorption, reflectivity) of the sample directly below the tip and yields nanoscale images simultaneous to mechanical properties. In addition to optical nanoscopy the technology has been advanced to enable hyperspectral, nanoscale Fourier-transform spectroscopy (nano-FTIR) using broadband radiation. Equipping s-SNOM systems with IR tunable light sources, nanoscale chemical mapping can be performed at time scales of 30-300s per image. Use of material-selective frequencies in the mid-IR spectral range can be exploited to fully characterize biomaterials, polymer blends or phase change polymers with nanometer-scale domains. New Single widely tunable laser wOPO: 1.4 - 18.4 µm (7 140 - 540 cm-1) will be discussed and broad range of applications of the s-SNOM technology for biological materials, inorganics and 2D materials research, will be presented.

Standardization/Nanocharacterization - Techniques

KOLTSOV Denis *BREC Solutions/ISO TC229 (Nanotechnologies), Lancaster, United Kingdom*

***** INVITED LECTURE *****

Nearly 20 Years of Standarisation of Nanomaterials - Where Are We and Where Is It Going E11

In 2025 ISO and CEN international standards committees on nanotechnology will celebrate 20 years of tireless efforts in developing terminology, characterisation, safety and material specifications for all aspects of nanoparticles and nanomaterials. This talk will take us on the journey of the last 20 years with more than 100 international standard documents published and more in the pipeline. We also look at the trends in the industry, the rise and fall of wonder materials and will look ahead into future developments and global priorities and their driving forces.

AMAL JESURAJ Stephena Elsie *Ariel University, Ariel, Israel*

Solvent Kinetic Isotope Effect on Ag0 NPs Formed via Borohydride reduction E12

It was recently proposed that agglomeration of (H2O)AgH forms the seeds of Ag0-NPs formed via Creighton's procedure (borohydride reduction).1 Furthermore, it was shown that when Ag0-NPs are formed via Creighton's procedure in D2O their sizes are considerably larger than that of those formed in H2O.2 We synthesized Ag0-NPs in water and heavy water, D2O, from two different precursors, silver sulfate and silver nitrate, and studied the nucleation and growth processes. The diameters of nanoparticles formed using water and D2O for Ag2SO4 and AgNO3 are 4, 9 nm, and 9, 6 nm, respectively. These measurements indicate that the solvents affect the size of the Ag0-NPs formed from sulfate and nitrate salts in opposite directions. It was proposed that the isotope effect in the reduction of Ag2SO4 is due to different hydrogen bonding of (H2O)AgH and (D2O)AgH. TEM, UV-Vis, and XPS analyses demonstrate that the nanoparticle production process varies depending on the solvent used for each precursor. In the presence of H2O as a solvent, the Ag0-NPs generated from silver sulfate are small. In the case of silver nitrate, the nitrate is reduced to ammonia during the process, which slows down the Ag0-NPs formation and, therefore, results in larger nanoparticles. Using D2O as a solvent, XPS confirmed that nitrate was only partially converted to ammonia, i.e., the kinetic isotope effect reduces the competition of the nitrate reduction process with the Ag0-NPs formation. As a result, the sizes of the formed nanoparticles decrease. This work allows a better understanding of the mechanism underlying the solvent and anion influence on nanoparticle development. 1. T. Mondal, A. Sermiagin, D. Meyerstein, T. Zidki, H. Kornweitz, Nanoscale, 12, 1657-1672, 2020. 2. A. Sermiagin, Ph.D. Thesis, Ariel University, 2021.

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XPS Characterization of Mo-Nb Mixed-oxide Nanorod Arrays via the Anodizing of Thin Al/Mo-Nb-alloy Bilayers on Substrates E13

Molybdenum oxides form a large group of materials resulting from the ability of Mo to possess different formal oxidation states and local coordinations, which may give rise to mixed-valency oxides indispensable for energy storage, gas sensing, electrochromic or catalytic applications. Nanostructuring and doping molybdenum oxides with foreign elements or mixing with similar or dissimilar metal oxides may theoretically substantially advance the properties of the individual oxide, although such an approach typically requires exceptionally high temperatures, high vacuum, and high-budget equipment. In this work, we present an alternative approach to creating arrays of molybdenum oxide mixed with niobium oxide nanostructures via a simple, self-organized, room-temperature electrochemical anodizing of thin Al layers superimposed on thin Mo-Nb metal-alloy layers of variable component concentrations prepared by the magnetron sputter-deposition. Anodizing was carried out in sulfuric or oxalic acid solutions, resulting in the formation of porous anodic alumina (PAA), followed by PAA-assisted oxidation of the alloy underlayers, and finishing with selective dissolution of the PAA overlayers.

Detailed XPS analysis of Nb 3d and Mo 3d narrow-scan spectra revealed that the highest amount of Mo in the nanostructures' surface was 93 at.% (Mo+Nb = 100%). The dominating molybdenum-oxide component comprised Mo cations with various oxidation states (Mo6+, Mo5+, Mo4+, and Mo3+), whereas the niobium-oxide inclusion was entirely stoichiometric Nb2O5. The success of preparing and analyzing the Mo-Nb mixed-oxide nanostructures is vital for understanding the formation-structure-morphology relationship and exploring the functional properties of the novel nanoarrays. This research was supported by GACR grant no. 23-07848S.

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Investigating the Excited-State Dynamics of the Phase-transformable Photoactive Metal-Organic Framework Mip 177 Using Time-Resolved Infrared Spectroscopy E14

MIP 177 LT and MIP 177 HT are two phase-transformable metal-organic frameworks featuring a Ti12O15 oxocluster and a tetracarboxylate ligand. They exhibit strong chemical stability and enhanced photoactivity, with MIP 177 LT outperforming MIP 177 HT in both chemical and photoactivity due to differences in the attachment of Ti-Oxo subunits. To study their excited-state dynamics, mid-IR time-resolved infrared spectra were obtained using step-scan Fourier transform absorption difference spectroscopy with 2.5 ns time resolution. Analysis of the data following 355 nm laser excitation reveals temporal changes in the ν (O-Ti-O) vibrations of the Ti-O metal cluster and the ν (-COO) vibrations of the ligand, indicating that these moieties are the primary sites for localized excited charges at the nanosecond timescale (Figure 1). The differential absorbance (Δ Absorbance) shows a direct negative correlation, reflecting the charge transfer between these moieties. MIP 177 LT demonstrates a longer-lived transient signal of up to 180 ns compared to 100 ns for MIP 177 HT, suggesting a more extended lifetime of reactive charges on its surface, which enhances its effectiveness. Additionally, a notable ultrafast transition from bidentate to monodentate bridging in the -COO-Ti-O ligand-metal coordination environment was observed in MIP 177 LT following photoexcitation. This long-lived change was not observed in MIP 177 HT and may explain MIP 177 LT's superior ability to accumulate electrons during continuous photoexcitation, leading to enhanced photocatalytic activity.

Co-authors: ***PAZ Yaron***

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Flexible Conductive Nonwoven Fabrics for Wearable Electronics E15

Poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT) nanofiber-based materials represent advanced solutions for application in wearable electronics due to their biocompatibility, lightweight, permeability and improved sensitivity related to their large surface area. Since PEDOT is a conductive polymer, the electrospinning process for manufacturing thin, flexible nonwovens made of homogeneous nanofibers is not well-studied yet. In this research, we have investigated the fabrication and characterization of electrospun conductive nanofibers composed of varying concentrations of PEDOT mixed with poly(ethylene oxide) (PEO). The electrospinning technique was employed to produce these conductive nonwovens, and their morphological properties were evaluated using scanning electron microscopy (SEM). To enhance the water resistance of nanofibers, a thermal treatment was applied to remove excess PEO. The resulting samples demonstrated significant improvements in water stability, whereas untreated samples dissolved in pure water almost immediately. Electrical characterization of conductive nonwovens was performed, revealing resistivity in several hundreds of Ohm•m. To further investigate the electrical response and electrochemical behavior of the material when in contact with specific compounds, we conducted electric impedance spectroscopy (EIS) and cyclic voltammetry (CV). The EIS measurements provided insights into the impedance characteristics, while the CV analysis elucidated the redox properties and a purely resistive behavior. Our findings suggest that the optimized PEDOT/PEO nanofibers exhibit promising electrical and electrochemical properties, making them suitable for applications in flexible electronics and wearable sensors. This study contributes to the understanding of the relationship between the fabrication process, structural morphology, and functional performance of electrospun conductive nonwovens with the potential to significantly impact the wearable technology field.

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WORKSHOP NanoEnviCz

Chairman

Dr. Jan TOPINKA Institute of Experimental Medicine of the CAS, Czech Republic, EU

ŘEZANKA Michal *Technical University of Liberec, Liberec, Czech Republic, EU*

Advanced Instrumentation in NanoEnviCz at TUL: Nuclear Magnetic Resonance for Nanomaterials Characterization W1

The NanoEnviCz research infrastructure provides access to state-of-the-art instrumentation for the study of nanomaterials, supporting cutting-edge research in environmental applications. This presentation will provide an overview of key instruments available within NanoEnviCz at the Technical University in Liberec (TUL), with a focus on nuclear magnetic resonance (NMR) spectroscopy. NMR is a powerful tool for the detailed characterization of nanomaterials, offering insights into molecular structure, dynamics, and interactions. By highlighting specific examples of NMR applications, the talk will demonstrate how this technique enhances our understanding of nanomaterials' properties and behaviors, ultimately contributing to the development of innovative solutions in nanotechnology. ACKNOWLEDGEMENTS: The authors acknowledge the assistance provided by the Research Infrastructure NanoEnviCz, supported by the Ministry of Education, Youth, and Sports of the Czech Republic under Project No. LM2023066.

SAZAMA Petr *J. Heyrovský Institute of Physical Chemistry of the CAS, Prague, Czech Republic, EU*

Effects of Nanoconfinement on Catalysis W2

Confinement of catalytic sites and reactant molecules within nanometer-scale pores plays a crucial role in the functionality of numerous heterogeneous catalysts in chemistry and enzyme-based catalysts in bio-chemistry and nature. The active sites within the catalyst's pores, which are of a size comparable to that of the reactant molecules involved in the reaction can influence the course of the catalytic transformation as well as the nature of the catalytic center. In this contribution, we focus on the studies that were carried out with the assistance of the NanoEnviCz infrastructure, and which contributed to the development and understanding of nanoconfined catalysts. The presentation will introduce a concept for the creation of heterogeneous catalysts with a confined reaction environment, combining the advantages of shape-defined and accessible porous structures resembling zeolites together with the very high surface area, stability, and physical properties of graphene carbon. ACKNOWLEDGEMENTS: The authors acknowledge the assistance provided by the Research Infrastructure NanoEnviCz, supported by the Ministry of Education, Youth, and Sports of the Czech Republic under Project No. LM2023066.

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Innovation of Instrumental Techniques and Practical Example of Using of Support of NanoEnviCz Project W3

The NanoEnviCz is a large infrastructure offering a simple way to contact the specialist and support any research within the student thesis or research on nanotechnology or environmental topics. The universities and academic institutions form a network of six academic subjects. All institutions have experience with syntheses and characterization of nanomaterials, detection of contaminants or decontamination of pollutants, studying toxicity, etc. The innovation of instrumental techniques is very important because of better detection sensibility, quicker analysis, and more practical solutions or completely new kinds of information. IIC will get untill the end of this year a new infrared spectrometer and, next year, a small X-ray powder diffractometer, which is useful for quick monitoring in the laboratory. Effective decontamination of drinking water or water in general is actually problematic. The sorbents that could be applied are in many different groups. The most critical parameters are the price and availability to be prepared on a large scale and the selectivity or the opposite to have multifunctionality. ACKNOWLEDGEMENTS: The authors acknowledge the assistance provided by the Research Infrastructure NanoEnviCz, supported by the Ministry of Education, Youth, and Sports of the Czech Republic under Project No. LM2023066.

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Sustainable Solutions for Safer Lithium-ion Batteries: From Advanced Materials Development to Comprehensive Critical Raw Materials Recovery W4

Lithium-ion batteries (LIBs) are pivotal in energy storage, particularly for mobility applications and electric vehicles (EVs). Commercial LIBs were first introduced by Sony Inc. in the 1990s. Since then, they have become widely used in various applications, from consumer electronics to EVs. Over the past decade, their adoption has surged due to their superior energy density compared to lead-acid batteries and their high efficiency. During this period, their energy density has doubled, while their cost has decreased by a factor of ten or more. State-of-the-art LIBs can achieve specific energy levels above 250 Wh/kg at the cell level and 175 Wh/kg at the pack level, with estimated costs ranging from 100 to 150 €/kWh at the pack level. For a relatively large battery, this translates to a range of approximately 400 km and an estimated lifespan of around 150,000 km. The next generation aims for energy densities of about 450 Wh/kg at the cell level to support heavy-duty applications. LIB technology has advanced to Gen 3, while the next generation, for example, based on solid-state components, is still in the research and development phase. Our main aim is to drive genuine advancements to develop safe-and-sustainable-by-design materials, to ensure the economical and widespread utilization of safer LIBs in modern society. The pivotal scientific and technological challenges encompass the development of functional materials, the design of sustainable fabrication and recycling processes, and the understanding of pertinent interfacial phenomena and degradation mechanisms. Specifically, our research focuses on (i) fabricating innovative nanofiber-based architectures for smart-functioning separators able to protect battery flaws - especially thermal runaway; and on (ii) developing cutting-edge and eco-friendly recycling processes to recover all materials (metals, separators - via solvolysis&pyrolysis - and electrolyte) from end-of-life LIBs. NanoEnviCz provides a unique set of facilities for advancing the complex and comprehensive analysis of LIBs. We will present some of our facilities which include the latest atomic-force microscopy or analytical instruments used to identify complex compounds in the chemical recycling processes of polymers in LIBs. ACKNOWLEDGEMENTS: The authors acknowledge the assistance provided by the Research Infrastructure NanoEnviCz, supported by the Ministry of Education, Youth, and Sports of the Czech Republic under Project No. LM2023066 (www.nanoenvicz.cz/en), REPOBAT TA ČR TN02000051/016, and the Horizon Europe project INERRANT GA No. 101147457 (https://inerrant-batteries.eu/). We are also grateful to our industrial partners, namely nanoSPACE Technology, s.r.o and IBG Česko, s.r.o. for their support.

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NanoEnviCz: New Instrumentation for Single Cell Toxicogenomics available at IEM W5

The services of the NanoEnviCz research infrastructure were recently broadened by unique instrumentation ChromiumX capable to analyze gene expression changes (mRNA).and detection of surface proteins on the level of individual types of cells in tissues and mixtures of cell cultures. Chromium X is a state-of the-art device for single-cell analyses that enables to study mechanisms of interactions between nanomaterials and biological system on a molecular level in individual cells. In comparison to bulk sample analyses (providing an average signal of all the tested cells), single-cell analyses enable the study of each cell's unique genetics, gene expression, and other molecular features. As such, single cell analyses detect heterogeneity within the tissue or cell populations and reveal mechanism of different cell functions and behaviors in response to various stimuli, such as nanomaterial treatment. The instrumentation might be useful in nanomedicine (drug development, personalized medicine), and nanosafety (nanotoxicity, adverse outcome pathways, new approach methodologies). Chromium X can also be employed in microbiology (interactions between nanomaterials and microorganisms, microbial resistance), environmental biotechnology (bioremediation, wastewater treatment), and other environmental sciences (biomonitoring, biosensoring). The presentation will summarize the advantages and possibilities of this new instrumentation in comparison with technique used within NanoEnviCz. Until now. ACKNOWLEDGEMENTS: The authors acknowledge the assistance provided by the Research Infrastructure NanoEnviCz, supported by the Ministry of Education, Youth, and Sports of the Czech Republic under Project No. LM2023066.

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CZECH-TAIWANESE SYMPOSIUM

KUO Chien-Cheng ***National Sun Yat-sen University, Kaohsiung, Taiwan***

Electronic and Spintronic Structures of Low-Dimensional Materials **CT1**

In our quest to study quantum phenomena, we focus on low-dimensional structures as they provide a testing ground for both quantum field theory and condensed matter physics. In this presentation, we will share our recent advancements in characterizing the electronic and spintronic structures of low-dimensional materials using scanning tunneling microscopy/spectroscopy and synchrotron-based photoemission microscopy. One of our significant findings involves the observation of distinct Landau levels in epitaxial graphene with Moiré structures on the Ru(0001) substrate, indicating the presence of a pseudo-magnetic field reaching magnitudes of several hundred teslas in these periodically strained systems. Additionally, through the direct selenization of platinum single crystals, we discovered the coexistence of multiple crystal structures of platinum selenites on the surface, each with different electronic properties. This discovery offers valuable insights into the microscopic understanding of van der Waals structures. By employing specially designed samples and synchrotron-based microscopy, we are able to investigate the individual magnetic properties of layerwise magnetic coupled structures. Moreover, by characterizing magnetic domains in relation to thickness variations, we can quantitatively identify the magnetic anisotropies of complex structures. During the presentation, we will delve into the scientific and technical details behind these intriguing discoveries.

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Collaboration: ***The Tokyo University, Institute of Solid State Physics, Japan; National Central University, Department of Physics, Taiwan***

LIN Wen-Chin ***National Taiwan Normal University, Taipei, Taiwan***

Sensitive Hydrogenation Effect on Antisymmetric Magnetoresistance in Co/Pd Multilayers **CT2**

In Co/Pd multilayers, we observe controllable anomalous magnetoresistance (MR) influenced by the unique geometric relationship among current, magnetization, domain wall motion, and hydrogen loading. An antisymmetric MR is measured in the ambient condition, because of the presence of perpendicular magnetic anisotropy (PMA) and the asymmetric domain wall motion, as shown in Fig. 1(a)-(e). The investigation, including magnetic domain images acquired through the Magneto-Optical Kerr Microscope and transport properties measurements, attributes the antisymmetric MR to the anomalous Hall effect within the PMA sample. Upon hydrogen absorption, the magnetization becomes tilted and then turns to in-plane anisotropy. Meanwhile, the MR curve sensitively changes with slight hydrogenation, corresponding to the spin-reorientation transition process in the Co/Pd multilayer, as shown in Fig. 1(f)-(h). Upon more hydrogen exposure, an obvious MR is only present when an in-plane magnetic field is applied, signifying a transition to in-plane anisotropy. This study emphasizes the tunable nature of MR in the Co/Pd multilayer system, providing novel insights into the diversity of MR, which holds the potential to influence the multifunctionality of spintronic devices. The high sensitivity of PMA and MR behavior to a few mbar hydrogen pressure suggests its potential for application.

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YANG Chun-Chuen ***National Central University, Taoyuan, Taiwan***

Investigation of the Complex Magnetic Behavior of Fe1.5V1.5O4 Spinel Nanoparticles **CT3**

The 50 nm Fe1.5V1.5O4 nanoparticles exhibit complex magnetic behavior due to the doping of Fe ions at the A and B sites of the spinel structure. Ferromagnetic behavior begins to appear as the temperature drops from 475 K to 400 K. Above

187 K, the material displays characteristics of cluster glass-like magnetism. The magnetic susceptibility experiment shows an antiferromagnetic feature peak at 187 K. Neutron diffraction data suggest that this phenomenon arises from the Fe ions at the A and B sites producing magnetic moments of different magnitudes, leading to a ferrimagnetic property. The neutron inelastic scattering experiment reveals the presence of a 6.8 meV spin gap at 1.5 K, induced by the spin-orbit interaction in the divalent iron located at position A. At 3.3 K, the magnetic space group is I41am'd' and the magnetic moments of the Fe ions at the A and B sites reach 3.25 and -1.25 µB/Fe, respectively, aligning with the M-H curve results. Furthermore, the M-H curve at 2 K reveals the formation of magnetic domains, with a coercivity of 3500 Oe.

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LIAO Yen-Fa ***National Synchrotron Radiation Research Center, Hsinchu, Taiwan***

The HArd X-ray PhotoElectron Spectroscopy (HAXPES) at TPS 47A beamline CT4

We established a new hard X-ray photoelectron spectroscopy (HAXPES) experimental end station on the Taiwan Photon Source 47A beamline. This HAXPES end station utilizes the superior synchrotron radiation light source provided by the high brightness source -TPS and the high energy resolution monochromator (HRM) specifically designed at the TPS 47A beamline. The TPS 47A beamline offers impressive capabilities, including energy resolution below 100 meV and photon flux in excess of 1 x 1011 photons/second. The beam spot size in our setup is 6 x 6 microns. Our HAXPES end stations feature a modular chamber design that facilitates seamless transition between NAP and UHV modes to meet the user's specific requirements. The high penetration of hard X-rays in this experimental setup gives it a clear advantage when studying semiconductor devices or multilayer systems involving inner layers and interfaces. One of our primary research goals is to investigate the interface in semiconductor devices to enhance their performance and operational stability. The distribution of elements at the interface and the corresponding chemical shifts can be analyzed using HAXPES. This data enables us to identify factors affecting the efficiency of semiconductor devices and devise performance improvement strategies. Furthermore, developing in situ/operando setups for semiconductor devices will be a key research focus at our HAXPES experimental end station.

Co-authors: ***HU Chih-Wei, HAW Shu-Chih, LIN Yu-Chang, CHEN Jin-Ming***

POSTER SESSION (A - E)

POSTER SESSION A

Nanocomposites

KOUSAL Jaroslav *Charles University, Prague, Czech Republic, EU*

Demonstration of Copper:pla-Like Nanocomposite-Based Distributed Bragg Reflector Gas Sensor PA1

Plasma polymerization, commonly considered a type of plasma-enhanced chemical vapour deposition (PECVD), is a popular method for depositing organic thin films. However, it often produces films with limited molecular complexity due to the necessity to use relatively low molar mass precursors that can be vaporized. To address these limitations, plasma-assisted vapour thermal deposition (PAVTD) was developed. In PAVTD, a solid polymer undergoes thermal degradation (evaporation) in a crucible, producing oligomers with higher molar masses (10^2-10^3 g/mol) than typical PECVD precursors. These oligomers are then re-polymerized in RF plasma, allowing PAVTD films to exhibit properties characteristic of classical polymer physics and chemistry, a rarity for plasma polymers. This process enables the precise control of properties such as biodegradability and hydrolyzability, as demonstrated in polylactic acid (PLA)-based films. PAVTD effectively bridges the gap between classical and plasma polymers. To enhance stability and deposition rates, continuous-PAVTD has been developed using standard FDM 3D printing filaments, achieving deposition rates up to several nanometers per second. This advancement addresses deposition duration and stability issues, making PAVTD a practical tool for studying plasma polymerization. Furthermore, PAVTD can be combined with other vacuum-based thin film deposition techniques like gas aggregation source of nanoparticles (GAS). This capability was demonstrated by fabricating Cu:PLA-like nanocomposite-based distributed Bragg reflectors (DBR), where the reproducibility of the deposition rate matters significantly. This reflector was tested as a gas sensor for ethanol vapours, exhibiting strong reflectance peak shifts.

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HEJAZI Hossein *Palacký University Olomouc, CATRIN-RCPTM, Czech Republic, EU*

Redefining Defect Engineering in Brookite TiO2: From Single-Atom Hosts to Optimized Sites for Photo-oxidation Reactions PA2

Traditional strategies for enhancing photocatalytic activity focus on tuning visible light response, crystal facets, and nanocrystal shape. Here, we used defect engineering approach to design efficient photocatalysts with substrate-specific reactivity. Platinized, defective anisotropic brookite TiO2 photocatalysts exhibit up to an 11-fold increase in methanol oxidation rate compared to pristine brookite, with much lower rates for ethanol and isopropanol. We demonstrate that increased alcohol oxidation boosts hydrogen evolution, with reduced anisotropic brookite showing up to 18-fold higher photoactivity than anatase and isotropic brookite nanocrystals. Controlled engineering of oxygen vacancies and lattice strain generates large electron polarons that host substrate-specific active sites for alcohol photo-oxidation. Photoluminescence excitation spectroscopy of charge carrier recombination in stoichiometric and reduced brookite nanorods identifies specific photoluminescence enhancement in reduced brookite, indicating conduction band electron injection during ethanol photo-oxidation. This explains their exceptional reactivity and efficient hydrogen generation.

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Synthesis and Characterization of Electricaly Conductive Composite from Glucose-Montmorillonite Nanocomposite **PA3**

The main objective of this study was to investigate the feasibility of preparing an electrically conductive composite containing graphite or graphene from a glucose-montmorillonite (MMT) nanocomposite. Four different ratios of crystalline glucose and MMT were mixed, thoroughly combined in a mortar, pressed into tablets, and calcined at 1300 °C. To understand the impact of calcination, the electrical conductivity of both non-calcined powder samples and pressed tablets was measured. The tablets were damaged during high-temperature calcination, so the calcined samples were crushed in a mortar for further testing. Various analytical techniques were used to characterize both calcined and non-calcined samples. X-ray diffraction (XRD) determined the crystalline structure and identified any new phases formed during calcination. Raman microscopy studied the presence of graphite or graphene. Transmission electron microscopy (TEM) provided an in-depth observation of the microstructure, revealing whether the layers in the samples matched the distances associated with graphite or graphene. Thermogravimetric analysis (TGA) assessed the thermal stability and composition of the samples. Elemental analysis examined the effect of glucose content before calcination and the carbonaceous content in the calcined samples. The combined results confirmed that calcination has an impact on electrical conductivity thanks to the formation of conductive carbon material, with the final properties dependent on the ratio of MMT to glucose. This work was supported by the SGS project no. SP2024/041.

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Investigating the Impact of Synthesis Procedures on Electrochemical Properties of rGO-CeO2 Nanocomposite **PA4**

rGO-CeO2 nanocomposite has been applied in the field of electrochemical sensors, which leads to a significant improvement for this type of sensors in terms of facility, sensitivity, and accuracy. Additionally, it is well known that synthesis procedures play an important role in the structure of nanomaterials (e.g., morphology), which in turn has a big impact on various properties. Hence, it is necessary to investigate the effect of synthesis procedures on characteristics of this nanocomposite to maximize the electrochemical performance (e.g., enhancing limit of detection) of the sensor using rGO-CeO2. In this study, two different approaches, namely in situ and ex situ methods, were used to synthesize GO-CeO2, then GO-CeO2 was reduced by hydrazine to form the final product rGO-CeO2. Subsequently, the morphology and elemental analysis/mapping of this nanocomposite were examined by Scanning Electron Microscopy and Energy Dispersive X-ray Spectroscopy, respectively. Afterwards, the nanocomposites were drop-casted on the surface of glassy carbon electrode, and the electrochemical properties, namely electroactive surface area and charge transfer resistance, were evaluated by Cyclic Voltammetry and Electrochemical Impedance Spectroscopy in the presence of ferrocyanide/ferricyanide redox probe. The results indicated that CeO2 nanoparticles were evenly distributed on the surface of wrinkled rGO sheets, and the nanocomposites from both approaches improved the electrochemical properties in comparison to bare glassy carbon electrode.

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Carbon Coating on Carbon Matrix Synthesized by Chemical Vapor Deposition Method for Composite Application **PA5**

A carbonaceous coating on a carbonaceous matrix was synthesized by the modified chemical vapor deposition (CVD) method. The specific morphology of the coating, with graphitic spikes protruding from the substrate and connected by fringes of multilayer graphene materials, was observed by scanning electron microscopy (SEM) and high-resolution transmission electron microscopy (HRTEM). X-ray diffraction (XRD) and Raman microspectroscopy demonstrated the coating's crystalline nature, with increased crystallinity leading to improved thermal resistance of the coated carbonaceous matrix in the presence of an oxygen atmosphere. The unique surface of the carbonaceous materials and their increased heat resistance make them intriguing for composite material applications.

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Nanoelectronics

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Electronic Structure Calculations of GaAs Using a Quantum Computer Simulator PA6

Simulating and characterizing physical systems is one of the most promising applications of quantum computing. In our research, we focused on electronic structure calculations of GaAs using quantum computer simulator. This work explores the binary crystal gallium arsenide, employing Variational Quantum Deflation (VQD) and the Subspace-Search Variational Quantum Eigensolver (SSVQE) to access the full energy spectrum. A tight-binding Hamiltonian is used to investigate the effects of optimization methods, hyperparameter tuning, and quantum circuit architecture on the performance of these variational quantum algorithms. Our findings show that higher-energy states require more iterations for accurate evaluation, with the Constrained Optimization BY Linear Approximation (COBYLA) method proving to be the most effective.

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Deciphering Emission Dynamics of Colloidal PbS QDs: Spectroscopic Insights under Diverse Experimental Conditions PA7

Lead-salt (IV-VI) semiconductor quantum dots (QDs) have been extensively investigated as highly promising fluorescent materials due to their many attractive features, including a simple, highly symmetric crystal structure, small bulk bandgaps, large exciton Bohr radii, and narrow emission spectra. Small PbS QDs (~a few nm) emitting in the near-infrared (NIR) range are of significant current interest, particularly in the fields of infrared photodetectors, solar cells, and biomedical imaging. However, little progress has been made in exploring mechanisms to manipulate their optical properties, such as lifetimes and lifetime distributions, which substantially limits the broader application of PbS QDs. We found that the excited-state dynamics of PbS QDs can be significantly altered by concentration-driven ligand dynamics, as well as by experimental parameters such as excitation pulse duration and laser power. We describe these effects in detail using a combination of spectroscopic techniques, including absorption, photoluminescence (PL), time-resolved PL kinetics, and transient absorption measurements. We demonstrate a distinct peak in lifetime spectral dispersion and show that it can be adjusted by varying the volume of added ligand molecules. By modulating the excitation pulse duration, we demonstrate the ability to manipulate the lifetime distributions. We believe that our findings suggest a new design principle for bright NIR-emitting PbS QDs with enhanced PL, which are urgently needed for a wide range of applications requiring microsecond-range lifetimes. Furthermore, our study emphasizes the critical role of capping ligands and experimental conditions in determining the PL properties of PbS QDs.

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On-chip Electrically Tunable Nanolasing Device Harnessing Exciton Resonances in CsPbBr3 PA8

Optical metasurfaces, ultrathin, nanoscale structures capable of precisely controlling light, offer compact alternatives to traditional bulky optical components. However, a major challenge remains in achieving their effective electrical tunability, which is crucial for creating active, reconfigurable devices. Traditional approaches using plasmonic or Mie resonances have been limited in this respect. Our research explores the potential of harvesting the excitonic resonances in all-inorganic metal halide perovskite CsPbBr3, since it supports room-temperature stable excitonic states and exhibits highly tunable optical properties across the visible spectrum. These attributes are making CsPbBr3 an ideal candidate for electrically tunable optical metasurfaces. We aim to demonstrate a novel on-chip nanolasing device utilizing a CsPbBr3 micro-resonator. Furthermore, by investigating the voltage-dependent behavior of exciton resonances, we seek to create a nanolaser with distinct ON/OFF states, advancing the functionality of active metasurfaces. This research has significant implications for the future of quantum communication technologies, where precise control of excitonic properties is essential.

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Antiphase Boundary in Ni2MnGa PA9

Ni-Mn-Ga alloy is the most promising candidate as material for magnetic shape memory applications. In addition to austenite, it is also found in variety of martensite phases. Antiphase boundaries (APBs) are planar defects that play a critical role in strengthening Ni-based alloys, and their sensitivity to alloy composition offers a flexible tuning parameter for alloy design. We combine experimental and theoretical (ab initio) methods to analyze the stability and magnetic order in the vicinity of an antiphase boundary in Ni2MnGa possessing L21 order. Ab initio electronic structure calculations based on density functional theory are used to investigate the magnetic order in structure simulating APBs in cubic austenite. Total energy calculations indicate that at the interface, the ferromagnetic arrangement changes its orientation in the opposite direction. This sudden change in magnetization is observed in microscope images by magnetic force microscopy. The images are shown and discussed.

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Metallic and Semiconductor Nanoparticles Integrated Into Thin Layers of Hydrogenated Amorphous Silicon or Siliconcarbide PA10

The combination of plasma enhanced chemical vapor deposition and vacuum evaporation at one vacuum chamber is in situ method how to integrate metallic (Sn) and semiconductors (Ge) nanoparticles into amorphous hydrogenated thin films and their structures on the base of a-Si:H or a-SiC:H. The transmission and scanning electron microscopy and atomic force microscopy structures are used for their microscopical characterization while the photothermal deflection spectroscopy and photoluminescence spectroscopy are used for spectroscopical characterization. For the final characterization of the electronic properties is used the measurement of temperature dependence of electrical conductivity with evaluation of the activation energy. ACKNOWLEDGEMENTS: The work was supported by the Czech Science Foundation project 24-10607J. This work has used the large research infrastructure CzechNanolab supported by the MEYS through the project No. LM2023051.

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2D Nanostructures

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Modeling of Fluorine-terminated Yttrium Carbides **PA11**

In order to overcome the restacking problem of 2D materials, different approaches to designing MXene into 3D structures have been studied extensively. One material that has attracted considerable attention in this context is fluorine-terminated yttrium carbide (Y2CF2). Herein, we have investigated the structural and electronic properties of Y2CF2 as a pure 3D crystalline stack of MXene-like sheets by using different density functional theory (DFT) exchange-correlation functionals. We first focused on interlayer interactions, possible stacking conformers, and stability. Next, we aimed to explore the optical, mechanical, and thermal properties of both the 3D crystalline structure and its 2D constituent.

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Heterostructured Graphene Oxide/η6-Areneuruthenium Films for Hydrogen and Oxygen Evolution Reaction Electrodes **PA12**

Hydrogen and oxygen evolution reactions (HER and OER) are crucial for the development of water splitting processes and green hydrogen production that meet the energy demands of modern society. The efficiency of these electrode reactions is primarily governed by the nanostructure and chemical reactivity of the components present in the electrocatalyst. This work aims to generate hybrid materials based on graphene oxide (GO) and an organometallic η6-areneruthenium coordination polymer containing 1,3,5-benzenetriacetate as a bridging ligand, for constructing electrodes for HER and OER. Two types of deposition methods were tested: dip-coating and the Langmuir-Blodgett (LB) method. After obtaining the GO films, they were alternately immersed in η6-areneruthenium and benzenetriacetate solutions for varying durations (from 5 to 30 minutes). The films were characterized by spectroscopic techniques. Linear sweep and cyclic voltammetry were performed in a 3 mol·L-1 NaCl solution. The best performance was achieved by the films deposited using the LB method, which generated cathodic currents per mass per area of nanocatalyst in HER that were eight thousand times higher than the analogous dip-coated films at the same mild potential. These results revealed the influence of the heterostructure in the electrocatalytic activity, that present higher efficiencies and more rational use of resources.

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Magnetic Polaron States in Photoluminescent Carbon DotsEnable Hydrogen Peroxide Photoproduction **PA13**

Photoactivation of aspartic acid-based carbon dots (Asp-CDs) induces 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 depends on the solvent polarity, featuring a substantial stabilization of the triplet state in a non-polar environment (benzene). The electronic properties of the photoexcited Asp-CDs emerge from their spatial organization being interpreted as multi-layer assemblies containing a hydrophobic carbonaceous core and a hydrophilic oxygen and nitrogen functionalized surface. The system properties are dissected theoretically by density functional theory in combination with molecular dynamics simulations on quasi-spherical assemblies of size-variant flakelike model systems, revealing the importance of size dependence and interlayer effects. The formation of the spin-separated states in Asp-CDs enables the photoproduction of hydrogen peroxide (H2O2) from water and water/2-propanol mixture via a water oxidation reaction.

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Films/Layers

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Hybrid Gas Sensor Based on Diamond-coated QCM with Ink-jet Printed IDT Electrodes PA14

Environmental cleanliness is of paramount importance in maintaining a high quality of life on Earth. This study integrates the mass quartz crystal microbalance (QCM) and conductive interdigital transducer (IDT) metallization in a hybrid sensor. The active layer of the sensor compromises hydrogen-terminated nanocrystalline diamond (H-NCD), which is a highly intriguing wide-bandgap material known as well responsive to a range of external stimuli, including oxidizing and reducing gases, light illumination, bio molecules, and other surrounding conditions. The H-NCD exhibits distinctive properties in induced subsurface p-type conductivity, also known as two-dimensional hole gas (2DHG), which is sensitive to exposed gases or organic molecules. To fabricate the hybrid sensor, the QCM crystal was initially coated with a thin H NCD layer. The IDT structure was then printed on this structure using the ink-jet method with silver ink. The high thermal conductivity of the diamond layer enhanced the print quality, as the ink dried more rapidly and increased the resolution of the printed structures. The IDT structures were dried by annealing process at 150°C for one hour. This hybrid sensor employs two distinct detection principles: the QCM component responds to the mass of bound molecules on the sensor's surface while the IDT measures the conductivity changes within the subsurface 2DHG layer due to the charge transport/exchange between diamond and gas molecules. These complementary sensing principles form a hybrid sensor with enhanced detection capability and selectivity for environmental influences compared to individual sensors.

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Fabrication and Modification of SiV-doped Diamond Films: Towards Tailored Nanostructures with Enhanced Photoluminescence PA15

Optically active diamond structures have gained significant importance as the material of choice for biological, optoelectronic, and quantum sensing applications. In this sense, ultrananocrystalline diamond (UNCD) films incorporating photoluminescent color centres have emerged as promising initial material for fabrication of diamond nanoparticles and membranes. Especially, negatively-charged silicon-vacancy color centers (SiV) in diamond are often inflected due to the bright and spectrally narrow photoluminescence (PL) at room temperature, with a short decay time and high photostability. This study focuses on the synthesis and optical properties of UNCD films with SiV centers fabricated by chemical vapor deposition (CVD) method, where SiV are incorporated into diamond either from solid silicon source or silane as gas silicon source. The incorporation and characteristics of SiV centers from both sources were critically evaluated. Additionally, we present a molten salt thermal etching (MSTE) process as a perspective approach for future nanoparticles and membranes creation from UNCD films. Our results demonstrate a versatile approach to UNCD growth and modification that offers controllable porosity and concentration of SiV centers. This method opens the way to advanced quantum sensing applications. The findings of this study contribute to the growing body of knowledge on diamond-based materials for quantum technologies and nanoscale sensing. This work was supported by the MEYS project Mobility plus DAAD 24-13 and the bilateral GACR LA project no. 23-04322L.

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Tailorable Diamond Cavities: A Novel Approach to Self-Standing Diamond Film Fabrication **PA16**

This study presents a novel approach for fabricating self-standing diamond films with tailorable cavities, eliminating the need for reactive ion etching (RIE). We employed selective area deposition on SiO2/Si substrates in a microwave plasma CVD system at high temperatures (1000°C). The method exploits the thermal expansion mismatch between diamond and SiO_2/Si substrates to induce film delamination, resulting in free-standing structures. Diamond films with thicknesses of approximately 50 µm were produced, featuring cavities whose dimensions could be controlled by lithography mask dimensions and deposition time. Raman spectroscopy confirmed the high quality of the diamond films, showing a dominant peak centered at 1330 cm^{-1}. The presented technological approach offers a promising solution for microstructuring of diamond films with potential applications in high-tech applications.

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Optical and Impedance Spectroscopy of Undoped and In, Ga and Al Doped ZnO thin Films Deposited by Pulsed Laser Deposition on Sapphire Substrates **PA17**

In this work, the nominally undoped and In, Ga and Al-doped ZnO thin films were pulsed laser deposited (PLD) on sapphire substrates and tested for potential applications in photodetector devices. Optical measurements by photothermal deflection spectroscopy (PDS) show a systematic change in the optical absorption edge and Urbach energy with increasing doping concentration, indicating a modification of the electronic structure and defect states. Complementary photoluminescence (PL) spectra were acquired to elucidate the radiative recombination processes and defect-related emissions in the ZnO films. The PL data corroborated the PDS findings, showing a shift in the near-band-edge emission and changes in defect-related peaks as a function of In (Ga, Al) doping. Impedance spectroscopy was employed to investigate the electrical properties and charge transport mechanisms in the ZnO films. The IS data were analyzed using equivalent circuit models to extract key parameters such as carrier concentration, mobility, and interfacial resistance. The combined analysis provided a comprehensive understanding of the optoelectronic properties of ZnO films. The findings suggest that optimized doping can enhance the photoresponse and charge transport properties of ZnO, making ZnO a promising material for high-performance photodetector applications. The work was supported by the Czech Science Foundation project 24-10607J, Ministry of Education, Youth and Sports of Czech Republic (MEYS) Danube project 8X23025 and the Mobility Plus project SAV-23-13 (CAS-SAS-2022-08). The authors also acknowledge the Czech Ministry of Education, Youth and Sports grant no. CZ.02.01.01/00/22_008/0004617 - "Energy conversion and storage".

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Real-Time Monitoring of Pseudomonas Syringae Biofilm Formation Using a Dual-Sensing Approach: ATR FT-IR and Impedance Spectroscopy **PA18**

This study investigates the real-time formation of Pseudomonas syringae pathovar morsprunorum CCM 2534 (Psm) biofilms, a novel dual-sensing approach integrating attenuated total reflection Fourier-transform infrared (ATR FT-IR) spectroscopy and impedance spectroscopy under continuous medium flow. While ATR FT-IR effectively characterizes the initial stages of biofilm formation, particularly adhesion and early development, it may provide limited information on the growth and maturation of biofilms with tall structures (mushroom-shaped microcolonies). To address this limitation, we employed complementary impedance measurements. ATR FT-IR spectra of the Psm biofilm, recorded within the 4000-800 cm-1 spectral window, revealed characteristic absorption bands at 1141-1006 cm-1, 1420-1380 cm-1, 1580-1490 cm-1, and 2935-2915 cm-1. The integrated areas of these bands were utilized to monitor the progression of individual phases of Psm biofilm development, including inoculation, washing, recolonization, restructuring, and maturation. Impedance measurements, conducted with a constant voltage of 500 mV over a frequency range of 10 Hz to 100 kHz, enabled a comprehensive analysis of biofilm growth due to varying current paths through/around the Psm cells. This technique showed promise in capturing the later stages of Psm biofilm development, particularly data recorded at lower frequencies during the first 72 hours. However, further optimization of impedance measurements is necessary to establish this approach as a reliable complement to ATR FT-IR for long-term monitoring. This dual-sensing technique offers a promising perspective for in-depth, real-time analysis of biofilm formation, potentially advancing our understanding of microbial colonization processes.

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Magnetic, Metal and Oxidic Nanomaterials & Other Nanostructures

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Iron-Nickel Nanocrystalline Particles - Effect of Preparation of Precursors PA19

Fe-Ni-based nanoparticles are promising materials for the production of high-performance permanent magnets. The research explores the preparation of Fe-Ni alloys using iron-nickel oxalate precursors, which were synthesized via the coprecipitation method and subsequently reduced in a hydrogen atmosphere. One of the aims of the work is to compare the effect of different methods of preparation of precursors on the particle size and composition of the resulting materials. Structural, magnetic, and morphological properties were analysed using a combination of Mössbauer spectroscopy, X-ray powder diffraction (XRD), and scanning electron microscopy (SEM). The relative proportions of iron and nickel content in the prepared oxalate precursors were approximately 50% by weight, according to EDS analysis. The precursor samples consisted of clusters of particles with undefined shapes, exhibiting a wide range of particle sizes. After annealing, multiple Fe-Ni phases were present in the sample. Structure investigation and magnetic measurements confirmed the formation of phases suitable for magnetic applications.

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Characterization of Ground Glass Waste and Nanodiamonds Using Calibrated Kelvin Probe Method PA20

The construction industry faces increasing demand for alternative raw materials due to resource depletion. Recycled glass waste has been proposed as a partial replacement for sand in concrete. However, the macroscopic properties of concrete and cementitious composites are influenced by the initial properties of their components and their interactions, necessitating precise bulk & surface analysis and modification(s). This study enhances previous observation on plasma-treated ground glass waste (GGW) which surface modifications were detected via changes in photoluminescence [10.3390/nano14131091]. We continue this research by using another surface-sensitive method, Kelvin probe, which measures the contact potential difference (CPD) between the studied material and a probe that can be next recalculated to work function (WF). However, accurate measurement requires the probe to be calibrated on a material of known WF, which is still a challenging task due to the high fluctuations in WF values (e.g. gold WF is reported in the range 5.0-5.4 eV). We use a more reliable Kelvin probe calibration procedure using a set of 6 metals with different WFs to address the variability in the WF values above-mentioned. The probe WF is obtained from the intercept of the linear fit of the data which resulted in WF of 5.15 eV in our case. Such a calibration method provides consistent and reproducible values over months. As a result, we observed only negligible WF shifts for the differently treated GGW, most likely because of its insulating nature and/or still too small surface to volume ratio. Furthermore, this methodology was validated by investigation of another nanoscopic material of not yet proved electrical conductivity - nanodiamonds. We investigated the size-dependence of nanodiamonds (diamond nanoparticles in the range of 18 - 125 nm) WF as a function of hydrogenation temperature (800 - 1000°C). We obtained consistent results and found a local minimum of WF at 4.5 eV for 50 nm nanodiamonds hydrogenated at 900 and 1000°C. The results will be discussed considering the influence of surface areas, film thicknesses, and electrical, physical, and chemical properties of the materials. These findings contribute to the understanding of surface properties in recycled materials on nano-sized dimensions, potentially finding future applications in the construction industry.

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Quantum-Computing Study of the Electronic Structure of Diamond-Structure Crystals PA21

Quantum computing is a newly emerging information-processing technology that is foreseen to be exponentially faster than classical supercomputers. Current quantum processors are nevertheless very limited in their availability and performance and many important software tools for them do not exist yet. Therefore, various systems are studied by simulating the run of quantum computers. Building upon our previous experience with quantum computing of small molecular systems (see I. Miháliková et al., Molecules 27 (2022) 597, and I. Miháliková et al., Nanomaterials 2022, 12, 243), we have recently focused on computing electronic structure of periodic crystalline materials. Being inspired by the work of Cerasoli et al. (Phys. Chem. Chem. Phys., 2020, 22, 21816), we have used a hybrid variational quantum deflation (VQD) algorithm, which combined classical and quantum information processing. Employing a tight-binding type of crystal description, we present our results for crystalline diamond-structure materials, such as Sn or Si. In particular, we focus on the states along the lowest occupied band within the electronic structure of Sn and compare the results with values obtained by classical means. While we demonstrate an excellent agreement between classical and quantum-computed results in most of our calculations, we further critically check the sensitivity of our results with respect to computational set-up in our quantum-computing study.

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Carbonyl Iron Particles With Covalently Bonded Dendritic Structures Using Atrp Approach: Stability Study in Silicone-Based Environments PA22

This study is focused on the covalent grafting of the carbonyl iron (CI) particles with poly(2-(trimethylsilyloxy)ethyl methacrylate) (PHEMATMS) using ATRP approach. In the first step the CI particles were grated with PHEMATMS brushes and in the second step each brush structure was further grafted with another PHEMATMS chain to create the dendritic-like shape. In this respect, the first generation (brushes) and second generation (dendrites) were confirmed using GPC and NMR investigations. The presence of the in nano-sized layer grafted PHEMATMS on the CI particles was elucidated using TEM and SEM-EDS investigations. The enhanced compatibility with silicon oil and silicon elastomer was investigated using contact angle measurements. The stability of CI-brush and CI-dendritic particles in silicone oil suspension and also their enhanced compatibility in silicone elastomer was thoroughly investigated using sedimentation stability approach and rheological investigation, respectively. Finally, it will be presented the crucial impact of the grafting on the overall magneto-responsive capabilities. ACKNOWLEDGEMENT: Authors acknowledge to the Czech Science Foundation no. 23-07244S for financial support.

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The Effect of Conditions of Thermal Treatment of Ti+Al+C Mixture on the Formation of MAX Phases PA23

MAX phase materials are nano-layered, hexagonal, machinable, early transition-metal carbides, and nitrides, where M is a transition metal, A is an element of the A-group (mostly groups 13 and 14), and X is C and/or N. These phases exhibit a unique combination of both metallic and ceramic properties. In this study, the Ti-Al-C MAX phases were prepared. In the case of the Ti-based MAX phases, Ti, Al, and C powders are used for synthesis. Physical and technological troubles usually affect the synthesis of MAX phases, resulting in decreased yields of the MAX phase and promoting the formation of undesirable phases. For example, the titanium carbide TiC and the Al3Ti, TiAl and Ti3Al intermetallics can also be formed under the synthesis process of the Ti3AlC2 MAX phase. Additionally, Al is oxidized, and Al2O3 occurs often. The successful preparation of MAX phases depends on various conditions such as: heating temperature, holding time, purity of inert atmosphere, heating rate, or gas flow. In our study, we used the thermal analysis method to find optimal conditions to obtain a Ti3AlC2 phase. MAX phase evolution during different conditions was analyzed using powder X-ray diffraction. ACKNOWLEDGEMENTS: This research was supported by project No. CZ.02.01.01/00/22_008/0004631 Materials and technologies for sustainable development within the Jan Amos Komensky Operational Program financed by the European Union and from the state budget of the Czech Republic. Authors also thank the VSB-Technical University of Ostrava project SP2024/025) for the financial support.

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Study of Temperature Dependent Mechanical Properties of Materials Using In-Situ High Temperature Nanoindentation PA24

In this work, a Hysitron TI 950 instrument equipped with an xSol 800 stage (Bruker) has been used to evaluate the mechanical properties of selected materials. The hardness and reduced elastic modulus of the coatings have been measured both at room temperature and elevated temperatures. The measurement of the thermal dependence of the mechanical properties was carried out in steps with an increase of 50 degrees C starting from 24 degrees C up to 600 degrees C. At each temperature step system calibration procedures after each 10 indentations were performed. ACKNOWLEDGEMENTS: This research has been supported by the Czech Science Foundation under project GA23-06263S. We acknowledge CzechNanoLab Research Infrastructure supported by MEYS CR (LM2018110).

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Theoretical Study of Structural, Electronics and Thermoelectric Properties of h-BN Nanotube Activated by Fe Ions PA25

Actually, Boron Nitride nanotubes (BNNT) have received great interest as material dedicated to many applications such as electronic and thermoelectrical devices. This work is a theoretical study of the structural, electronic and thermic transport properties of pure and iron (Fe) doped Boron Nitride nanotubes (BNNT) in its hexagonal phase (h-BN). This theoretical study was performed with the CRYSTAL program (www.crystal.unito.it) providing crystalline orbitals built on localized orbitals at the DFT (B3LYP hybrid hamiltonian) level of approximation. We have shown that Fe-doping nanotubes could behave as narrow bandgap semiconductors, the presence of Fe atoms modifying the gap value because of the presence of sates participating to the thermoelectrical transport. Our calculations show that the undoped nanotubes are ceramic materials with a large band gap around 6 eV while this latter value can be divided by 2 when the nanotube is doped by Fe. The related Seebeck coefficient, and electrical and thermal conductivity properties allow to deduce the values of the figure of merit ZT. Obtained results indicate that BNNT can be considered promising as thermoelectrical materials.

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A Low-Temperature Sol-Microwave Method for Ultra-Small Rutile Titanium Dioxide Nanoparticles PA26

Owing to its unique physical, chemical, optical and electrical properties, TiO2 nanoparticles (NPs) are widely used in photocatalysis, electrochemistry, and production of cosmetics, pigments, and biomedicine. The performance of TiO2 NPs in all the aforementioned applications is predominantly influenced by their size. In nature it exists in several polymorphs; stable rutile, metastable anatase and brookite. Rutile phase is the only high refractive index phase of TiO2. Moreover, it has higher relative permittivity and ultraviolet ray absorption rate. The rutile TiO2 can generally be obtained by high-temperature calcination of anatase NPs. However, calcination undoubtedly leads to agglomeration and crystal growth, hence increasing particle size. So, fabrication of rutile titania NPs at low temperatures is of great importance. Here, ultra-small rutile TiO2 NPs of ~ 5 nm has been synthesized by developing a facile reproducible sol-microwave method at low temperature (150 °C). These rutile TiO2 NPs have shown no surface defects, such as trivalent titanium (Ti3+) ions and oxygen vacancies. The resulting samples were analyzed by the following methods: X-ray diffraction to determine the crystallinity and phase composition, Raman spectroscopy to refine the phase composition, X-ray Photoelectron Spectroscopy to identify oxidation states and phase composition in surface layers, and High-Resolution Transmission Electron Microscopy to study morphology, phase analysis, and surface quality assessment. ACKNOWLEDGEMENT: The work was supported with the Czech Science Foundation, project No. 21-31852J and CzechNanoLab project LM2018110 funded by MEYS CR is gratefully acknowledged for the financial support of the measurements/sample fabrication at CEITEC Nano Research Infrastructure.

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POSTER SESSION B

Industrial Applications - Nanofibres, Thin Films, Layers, Catalysis

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Preparation of Ti3C2TX Nanosheets from a Large-Size Max Phase Precursor for the Electroconductive Functionalisation of Cellulose Fabric **PB1**

The main aim of the presented research was to synthesize Ti3C2Tx nanosheets with proper structure, flake size and high capacitance by means of a top-down synthesis approach utilising a large-size Ti3AlC2 (MAX) phase precursor (100 μm) for further electroconductive functionalisation of cellulose fabric. Thus, the synthesis parameters were changed, i.e., time, temperature and concentrations of selected etchants, preparing eight stable aqueous dispersions of Ti3C2TX nanosheets plus reference Ti3C2TX (from small-size 40 μm MAX precursor). As-synthesised products were characterised using various analytical techniques such as Scanning Electron Microscopy (SEM), X-ray powder Diffraction (XRD) and Dynamic Light Scattering (DLS). In addition, prepared Ti3C2Tx nanosheets were applied to cellulose fabric by an optimised dip-coating procedure, and fabrics' surface morphologies, as well as electrical resistances, were inspected. The obtained SEM and XRD results showed successful preparation of the Ti3C2TX nanosheets, wherein the synthesis parameters influenced their size and morphology. Ti3C2TX applied to cellulose fabric exhibited high electrical conductivity, revealing effective cellulose fabric’ functionalisation and, therefore, indicating the potential use of Ti3C2TX in wearable electronic applications. ACKNOWLEDGEMENTS: The results leading to this work were funded by the Slovenian Research and Innovation Agency (ARIS) in the frame of research project no. J2-50087 and a research core program group for Textile Chemistry and Advanced Textile Materials P2-0118 within the Young Researchers Programme.

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Enhanced Washing Durability of Electroconductive Ti3C2TX MXenes on Cotton Fabric Using Various Protective Coatings **PB2**

The incorporation of electroconductive compounds onto the textiles' surfaces leads to the fabrication of flexible electronic textiles (e-textiles) for numerous application fields, i.e., sport, medical, protective, fashion, military, etc. Their long-term functionality during daily usage depends on the sufficient durability of applied electroconductive compounds against washing, which can be significantly improved by the employment of protective layers. Thus, this study investigated the efficacy of different coatings for the protection of Ti3C2Tx MXene nanosheets dip-coated onto cotton fabric against laundering, without essentially influencing the electroconductive properties of MXene-coated fabric. Two Mxene-functionalised samples were protected with three different compounds, i.e., modified acrylate resin (MAR), waterborne polyurethane resin (WPR) and biantennary oligoglycine peptide (tectomer - 2 tailed, T) utilising spray-coating, dip-coating and impregnation procedures, respectively. MXene-functionalised/protected samples were washed up to 20 washing cycles and characterised by the determination of their electrical resistance, mass loss, water contact angle, optical properties and changes in surface morphologies. Based on these results, WPR provided the most suitable protection of MXenes on cotton fabric, followed by MAR, balancing high conductivity with long-term stability. Tectomer is not recommended for MXene protection, due to its low durable performance against harsh washing conditions. ACKNOWLEDGEMENTS: The results leading to this work were funded by the Slovenian Research and Innovation Agency (ARIS) in the frame of research project no. J2-50087 and a research core program group for Textile Chemistry and Advanced Textile Materials P2-0118 within the Young Researchers Programme.

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Influence of Lignocellulosic Nanofiber Sources on the Performance of Polylactic Acid Composites PB3

Composite materials were produced using polylactic acid (PLA) reinforced with lignocellulosic nanofibers (LCNF) dispersed in polyethylene glycol (PEG). To evaluate the effect of LCNF sources on composite properties, suspensions were made from different pulps, including those containing cellulose exclusively, others with cellulose and hemicellulose, and those with cellulose, hemicellulose, and lignin. Each pulp underwent mechanical and enzymatic pretreatments, and homogenization was performed under a pressure of 700 bar. The resulting LCNF suspensions were mixed with PEG and processed in a mixer at 190°C with PLA. Films were produced through compression molding, with a constant PLA/PEG ratio of 80/20, while LCNF amounts varied. The most favorable outcomes were observed for nanofibers consisting of a blend of cellulose and hemicellulose, with 2.5% (w/w). In this case, the materials' tensile strength and Young's modulus increased by 26% and 102%, respectively, compared to the PLA/PEG matrix. This effect was less noticeable for the other composites. We found that the zeta potential modulus of the suspensions of LCNF containing cellulose and hemicellulose decreased from -57.7 to -12 mV in the presence of PEG, while those that only contained cellulose remained unchanged. It is suggested that PEG binds to the surfaces of hemicellulose. Furthermore, FTIR analysis revealed changes in the carbonyl peaks of PLA and the hydroxyl peaks of LCNF and PEG, indicating the formation of hydrogen bonding interactions. Therefore, the improved mechanical properties of these composites can be attributed to a decrease in the tendency of nanofibers to agglomerate due to a reduced number of available hydroxyl groups on the nanofibers. When the concentration of LCNF was increased to 3.75% (w/w), micrometer-sized fibers were observed in the SEM images, which affected the mechanical properties of the composites. These findings provide important insights for selecting suitable lignocellulosic nanoparticles, paving the way for innovative material solutions.

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Thermal Analysis of Pristine and Caffeine Loaded Polyamide 4,6 100% Nanofibrous Materials PB4

This work focuses on the research and development of composite multilayered AC electrospun materials for applications in technical, medical, and bioengineering fields. It investigates the effects of AC electrospinning on the thermal properties and morphology of Polyamide 4,6 (PA 4,6), both in its base pellet form and as nanofibrous materials with and without caffeine as a model drug. The high voltage applied during AC electrospinning can influence the crystallinity and thermal behavior of the material. Differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) were employed to analyze thermal transitions, crystallinity, stability, degradation profiles, and as a tool to properly asses the loading of the model drug. Scanning electron microscopy (SEM) was used to examine fiber morphology and material structure. DSC analysis revealed that, compared to PA 4,6 pellets, the pristine nanofibrous material exhibited a decrease in normalized melting enthalpy and a slight increase in melting temperature, while the caffeine-loaded nanofibrous material showed an increase in normalized melting enthalpy and a decrease in melting temperature. TGA confirmed the proper loading of the model drug with initial weight loss corresponding to the PA 4,6:caffeine ratio of 8:2 in solution. The inflection point decreased for both electrospun materials when compared to the pellets. SEM analysis showed smooth, randomly oriented nanofibers, with a reduction in fiber diameter for the caffeine-loaded sample. This study provides clear insights into the effects of AC electrospinning and the addition of a model drug on the thermal properties and fiber morphology of PA 4,6. This serves as a solid base for the next steps in analyzing the release profiles of biologically active substances from composite/layered AC electrospun nanofibrous materials. ACKNOWLEDGEMENTS: The study was supported by the Czech Health Research Council, project no. NW24-08-00133 "Nanofibrous sutures functionalized by bioactive compounds", provided by the Ministry of Health of the Czech Republic. This study was supported by the National Competence Centres II program, project no. TN02000018/015 “Technology for the continuous production of multi-layer nanofibrous composite material using the AC electrospinning”, provided by the Technology agency of the Czech Republic.

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Fibre Extraction Sorbents for Chromatographic Analysis PB5

In general, one of the challenges of chemical analysis is the processing of environmental or medical samples with significant amounts of water or other polar components and high molecular weight analyses. Such samples must undergo a so-called sorbent pretreatment method before analysis (most often by liquid chromatography) to ensure the necessary concentration, purity and overall quality of the sample for analysis. Sorbents made of a mixture of polymeric micro and nanofibres appear to be very interesting for these pretreatments. Polymer fibre sorbents have been made using the Spun-blown - BIAX technology, which, when optimally set up, allows in the case of some polymers the one-step production of a bulky fibre layer containing a homogeneous mixture of micro- and nanofibres. In the structure thus formed, the microfibers provide mechanical stability and sufficient porosity; on the other hand, the nanofibers provide the necessary specific surface area for binding interactions with the analytes. Specifically, fibre sorbents were prepared from polycaprolactone, polybutylene terephthalate and polyamide 6, which exhibit different functional groups and polarity. The extraction properties of the microfibrous and nanofibrous sorbents were tested as part of the extraction centrifugation filters. ACKNOWLEDGEMENTS: This research was supported by Czech Science Foundation - GAČR through Project No. 23-05586S and also Czech Technological Foundation - TAČR under Project No. FW06010698. The research was also realised thanks to Student grant support by Project No. SGS-2024-6429 funded by the Ministry of Education, Youth and Sports (CZE) in 2024.

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Preparation and Characterization of Spartium Junceum Fibers Filled Polycarbonate Composites Applicable in the Automobile Industry PB6

Due to increasing environmental awareness and the encouragement of sustainable development the new biodegradable materials acceptable for the environment were developed. Natural fibers represent sustainable materials, easily available in nature, with several advantages such as low cost, light weight, renewability, biodegradability and high specific properties, so the development of new polymer materials reinforced with natural fibers are gaining increased attention in both the academic and industrial world. Spanish broom is a wild plant that mostly grows in Mediterranean countries and provides exceptionally strong fibers. Polycarbonate (PC) belongs to group of thermoplastic polymers that contain carbonate groups in their chemical structure. In this study composite materials based on polycarbonate (PC) and Spartium junceum (Sj) fiber extracted from the stem of Spanish broom as reinforcement were investigated, the potential application of such materials is in the automobile industry. PC/Sj composites were prepared by mixing Sj fibers in content of 5, 10, 15, and 20 wt.% in the neat PC in a Brabender mixer. The thermal, mechanical, viscoelastic properties as well as structure and the degree of swelling of the prepared PC/Sj composites were investigated, and the characterization was carried out using differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), dynamic mechanical analysis (DMA), and FTIR-ATR spectroscopy. The glass transition temperature Tg in PC/Sj composites shifted to lower temperatures compared to the neat PC due to the amorphous structure of lignin. Based on the TGA results the thermal stability of the PC/Sj composites decreased as the Sj fibers content increased. DMA results indicated that with an increase in the content of Sj fibers, Tg shifted to lower temperatures, and the stiffness of PC/Sj composites increased. The FTIR analysis results showed the presence of Sj fibers in PC/Sj composites and the overlap of absorption bands of Sj and PC. The obtained results of mechanical properties show that the Sj fibers increased the tensile strength and reduced the elongation of composites. Examination of swelling determined that PC and Sj fibers, as well as their composites are hydrophobic materials that swell only slightly in distilled water.

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Effect of Framework Defects in Micro-Mesoporous H-ZSM-5 Zeolites on Catalytic Performance and Stability in Methanol-to-Hydrocarbons Conversion **PB7**

The conversion of methanol to hydrocarbons (MTH) over H-ZSM-5 zeolites offers an alternative route for hydrocarbon production independent of crude oil. The MTH process transforms methanol into a mixture of olefins, paraffins, and alkylaromatics, with the potential to produce hydrocarbon mixtures rich in gasoline-range components (MTG) or short-chain olefins (MTO). However, MTH processes are generally challenged by issues of selectivity and catalyst deactivation or regeneration [1]. In this study, we investigate the impact of Si- and Al-related framework perturbations (defects) within the regular structure of small crystals of microporous and micro-mesoporous H-ZSM-5 on their catalytic activity, selectivity, and lifetime during methanol conversion to hydrocarbons [1-4]. The results highlight the critical role of a highly regular H-ZSM-5 framework in methanol-to-olefin conversion and suggest that the preparation of micro-mesoporous H-ZSM-5 through desilication with alkaline solution followed by acid leaching of electron acceptor sites significantly enhances catalyst lifetime. ACKNOWLEDGEMENT: This work was supported The Technology agency of the Czech Republic under Project No. FW10010328. The authors acknowledge the assistance provided by the Research Infrastructure NanoEnviCz, supported by the Ministry of Education, Youth, and Sports of the Czech Republic under Project No. LM2023066. REFERENCES: 1. P. Sazama et al., Microporous and Mesoporous Materials 143 (2011) 87-96; 2. P. Sazama et al., Angewandte Chemie - International Edition 52 (2013) 2038-2041; 3. J. Brus et al., Angewandte Chemie - International Edition, 54 (2015) 541-545; 4. J. Pastvova et al., ACS Catalysis 7 (2017) 5781-5795.

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Industrial Applications - in Construction, Energy Production, in Consumer and Other Industries

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Wet Chemistry Treatment and Surface Modification of Recycled Glass Particles for Sustainable Construction Applications **PB8**

The soda-lime glass is recognized as one of the best recyclable materials. However, surface contamination of glass waste or bulk impurities in the glass matrix can significantly alter glass properties limiting its direct reuse in the glass industry. As an alternative utilization strategy, the incorporation of waste glass as a partial replacement for sand or binder in concrete-based materials for sustainable construction applications has shown promise. Nevertheless, impurities in glass that may affect the alkalinity of concrete or calcium-silicate-hydrate formation must be carefully considered. For example, when the glass waste is in the form of shards or small fragments (particles), the potential diffusion of metal ions into the environment (e.g., through reaction with rainwater) becomes an important issue. In this work, we perform wet chemistry treatment on the recycled glass particles obtained from the commercial source. The resulting changes in glass particle properties were analyzed using microscopic and spectroscopic techniques. In particular, changes in the concentrations of Mg, Al, Ca and Na near the particle surfaces were detected, indicating potential to elements release to the environment via leaching. The observed results can be helpful in the explanation of processes at interfacial transition zones in waste glass containing concrete-based materials. The work was supported by the Czech Science Foundation project no 23-05500S.

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Enhancing the Physical and Mechanical Properties of Urea-Furfural Resin with Nano-Clay and Nano-Graphene Oxide for Poplar Oriented Strand Board Production PB9

This investigation delves into the augmentation of urea-furfural resin attributes via the incorporation of bentonite nano-clay at levels of 0.5%, 1%, and 2%, alongside nano-graphene oxide at concentrations of 0.05%, 0.15%, and 0.25% for the fabrication of oriented strand boards (OSB). Critical parameters of the resin, including density, solid content, viscosity, and gelation time, were meticulously evaluated. Advanced analytical techniques such as Fourier Transform Infrared Spectroscopy (FTIR), Field Emission Scanning Electron Microscopy (FESEM), and X-ray Diffraction (XRD) were employed to scrutinize the interaction of nano-clay and its dispersion within the resin matrix. The shear strength of the resin adhesive was notably enhanced, rising from 1.7 MPa in the control specimen to 2.7 MPa in samples containing 0.5% nano-clay and reaching 2.92 MPa in samples augmented with 0.05% nano-graphene oxide. Subsequently, the physical and mechanical properties of poplar strand boards fortified with nano-clay and nano-graphene oxide were thoroughly assessed. The outcomes revealed a substantial increase in bending strength, from 55 MPa in the control boards to 83 MPa in boards synthesized with resin incorporating 0.5% nano-clay, and further to 89 MPa in boards containing 0.05% nano-graphene oxide. Furthermore, the internal bond strength exhibited significant improvement, escalating from 0.33 MPa in the control samples to 0.45 MPa in boards with 0.5% nano-clay, and advancing to 0.52 MPa in boards with 0.15% nano-graphene oxide. Viscosity measurements demonstrated an increase from 95 seconds in the control boards to 145 seconds in boards with resin infused with 0.5% nano-clay and to 152 seconds in boards containing 0.05% nano-graphene oxide. The gelation time decreased from 180 seconds for the control boards to 147 seconds for boards with 0.5% nano-clay, and to 160 seconds for boards with 0.05% nano-graphene oxide. Moreover, thickness swelling was reduced from 11.2% in control boards to 6.57% in boards with 2% nano-clay and to 9.17% in boards with 0.25% nano-graphene oxide. In light of these findings, it is evident that urea-furfural resin, enhanced with 0.5% nano-clay and 0.05% nano-graphene oxide, stands as a superior alternative to urea-formaldehyde resin for OSB production. This improved resin formulation is also highly recommended for applications in the particleboard and fiberboard industries.

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Issues in Machining Epoxy Resin - nano Reinforcement Composite Systems with Respect to Surface Integrity and Tool Wear PB10

With the development of polymer nanocomposites and their application in various industries, it was necessary to be able to adapt the nanocomposites themselves to the design specifications. Thus, machining operations are required to fabricate the composite into its final form. Unlike metals, machining of these materials is more demanding discipline due to the inhomogeneous structure, poor thermal conductivity and the possible occurrence of delamination. These properties particularly affect tool wear, which has an impact on the quality of the machining process and the resulting quality (roughness) of the machined surface.

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The Effect of Humidity and Temperature on the Self Cleaning Properties of TiO2 Based Coatings on Cement Pastes PB11

In this research we investigated the effect of humidity and temperature on the self-cleaning performance of water based TiO2 coatings applied on the surface of hardened cement pastes. P25 titanium dioxide was used for the preparation of stable water suspensions. The suspensions were sprayed on the surface of hardened pastes made of Portland cement. The self-cleaning performance of such treated surfaces was tested using discoloration of rhodamine B applied on the surface under the investigation. The self-cleaning performance under UV irradiation was tested in environmental chambre at the temperatures 10, 20 and 30°C and relative humidity 20, 40, 60 and 80 %RH. The results showed the best performance of the TiO2 coating at temperature 20°C, and 80 %RH. ACKNOWLEDGEMENTS: This research was supported by the Czech Science Foundation (project 24-10949S), while the infrastructure has been utilized in the frame of project No. CZ.02.01.01/00/22_008/0004631 Materials and technologies for sustainable development within the Jan Amos Komensky Operational Program financed by the European Union and from the state budget of the Czech Republic. Authors also thank to project SP2024/025 (VSB - Technical University of Ostrava).

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Bottom-up Synthesis of BN-Embedded Corannulenes as Efficient Fluorescence Organic Light-Emitting Diode Emitters PB12

Heteroatom-doped nanocarbons (HNCs) are attracting attention as electrocatalysts for electric double-layer capacitors and fuel cells. HNCs synthesis has mainly been carried out by adding a heteroatom source during the synthesis and chemical modification of nanocarbons, however the uncontrollable amount and position of doping has been a problem. It is not easy to synthesize hetero-π-conjugated compounds with partial structures of HNCs, and the precise synthesis of HNCs has not progressed. On the other hand, corannulene derivatives are an important class of materials for liquid crystals, molecular tweezers, single-chirality carbon nanotubes. However, corannulene analogues having heteroatoms incorporated into corannulene skeletons have not yet been studied in detail, even though doping of heteroatoms in polycyclic aromatic hydrocarbons is highly important in order to realize new functions by modulating the physical properties and molecular structures of these species. Very recently, corannulene analogues having one nitrogen atom have synthesized, and their bowl-shaped structure and C60 binding behaviour have been revealed. Herein, we report the scalable synthesis of the BN-embedded corannulenes (BN-Cors) in four steps from commercially available compounds. In addition, we report the late-stage diversification of BN-Cors via coupling reactions to provide a variety of arylated derivatives, exhibiting strong blue fluorescence. An organic light-emitting diode (OLED) employing one of the derivatives as an emitter exhibited a high external quantum efficiency and long operational lifetime, indicating the significant potential for the development of efficient and stable OLED materials. The synthetic details, crystal structures, and physical properties of these compounds will be reported in this presentation.

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Nanocomposites of ZnO-decorated HPHT Nanodiamond as a Perspective Green Photocatalysts PB13

Electrical and optical properties of zinc oxide, in particular the relatively wide direct band gap of ~3.3 eV predetermines ZnO as a photocatalytic material at room temperature. ZnO itself is non-toxic and the hydrothermal growth method we use to prepare its nanostructures is environmentally friendly. These facts contribute to the attractiveness of this material. Recently, we have focused on studying the influence of doping or of plasma surface treatment on the photocatalytic efficiency of ZnO. However, the main disadvantages are the high recombination rate of charge carriers and the poor use of visible light. The solution is the use of ZnO as part of nanocomposites. In the past, ZnO-detonation nanodiamons (DND) composites were studied. The disadvantage of DND is the formation of clusters of different sizes, therefore we focused our attention on the use of HPHT nanodiamonds (NDs). We modified the surface of commercial HPHT NDs by oxidation in order to increase the concentration of hydroxyl-, carbonyl- and carboxyl- functional groups. The resulting ZnO-HPHT NDs composites were synthesized using a dehydration-condensation process between oxygen-containing functional groups on the NDs surface and hydroxyl groups on the ZnO surface. The prepared nanocomposites were characterized by SEM, AFM, FTIR and PL and tested by photocatalytic dye degradation. This work was supported by the Slovak Research and Development Agency under the Contract no. DS-FR-22-0035 and Ministry of Education, Youth and Sports of Czech Republic (MEYS) Danube project 8X23025, and the Mobility project CAS-SAS-2022-08 (SAV-23-13) and by the Slovak Scientific Grant Agency (VEGA: 2/0132/23).

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Pulsed Laser Deposition of Novel Spinel Materials for Photovoltaic Conversion **PB14**

While all traditional photovoltaic materials are covalent compounds with coordination number 4, currently the most progressive materials - hybrid halide perovskites - have coordination number 6 and are ionic. We believe that this can be the key to success, especially in terms of surface electronic properties, which are essential for polycrystalline semiconductors. This motivates us to explore completely new materials - cubic lithium thiospinels - and compare them with the former. Li thiospinels are prepared from stoichiometrically mixed precursors in the form of pellet in nitrogen filled glove-box. This tablet serves as a target in Pulsed Laser Deposition (PLD) and a special chamber is constructed that avoids air exposure of the precursor tablet during the loading. Thin films of lithium thiospinels are deposited on glass substrates and they are characterized by X-ray diffraction and optically by Photothermal Deflection Spectroscopy for accurate determination o absorption edge. Results are compared with properties of hybrid halide perovskites. ACKNOWLEDGEMENTS: The work was supported by Czech Science Foundation grant no. 23-06285S

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Polycrystalline Ga2O3/diamond Heterojunctions for Next-Generation Deep-UV Solar-Blind Photodetectors: A Comparative Study of Growth Approaches **PB15**

The development of solar-blind ultraviolet photodetectors represents a significant challenge in the field of electronic devices. For deep-UV optoelectronics (wavelength less than 280 nm), the active material’s bandgap has to be greater than 4.4 eV, leading to the development of ultrawide bandgap semiconductors such as AlxGa1-xN, hBN, Ga2O3, and diamond. While exceptional properties are typically assigned to single-crystalline materials, their high cost and limited availability necessitate alternative solutions. Polycrystalline materials offer a cost-effective solution with tailorable opto-electronic properties and customizable technological processes. This study focuses on the fabrication of a heterojunction-based UV-sensitive photodetector utilizing highly-textured or polycrystalline n-type Ga2O3 and polycrystalline p-type diamond. Due to the limited research on the technological procedures for this material combination, we investigate two distinct approaches: i) diamond growth on Ga2O3 films and ii) Ga2O3 growth on diamond films. The prepared individual films and heterostructures were characterized by Raman, SEM, TEM, I-V, and optical measurements. Preliminary results validate the proof-of-concept and demonstrate the viability of both approaches with great potential for continued optimization. Our findings suggest that the next generation of deep-UV solar-blind photodetectors based on polycrystalline Ga2O3/diamond heterojunctions may outperform the current mainstream technologies. ACKNOWLEDGEMENTS: M.V. acknowledges support from the project IM-2023-87 funded by the Slovak Academy of Sciences via the programme IMPULZ 2023. F.G. acknowledges the funding from International Visegrad Fund (project # 22320095) and Slovak Research and Development Agency (project # APVV-20-0220).

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N,P-doped Carbon Nanotubes for Catalysis and Energy Storage Applications **PB16**

Recently, doped carbon has gained much attention in the fields of electrochemistry and energy storage. However, there is not a universal method to prepare well-defined doped carbon nanostructures. In this work, we report a simple way to obtain nitrogen and phosphorus-doped carbonized polypyrrole nanotubes (NP-cNTs) as a catalyst for ORR and HER reactions, as well as a materials for supercapacitor. First, polypyrrole nanotubes were synthesized and then carbonized under an inert atmosphere to obtain NP-cNTs. The successful synthesis and chemical composition, of the desired structures was confirmed by scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy SEM-EDX. The amorphous nature of the obtained materials was confirmed by XRD analysis. The chemical composition was further investigated by X-ray photoelectron spectroscopy (XPS) and Raman spectroscopy. Subsequently, the electrochemical activity was investigated using model reactions of HER and ORR. Both reactions showed enhanced catalytic properties of the NP-cNTs compared to undoped material. Furthermore, the prepared materials demonstrated potential for energy storage applications. ACKNOWLEDGEMENT: This work was supported by the GACR under project 22-25734S.

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Geometrical Stabilities and Electronic Structures of Rh5 Nanoclusters on Rutile TiO2 (110) for Green Hydrogen Production **PB17**

Addressing the urgent need for sustainable energy sources, this study investigates the intricate relationship between Rhodium (Rh5) nanoclusters and TiO2 rutile (110) surfaces, aiming to advance photocatalytic water splitting for green hydrogen production. Motivated by the imperative to transition from conventional fossil fuels, the study employs density functional theory (DFT) with DFT-D3 and HSE06 hybrid functional to analyse the geometrical stabilities and electronic structures of Rh5 nanoclusters on TiO2 rutile (110). TiO2, a prominent photocatalyst, faces challenges such as limited visible light absorption, leading researchers to explore noble metals like Rh as cocatalysts. Our results show that bipyramidal Rh5 nanoclusters exhibit enhanced stability and charge transfer when adsorbed on TiO2 rutile (110) compared to trapezoidal configurations. The most stable adsorption induces oxidation of the nanocluster, altering the electronic structure of TiO2. Extending the analysis to defective TiO2 surfaces, the study explores the impact of Rh5 nanoclusters on oxygen vacancy formation, revealing stabilisation of TiO2 and increased oxygen vacancy formation energy. This theoretical exploration contributes insights into the potential of Rh5 nanoclusters as efficient cocatalysts for TiO2 -based photocatalytic systems, laying the foundation for experimental validations and the rational design of highly efficient photocatalysts for sustainable hydrogen production. The observed effects on electronic structures and oxygen vacancy formation emphasize the complex interactions between Rh5 nanoclusters and TiO2 surface, guiding future research in the quest for clean energy alternatives.

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Fabrication and Antibacterial Activity of Allyl Isothiocyanate-loaded Chitosan Nanoparticles for Enhanced Food Preservation **PB18**

Allyl isothiocyanate (AITC) has been recognized for its potent antibacterial and antioxidant properties, positioning it as a promising agent for food preservation. However, its practical application in the food industry is significantly hindered by its high volatility and strong, unpleasant odor. To address these limitations, we utilized the multifunctional attributes of chitosan, a polysaccharide derived from chitin, to stabilize and enhance the efficacy of AITC. The abundance of amino and hydroxyl groups in chitosan chain facilitates strong interactions with AITC, thus achieving high encapsulation efficiency. Additionally, the inherent antibacterial properties of chitosan synergizes with AITC, potentially reducing the required dose for effective microbial inhibition. In this study, AITC-loaded chitosan nanoparticles (AITC-CSNPs) were synthesized using a two-step emulsion-ionic gelation method. Comprehensive characterization of the nanoparticles was performed using Dynamic Light Scattering (DLS) to determine their hydrodynamic size, zeta potential, and polydispersity index, while Scanning Electron Microscopy (SEM) provided detailed insights into their morphology and distribution. Afterwards, the antibacterial properties of AITC-CSNPs were evaluated on prevalent food-borne pathogens through the agar well diffusion assay. The findings indicated that the as-synthesized AITC-CSNPs possessed a sperical shape with nanosize and demonstrated satisfactory antibacterial effects, thereby presenting a viable method for extending the shelf life of perishable food products. ACKNOWLEDGEMENTS: This study was supported by the VUT Specific Research Project CEITEC VUT-J-24-8615, Brno University of Technology

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Environmental Applications

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In-situ Synthesis of Mixed-Valence Cu(I)/Cu(II) Single Atoms over N-Doped Graphene Acid for Electrocatalytic Nitrate Reduction to Ammonia **PB19**

The escalating global energy demand has significantly contributed to the rise in greenhouse gas emissions, an issue urgently addressed at the 27th Conference of the Parties, which called for immediate and collective action towards sustainable energy and decarbonization technologies. Given that the fertilizer industry heavily relies on the energy-intensive Haber-Bosch process, which is a major source of CO2 emissions, the future of food security depends on developing sustainable alternatives for ammonia production, a critical fertilizer feedstock. In this work, we present an alternative pathway for ammonia synthesis through electrocatalytic nitrate reduction, utilizing nitrates commonly found in wastewater streams. Our approach focuses on the strategic integration of Single Atom Catalysts (SACs), achieved by coupling single metal atoms with functionalized graphenes. Specifically, we synthesize Cu(I)/Cu(II) mixed-valent species stabilized on N-doped graphene acid. The functionalities on the graphene lattice not only enhance the coordination of metal atoms but also facilitate the reduction of Cu(II) to Cu(I). When applied in electrocatalytic nitrate reduction to ammonia, the Cu(I) sites serve as nucleophilic centers, coordinating H+ and converting it to H*ads, while Cu(II) sites coordinate with nitrates. The subsequent reduction of nitrates by H*ads leads to ammonia formation. This process not only offers a sustainable route for ammonia electrosynthesis but also valorizes wastewater contaminants, reducing the environmental and health risks associated with high nitrate levels.

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Magnetically Modified Bentonite and Ladle Furnace Slag for Strontium Sorption **PB20**

In the present paper, two different types of materials were used for strontium elimination from an aqueous environment. Bentonite (B) and ladle furnace slag (FS) were modified by iron oxide (FexOy) nano/micro-particles (NPs) with magnetic properties by microwave procedure. Sorption properties, stability and influence of magnetically modified bentonite (MB) and ladle furnace slag (MFS) modification by FexOy NPs were tested. Although the sorption properties of both magnetically modified adsorbents (MB and MFS) were slightly lower than the sorption properties of original B and FS, the Sr elimination from solutions was still effective. The maximum sorption capacity was determined as follows: 24.2 mg/g for B, 20.6 mg/g for MB, 50 mg/g for FS and 35 mg/g for MFS, respectively. The release of FexOy NPs during the sorption experiments was monitored as well. The determined concentration of Fe in solutions after sorption experiments was lower than 0.01 mg/l. The presence of FexOy NPs on the MB and MFS surface after sorption experiments was confirmed by scanning electron microscopy. The MB and MFS were magnetically active and were removed from the solution after sorption using a magnet. The experimental results demonstrated that the FexOy NPs were not released into aqueous solutions during the sorption. Therefore, MB and MFS are stable and promising sorbents for pollutant elimination.

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Inkjet-Printed Chemiresistive Sensor Array with Integrated Heater **PB21**

An inkjet printing method was used to fabricate a flexible gas sensor. This fabrication method is characterized by low material consumption, fast design to the fabrication process, and low fabrication cost. Thanks to these properties is this technology still more popular in the fabrication of electronic circuits and devices. Gas sensors are devices that are generally used to detec the presence, or in a more complex solutions, to measure the concentration of the various gases.

The used fabrication technology or material determines sensor properties like sensitivity, selectivity, repeatability, and stability for the application in the general or industrial environment. In this research, we present the design preparation, fabrication, and characterization of the inkjet printed gas sensor. The structures are based on silver nanoparticle ink and dielectric ink. The structures are printed on a flexible substrate and are sintered with intense pulsed light and UV light, respectively. The printed sensors consist of an Interdigital electrode (IDE) structure, dielectric separation layer, and heater pattern. The IDE structure is printed on the dielectric layer which separates the heating and sensing structures. As a sensing layer, polyaniline is dropcasted on the top of the IDE sensor structures. The inkjet printed sensor was characterized in a term of response to the humidity and testing gas.

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Non-destructive Evaluation of Photocatalytic g-C3N4 Deposition in/onto Polymeric Matrix PB22

Electrospun fibrous membranes are used for the filtration of pollutants from air and water, but continued use can lead to pollutant accumulation and a decrease in effectiveness. To address this issue, we developed polyvinylidene fluoride (PVDF) fibrous membranes modified with photocatalytic graphitic carbon nitride (g-C3N4) particles using three methods: blending, thermal, and chemical. Their photocatalytic efficiency was investigated using phenol as a model pollutant compound under visible light irradiation. The membranes prepared via chemical activation exhibited the highest activity (kapp of 21.7×10-4 min-1) compared to those prepared by the thermal method (kapp of 5.41×10-4 min-1) and blending method (kapp of 2.51×10-4 min-1). For full membrane characterization, a new non-destructive method was developed to determine the area density differences of g-C3N4 among the methods. The membranes were exposed to LED irradiation (λ = 365 nm) to obtain the photoluminescent emission of the g-C3N4 particles, which was captured by a spectrometer for analysis and compared to a calibration sample with a known area density of g-C3N4. Despite the highest g-C3N4 area density (1.7098 ± 0.0404 mg·cm-2) for the blend method, the photocatalytic activity was the lowest due to particle encapsulation in the polymer fibre. Although, chemical method led to low particle concentration (0.3321 ± 0.0736 mg·cm-2), the covalent bonds between PVDF and g-C3N4 on the fibre surface allow the formation of oxidative species on their surface leading to the highest photocatalytic activity. ACKNOWLEDGEMENT: This work was supported by the European Union under the REFRESH project number CZ.10.03.01/00/22_003/0000048 and NCK polymery TN7503813.

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Self Cleaning Coatings for Sand Stones PB23

In this research, we tested the performance of the self-cleaning coatings based on exfoliated g-C3N4 applied on the surface of sandstone. Research activities include: i) preparation of exfoliated g-C3N4, ii) preparation of exfoliated g-C3N4 water suspensions, iii) application of the suspensions on the surface of the sandstone samples, and iv) testing of the self-cleaning performance. Exfoliated g-C3N4 was prepared by thermal exfoliation of bulk g-C3N4 prepared by thermal polycondensation of melamine. Water suspensions of g-C3N4 (XX and XX g/l) were prepared and applied on the surface of the sandstone samples using the spraying technique. Such prepared samples were subjected to the self-cleaning performance test based on the discolouration of rhodamine B under VIS irradiation and constant humidity and temperature. Changes in the the a* coordinate in CIE L*a*b* colour space were used to quantitatively monitor the discolouration of the tested samples. ACKNOWLEDGEMENTS: This research was supported by the Czech Science Foundation (project 24-10949S) and VSB-Technical University of Ostrava under the project SP2024/025.

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Polyamide (Pa6) Nanofibers With Graphitic Carbon Nitride for Efficient Removal of Pollutants from Wastewaters. PB24

For the past few decades, wastewater treatment has become one of the largest worldwide concerns, particularly regarding pharmaceutical contaminants due to an increase in their consumption rate. Graphitic carbon nitride (g-C_3N_4) is a popular choice in wastewater treatment due to its low-cost preparation method, physiochemical stability and non-toxicity. It has large surface area, porous structure, and photocatalytic activity in visible range. By incorporating g-C_3N_4 into PA6 nanofibers (“fabric”), our goal was to create a robust and photocatalytically active surface. We employed atmospheric pressure plasma (dielectric coplanar surface barrier discharge) to modify the fabric. We have treated the fabric in ambient air, oxygen, and nitrogen plasma at various times. All the chemical and structural changes were analyzed by SEM, EDX, XRD and XPS. We have used wastewater model with diclofenac, a non-steroidal anti-inflammatory medicine that is used as an analgesic and is taken in around 940 tons annually worldwide. We have also tested real wastewater effluent. ACKNOWLEDGEMENTS: Authors wish to acknowledge the Czech Science Foundation for supporting financially the research, project No. 23-06843S. This research was also supported by projects LM2023039 and LM2023051 funded by the Ministry of Education, Youth and Sports of the Czech Republic.

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The Differences in the Effects of PVP-stabilized Silver Nanoparticles on the Microalga Porphyridium Cruentum and the Cyanobacterium Arthrospira Platensis PB25

Nanoparticles are increasingly becoming part of microalgal biotechnologies. Certain types of nanoparticles are suggested as stimulators for lipid synthesis in microalgal biofuel production. The variety of responses from microalgal cultures depends on many factors, such as the type of nanoparticles, their size, concentration, origin, the duration of contact with microorganisms, the age of the culture, and the cultivation conditions. Another determining factor in the relationship between microorganisms and the presence of nanoparticles in their growth environment is the type of microorganisms. Eukaryotic organisms, such as microalgae, respond differently to nanoparticles than prokaryotic organisms, such as cyanobacteria. A study was conducted to determine the differences in the effects of PVP-stabilized silver nanoparticles on the microalga Porphyridium cruentum and the cyanobacterium Arthrospira platensis. Silver nanoparticles at concentrations ranging from 0.05 mg/L to 5 mg/L were added to the mineral medium from the first day of the cultivation cycle. The microorganism cultures were cultivated under autotrophic conditions. Biochemical tests were performed on the collected biomass. The cyanobacterium Arthrospira platensis reacted to AgNP-PVP by reducing biomass content and showing an insignificant change in structural compounds. Reduced antioxidant levels evidenced stress in cyanobacterial culture. For Porphyridium cruentum, biomass content increased, while lipid and carbohydrate content decreased. Higher malondialdehyde levels indicated stress in microalgal culture. The variety of responses from microalgae and cyanobacteria cultures to silver nanoparticles supports the idea that diverse mechanisms are involved in maintaining viability, which creates the possibility of remodeling biosynthetic activity depending on the intended purpose. This work was supported by a grant of Ministry of Education and Research of Republic of Moldova, project number 020101.

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Exploration of Catalytic Activity for Wastewater Treatment Using Ag Modified Sodium Bismuth Titanate Particles PB26

Ag modified $Bi_{0.5}Na_{0.5}TiO_3$ particles with different concentrations of 0.0, 1%, 3%, and 5% has been synthesised via sol-gel route to explore its catalytic activity. All samples were characterized by X-ray diffraction, Raman, SEM and UV-absorbance spectroscopy. XRD verified that all compositions had a monoclinic phase structure with a Cc space group. To further confirm the phase purity of the samples, the FullPROF program was used for the Rietveld refinement. Raman spectra also confirmed the structure by matching vibrational modes. The particle size ranged from 300 to 400 nm using energy dispersive x-ray spectra (EDX) and scanning electron microscopy (SEM) for morphological and elemental analysis. The optical bandgap for all synthesized particles was determined using UV-vis absorbance spectra, and it was found to be between 3.65-2.63 eV. The best piezo-photocatalytic activity for sample x=0.01 evaluated for rhodamine B dye was around 82%, when subjected to mechanical disturbances and UV light for 80 minutes. In contrast, degradation was approximately 52.4% and 22.7% for photo- and piezocatalysis, respectively. Using the first order rate kinetics equation, kinetics study and rate constant values were determined. Systematic trapping experiments and stability tests were conducted on the catalysts, revealing that the primary active species are superoxide and hydroxyl radicals. A decrease of around 9% in degradation capacity after three cycles was seen as a result of catalyst loss. Less recombination rate, more oxygen vacancies, high degradation yield, high absorption capacity, and optimal bandgap values over the other compositions are found to be responsible for the degradation improvement. Consequently, a unique, effective piezo-photocatalyst for the treatment of organic dyes may be found in a 1% Ag doped BNT sample.

POSTER SESSION C

Nanomedicine: Diagnostics and Therapy

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RGD-Functionalized Photothermal Molybdenum Oxide Nanoparticles as a Promising Strategy for Cancer Treatment PC1

Nonstoichiometric molybdenum oxide (MoOx) nanomaterials are promising photothermal nano-agents capable to respond to near IR irradiation with rapid heating. Combining with active targeting elements a selective cancer eradicating platform can be built. RGD peptides (amino acid sequence Arg-Gly-Asp) are recognized by cell adhesion receptors, called integrins (specifically αvβ3, αvβ5, and α5β1), which are highly expressed on the surface of multiple cancer cell lines, but absent on epithelial and mature endothelial cells. Despite a decade of research, MoOx nanomaterials remain a significant player in the field of cancer treatment, exhibiting ongoing scientific interest. Here, we demonstrate for the first time the potential behind MoOx-RGD nanoconjugates in selective cancer treatment. Studies on cell viability, internalization rates, process of binding of nanoparticles and cell death upon photothermal treatment were conducted. Our investigations demonstrated that MoOx-RGD nanoconjugates are highly effective and selective in destroying cancer cells. These findings highlight the potential of MoOx-RGD nanoconjugates as a novel therapeutic approach for cancer treatment. ACKNOWLEDGEMENT: This work was supported by the Slovak Grant Agency for Science under contract No. VEGA 2/0117/22, the Slovak Research and Development Agency contract No. APVV-20-0485 and SK-FR-22-0012, and by DoktoGrant SAS No. APP0492.

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Conjugates of Photon-upconversion Nanoparticles with Antibodies for Immunochemical Detection of Tumor Biomarkers PC2

The diagnosis of numerous illnesses relies on the sensitive detection of clinical biomarkers. It is of the utmost importance especially in the case of tumor diseases, allowing for early-stage cancer diagnosis and monitoring of treatment response. Due to the high specificity provided by antibodies, various kinds of immunochemical assays are used for this purpose. However, conventional immunoassays often provide insufficient sensitivity for the detection of low-abundance biomarkers. A common strategy to enhance immunoassay sensitivity involves replacing conventional labels with nanoparticles. Photon-upconversion nanoparticles (UCNPs) stand out among the most promising options. These lanthanide-doped nanocrystals convert near-infrared radiation into visible light, significantly reducing the optical background. Moreover, their emission spectra can be tuned by altering the dopant ions. The heterogeneous immunoassay format is typically predominant due to its high sensitivity and specificity. However, it requires immobilization and washing steps, leading to a prolonged procedure. Conversely, even though homogeneous immunoassays omit these time-consuming steps, they come at the cost of reduced specificity and sensitivity. To overcome these drawbacks, we have developed a novel artificial intelligence-aided homogeneous immunoassay format based on massively parallel spectroscopy (MPS). This single-molecule method utilizes two different UCNP-antibody labels binding to analyte molecules, detecting only sandwich immunocomplexes containing the analyte molecule and both labels with different doping. We have successfully employed this method in immunoassays for tumor biomarkers prostate-specific antigen and protein p53, proving its high potential. MPS promises to become a fast and high-throughput method for the detection of biomarkers.

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Enantioselective SERS Detection Using Chiral Au Helicoids PC3

The interaction between light and matter can be significantly enhanced through the excitation of surface plasmons, enabling sub-diffraction focusing of light energy. This phenomenon is especially pronounced in the case of the creation of plasmonic hotspots, which have found wide application in surface-enhanced Raman spectroscopy (SERS). This work focuses on the preparation and use of ordered chiral gold nanostructures with unique helical shapes and chirality encoded in each individual nanoparticle. An ordered layer of Au helices with a consistent gap between nanoparticles on a plasmon-active gold grating was fabricated, capable of supporting the excitation and propagation of surface plasmon-polaritons and local plasmons. Chiral molecules of the analyte(s) were placed in the space between Au helicoids (i.e., in the place of the plasmonic hot spots). The influence of the chiral dielectric „spacer“ on the intensity of the local electric field and the SERS response of the enantiomers is investigated. In particular, a significant difference in SERS enhancement was observed, depending on the interplay of helicoids chirality and analytes chirality. ACKNOWLEDGEMENTS: This work was supported by the GACR under project 23-05197S.

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Application of Spin Trap EPR Technique for Detection of Singlet Oxygen in Photoactive Materials for Self-Sterilizing Surfaces PC4

Bacteria resistance to many antibiotics has emerged as a huge problem. This critical health issue necessitates a dynamic approach to produce antimicrobial surfaces to cut the transmission path of microbes from various highly touched objects. Our objective is to develop the transparent daylight triggered photoactive composite polymer. A photochemical reaction occurs when a photosensitizer, embedded in the material, is irradiated with visible light, leading to the generation of reactive oxygen species and creating an antibacterial, self-sterilizing surface. We describe and focus on the application of the spin trap EPR (electron paramagnetic resonance) technique, using TEMP as a spin trap, for the detection of reactive oxygen species, specifically singlet oxygen, in photoactive materials, before and after incorporation into a polymer matrix. We detect and analyse the production of singlet oxygen at different wavelengths of light (colors) with the aim of developing a photosensitive material with a high quantum yield under daylight conditions and artificial indoor lighting. The photoactive materials studied include various types of carbon-based materials such as carbon quantum dots, graphene quantum dots, chitosan, etc. Our experiments have demonstrated significant photoactivity of these materials, making suitable candidates for the development of self-sterilizing surfaces. This research contributes to the growing body of knowledge on the use of carbon materials for antibacterial applications, providing new insights into their potential and efficacy. As a results the state-of-the-art products, such as antibacterial door handles, antibacterial cell phone cases, etc have been developed. ACKNOWLEDGEMENTS: This research was supported by the Science Fund of the Republic of Serbia, grant no. #7741955, Are photoactive nanoparticles salvation the global infection threat? PHOTOGUN4MICROBES.

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Synthesis and Phase Composition Study of Iron Oxide Core-shell Nanocubes for Magnetic Hyperthermia PC5

We recently reported the size-controlled synthesis of core-shell FeO/Fe3O4/FeOOH nanocubes (16-23 nm). The PMAO-coated NCs demonstrated the best stability in water (>one year) and good material yield. Powder XRD and Mössbauer spectroscopy identified wüstite, magnetite, and goethite phases in the NCs. XRD data collected over time showed the transformation of wüstite to magnetite. A theoretical model based on the reaction-diffusion Master equation was developed describing the diffusion of O2 into the NC, O2 dissociation accompanied by charge transfer, and the resulting local phase transformation of wüstite to magnetite. The consequent formation of magnetite shell alters the diffusion barriers for further passage of O2, and thus, long-term oxidation proceeds less rapidly. The model gives relatively accurate predictions of the NCs' oxidation rate at elevated temperatures (annealing). Annealing methods were introduced to enhance the magnetic properties of the NCs. The highest SAR values were found in 20 nm NCs annealed in an organic solvent and 23 nm NCs annealed in water for 48 hours. The SAR values of 16-20 nm NCs were less sensitive to viscosity changes post-annealing than 23 nm NCs. For MRI and MPI applications, T2 relaxivity measurements showed an increased r2 relaxation rate with a larger magnetic domain size, peaking at 20 nm. The 20 nm NCs had an r2 relaxation rate around 300 mM-1 s-1 at 1.5 T, slightly higher than 23 nm NCs. MRI scans confirmed these results, with 20 nm NCs showing the most significant T2 contrast darkening. (1) Sojková, T.; Rizzo, G. M. R.; Di Girolamo, A.; Avugadda, S. K.; Soni, N.; Milbrandt, N. B.; Tsai, Y. H.; Kuběna, I.; Sojka, M.; Silvestri, N.; Samia, A. C.; Gröger, R.; Pellegrino, T. From Core-Shell FeO/Fe 3 O 4 to Magnetite Nanocubes: Enhancing Magnetic Hyperthermia and Imaging Performance by Thermal Annealing. Chem. Mater. 2023, 35 (16), 6201-6219. https://doi.org/10.1021/acs.chemmater.3c00432. (2) Sojková, T.; Gröger, R.; Poloprudský, J.; Kuběna, I.; Schneeweiss, O.; Sojka, M.; Šiška, Z.; Pongrácz, J.; Pizúrová, N. Kinetics of Spontaneous Phase Transitions from Wüstite to Magnetite in Superparamagnetic Core-Shell Nanocubes of Iron Oxides. Nanoscale 2024, 16 (11), 5551-5560. https://doi.org/10.1039/D3NR06254F.

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Ab Initio Investigation of Intricate Ferrimagnetic States in Iron Oxide Nanoparticles PC6

Maghemite (γ-Fe_2O_3) is a ferrimagnetic iron oxide that crystallizes in an inverse spinel structure, notable for its biocompatibility and low cytotoxicity. It can be viewed as magnetite (Fe_3O_4) with the introduction of iron vacancies into the octahedral sublattice. While the magnetic behavior of maghemite and magnetite is similar, magnetite exhibits a higher total magnetic moment. Iron oxide nanoparticles related to maghemite have numerous applications, including advanced contrast agents for magnetic resonance imaging, carriers for targeted drug delivery, and heat sources for localized magnetic hyperthermia treatment, among many other profitable uses. These arise from the combination of their unique magnetic properties (high saturation magnetization, low coercivity) and small size. Although their applications are well studied, a deeper understanding of the structure-property relationship is still highly desired. This motivates our study, in which we employ density functional theory (DFT) calculations to investigate the properties of iron oxide nanoparticles. Our nanoparticle models are based on bulk maghemite (γ-Fe_2O_3), where tetrahedrally and octahedrally coordinated Fe sublattices exhibit opposing magnetic moment orientations. Notably, our findings revealed that the surfaces of the nanoparticles generate significantly more intricate magnetic states compared to the magnetic arrangements observed in bulk maghemite or magnetite. These intricate magnetic states are characterized by what we term "nested" ferrimagnetism, where Fe atoms exhibit locally opposing magnetic moments even within the same (tetrahedral or octahedral) sublattice.

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Fluorescent and Colorimetric RT-LAMP as a Rapid, Reliable, and Specific Qualitative Method for POCT PC7

Point-of-care testing (POCT), also known as near-patient testing or bedside testing, is a vital aspect of medical diagnostic testing that is applied directly at the site of need. This type of testing plays a significant role in the diagnosis and subsequent treatment of patients. In the context of the COVID-19 pandemic, POCT has been developed rapidly to improve speed, sensitivity, and ease of use compared to traditional methods like nucleic acid amplification tests (NAAT) and rapid antigen tests. Golden standard laboratory test for detecting active infections reverse transcription-polymerase chain reaction (RT-PCR) requires sophisticated equipment, skilled technicians, and long turnaround times. This all doesn't meet POCT requirements. To overcome these challenges, isothermal amplifications such as reverse transcription loop-mediated isothermal amplification (RT-LAMP) have become more popular, as they eliminate the temperature cycling step and simplify the process, making it faster, cost-effective, and energy-efficient. RT-LAMP is the most sensitive and specific of the isothermal amplification approaches, utilizing four to six primers that recognize six to eight different regions in the target nucleic acid molecule. Amplification is performed at a constant temperature between 60 °C to 65 °C, eliminating the need for thermal cycling and fluorescence monitoring, simplifying the process, and reducing dependence on complex equipment. RT-LAMP is an appropriate method for POCT and on-site testing scenarios where immediate results are critical for informed decision-making. RT-LAMP can be monitored in real-time by highly sensitive fluorescence or colorimetry. While fluorescence-based detectors can be complicated for POCT due to the general requirement for bulky and expensive fluorescence instruments, high background, and often inhibition of the amplification process due to the increased dye concentration, colorimetry is simpler and exposed to fewer cross-contamination risks. The color-change is caused by colorimetric indicators, which change color in response to pH shifts during amplification. This option is increasingly attractive for POC applications as it does not require complex equipment and optical modules. In this work, we demonstrate two versatile approaches for POC applications, utilizing fluorescence and colorimetric RT-LAMP analysis using specifically modified magnetic nanoparticles for sample preconcentration and nucleic acid isolation. These systems are highly sensitive, specific, and effective tools with potential in human and veterinary medicine.

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Nitrogen-Doped Carbon Quantum Dots for Theranostics Applications PC8

Carbon quantum dots (CQDs), crystalline graphitic nanoparticles, have excellent bioapplication potential, especially in bioimaging, because of their fluorescent properties, biocompatibility and water solubility. We prepared the nitrogen-doped CQDs (N-CQDs) from glucose and ethylenediamine using a one-step and fast (a few minutes) microwave-assisted hydrothermal synthesis. The average size of the particles was 3.8 nm, and high-resolution TEM confirmed their crystalline graphitic nature. The carbon structure contained 18.6 at.% of nitrogen and 12.6 at.% of oxygen. The NCQDs exhibited tunable photoluminescence (PL) emission in the entire visible spectral region, which extended to near-ultraviolet and slightly to near-infrared. We demonstrated theranostic applications of hydrothermally synthesized N-CQDs when drugs, e.g., against neurodegenerative diseases. The advantage of such coupling lies in the excellent water solubility of the complexes thanks to N-CQDs and the possibility of imaging the distribution process.

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Electro-signal Amplification Using Multilayered MXene-Ti3C2Tx for Ultrasensitive and Selective Neurotransmitter Dopamine Monitoring in Real Serum Samples. **PC9**

Electrochemical biosensing has shown great interest in two-dimensional (2D) transition-metal MXene-Ti3C2Tx carbide layered materials due to their outstanding conductivity and variable surface chemistry. We developed a ultrasensitive molecular complex for neurotransmitter dopamine sensing by utilizing multilayered MXene (Ti3C2Tx) nanomaterials. Additionally, its on-site application was realized by fabricating a label-free screen-printed carbon electrode (SPCE) for electro-sensing dopamine levels in buffer and serum samples at the point-of-care (POC) testing. Importantly, 4-aminophenyl boronic acid polymerization with high specificity on the MXene-Ti3C2Tx surface for SPCE is easily implemented with the most excellent electrochemical signal amplifying. In this conceptual study, the electrochemical biosensor was logically inexpensive, straightforward, label-free, quick and easy detection of dopamine in clinical samples. It could selectively measure dopamine levels with a limit of detection (LOD) of 2 nM in the human serum sample and 1.3 nM in PBS buffer (pH 7.4). It had a wide range of linear detection of dopamine concentrations of 40 to 500 nM, with a sensitivity of 0.0134 µA nM-1. This study paves a new path for 2-D MXene-Ti3C2Tx/4-APBA modification for biomedical and electrochemical sensing applications at nanomolar concentrations with high specificity. ACKNOWLEDGEMENT: This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (RS-2023-00244250)

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The Effect of Silver Nanoparticles on the Microalgae Haematococcus Pluvialis **PC10**

The green alga Haematococcus pluvialis is highly regarded as a producer of astaxanthin. Due to its antioxidant properties, astaxanthin has become a popular nutritional ingredient. Astaxanthin has demonstrated potential pharmacological effects including antidiabetic, anti-inflammatory, and antioxidant activities and cardiovascular and neurological protective properties. Nanoparticles have become integral components of microalgal technologies, serving as stimulators for the production of biologically active compounds. The stimulating effect of nanoparticles is based on the induction of oxidative stress. In this study, oxidative stress was induced by silver nanoparticles (AgNPs) and combined with stress from a nutrient-deficient cultivation medium. Citrate-stabilized AgNPs of 10 nm and 20 nm were used. They were applied to the mineral medium from the first day of the cultivation cycle in concentrations ranging from 0.01 mM to 10 mM. The microalgal culture in the red cyst phase was used as the inoculum. The results demonstrated a significant increase of 80-90% in the astaxanthin content in the biomass of the red cysts without altering the biomass content. Additionally, the lipid content in the biomass also increased significantly. The dose/effect relationship between the concentrations of 20 nm AgNPs and astaxanthin values was direct. For 10 nm AgNPs, low concentrations resulted in increased astaxanthin values. Combined stress, with the variable factor being the concentrations of silver nanoparticles, can be proposed as a strategy in the biotechnology of Haematococcus pluvialis for astaxanthin production. ACKNOWLEDGEMENTS: This work was supported by a grant of NARD, project number 24.80012.7007.08 SE

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Nanomedicine: Diagnostics and Therapy/Drug Delivery Systems

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Flat Nanocarrier for Enhanced Transdermal Delivery of Active Moleculer for Anti-Inflammatory PC11

Titrated extract of centella asiatica (TECA) has drawn attention as a functional cosmetic compound by the virtue of its anti-inflammatory, antioxidant, and wound healing activity, but its feasibility has been limited due to its low water-solubility and stability, and extensive studies have been devoted to overcoming these limitations. In this study, we suggest a bilayered micelle, or so called bicelle, as a novel nanocarrier for dermal delivery of TECAs. The physicochemical properties of TECA-loaded bicelles were investigated and their skin permeability and therapeutical efficacies were evaluated. TECA-loaded bicelles were prepared via the hydrodynamic focusing method. To visualize the penetration depth of bicelles, coumarin-6 was incorporated into the bicelles and fluorescent images of vertically cryo-sectioned samples were obtained. Anti-inflammatory activity and wound healing activity of TECA-loaded bicelles were evaluated using HaCaT and HDF cells. In conclusion, the bicelles entrap and protect the non-water-soluble molecules as with liposomes, but the small size and discoidal shape enables the deeper penetration and higher therapeutical effect. ACKNOWLEDGMENTS: This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (RS-2024-00356054, RS-2024-00432685

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Hydrogenated Nanodiamonds as Carriers for Silver Nanoparticles PC12

Nanodiamonds (ND) exhibit specific bulk and surface properties that predispose them to a wide range of applications. For example, their positive zeta potential after hydrogenation makes them attractive e.g. for drug delivery or selective sequestration of specific cell signalling molecules. Here, we exploit the positive zeta potential of hydrogenated high pressure high temperature NDs and investigate their applicability as carriers for antibacterial silver nanoparticles (AgNPs). The preparation of the AgNP-ND nanocomposites was carried out in two steps. In the first step, the surface of hydrogenated NDs was coated with a thin chitosan layer, which acts as an anchoring element for the reduced silver nanoparticles and simultaneously improves the stability and dispersibility of the NDs in ionic environments and protect them during sterilization. In a second step, silver nanoparticles were prepared in situ by reduction from AgNO3 precursor and anchored to the surface of the nanodiamonds. The final AgNPs-ND nanocomposites retain a positive zeta potential and enhanced colloidal stability which allowed efficient attachment to the negatively-charged gram-positive and gram-negative model bacteria. We found out that while AgNPs on NDs 0 - 30 nm in size show an antibacterial effect, AgNPs attached to 0 - 250 nm NDs show no significant effect on bacterial growth. This principle can be utilized for the preparation of nanocomposites with scalable antibacterial effects while preserving the specific properties of each ND and AgNPs constituents.

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Thermodynamic Analysis of Biofunctionalized Gold Nanocluster-Serum Albumin Interactions PC13

The potential application of fluorescent gold nanoclusters in drug delivery monitoring is becoming more apparent. These nanoclusters have been effectively employed as fluorescent markers for imaging of cells and tissues. Furthermore, one of the main areas of research is the creation of biosensors using structure-tunable fluorescent nanoclusters. Selective identification of, for example, metal ions, tiny compounds with neuroactive or antioxidant effects, or proteins is usually the aim of these sensor applications. In general, there is not enough time during these application-focused advances to thoroughly investigate the thermodynamically-driven interactions between nanoclusters and pertinent biomolecules and proteins. Thus, the main goal of this work is to conduct several experiments in order to partially fill this scientific gap. Besides the well-known fluorescent probes, the cited interactions were investigated applying unconventional methods as surface plasmon resonance (SPR) and isothermal titration calorimetry (ITC). These two-dimensional (at the solid/liquid interface) and three-dimensional (in the bulk phase) measuring arrangements provide a unique opportunity for the thermodynamic characterization of the interaction between different gold nanoclusters containing various surface functionalizing ligands and proteins.

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Alendronate-Decorated Polymeric Nanoparticles for Bone Tumor-Targeting and Retention PC14

Bone tumors present a formidable challenge due to their mineralized extracellular matrix predominantly composed of hydroxyapatite, which hinders the effective delivery and action of anticancer agents. Herein, we present a novel bone tumor-targeting polymeric nanoparticles (NPs), named PLCSA-AD NPs, comprising alendronate-decorated chondroitin sulfate A-graft-poly(lactide-co-glycolide) and doxorubicin (DOX). These NPs demonstrated a prolonged retention within the tumor microenvironment and enhanced therapeutic efficacy by inhibiting the mevalonate pathway. The PLCSA-AD polymer was synthesized through a coupling reaction of chondroitin sulfate A (CSA) and poly(lactide-co-glycolide) diamine (PLGA-NH2), followed by subsequent coupling of alendronate (AD). PLCLA-AD NPs were then fabricated by loading DOX via a self-assembly process. PLCSA-AD NPs exhibited a 1.72-fold lower IC50 value than free DOX and displayed a higher affinity for hydroxyapatite compared to PLCSA NPs in HOS/MNNG cell-based bone tumor models. The inhibition of the mevalonate pathway by PLCSA-AD NPs in tumor cells was confirmed by examining the cytosolic fraction of unprenylated proteins. Blank PLCSA-AD NPs notably increased the expression of cytosolic Ras and RhoA without altering their total cellular levels. In a bone tumor-mimicking xenografted mouse model, PLCSA-AD NPs significantly enhanced tumor accumulation compared to PLCSA NPs, with histological analysis revealing increased adsorption to hydroxyapatites within the tumor. Collectively, bone tumor-targeting PLCSA-AD NPs achieved prolonged retention within the tumor microenvironment through ion interactions with hydroxyapatites and facilitated apoptotic process via mevalonate pathway inhibition.

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Biological Characterization of Antibody Functionalized Molybdenum Oxide Nanoparticles PC15

Molybdenum oxide represents a material with promising photothermal activity which is able to induce apoptosis in cells after irradiation with near-infrared laser. By functionalization of MoOx nanoparticles (NP) with antibody against carbonic anhydrase 9 (CAIX) we have enabled specific targeting of cancer cells. Transmembrane protein carbonic anhydrase 9 is a biomarker associated with aggressive tumors and poor clinical outcome. We have characterized biological properties of functionalized NP, such as their binding selectivity, influence on cell rigidity, kinetics of NP binding and their membrane and intracellular localization. We confirmed their biocompatibility by viability measurements. MoOx NP functionalized with anti-CAIX antibody bind to CAIX present on the cell surface, followed by the internalization of NPs and their transport by endocytic pathways. Characterization of the functionalized nanoparticles and of their interaction with target cells represents an important step in the development of a multifunctional nanoplatform for cancer therapy. ACKNOWLEDGEMENT: Supported by APVV-20-0485, APVV-20-0480, VEGA 2/0117/22, SK-FR-22-0012

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Transport and Immobilization of Pharmaceuticals in Humic Hydrogel **PC16**

Pharmaceuticals can be found in soil and aquatic environments as a result of human activity. They are released into the environment where they undergo soil sorption, photodegradation, and chemical transformation. It is known that their migration ability and toxicity can be significantly affected by interactions with organic matter. The interactions can result in their immobilization in humic structure and decrease in their bioavailability. Humic substances as important constituents of natural organic matter are investigated from point of view of their interactions with different pollutants (including pharmaceuticals) mainly by means of traditional batch adsorption experiments. Our approach is different. Humic substances are used in the form of hydrogel which can be considered as a model system of soil with characteristic content of organic matter. The hydrogel form is advantageous for its defined parameters which can be reflected in initial and boundary conditions necessary for mathematical description of transport in the system. Ibuprofen (sodium salt) and tetracycline are studied from point of view of their transport and immobilization in humic hydrogel by the method of instantaneous planar source. It means that small defined amount of diffusing substance is placed on the circular surface of cylinder-shaped hydrogel (placed in glass tube to achieve one-dimensional diffusion). Diffusion coefficients for both studied pharmaceuticals are determined. Their mobility in humic systems as well as the immobilization ability and their effect on the bioavailability of pharmaceuticals are discussed.

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The Effect of Molecular Weight of Polycaprolactone in Blended Nanofibers on the Vaginal Microbiome Response **PC17**

The health of the vaginal microbiota is a crucial component of an intricate system. Vaginal drug delivery systems play an integral role in women's health by offering targeted and efficient treatment options for various gynecological conditions, while aiming to minimally impact said bacterial population. We propose using nanofibrous materials based on the polymers polycaprolactone (PCL) and poly(lactic acid) (PLA) due to their favorable properties. The molecular weight of PCL can significantly influence the properties of blended nanofibers, which in turn affects their interaction with the vaginal microbiome. Higher molecular weight PCL tends to enhance the mechanical strength and stability of the nanofibers, potentially leading to a more controlled and sustained release of incorporated substances. This controlled release is crucial for maintaining a balanced microbiome, as it may help in the gradual release of antimicrobial agents or probiotics. A healthy vaginal microbiome is dominated by various types of Lactobacilli, which produce lactic acid and antimicrobial compounds. We tested the effect of blended nanofibers with PCL of two molecular weights (Mn 45,000 and 80,000) on the growth rate of three Lactobacilli species: L. crispatus, L. gasseri, and L. jensenii. There was no distinguishable effect on the growth rates of L. crispatus and L. gasseri, but the growth rate of L. jensenii was affected by PCL of both molecular weights. This is an important finding for future use of PCL based nanofibers in vaginal drug delivery.

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Nanomedicine: Biosensing

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Nanobiosensor for Rapid Detection of Creatinine Crystals Present in Urine **PC18**

Creatine is synthesized primarily in the liver and kidneys from amino acids and is phosphorylated to phosphocreatine, which serves as an energy source in muscle. Creatine is non-enzymatically degraded to creatinine at a constant rate and excreted in the urine. Its formation mainly depends on the muscle mass. Changes in creatine and creatinine levels may be related to various diseases (e.g. kidney disease, rhabdomyolysis etc.). Several methods are used to determine creatinine, such as for example the Jaffe method using the reaction of creatinine with picric acid in an alkaline medium, forming a red-orange complex or the enzymatic Trinder reaction. In some cases, crystals or larger aggregates are present in the urine. Primary diagnosis of such crystals is focused on microscopic evidence of the presence of the structure and may be confirmed by FTIR. The three enzymes, creatinase, creatininase and sarcosine oxidase can also be used for qualitative assessment of creatinine. The aim of this work was to design a SPION nanobiosensor for qualitative proof of the presence of creatinine in a sample. The methodology uses the highly sensitive Red Amplex fluorophore. Absorbance dependence on creatinine concentration read off at the wavelength of 572 nm was linear over a total range of 0-1000 µM.

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Universal Nanocomposite Coating for Point-of-Care Electrochemical Affinity Biosensing **PC19**

While electrochemical biosensors hold promise for enabling the development of multiplexed point-of-care diagnostics, their commercial viability has been hindered by challenges such as electrode biofouling and the absence of inherent redox properties. We have successfully developed a universal nanocomposite coating which is the first of its kind to not only allow the oriented conjugation of the biorecognition element but also enable specific detection directly in complex biological fluids such as urine and serum due to its inherent antifouling and redox capabilities. This multifunctional coating comprises a 3D porous matrix of cross-linked bovine serum albumin (BSA) embedded with graphene nanosheets functionalized with amino-ferrocene (Fc-GNS). The components and functions of this coating include: (i) A 3D BSA matrix that facilitates oriented covalent conjugation of the biorecognition element, eliminates biofouling, and permits analyte diffusion through its pores without hindrance. (ii) Embedded Fc-GNS for enhanced conductivity and mediator-free biosensing directly in complex biological fluids. Our developed nanocomposite coating exhibited outstanding antifouling properties even after a month-long incubation in 1% BSA, artificial urine, and untreated human serum. For proof-of-concept feasibility studies, we employed the nanocomposite coating-modified electrodes for electrochemical immunosensing of two bladder cancer protein biomarkers, namely IL-8 and VEGF. These electrochemical immunosensors achieved a remarkable limit of detection (LOD) of 41 pg/mL for IL-8 and 67 pg/mL for VEGF, a broad sensing range of 0.1 to 1000 ng/mL for both biomarkers, and a high specificity against other protein interferents such as NMP-22, FGFR3, and HSA. This universal coating holds significant potential in facilitating multiplexed electrochemical biosensing of a wide array of biomarkers found in biological fluids, thus enabling reliable point-of-care testing for various medical conditions.

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Nanoengineered Hybrid Hydrogel-MXene Nanocomposite: A Robust Antifouling Coating for Enhanced Electrochemical Biosensing of Estradioll **PC20**

This study presents a new approach to address the biofouling challenges in electrochemical biosensors, specifically for detecting estradiol (E2). The approach involved developing an antifouling nanocomposite coating interface (ANcI), which is a combination of natural polymers and advanced nanomaterials. The ANcI consisted of a hybrid hydrogel network formed by crosslinking carboxymethyl chitosan with sodium carboxymethyl cellulose, doped with highly conductive Ti3C2Tx MXene nanostructures. This innovative coating provided excellent antifouling properties and high electrical conductivity, crucial for maintaining sensor performance in complex clinical samples. The biosensor was fabricated on a screen-printed carbon electrode by drop-casting the ANcI as an antifouling layer, followed by a gold nanoparticle supporting layer modified with E2-specific aptamers as biorecognition elements. The biosensor's antifouling capabilities were evaluated in human serum and bovine serum albumin, showing promising results. This research addresses the crucial need for reliable E2 detection in clinical diagnostics, environmental monitoring, food safety, and paves the way for enhanced accuracy, sensitivity, and a clinically relevant detection range of 0.1 pg/mL to 1000 pg/mL in electrochemical biosensors. ACKNOWLEDGEMENT: This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) (RS-2023-00243390).

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Investigation of Covalent Binding of Gold Nanoparticles to Chitosan Nanofibers Using Cellulose and Hyaluronate Dialdehydes **PC21**

In this study, the reaction mechanisms of gold nanoparticles (AuNPs) synthesis using dialdehyde cellulose (DAC) and dialdehyde hyaluronate (DAH), and their covalent binding to chitosan nanofibers (CHIT), was investigated. The synthesis uses a redox reaction where dialdehyde polysaccharides are oxidized to dicarboxy polysaccharides and the gold salt precursor is reduced to elemental gold. The formation of the AuNPs-CHIT composite involves Schiff base chemistry, where reactive aldehyde groups of the polysaccharide shell around AuNPs react with chitosan's amine groups, forming pH-labile imine groups, which can be subsequently stabilized using reductive amination. FT-IR and XPS analyses were used to confirm the proposed reaction mechanisms. Next, the catalytic activity of AuNPs synthesized using DAC and DAH was evaluated for the reduction of 4-nitrophenol to 4-aminophenol with sodium borohydride. Rapid conversion rates and high turnover frequency were observed. The morphology and structure of the composites were characterized using transmission electron microscopy (TEM), scanning electron microscopy (SEM), and X-ray diffraction (XRD). These analyses confirmed the sub-10 nm size of the AuNPs and their uniform distribution on chitosan nanofibers. The findings confirm the proposed reaction mechanisms, showcase the morphology and catalytic activity of the prepared nanoparticles and highlight their potential industrial applications. The versatility of this method also opens avenues for further functionalization and broader applications of AuNPs in biomedical fields such as biosensors and drug delivery systems.

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Nanomedicine: Tissue Engineering and Implants

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Composite Material for Wound Healing Based on Thin Film and Nanofibrous Layer from Hyaluronan **PC22**

Hyaluronan (HA) or its derivatives are often considered as a suitable material for application in regenerative medicine, cosmetics, or dermatology. HA is a natural polysaccharide present in the extracellular matrix, synovial fluid, cartilage, and skin and at the same time it plays an important role, e.g. in the wound healing process. HA or its derivatives can be processed into various morphological forms to enhance their key properties. By a combination of these forms, it is possible to eliminate partial shortcomings and achieve a remarkable synergy. Composite materials consisting of a HA nanofibrous layer containing an active substance (AS) and a thin film based on hydrophobized HA derivatives were prepared. Such a material could be used, for instance, as a wound dressing. Nanofibrous layer dissolves immediately upon contact with wound environment, releasing the AS and forming HA gel. Thin film serves as a mechanical protection controlling the moist environment. The thin film is transparent so the state of the wound could be regularly monitored. Various composite materials were prepared by combining thin films based on different HA derivatives and nanofibrous layers containing hydrophilic or hydrophobic model AS. Different properties, primarily the adhesion between the two forms and the behavior of the AS under moist conditions were analyzed by the T-PEEL test and the confocal fluorescence microscopy, respectively. To conclude, the optimal combination of the materials and the preparation method were selected to obtain a composite material with sufficient adhesion for standard manipulation and desired behavioral properties of the AS.

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Synthesis of Methacrylate Hydrogels with Antimicrobial Properties PC23

The rise of antimicrobial resistance due to extensive antibiotic use has become a critical issue, necessitating the development of novel antibacterial materials. This study investigates the potential of hydrogels incorporating ionic liquids and copolymers of 2-hydroxyethyl methacrylate (HEMA) containing positively charged thiazolium groups. Hydrogels were synthesized using 2-HEMA and MTA monomers in four distinct molar ratios through free radical polymerization in aqueous solutions. Comprehensive characterization of the hydrogels was conducted using Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), thermogravimetric analysis (TGA), rheological assessments, and swelling tests. The results indicated that increased thiazolium content enhanced the hydrogels' swelling capacity but compromised their mechanical properties and thermal stability. However, these hydrogels demonstrated substantial antibacterial and antifungal efficacy, highlighting their potential in medical and environmental applications. This research underscores the need for advanced materials to combat antimicrobial resistance and positions hydrogel polymers as a promising avenue for further investigation. ACKNOWLEDGEMENT: This work was created as part of the project No. CZ.02.01.01/00/22_008/0004631. Materials and technologies for sustainable development within the Jan Amos Komensky Operational Program financed by the European Union and from the state budget of the Czech Republic and with the financial support of the European Union under the REFRESH - Research Excellence For REgion Sustainability and High-tech Industries project number CZ.10.03.01/00/22_003/0000048 via the Operational Programme Just Transition.“

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The Use of Polydioxanone for 3D Printing of Absorbable Implants and the Effect of Plasma Surface Modification on Their Biocompatible Properties PC24

Nowadays, additive manufacturing in the form of three-dimensional printing is an up-and-coming technology in regenerative medicine and tissue engineering. The growing popularity of this technology in the biomedical community is due to its versatility in terms of approach to processing, choice of materials and final design. With the possibility of using a whole range of thermoplastic biodegradable polymers with various properties, the subject of current research is mainly the printing technology based on the deposition of extruded thermoplastic polymer - FDM / FFM. One of these thermoplastic polymers is polydioxanone, a biodegradable polyester with excellent mechanical properties, thanks to which it can be used in surgery as implants. In particular, the degradation profile of printed samples needs to be extended for broader application in orthopaedic chiropractic. Therefore, this research focuses on the subsequent plasma treatment of printed polydioxanone implants. The goal is to extend their degradation time by increasing hydrophobicity via forming a thin film deposited from hexamethyldisiloxane. This work compares the effect of plasmatic surface modification on the resulting biocompatibility of the material, surface texture, and change in contact angle to the unmodified sample. ACKNOWLEDGEMENT: The research was supported by the SGS project Reg. No. SGS-2024-6426 funded by the Ministry of Education, Youth and Sports (CZE) in 2024.

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Antibacterial activity of Silver Nanoparticles Biosynthesized Using the Sulfated Polysaccharides from Arthrospira Platensis Biomass **PC25**

Arthrospira platensis (spirulina) is known for its high biological activity, including antioxidant, anti-inflammatory, and antiviral properties. In recent years, spirulina polysaccharides have been actively researched in fields such as tissue engineering, targeted drug delivery, and wound healing. These substances also possess a high reducing capacity, making them suitable matrices for the biosynthesis of metallic nanoparticles from metal ions. For instance, silver, known for its antimicrobial properties, can be biosynthesized as AgNPs on polysaccharide matrices derived from spirulina biomass, potentially combining the effects of the nanoparticles and the matrix for developing wound coverings. In this study, sulfated polysaccharides were extracted from spirulina biomass grown under controlled conditions to stimulate carbohydrate accumulation. AgNPs biosynthesis was carried out using polysaccharides solubilized in deionized water at 10 mg/ml and AgNO3 solutions of various concentrations, under different process parameters. The nanoparticles obtained were tested for antibacterial properties against Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, and antifungal properties against Candida albicans. The AgNPs demonstrated significant antimicrobial activity, with MIC and MBC values varying based on the biosynthesis conditions. These results indicate that AgNPs biosynthesized on spirulina sulfated polysaccharide matrices possess antimicrobial properties, making them promising for developing wound dressing materials. ACKNOWLEDGEMENTS: This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS-UEFISCDI, project number 12ROMD/20.05.2024, project PN-IV-P8-8.3-ROMD-2023-0060, within PNCDI IV.

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Microbiology and Others

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Functionalization of Polyurethane and Poly(lactic-co-glycolic) Acid Based Nanostructures to Overcome Biofouling and Microbial Colonization **PC26**

Polymer nanofibers have been established as effective structures in a variety of application. Nowadays, they can be found in filtration processes of both gas and liquid media, where the greatest challenge is to maintain their functionality with respect to filtration efficiency and biofouling threat brought by the filtrated substances. For this purpose, the most effective approach is a combination of nanofibrous polymeric material and antimicrobial nanomaterial; the polymeric part can be fulfilled by polyurethane (PUR) and the silver (in a nanoparticle form) can guarantee the antimicrobial action. PUR fibers are mechanically stable and silver has approved to be a reliable antimicrobial agent, which can prevent biofouling of the final composite filtration material and this way prolong the lifespan of the filter. However, the antifouling agent should be covalently immobilized on the surface of the independent fibers, where the prevention of microorganism colonization is likely to start. The functionalization agent of the fibers should be then release-resistant, which can be achieved only with the silver nanoparticles covalently bonded to a linker, which is anchored in the fiber itself. Similar approach can be used also for a safe application of polymer-nanomaterial based composite in the second major application field - in medicinal applications. In this field the poly(lactic-co-glycolic) acid (PLGA), in a form of either particles or fibers, and functionalized in its entire volume or just on the surface with silver nanoparticles, represents a composite material, which brings advantages of both counterparts. PLGA is an FDA approved material for this purpose and a composite of such a material decorated with silver nanoparticles represent a material against which bacterial resistance hasn´t been proved. ACKNOWLEDGEMENTS: Authors gratefully acknowledge the support of Project TN02000051- Polymer Materials and Technologies of the 21st Century, which is co-financed by the Technology Agency of the Czech Republic under the National Centre of Competence Program and from European Regional Development Fund - Project Excellence in Regenerative Medicine" (No. CZ.02.01.01/00/22_008/0004562).

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POSTER SESSION D

Health, Toxicity, Environmental Challenges, Safety

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The Effects of β-irradiation on Electrospun Polycaprolactone Nanofibres **PD1**

Microplastics originating from the degradation of plastic waste are considered a global concern for the environment, with microplastic fibers from synthetic textiles being responsible for the majority of microplastic pollution. Over the past few decades, there has also been a notable increase in the production of synthetic polymeric materials in the form of nanofibers for various applications. Despite this fact, knowledge in the field of aging of nanofibrous materials is very limited. To evaluate the effects of polymer aging, accelerated aging techniques involving high-energy irradiation are commonly used. This work focuses on the impact of β-irradiation on electrospun polycaprolactone nanofibers. Polycaprolactone (PCL) is a semicrystalline biodegradable polyester widely used in medical applications; thus, any potentially formed fiber fragments pose less risk to the environment and health compared to non-biodegradable counterparts. The impact of irradiation was evaluated in terms of the mechanical properties of the prepared nanofibrous mats. Additionally, the effects on fiber morphology and crystallinity were assessed, as well as the impact of irradiation on the biocompatibility of the material. ACKNOWLEGEMENT: This work was developed thanks to the financial support of the student grant competition project (SGS-2024-4481) from the Technical University of Liberec.

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Assessment of the Toxicological Properties of Purified Wastewater in Relation to the Environmental Environment Under the Conditions of Fire Suppression **PD2**

The water management sector in the Czech Republic is not fully prepared to fulfill the capabilities of the circular economy because technological costs prevent the strategic decision of the use of technologies with the use of waste purified water or new alternative sources. The governments of many countries are trying to introduce new, very ambitious targets to limit the anthropogenic impacts of climate change and water reuse has a very significant potential in this regard. Water itself is largely an undervalued and also the most polluted component of the environment. Population growth in general, increased industrial growth and urbanization have increased the demand for water. Wastewater treatment is becoming essential to ensure the continued existence of the human species, but under the current policy of using water resources, it is possible and probable that the availability of water resources for the population will be lost. Wastewater, on the other hand, offers the potential for further use to meet the demand for water. From the consumer's point of view, purified water is an alternative source with an unlimited supply. The question is whether it is possible to keep user contamination completely under control and at an acceptable level. The clean-up process is complex in relation to the possible interactions between technical, environmental and economic links that are associated with public health. Water from the hydrant network is a water supply for the population. At the same time, however, it also fulfills the function of fire water to secure the area. The fire brigades of the Czech Republic use the backbone hydrant network to secure the tasks, especially extinguishing fires. However, in crisis situations of the state, for exampe lack of drinking water could take away valuable liquid from the population. Firefighters use both natural and man-made water sources to fight fires and that is why the idea of using purified wastewater is actively coming to the forefront of interest not only for the environmentally minded. This topic is very controversial in many ways. Changing the way fire water is provided will save water used for fire purposes. The current layout of the wastewater treatment plants (WWTPs) allows for rapid and operational provision of fire water with the possibility of pumping from open water or with a constructed pumping station, unless there is no other suitable natural or multipurpose source of fire water in the respective municipality or settlement.

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Quantification and Characterization of Polystyrene Micro and Nanoplastics in Cress (Lepidium Sativum) Stems: Raman Spectral Imaging PD3

Micro and nanoplastics have emerged as ubiquitous contaminants in the environment, posing potential risks to ecosystems and human health. This study focuses on elucidating the uptake and distribution of polystyrene micro and nanoplastics in cress (Lepidium sativum) stems using Raman spectral imaging. Through this technique, we quantified the concentration of micro and nanoplastics within the plant tissue and characterized their morphological properties, including size, shape, and spatial distribution. Our results provide insights into the interaction between plastics and plants, highlighting the potential pathways for plastic contamination in the food chain and informing strategies for mitigating plastic pollution. Understanding the occurrence and degradation of these plastics is crucial, as they can negatively affect aquatic habitats and potentially disrupt both ecosystems and human health. Future research should explore the long-term effects of plastic exposure on plants and further elucidate the mechanisms of plastic uptake, translocation, and potential transfer through food chains. In conclusion, our research underscores the importance of interdisciplinary efforts in addressing plastic pollution's complex challenges. By advancing our knowledge of plastics interactions with plants, we contribute to informed decision-making for sustainable environmental management and underscore the need for proactive measures to mitigate plastic pollution's impact on ecosystems.

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The Way to Assess the Toxicity of Fullerene Nanostructures for Aquatic Species PD4

Fullerene molecules have a size of nanoparticles. They are used in the production of nanomaterials in various fields such as medicine, chemistry, electronics and others. Potential toxic effects of FDs on the aquatic environment was analyzed using binding affinity of 169 FDs to ten human proteins (1D6U, 1E3K, 1GOS, 1GS4, 1H82, 1OG5, 1UOM, 2F9Q, 2J0D, 3ERT) obtained from the Protein Data Bank (pdb) which showed high similarity to proteins from aquatic species. In addition, we focused on the binding activity of FDs to the enzyme acetylcholinesterase (AChE), which is a target of the toxin in minnows and Daphnia magna and causes the inhibition of this enzyme. To confirm the possible mechanism of action, an analysis of the structural aquatic toxicity alerts obtained from ToAlert was performed [1]. Counter-propagation artificial neural network (CPANN) models were used to determine the most important factors in terms of descriptors expressing the electronic, size, topological, stereo and other properties of FDs that affect binding to proteins associated with aquatic toxicity [1]. We have highlighted the structural characteristics of FDs with the greatest impact on aquatic species that help prioritize FDs before manufacturing decisions are made.

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TiO2 P25 Nanoparticles Cause an Impairment in Neuronal Cells PD5

Over the past years, the development, production, and occurrence of TiO2 nanoparticles (NPs) is steadily rising, resulting in increased exposure to the human body. Therefore, concerns arise about the safety of TiO2 NPs. Due to their small size, TiO2 NPs can enter the human body through different ways and via subsequent blood transport, can cross the blood-brain barrier and reach the brain. Thus, it is crucial to evaluate the biological effects of TiO2 NPs in neuronal cells to understand their potential neurotoxicity. We aimed to assess the biological effects of commercially available TiO2 P25 NPs using human neuroblastoma cells (SH-SY5Y). SH-SY5Y cells were treated with 0 100 µg·mL-1 TiO2 P25 NPs for 24-72 h. Multi-walled carbon nanotubes were used as a positive control. After incubation with nanomaterials, we evaluated dehydrogenase activity, oxidative stress focusing on the change in glutathione levels, nuclear condensation, and fragmentation in SH-SY5Y cells. The results showed a dose-dependent decrease of the dehydrogenase activity, changes of glutathione levels, and nuclear condensation and fragmentation of SH-SY5Y cells after exposure to tested nanomaterials. In conclusion, TiO2 P25 NPs caused a significant impairment of SH-SY5Y cells. This study was supported by the FCHT/SGS/2024/002 project.

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Comparison of TiO2 P25 Nanoparticles Effect in 2D and 3D Cultured Neuronal Cells PD6

Titanium dioxide nanoparticles, 25 nm in size of crystallites (TiO2 P25 NPs), are one of the most widely used nanoparticles in industry due to their variability in applications. Because of their small size, they can easily permeate into the human body and cause cell impairment. Our aim was to characterize a biological effect of TiO2 P25 NPs in the human neuroblastoma cell line. Because the arrangement of cell culture conditions can significantly influence the results, we aimed to compare the biological effect of TiO2 P25 NPs treatment in the SHSY5Y cell line cultured as a 2D monolayer and in 3D spheres. Cells were exposed to 0-100 µg·mL-1 TiO2 P25 NPs for up to 48 h. We used the measurement of dehydrogenase activity and glutathione levels to characterize the cell damage. In addition, fluorescence microscopy was used to detect cell morphology changes. In conclusion, we established a 3D model of SH-SY5Y cell culture. We found changes in dehydrogenase activity and glutathione levels after 24 and 48 h of incubation with TiO2 P25 NPs. We also observed changes in 3D cultured cells treated with TiO2 P25 NPs confirming that 3D cultures of SH-SY5Y cells were less sensitive to TiO2 P25 NPs effect than 2D monolayer cells. This study was supported by the FCHT/SGS/2024/002 project.

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In Vitro Tests of Nanoparticles Obtained After 3d Printing Process PD7

This study aims to verify the environmental safety of additive technologies and demonstrate the potential impacts of 3D print degradation in medical applications. The in vitro effects of nanoparticles (NPs) produced as a by-product during 3D printing by selective laser melting of 316L grade stainless steel metal powder were investigated. The NPs were characterized by microscopic methods and tested for immune response in a model of human blood. The experimental data indicated no impact on the viability of 316L NPs at the tested doses. However, functional immune assays demonstrated a significant immunosuppressive effect of the NPs. Monocyte phagocytic activity was moderately stimulated (17 %), while there were no substantial changes in the phagocytic activity and respiratory burst of granulocytes. A notable dose-dependent increase in the levels of the pro-inflammatory cytokine TNF-α was observed in blood cultures treated with NPs. Conversely, IL-8 chemokine levels were significantly suppressed. The levels of the pro-inflammatory cytokine IL-6 were reduced by only a single concentration of NPs. These findings can help minimize potential health risks and highlight the need for further research. ACKNOWLEDGEMENTS: This research was supported by the student projects SP2020/6, SP2023/095, and SP2024/053 of VSB-Technical University of Ostrava. This research was created as part of the

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Chip Sizes for Milling Carbon Fibre Composite Material PD8

Applications of composite materials require subsequent mechanical processing to achieve the final shape of the designed parts and their assembly. However, mechanical processing of polymeric materials with fiber reinforcement generates dust. The generation of dust during the machining of fiber composites poses health and environmental risks. The morphology and concentration of these dust particles determine the severity of these potential risks. Some toxicological studies describe potential health risks associated with machining composites, but with the expanding application of these materials, this issue and its elimination have not received sufficient attention. This study addresses the issue of dust particle generation during the milling of carbon fiber composite material with implications for human health. The study aimed to determine, using a scanning electron microscope, how large dust particles are generated under different cutting conditions and what the effects are on, the amount of these particles. During the evaluation of dust particles, 3 types of dust particles were captured, characterized as fine dust (mixture of matrix and reinforcement), loose fibers of different lengths and so-called fragments, clusters of fibers with matrix. It is the fine dust form containing micro-sized fibre particles that is most harmful to human health.

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Nanodiamonds Are Non-Cytotoxic Yet Evoke Vigorous Interferon Responses in Primary Human Dendritic Cells PD9

Nanodiamonds (NDs) are endowed with a tunable, readily functionalized surface, rendering them promising for biomedical applications such as drug delivery. However, their interactions with immune cells remain poorly understood. Here, we investigated the interaction of amino-, carboxyl-, and poly(ethylene glycol) (PEG)-terminated NDs with primary human immune-competent cells. First, using cytometry by time-of-flight (CyToF), we analyzed the impact of NDs on peripheral blood mononuclear cells (PBMCs), and found an increase in plasmacytoid dendritic cells (pDCs), a subset of DCs that are critically involved in antiviral responses. Subsequent experiments demonstrated that NDs triggered a vigorous type I interferon response through the endosomal Toll-like receptors, TLR7 and TLR9. In contrast, TiO2 nanoparticles of comparable size and similar surface functionalization did not elicit TLR7 or TLR9 activation. Subsequent analyses revealed that NDs were readily internalized by PBMCs, yet no cytotoxicity was detected. Taken together, NDs were shown here to be non-cytotoxic while triggering a virus-like response in pDCs. These findings deepen our understanding of ND interactions with the immune system and yield new insights for future biomedical applications of NDs.

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Development of Theranostic Ferumoxide and Gadolinium Nanoliposomes for Controlled Release of Cytokines

PD10

Several experimental strategies have been formulated to develop theranostic liposomes by incorporating both drugs and various imaging contrast agents. Liposome kinetic and cracking could be potentiated by external forces (ultrasound and electro-magnetic). Gd and Fe-oxide are contrast agents, detectable by histological electro microscopy and tomography. In order to reveal possible adverse effects of Gd–liposome and Fe-oxide-liposome that may precede visible manifestation of cytotoxicity, we exposed dermal model to both type of liposomes for 24h, and relative changes of cell viability, ROS and metal deposit inside the cytoplasm and nuceus were quantified. The biodistribution of Gd and Fe-oxide on dermal and subdermal layer was also investigated and the kinetic model was described. Results revealed that Gd-liposomes and Fe-liposomes have very similar size (115 versus 122 nm) similar zeta potential and subdermal distribution during 24h. It has been demonstrated the gadolinium and iron-oxide liposomes are stable particles in dermis and subdermal region, still detectable after 24h as compact nanobodies with high contrast under electron microscopy in dermal tissue. Only 1-3% of liposomes were internalized inside the cells. The simple dose of 20 ug per 1cm2 of dermal tissue resulted to very low apoptosis and generation of ROS during 24h. The multiple doses resulted to higher ROS concentration for Gd variant only. The multiple doses combined with mechanical and electro-magnetic forces resulted to significant apoptosis for both type of liposomes. ACKNOWLEDGEMENT: TACR – project FW01010106 „Development of new generation medical devices by means of the translational medicine and physical interventions principle".

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POSTER SESSION E

Advanced Methods of Preparation and Characterization of Nanomaterials

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Enhancing Silicon Nitride Waveguide Performance: Utilizing Chemo-Mechanical Polishing and Thermal Annealing for Low-Loss Applications through Advanced Chip-Upending Techniques and Tree-Based Modeling **PE1**

This study introduces an innovative chip-upending technique to enhance the quality of silicon nitride waveguides by reducing top surface roughness via chemical mechanical polishing and internal absorption via thermal annealing, both of which are critical for reducing optical propagation losses. We employ atomic force microscopy to measure the top surface roughness of the waveguides and also waveguide sidewalls via a special tilting technique, ensuring precise characterization of the surface topography. Furthermore, we determine the absorption quantitatively with ellipsometry and in-line Fourier transform infrared spectroscopy. The fabrication process includes the integration of waveguide annealing and chemical mechanical polishing within a Design of Experiments framework to ensure statistical robustness in the evaluation process for frontend and backend waveguide platforms. Propagation and bend loss measurements at 850 nm are conducted across waveguides of various widths, with thicknesses ranging from 200 to 400 nm. These measurements, in correlation with the roughness and absorption analysis, result in notable improvements in light propagation efficiency. The inclusion of knowledge discovery process in form of a tree-based ensemble modeling in optimizing relevant parameters in the fabrication contributes to a more efficient and controlled process. The findings suggest that our approach can be universally adopted for the fabrication of low-loss waveguides in photonic integrated circuits, with necessary wafer-to-wafer stability.

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Enhancing Silicon Nitride Waveguide Performance: Utilizing Enhanced Waveguide Etching and Resist Reflow for Low-Loss Applications through Advanced Chip-Upending Techniques and Tree-Based Modeling **PE2**

This study introduces an innovative chip-upending technique to enhance the quality of silicon nitride waveguides by addressing sidewall roughness through resist reflow and an optimized etching procedure. These improvements are critical for reducing optical propagation losses. We employ atomic force microscopy (AFM) to measure the waveguide sidewall roughness using a specialized tilting technique, ensuring precise characterization of the surface topography. The fabrication process encompasses both the etching procedure and sidewall roughness reduction within a Design of Experiments (DOE) framework, ensuring statistical robustness in the evaluation process for frontend and backend waveguide platforms. Propagation and bend loss measurements at 850 nm are conducted across waveguides of various widths, with thicknesses ranging from 200 to 400 nm. These measurements, correlated with roughness and absorption analysis, demonstrate notable improvements in light propagation efficiency. Additionally, the inclusion of a knowledge

discovery process, in the form of tree-based ensemble modeling, helps optimize relevant parameters in the fabrication process, contributing to a more efficient and controlled manufacturing process. The findings suggest that our approach can be universally adopted for the fabrication of low-loss waveguides in photonic integrated circuits, ensuring necessary wafer-to-wafer stability. This advancement not only enhances the performance of photonic devices but also supports the scalability and reliability of silicon nitride waveguides in a wide range of applications.

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Laser-mediated Synthesis of Metal Nanoparticles by Optical Vortex Beam PE3

Controlling nanoparticles (NPs) morphology in laser-mediated synthesis remains a significant challenge. This study introduces an innovative approach for synthesizing metal NPs using an Optical Vortex Beam (OVB) instead of the conventional Gaussian Beam (GB) in femtosecond laser ablation in liquids (fs-LAL). The primary objective is to achieve NPs shape modification through an environmentally friendly method, eliminating the need for chemical reagents and producing ligand-free NPs suitable for catalytic and biomedical applications. The transformation from GB to OVB was accomplished using a series of waveplates that first converted the linearly polarized GB to a circularly polarized beam and subsequently to a spiral phase wavefront beam, known as OVB. A key innovation of this study is the design of a 3D-printed ablation cell, which generates a thin liquid layer and ensures continuous liquid flow over the metal target, optimizing the laser-ablation setup. This optimization not only enhances productivity but also significantly reduces operation time. Results indicate that using OVB provides superior control over NPs morphology compared to GB, resulting in NPs with improved optical properties, as confirmed by Scanning Transmission Electron Microscopy (STEM) and UV-Vis spectroscopy. This approach holds potential for nanocatalysis, offering a cleaner and more efficient method for NPs synthesis.

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Nanocapsules With Oil Cores from Hydrophobically Modified Hyaluronan: Tailoring Properties for Various Applications PE4

Hyaluronan (HA) is a biopolymer abundant in the human body that can be grafted by acyl chains. Due to their amphiphilic character, hydrophobically modified HA (H-HA) materials can form nanocapsules with sizes from tens to hundreds of nm in combination with an oil phase. The hydrophilic hyaluronan shell preserves the desired properties of hyaluronan for the resulting emulsions (biocompatibility, mucoadhesion, etc.), and grafted hydrophobic chains stabilize the oil phase. Oils not only ensure high solubility of hydrophobic active substances, but they also have positive effects on the human body. Therefore, combining H-HA with oils appears promising for cosmetic and pharmaceutical formulations. Nanocapsules were prepared from H-HA with various chemical compositions using different oil phases. Nanocapsules were characterized by several physico-chemical techniques, such as dynamic light scattering, nanoparticle tracking analysis, confocal fluorescence microscopy, or fluorescence. H-HA’s chemical compositions significantly influenced the size of the nanocapsules. The influence of both aqueous and oil phase compositions on nanocapsules’ size and stability was also observed. Therefore, the nanocapsules can be tailored for different applications, such as topical or oral. Nanocapsules were found stable in the aqueous dispersion for an extended period. Hydrophobic active compounds were loaded into the oil phase, and their performance in nanocapsules was studied.

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External Electric Field Induced Structural Change of Oligo(ethylene Glycol) in Explicit Solvents: A Molecular Dynamics Study PE5

Polymer materials exhibit significant structural changes in response to an external electric field, which is important for various applications such as electrospinning technology [1]. This study explores the structural properties of oligo(ethylene glycol) (OEG) with different chain lengths in water and methanol under an external electric field, using extensive molecular dynamics simulations. These simulations aim to elucidate the findings of our previous research [2]. We analyze the size and shape anisotropy of the oligomer chain by measuring the end-to-end distance, radius of gyration, and other metrics derived from the gyration tensor. Additionally, we calculate the distributions of dihedral angles, the cosine of angles between the CC vectors of the COC segments and the OO vectors of the OCCO segments, and the dipole moments of the chain and solvents with respect to the electric field. To quantify the helicity of the chain, we count the monomer units in predefined helical patterns. Our results show that the initially isotropic chain in both solvents becomes increasingly anisotropic, adopting an oblate shape as the electric field intensity increases. However, in water, this effect diminishes with increasing chain length and eventually reverses, leading to a prolate shape. The population of the gauche conformation also increases significantly with higher field intensity. In methanol, the CC vectors of the COC segments and the OO vectors of the OCCO segments align perpendicular to the electric field. In water, however, the OO vectors shift to smaller angles, while the CC vectors remain perpendicular to the field. Additionally, the dipole moments of both the chain and solvents increasingly align with the direction of the electric field. Acknowledgements: This research has been supported by the Jan Evangelista Purkyně University in Ústí nad Labem within the student grant programme (Project No. UJEP-SGS-2022-53-002-3). Computational resources were supplied by the project "e-Infrastruktura CZ" (e-INFRA LM2018140) provided within the program Projects of Large Research, Development and Innovations Infrastructures. REFERENCES: [1] Jirsák, J., P. Pokorný, P. Holec a Š. Dědičová: A Molecular-Level Picture of Electrospinning. Water, 12(9):2577:1-31, 2020; [2] Dědičová, Š., J. Dočkal, F. Moučka a J. Jirsák: Molecular dynamics simulation study of the effect of a strong electric field on the structure of a poly(oxyethylene) chain in explicit solvents. Journal of Molecular Liquids, 338(2):116622, 2021.

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Different Sizes of Surface Structures and Their Application Created by Focused Gallium Ion Beam PE6

Periodic nanostructures formed on solid surfaces by ion bombardment were first observed in the mid-20th century. Following the initial observations, number of theoretical and experimental results have been published on this topic. In our experimental work, micro- and nanoscale surface structures were created using focused gallium ion beam at two different energies. During the low-energy (2 kV) ion irradiation, with the ion incident angle of between 60 and 80 degrees, regular ripple formations with characteristic size of 30 - 70 nm were produced. The optical properties of the formed nanostructured surfaces were investigated by spectroscopic ellipsometry and reflectometry to reveal industrial application possibilities. Based on the results, the reflectance of the created surfaces can be fine-tuned by the change of the ion incidence angle. In addition by the 30 kV ion irradiations, structures with dimensions comparable to the wavelength of the visible light were fabricated. Detailed examination was carried out for the ~35 degree of incidence angle case, where diverse morphologies were observed. These results can also provide the basis for further applications.

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Effects on the Detection Characteristics of Particles of a Copolymer Film Synthesized from Polyvinyl Alcohol, Formaldehyde and Polyvinyl Acetate. For Use in Alpha Spectrometry PE7

Alpha spectrometry is an extremely useful and sensitive for detection of alpha-emitting nuclides. Contamination of the silicon detectors for low-level alpha spectrometry by recoil nuclides is a serious problem in the measurement of alpha emitters decaying to daughter nuclides with short half-lives. This unwanted contamination leads to decreased measurement sensitivity causing a degradation of the limit of detection. The simplest method to prevent this radioactive contamination of detector is to use a catcher film between the alpha source and the detector. In this work we describe the obtaining of the thin Formvar films as stopper foils for recoil nuclei and we investigated the influence of these films on alpha spectrometry parameters, as energy shift (30 keV) and resolution (7%). No significant deterioration of the alpha spectrometry parameters was observed when using thin Formvar films. Using the ASTAR web databases, which calculate stopping powers for alpha particles, the thickness of Formvar films was estimated to be about 5.355 9 10-5 g/cm2. The measurements were performed with an AlphaQuatro SELENA alpha spectrometer with Si implanted detector.

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Advanced Methods of Preparation and Characterization of Nanomaterials: Films/Nanolayeres

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Thin Film Fabrication of Square-Planar Nickel (Ii) Complexes with Oxime Ligands Towards Chemi-Resistive Gas Sensing

PE8

Square planar geometry in coordination complexes can be achieved in late transition metal ions,1 e.g, in metal-containing phthalocyanines (MPcs), which are embedded in a π-conjugated macrocycle with a high degree of planarity allowing stacking in the solid state. The electron rich environment promotes interactions with gas analytes, leading to measurable physical changes2 and making them suitable candidates for chemiresistive sensing. We have investigated new chemiresistive sensing materials using square-planar Ni(II) complexes with oxime ligands based on substituted salicylaldehydes. These complexes are relatively stable under sublimation conditions, making them good candidates for thin film deposition and possible gas sensing which can be varied by the different substituents on the benzene moiety.3 Three Ni(II) complexes 4-7 were synthesized, purified by sublimation, and fully characterized. Thin films of various thicknesses were deposited using low-temperature high-vacuum evaporation. Deposition parameters, including substrates, temperature, deposition rate, and vacuum pressure were optimized to achieve uniform and homogeneous films with desirable morphological and structural properties. The thin films were fully characterized and AFM and SEM images revealed long needle-like crystals with a very high aspect ratio indicating a very large surface area for the interaction of analyte gas molecules. ACKNOWLEDGEMENTS: This work was supported by the Czech Science Foundation (GačR grant number: 23-05878S) and the OP-JAC project financed by European Structural and Investment Funds and the Czech Ministry of Education, Youth and Sports (Project No. SENDISO - CZ.02.01.01/00/22_008/0004596).

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Impedance and Photocurrent Spectroscopy of Intrinsic and Al Doped ZnO Thin Films Deposited by Pulsed Laser Deposition on Commercial Interdigitated Electrodes

PE9

Zinc oxide (ZnO is a low cost and environmentally friendly material with unique optical properties and variety of nano and microstructures imposing challenges for energy conversion, scintillators, photocatalytic wastewater treatment, electrochemical energy storage or sensing applications. In our previous work [1] we have presented the results on ZnO thin films prepared by reactive magneton sputtering of Zn target in pure oxygen atmosphere. We have shown that plasma hydrogenation effectively suppresses ZnO defects, leading to a significant increase in electrical conductivity and exciton-related UV luminescence. We found good room temperature stability of the plasma hydrogenated ZnO nanocrystals in air, but fast degradation at elevated temperature. In this work, the nominally undoped and Al-doped ZnO thin films were pulsed laser deposited (PLD) on commercial interdigitated gold 5/5 µm and 10/10 µm (electrode width/electrode gap) gold electrodes (MicruX Technologies, Spain) were tested by impedance and photocurrent spectroscopy. To further study the surface-related effects, we employed a custom-built inductively coupled plasma (ICP) 13.56 MHz reactor with up to 300 W RF discharge power and exposed ZnO samples to the ICP plasma with a mixture of hydrogen and argon for up to 30 min. The work was supported by the Czech Science Foundation project 24-10607J, Ministry of Education, Youth and Sports of Czech Republic (MEYS) Danube project 8X23025 and the Mobility Plus project SAV-23-13 (CAS-SAS-2022-08). The authors also acknowledge the Czech Ministry of Education, Youth and Sports grant no. CZ.02.01.01/00/22_008/0004617 - "Energy conversion and storage". [1] Remes Z, Chang Y Y, Stuchlik J and Micova J 2019 The photoluminescence and optical absorptance of plasma hydrogenated nanocrystalline ZnO thin films NANOCON 2018 - Conference Proceedings 10th International Conference on Nanomaterials - Research and Application, 17-19 October 2018 (Hotel Voronez I, Brno, Czech Republic: TANGER Ltd., Ostrava) pp 78-82.

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Development of Industrial-size PECVD Reactor with Possible Usage for Deposition of Copper-Containing Carbon-Based Nanocomposite Thin Films PE10

The aim of the present work is to develop an industrial-size reactor for plasma-enhanced chemical vapor deposition (PECVD). We used our small GEC geometry reactor as a template. The reactor is powered with an RF power supply through a matching unit. Initial experiments demonstrated successful transferability and reproducibility of diamond-like carbon thin film deposition processes from the smaller reactor. In the subsequent step, the focus shifted to the production of nanocomposite copper-doped thin films with antibacterial and antiviral properties. These films are deposited from a mixture of methane and a precursor containing fluorine and copper atoms: (hfac)copperVTMS (hfac = hexafluoroacetylacetonato and VTMS = vinyltrimethylsilane). The deposited thin films underwent comprehensive analysis using nanoindentation techniques, including thermal testing, atomic force microscopy, and X-ray photoelectronic spectroscopy. Moreover, the water contact angle measurement was used to perform a preliminary test of the film's adhesion to the substrate. ACKNOWLEDGMENT: This research has been supported by projects LM2018096 and LM2023039, funded by the Ministry of Education, Youth and Sports of the Czech Republic, and by project TN01000038, funded by the Technology Agency of the Czech Republic.

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Advanced Methods of Preparation and Characterization of Nanomaterials: Membranes/Nanofibres/Nanocomposites

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Ab-initio-based Analysis of Phonon Contributions to Negative Thermal Expansion of Alpha-tin PE11

Tin alloys have historically been used in a wide range of products, from organ pipes and everyday items to jewellery. In more recent times, industrial applications have included food cans and a significant proportion of electrical-engineering products, especially those using Pb-Sn solders. While Pb-containing ones were recently banned in favor of lead-free solders, the need of basic research of tin is more important than ever. In this theoretical study, we applied quantum-mechanical calculations to investigate the thermodynamic and dynamic stability of tin in its various allotropic forms. Specifically, phonon spectra and vibrational contributions to free energy were computed for the cubic diamond-structured alpha tin, as well as the body-centered tetragonal beta tin and metastable hexagonal gamma tin, using the harmonic approximation and quasi-harmonic approximation. Focusing specifically on the alpha-Sn, our results showed a negative thermal expansion in it within the temperature range from T = 0 K to T = 45 K. No similar phenomenon appears in spectra of other allotropic modifications of tin. That means that origin of this behaviour is connected to the diamond structure of alpha tin. I investigated behaviour of Grüneisen constant of alpha tin in reciprocal space to explain causes of this phenomenon. There are interesting temperature-dependent contributions of individual phonon modes from different k-points in the reciprocal space. In particular, these contributions are negative at all studied temperatures for the k-points around k-point X (0, 0, 0.5) and positive around k-point Γ (0, 0, 0). Negative thermal expansion of alpha tin at low temperatures is related to behaviour of phonons around k-points X, M and N. ACKNOWLEDGEMENTS: Financial support from the Czech Science Foundation, project "Causes and mechanisms of degradation of tin-based materials with a low content of alloying elements" No. 22-05801S, is gratefully acknowledged. Computational resources were provided by the e-INFRA CZ project (ID:90254), supported by the Ministry of Education, Youth and Sports of the Czech Republic. These resources were utilized through IT4Innovations National Supercomputing Center, MetaCentrum as well as CERIT Scientific Cloud.

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Mapping the Mechanical Properties of TZnSb (T = Pd, Ti, V, Cr) Materials with Promising Thermoelectric Applications PE12

In the present work the local mechanical properties of TZnSb (T=Pd, Ti, V, Cr) alloys with promising thermoelectric properties were studied using a fast nanoindentation technique: the accelerated mechanical property mapping (XPM) mode. This mode enables to obtain hardness and elastic modulus maps on multiphase materials with high spatial resolution and low acquisition times. Compared to the classical quasistatic grid indentation method the XPM measuring method is substantially faster. Large number of nanoindentation data (over 1000) was acquired using the above-described method. Several different phases may be distinguished on the mechanical property maps. According to the statistical distribution of nanoindentation data compared to the analytical electron microscopy results it was possible to evaluate the mechanical properties of the different phases of TZnSb materials. ACKNOWLEDGEMENTS: This research was supported by MEYS, Czech Republic via the bilateral Mobility project 8J23AT014 co-sponsored by the Austrian WTZ-CZ08/2023 and by Czech Science Foundation under project GA23-06263S.

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Structure Compatibility of Graphite and Phases Formed from Aluminum or Magnesium Phyllosilicates PE13

Calcination of phyllosilicate/organics nanocomposites in inert atmosphere leads to in situ formation of graphitic carbon layers on silicate phases. Electrically conductive material (ceramics) is thus obtained. Despite an intensive research in this area, attention has not yet been paid to carbon/silicate interfaces in these systems. This study is focused on structure compatibility of graphitic carbon and the most abundant phases formed by transformation of aluminum phyllosilicates or magnesium phyllosilicates, i.e. cristobalite, mullite, forsterite, and protoenstatite. The aim is to find whether the phases can or cannot have a significant influence on the graphitic structure formation, and if the type of phyllosilicate (aluminum or magnesium) must be taken into account. Structure compatibility is determined by original method calculating the overlaps of atomic pairs carbon/another element. Carbon atoms lie in graphite(001) plane, atoms of another element lie in the given phase(hkl) plane. Different crystallographic planes of phases formed from the original phyllosilicates exhibit various structure compatibility with the graphite. The average number of overlaps of individual graphite(001)/phase(hkl) systems revealed the highest structure compatibility for mullite (M) followed by forsterite (F), protoenstatite (P) and cristobalite (C), namely M(102) > F(001) > P(100) > C(100). This sequence suggests that aluminum phyllosilicates, from which M is formed, could be a more suitable input component compared to magnesium phyllosilicates, from which F and P are formed. The significantly lower number of overlaps for C compared to other phases indicates its small contribution to the overall structural compatibility. This work was supported by SGS project No. SP2024/041.

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High Fluence Implantation of Nitrogen Ions Into Beta Titanium Alloy **PE14**

Evolution of surface morphology and defects formation are investigated in high fluence nitrogen ion implanted TiNbZrTa beta titanium alloy. Ion implantation was performed with nitrogen ions with a fluence up to 9·1017cm-2 and an accelerating voltage of 90 kV. Changes in surface morphology were well observable for applied fluence of approximately 3·1017cm-2 and higher. Surface defects in the form of blisters, a typical sign of oversaturation, were found. Well visible cracking of the surface nitride layer and the presence of surface pores were observed. Self-service pores covered the entire surface, including the area of sputtered blisters at the highest fluence.

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Metrology/Progress in STM/AFM Applications

KLAPETEK Petr — *Czech Metrology Institute, Brno, Czech Republic, EU*

Two Probe Scanning Thermal Microscopy in Vacuum Conditions **PE15**

Scanning Thermal Microscopy is an established technique for measurements of local thermal properties of solid samples at nanoscale or microscale. It is based on using a small resistive heater on an apex of Scanning Probe Microscope probe, which can then sense local temperature or generate heat. Local thermal conductivity can be evaluated from the losses when probe is heated. However, in this configuration it is impossible to determine the parameters of anisotropic materials. By extending the technique to use of two probes simultaneously, we can control the direction of the heat flow and address more complex phenomena. The first experimental realization of the technique suffered by the heat flow between the probes via air, making the quantitative analysis almost impossible. Here we present a vacuum version of the setup which significantly improves the measured signals as is demonstrated in various measurement configurations.

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Gwyscope - Open Hardware Controller and Its Application In SNOM Experiments **PE16**

Gwyscope was developed as a low cost alternative for SPM controllers. Heard of Gwyscope is a low cost RedPitaya FPGA board enhanced by additional AD and DA converters, so it is capable of dimensional, mechanical, electrical and magnetic measurements including various sensing principles. It is also highly flexible, we can set up multiple controllers for dedicated tasks in one experiment. In this contribution, we will present results obtained with Gwyscope being a controller in Scanning Near-field Optical Microscope (SNOM). It will be demonstrated that it can be used to control probe-sample distance based on shear force, which is typical for aperture SNOM. We will show that we can simultaneously acquire topography and optical data on various samples not only in a standard configuration where only one laser wavelength in used, but also in a custom built SNOM enhanced for hyperspectral measurements.

Co-authors: ***KLAPETEK Petr, HORTVÍK Václav***

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Interpolation and Measurement Prediction of Mapping Data Using Gaussian Processes PE17

Detailed mapping of e.g. mechanical or thermal material properties using techniques such as scanning probe microscopy or instrumented indentation can be a very lengthy process. However, acquiring the complete image might not be needed e.g. when looking for a specific feature. We present a custom software tool, which, when possibly combined with a suitable measuring instrument, enables to quickly identify regions containing anomalies, and to gather information from suspect regions in the first place. The foundation for the tool is provided by iteratively employing Gaussian processes (GP), which can be considered a form of machine learning, and can be applied as an interpolation tool, able to predict the function value as well as the variance (uncertainty) of the prediction at a given point. GP can be implemented in computer using standard tools for linear algebra and optimization without need for large computation toolboxes. With our tool in each iteration, a GP is constructed and trained using data already acquired, and then used to suggest regions (points, lines) not yet measured where uncertainty of the prediction is greatest - this typically corresponds to areas in which the measured quantity changes noticeably. Performing the measurement at the suggested regions provides quick reduction of the overall uncertainty on the whole unmapped area. The procedure is then repeated until sufficient amount of information is gathered.

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Monitoring of Sic Synthesis Through Ftir Spectroscopy PE18

Silicon carbide (SiC) is one of the most extensively studied and utilized materials for self-healing applications due to its excellent thermal and mechanical properties. Several methods can be employed for SiC preparation, including combustion, high-energy milling, carbothermic reduction, chemical vapor synthesis, and the sol-gel technique. In our work, we focus on the sol-gel method, utilizing liquid phases of tetraethyl orthosilicate (TEOS) as the silicon source, solution of saccharose as the carbon source, and hydrochloric acid as the catalyst. Various initial parameters, such as reactant concentrations, pH levels, and temperatures of sol, were selected to investigate their influence on the sol formation and the characteristics of the final SiC product. Throughout the preparation process, Fourier-transform infrared (FTIR) spectroscopy was employed to monitor the chemical changes and track the formation of characteristic bonds. The final products were further characterized using FTIR and X-ray diffraction (XRD) analysis to confirm their crystalline structure and evaluate their phase composition and DLS was used for particle size evaluation. This approach provides critical insights into how the sol-gel method and its parameters affect the material quality of SiC. ACKNOWLEDGEMENTS: This work was supported by M-ERA.NET joint research project SAFER No. TH82020004 and by the financial support of the European Union under the REFRESH - Research Excellence For REgion Sustainability and High-tech Industries project number CZ.10.03.01/00/22_003/0000048 via the Operational Programme Just Transition.

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In Situ Measurement of the Photocatalytic Efficiency PE19

The photocatalytic activity of materials still cannot be determined by molecular simulations. Therefore, all photocatalytic activity of the materials is determined experimentally in laboratories. However, existing standard measurements are not free from disadvantages, and the whole measurement process is time-consuming. Therefore, we present the possibility of in situ measurement of the photocatalytic activity of powder materials. The in situ method is based on differences in laser absorption by the tested dye. The results were compared with the standard method for measuring photocatalytic activity, and a good similarity was observed.

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Indirect Calibration of Scanning Thermal Microscopy PE20

Scanning Thermal Microscopy (SThM) is a Scanning Probe Microscopy (SPM) technique allowing the measurement of local temperature, thermal conductivity and local thermomechanical properties down to the nanoscale. In order to obtain quantitative results, calibration and traceability are of critical importance. Direct calibration of the instrument is not possible and reference samples must be used instead. The calibration curve depends strongly on the properties of the thermal probe and as such is susceptible to wear. Thus the calibration curve should be measured together with the unknown samples. The resulting time requirements, sensitivity to wear and the fact that there only few reference samples are available limit the number of calibration points. The determination of the thermal conductivity of the unknown samples thus depends on fitting of few data points with considerable uncertainty with a nonlinear calibration curve. This represents a metrological challenge that needs complex data processing. In this contribution we present the acquisition of the calibration points, notably their uncertainty analysis, and the subsequent numerical analysis based on an algorithm for the both curve fitting and single step evaluation of local thermal conductivities and their uncertainties, simplifying this procedure.

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AC Electrospinning: Device for Controlled Production of Planar, Single-Layer Nanofiber Plume PE21

The work focuses on the development of a linear electrode for the production of flat nanofibrous material by spinning a polymer solution using the AC electrospinning technique. This method is characterized by high productivity and the absence of an electrically active collector, which predisposes it to the production of advanced nanofibrous structures that will find application in medical and technical applications such as filtration or tissue engineering. Current spinning electrodes for AC electrospinning are characterized by a working surface with a overcritical electric field intensity, from which polymer jets and subsequent nanofibers are created in all directions. A spatial, hollow nanofibrous plume is created by the natural periodic interconnection of fibers in the area of the virtual collector. The transport and deposition of such a nanofibrous structure on the supportive spunbond is unstable, when due to the air emerging from the inner space with higher concentration of the residual solvent, folds and other defects are created. By the geometrically modified electrodes with the help of simulation tools for electric field analysis, it is possible to efficiently modify the geometry and the working surface of the electrode so that the nanofibers are formed only in a single plane, thereby eliminating the negative effects of the spatial nanofibrous plume. Based on the analyses, electrodes capable of continuous operation producing nanofibers in the single plane and in the desired direction producing a planar nanofiber structure are developed and tested. With the use of these advanced devices, it is possible to produce more homogeneous surface layered nanofiber materials and advanced nanofiber structures for use especially in medical applications.

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The Development of Multivariate Calibration Models for Quantification of Major Minerals in Sedimentary Rocks by Raman Spectroscopy PE22

Knowledge of mineral composition of rocks is essential for determining their properties and subsequent applications.

Nowadays, analysis of mineral composition of rocks can be performed by several methods. The most commonly used method is X-ray diffraction. Raman spectroscopy represent a non-destructive and rapid alternative, which (unlike X-ray diffraction) allows the use of handheld instruments. A major disadvantage of using Raman spectroscopy in rock analysis can be the presence of intense fluorescence in the spectra, which very often causes a significant loss of spectral information. In this study, we deal with the possibility of using Raman spectroscopy as a tool for quantifying the mineral composition of claystones and clay shales. Samples from different locations were measured by dispersive Raman spectrometer using laser with wavelength of 633 nm. The measured spectra were affected by the presence of strong fluorescence and overlapping bands. Therefore, the quantification was based on the development of multivariate calibration models using the partial least squares regression method (PLSR). Multivariate calibration models were developed for three predominant minerals - quartz, muscovite and chlorite. Validation of calibration models was performed by cross-validation. ACKNOWLEDGEMENTS: This work was supported by the SGS project no. SP2024/041.

Co-authors: ***RITZ Michal***

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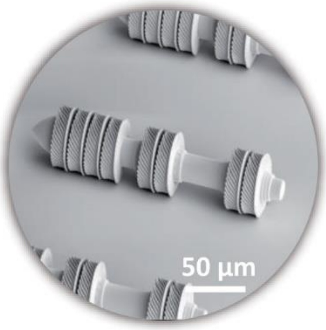
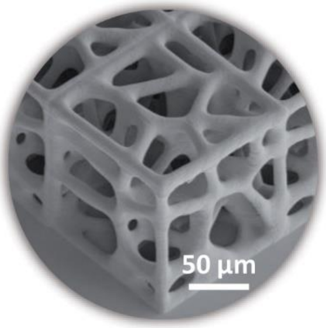


Mikro-mechanika



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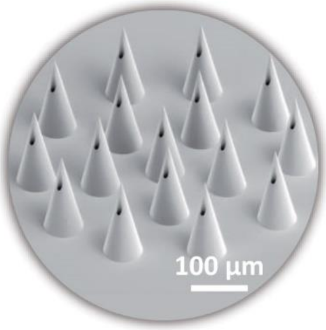

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Služba sdíleného hardwaru

Zaškolíme vaše operátory na práci s naším softwarem a tiskárnou. Po absolvování školení budete moci **vzdáleně využívat balíček tiskových hodin** na naší tiskárně a zároveň získáte odborné **konzultace** pro optimalizaci a efektivitu vašeho designu. **Hotové vzorky** pak **zašleme** do vaší laboratoře.

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- Pět balíčků tiskových hodin
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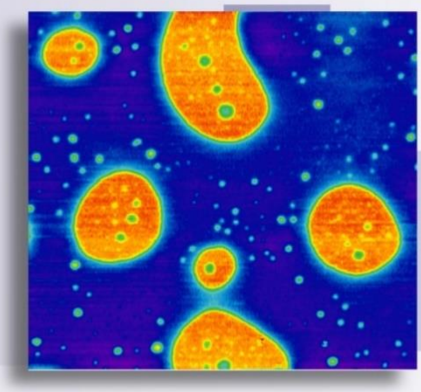
with IR-SNOM and Raman spectroscopy

The desire to know more and more has been always innate to humanity since the discovery of fire until Fausts of today. Nicolet CZ offers a series of sophisticated scientific systems including FT-IR and Raman spectrometers and microscopes or SNOM (scanning near field optical microscopy), the innovative technique of IR microscopy with ultra high resolution (down to 10 nm).



Raman microscope Nicolet DXR3xi

- High-performance imaging EMCCD detector
- 0.4µm resolution
- Non-destructive measurements
- Millions of spectra within tens of minutes
- Compatible with AFM (topography measurements), SPM and TERS
- Safe radiation source (UV, VIS or NIR laser)
- User friendly and intelligent software
- Suitable for studies of deposited graphene layers, pharmaceutical specimens, forensic analysis, distinguishing of individual polymorphs of a compound and many others

NeaSpec SNOM

- 10nm resolution
- IR-SNOM/Raman combined experiments
- Ultra-fast chemical imaging and topography measurement
- Non-destructive measurements
- Tunable broad-band IR laser as a safe radiation source
- User friendly and intelligent software
- Studies of plasmons, hyperbolic materials, polymer blends (orientation of molecules), organic and inorganic semiconductors, structural disorder of materials, charge distribution and electronic nanomotion, graphene layers, protein and virus complexes, nanomaterial properties, and many others

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