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ABSTRACTS BOOK

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Plenary Talks

Engineering and Discovering Matter at the Atomic Scale in 2D Materials

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Research on 2D materials is shifting from structural characterization only to engineering and discovering matter at the atomic scale. Energy storage, nano-catalysis, ultrathin dielectrics, and quantum materials increasingly rely on single-atom control of defects, dopants, and interfaces — and on identifying emergent atomic configurations that govern phase formation and transformation. This requires electron microscopy that combines atomic resolution with controlled interaction while minimizing beam-induced damage. Using low-voltage Cc/Cs-corrected TEM (SALVE) [1,2], we establish a platform that unites sub-ångström imaging with interaction-energy control. Applied to TMDs, TMPTs, confined nanoparticles, ultrathin oxides, and carbon layers [3–8], this approach reveals defect-mediated functionalization pathways and atomic-scale reactivity. Moreover, we introduce quantitative thickness metrology for ultra-thin materials using position-averaged convergent beam electron diffraction [9]. Most strikingly, we observe a previously unrecognized atomic state in liquid metals: stationary atoms coexisting with liquid atoms during solidification [10]. The latter challenges the classical description of liquids and illustrates that low-voltage aberration-corrected TEM can reveal fundamentally new atomic-scale physics.

Extending these concepts to beam-sensitive organic 2D systems, we resolve defects and crystallization pathways in imine-based polymers and covalent organic frameworks at sub-2 nm resolution. The realization of single-crystalline two-dimensional poly(arylene vinylene) COFs [11] and monolayer nanocrystalline graphene derived from Langmuir films [12] demonstrates that optimized 120 kV operation often is decisive for preserving chemical integrity while maximizing structural insight [13-15]. We further identify design principles for enhanced beam stability in conductive MOFs and reveal unexpected growth pathways in Cu3(BHT), where in-situ liquid-cell TEM uncovers the formation of Cu4(BHT) instead of the anticipated phase [15]. At atomic resolution and controlled interaction energies, TEM transforms from an observational tool into a platform for materials discovery — revealing phases, mechanisms, and states of matter previously beyond experimental reach.

Keywords: 2D materials, low-voltage transmission electron microscopy

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Biography:

Ute Kaiser received her Diploma and PhD in Crystallography from Humboldt University Berlin (1976, 1993) and completed her habilitation in Experimental Physics at the University of Jena (2002). From 2004 to 2023, she was a Full Professor at Ulm University and headed the Materials Science Electron Microscopy Center. Since October 2023, she has been Senior Professor at Ulm University.

From 2009 to 2018, she served as Scientific Director of the SALVE project, driving key advances in low-voltage aberration-corrected TEM. Her research focuses on atomic-scale imaging and functionalization of low-dimensional materials using low-voltage TEM. She has authored more than 400 peer-reviewed publications (h-index 97) and was recognized as a Highly Cited Researcher. Currently she serves as Physical Sciences Editor for Micron.

New concepts for PVD synthesis of electrical and optical films utilizing the advantage of low energy plasma activation

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Over decades, the topic of high-quality semiconductor device manufacturing has been devoted mainly to crystalline Silicon and to Silicon based thin film devices deposited almost exclusively by CVD and PECVD. Since the introduction of InGaZnO (IGZO) based transistors for active matrix OLED displays, this paradigm has changed and PVD methods such as rotatable magnetron sputtering achieved new interest for semiconductive and dielectrics.

For such applications, it's crucial to optimize the thin film growth conditions to obtain smooth and dense films with stable properties under load. The necessary activation of thin film growth is done by both, substrate heating and plasma activation, but the ability for substrate heating are very limited when it comes to sensitive organic materials. Our studies reveal that particle energies exceeding ~20 eV energy at the substrate have the potential to degenerate the film properties. On the other hand, low energetic high ion flux to the substrates has the ability to improve the film properties.

In this paper, we introduce a novel technique, the pulsed reactive hollow cathode gas flow sputtering [1], which offers plasma densities of $n_e = 10^{10}$ cm^{-3} at the substrate under conditions where DC magnetrons operate at $n_e = 10^8$ cm^{-3}. Pulsed operation of the source allows for extraction of fast particles from the plasma, where the energy can be controlled by the reverse voltage of the generator. The benefits of this approach will be shown for magnetron and hollow cathode gas flow sputtering of selected transparent conductive oxides, oxide semiconductors and dielectric materials.

Keywords: *Sputterring, oxide semiconductors, hollow cathode gas flow sputtering, thin film transistors*

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Biography

Bernd Szyszka received his Ph.D. degree in physics in 1999 from the Justus-Liebig-Universität Giessen. Until 2012, his research at the Fraunhofer Institute for Surface Engineering and Thin Films IST was devoted to the large area coating of optical and electrical films with strong emphasize on transparent and conductive oxide films, such as the ice-free windshield. In 2012, he became appointed as full professor for the technology of thin film devices at Technische Universität of Berlin. In 2011, he received the Ferchau innovation prize for a new method of magneton sputtering. In 2013, he received the mentor award of the society of vacuum coaters (SVC) for his contributions on reactive sputtering technologies. Since 2022, he serves as president of the International Council on Coatings on Glass (ICCG e.V.).

Molecular evolutionary growth of carbon nanotubes and its mass production

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The growth process in living systems is an ordered self-assembly process with a template autocatalytic ring with the ability to collect energy, which leads to the formation of chirality and a decrease in entropy in the system. The search for non-living systems with biological characteristics is significant, but it remains unreported. Carbon nanomaterials hybridized with sp2, such as carbon nanotubes, graphene, graphene, graphyne, etc., have the characteristics of good electrical conductivity, high mechanical strength and good chemical stability, and have been the focus of nanomaterial research in recent years.

We found that the growth process of ultra-long carbon nanotubes is consistent with the molecular evolution characteristics of organisms. Through experiments, the advantages of chiral assembly are revealed, and the distribution of chirality and decreasing entropy is gradually enriched by template autocatalytic growth, and the evolution of growth behavior is influenced by the environment.

Specifically, defective metal nanotubes are inferior to semiconductor tubes in terms of growth life, while semiconductor carbon nanotubes with double-walled and chiral properties have a longer lifespan and growth rate than single-walled and multi-wall tubes, very similar to the co-evolution behavior of molecules in living organisms. And when grown to hundreds of millions of generations, semiconductor double-walled nanotubes with chirality of nearly (2n, n) will evolve. The controllable growth of carbon nanomaterials was analyzed, and it was found that the rapid growth of array carbon nanotubes through kinetic selectivity by using the concept of template autocatalysis could obtain high-strength fibers with macroscopic strength, toughness and fatigue resistance higher than that of all current materials.

The engineering problem of how to carry out the macro preparation of carbon nanomaterials is discussed, the core of which is how to solve the problem of multi-scale transfer limitation in the preparation process of carbon nanotube, by improving the structure, morphology and aggregation state of carbon nanotube in the growth process, so that they are always in the fluidizable region, so that the transmission capacity of the process can be increased by tens of thousands of times, so as to accurately control the structure of carbon nanotubes to the nanoscale, so as to realize the large-scale application of carbon nanotube in batteries.

Keywords: *Carbon nanotube, growth, mass production*

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Biography

Director of Beijing key lab of green chemical reaction engineering and technology, Tsinghua University. Fei Wei obtained his PhD in chemical engineering from China University of Petroleum in 1990. After a postdoctoral fellowship at Tsinghua University (China), he was appointed an associate professor in 1992 and professor of chemical engineering of Tsinghua University (China) in 1996. His scientific interests are technological applications of chemical reaction engineering, catalysis, multiphase flow, carbon nano materials, and sustainable energy. He has designed and successfully running over 30 industrial fluidized bed reactors, and authored four books and over 600 refereed publications including 4 papers in Science and Nature, with more than 67000 citations with H index 116.

Peptide-Polymer Hydrogels As Cell Scaffolds

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By combining bioactive and self-assembling peptides with (bio)-polymers, cell scaffolds with improved properties are created. These materials have the potential to provide customized scaffolds with predictable and reproducible properties for culturing cells and determining cellular fate, by mimicking essential features of the ECM.

To imbue polymer scaffolds with biological activity, we introduce self-assembling peptides (SAPs) that allow to tailor cell-material interactions. Through a sequence optimization of SAPs, critical physical and morphological features that correlate with biological activity (viral transduction enhancement and neuro-regeneration) were identified, enabling the prediction of highly active peptide sequences. By introducing pH- and light-responsive groups, we gain control over the assembly and disassembly behavior of SAPs as well as their ability to present epitopes to cells (Figure 1a). We can create bioactive gradients on surfaces, which precisely control the number of cells that attach to the coated surface. Using photolithography to destroy pre-assembled photoreactive SAPs, patterns of cell-adhesive and cell-repulsive regions are created with high spatial precision (Figure 1b, c). Finally, hydrogels with novel properties are obtained when SAPs are connected to polymer backbones: We can create injectable and thixotropic hydrogels, where the SAPs act as supramolecular crosslinkers (Figure 1d). These gels show ultrafast and quantitative recovery of their mechanical properties after experiencing liquifying shear. Such peptide-incorporating polymers show great promise for microstructured and adaptable scaffolds for cell culturing.

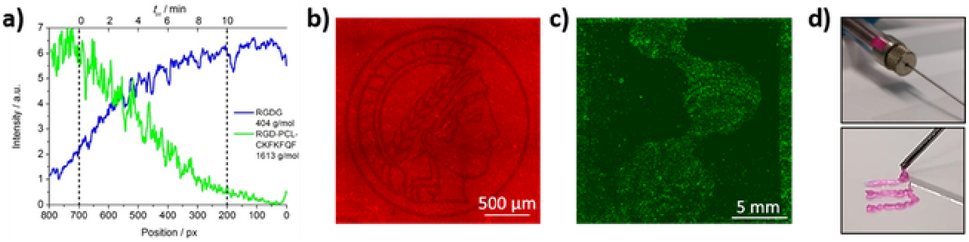

Figure 1 a) Bioactive gradient of RGD-presenting peptides measured in MALDI-MSI. b) Minerva pattern (Proteostat staining) and c) MPIP logo from A549 cells (calceine staining) obtained through photolithography of photocleavable peptide. d) Injectable hydrogel from peptide grafted biopolymer.

Keywords: *Hydrogels, Cell Scaffolds, Bioactive Peptides*

Biography

Dr. Synatschke is a group leader for "Hierarchical Materials Design" at the Max Planck Institute for Polymer Research in Mainz, Germany. His research interests are in creating structured materials from the bottom up, which allow to precisely interact with their environment, particularly with living cells.

Graphene and layered materials for photonics and optoelectronics

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Graphene and layered materials have great potential in photonics and optoelectronics, where the combination of their optical and electronic properties can be fully exploited, and the absence of a bandgap in graphene can be beneficial. The linear dispersion of the Dirac electrons in graphene enables ultra-wide-band tunability as well as gate controllable third-harmonic enhancement over an ultra-broad bandwidth, paving the way for electrically tuneable broadband frequency converters for optical communications and signal processing. Saturable absorption is observed as a consequence of Pauli blocking and can be exploited for mode-locking of a variety of ultrafast and broadband lasers. Graphene integrated photonics is a platform for wafer scale manufacturing of modulators, detectors and switches for next generation datacom and telecom. These functions can be achieved with graphene layers placed on top of optical waveguides, acting as passive light-guides, thus simplifying the current technology. Heterostructures based on layers of atomic crystals have properties different from those of their individual constituents and of their three dimensional counterparts. The combinations of such crystals in stacks can be used to design the functionalities of such heterostructures, that can be exploited in novel light emitting devices, such as single photon emitters, and tuneable light emitting diodes.

Biography

Andrea C. Ferrari earned a PhD in electrical engineering from Cambridge University, after a Laurea in nuclear engineering from Politecnico di Milano, Italy. He is Professor of nanotechnology and Professorial Fellow of Pembroke College. He founded and directs the Cambridge Graphene Centre and the EPSRC Centre for Doctoral Training in Graphene Technology. He chairs the management panel and is the Science and Technology Officer of the European Graphene Flagship. He is a Fellow of the American Physical Society, Fellow of the Materials Research Society, Fellow of the Institute of Physics, Fellow of the Optical Society and he has been recipient of numerous awards, such as the Royal Society Brian Mercer Award for Innovation, the Royal Society Wolfson Research Merit Award, the Marie Curie Excellence Award, the Philip Leverhulme Prize, The EU-40 Materials Prize. He also received 4 European Research Council Grants.

Controlled 2D materials for hybrid devices & sensing

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The surface chemistry of 2D materials a fascinating topic, as it goes hand in hand with the modification of the entire 2D material layer. However, strategies for the reliable functionalization are still in infancy, in particular because of detrimental polymeric residues on 2D material surfaces. We have identified ubiquitously hydrocarbon adlayers on 2D materials form lab and storage environment besides residues from transfer processes. [1] This has been revealed by a comprehensive Raman, XPS, and TOF-SIMS investigation of various 2D materials.

To counteract this, we have developed a robust method for non-covalent functionalization of pristine 2D materials. The functional layer is applied to as-grown or freshly cleaved 2D materials, avoiding detrimental effect due to contaminations. Examples for the modification MoS_2 mono- and double-layers with these self-assembled monolayers will be presented. [2] As for graphene these well define adlayers allow the attachment of antibodies for the specific sensing of small bio-active molecules. [3] These selective layers are highly attractive selective sensor arrays based on graphene.

Further this talk explores 2D materials and vertical heterostructures produced via scalable synthesis techniques such as chemical vapor deposition (CVD). Direct synthesis provides a promising route to exploiting the potential of these materials for next-generation electronics, optoelectronics, and sensing technologies.

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Well-defined nanostructuring for electrochemical energy conversion and storage

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Innovative technology for electrochemical energy conversion and storage is the key for so-called “clean energy” to realize a worldwide sustainable energy future. To compete with existing energy supply systems mainly based on fossil fuels, the efficiency of clean energy conversion and storage shall be largely improved. The intricate electrochemical reactions of energy conversion and storage and the involved kinetics and transport behaviors are closely associated with the selected materials and structures of electrodes. To this point, we proposed a concept of well-defined structuring of electrodes for improving the electrochemical performance of energy conversion and storage,[1-3] which have gained high research attention in the past years. We are using especially a template-based technique with scalable, cost-effective and fast fabrication processes for electrode design.[4-6] The well-defined electrode structures possess large-scale arrayed configuration with highly controllable geometrical parameters (i.e., size, shape, heteroarchitecture, spatial arrangement, composition, surface vacancies), high density and perfect regularity. Such well-defined electrode structures are highly desirable for constructing devices for efficient energy conversion and storage, including photocatalysis and electrocatalysis devices;[7-11]sodium-ion, potassium-ion and zinc-ion batteries,[12-16] and supercapacitors.[17-18] The achieved high performances demonstrated that the well-defined structuring and material design play a crucial role for optimizing the energy conversion and storage devices via precise controlling structural features, indicating the high potential and importance of template-based well-defined nanostructuring and material design for both basic research and industrial device applications.

Keywords: Well-defined nanostructures; energy conversion and storage; photocatalysis and electrocatalysis; sodium-ion, potassium-ion and zinc-ion batteries; supercapacitors

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Biography

Yong Lei is Professor and Head of Department of Applied Nano-Physics at Technical University of Ilmenau, Germany. He started to at Karlsruhe Institute of Technology in 2003 as an Alexander von Humboldt Fellow. From 2006 he worked at University of Muenster as a group leader and Junior Professor. In 2011, he joined Technical University of Ilmenau as a Professor. His research focuses include template nanostructuring for energy conversion and storage. He has received a few prestigious EU and German research funding including two ERC Grants. Prof. Lei is an Advisory Board Member of Advanced Energy Materials, Small, Energy & Environmental Materials, InfoMat, Carbon Energy, and Science China Materials. He has authored 366 publications (27265 citations, H-index 89), many published in high-level journals in physics and materials science, including 8 paper published in Nature-series journals, 48 papers in journals with IF > 20, 154 papers in journals with IF of 8-20.

Keynote Talks

Buckling Structure, a Relevant Signature of the Mechanical Properties of Film/Substrate Systems

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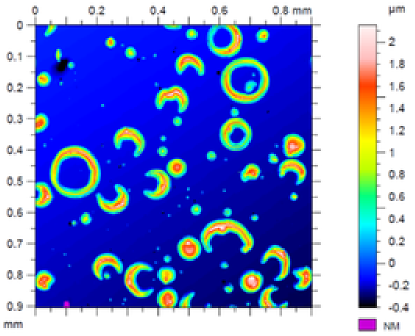
Thin films and coatings are used in a wide range of technological applications, such as microelectronics or optics. They often develop high residual stresses during the deposition process, sometimes about few GPa in compression. Such large compressive stresses may cause the nucleation and growth of buckling structures [1] that generally result in the loss of functional properties initially conferred to such film/substrate composites. The most common buckling structures are the circular blisters, the straight-sided buckles and the telephone cords. The aim of our studies is consequently to have a better understanding of the buckling phenomenon, by identifying the relevant parameters to prevent, to limit, or to control its occurrence.

Our studies concern the effect of elasticity [2,3] of the substrates on the maximum deflection of the buckles, the question of vacuum below the buckling structures [4], the effect of a pressure mismatch between the buckled film and its substrate on the occurrence of specific structures (such as donut-like or flower-like buckles) [5,6], the limit of the elastic theory framework to understand the buckling when plasticity is taking place in the film [7] or the morphology of a buckle in a thickness gradient [8]. From an experimental point of view, it is now well -established that the fine investigation by optical or atomic force microscopies of the morphology of elementary buckling structures can be of great interest in order to qualitatively, or even quantitatively, extract some mechanical parameters of the film/substrate systems.



Circular, donut-like and croissant-like buckles observed on Au 630 nm thick films on Si.

Keywords: *Buckling; Coatings; Mechanical properties; Stresses; Adhesion; Toughness*

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Biography

Christophe COUPEAU, Professor in Materials science, University of Poitiers, France. His research activity is related to a variety of problems in materials science concerned with plasticity, mechanical properties and stability, and failure phenomena in engineered-material systems. The approach is based on the development of scanning probe microscopy (AFM/STM) enabling nano-scale surface features to be routinely analysed, even under in situ deformation conditions. The investigation of the surface evolution under stress and the characterization at a nanometre scale of the surface effects allow a better understanding of basic deformation mechanisms controlling deformation kinetics and may establish the foundation to develop more reliable models for describing the elastic or plastic response of crystalline materials under stress. The works extend from the mechanical properties of thin films and coatings to the study of variable temperature deformation of advanced bulk materials.

Strategies for Controlled Growth and Interfacial Engineering of 2D Materials

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The leap from laboratory discovery to industrial integration is fundamentally a question of scale. While mechanical exfoliation ("scotch-tape" method) has been instrumental in uncovering the exotic physics of 2D systems, it cannot sustain a commercial ecosystem. To bridge this gap, fundamental studies into growth mechanisms are essential to unlock novel, large-scale synthesis routes with high reproducibility. Only by mastering these processes can 2D materials meet the rigorous demands of semiconductor manufacturing, flexible electronics, and high-performance sensing.

In this talk, I will describe our efforts to study the growth of 2D materials, specifically transition metal dichalcogenides (TMDs), using chemical vapor deposition (CVD) methodologies. I will discuss the importance of the precursor type, and the van der Waals (vdW) and quasi vdW epitaxial growth of TMDs at high and low temperatures. Additionally, I will present the post-synthesis formation of 2D inorganic-organic heterostructures via Langmuir-Blodgett (LB) methodologies, which enables the controlled deposition of conformal organic mono- and multi-layers, facilitating unique interactions with inorganic TMD (WS2 and WSe2) layers. Finally, I will discuss recent results regarding the growth of ternary compounds within the MePSx family (Me = transition metal).

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Recent advances in resistive switching – prussian blue analog materials, mechanisms and devices

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The physical and chemical properties of Prussian blue analogs (PBA) have attracted the attention of the scientific community due to its promising applications in batteries, electrochemical sensing, electrochromic devices, supercapacitors, magnetic systems, and others. Recently, we have studied the resistive switching effect in electrodeposited Prussian Blue (PB) [1], Prussian White (PW) [2] and other PBA [3] enabling potential applications in the field of memristors. However, to develop the full potential of PBA for memristors, the structure-property relationship needs to be investigated.

In this work, the relationship between film morphology, stoichiometry, chemical composition, crystalline structure, and resistive switching behavior of PBA films will be presented. Resistive switching behavior was detected in PBA films on large areas and locally. The electrical switching characteristics are carefully analyzed and discussed.

Keywords: hexacyanoferrate; electrodeposition; material characterization; prussian blue;
thin films; prussian blue analogs

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Biography

C. K. Müller received his diploma in Physical Chemistry from the Technical University of Chemnitz and his PhD in Physics from the Technical University of Dresden. This was followed by several stays as a Post-Doc in Germany and Brazil. Then he worked as Research Group Leader in the field of micro and nanosensors. He got his habilitation in the field of functional materials. Since 2018 he has been a Professor for Experimental Physics with focus on structure and surface analysis of materials. His research activities cover nanomaterials, sensor materials, composite materials, and other materials.

2D Materials for Electronic and Energy Storage Applications

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Two-dimensional (2D) materials exhibit extraordinary compositional and structural diversity, offering an almost limitless design space for tuning electronic, mechanical, and chemical properties. Beyond intrinsic variability, advanced strategies such as layer stacking, twisting, and heterostructure engineering enable the emergence of novel physical phenomena unattainable in bulk systems. This chemical and structural diversity, however, requires distinct and often material-specific approaches to crystal growth, processing, and functional modification.

This presentation provides an overview of synthesis and crystal growth strategies for major classes of 2D materials, including chalcogenides, halides, chalcogen–halides, and related emerging systems. The influence of growth parameters and post-synthetic treatments on crystal structure, phase stability, and functional properties will be discussed.

Special attention is given to exfoliation methodologies, particularly intercalation-assisted techniques, which enable the preparation of large-area monolayers as well as bulk intercalated compounds with tailored electronic and ionic characteristics. In addition, chemical exfoliation routes applicable to layered materials with partially or fully covalent interlayer bonding are presented, highlighting their advantages and limitations.

Finally, the application potential of 2D materials is reviewed across a broad range of technological areas, including nanoelectronics, energy storage, catalysis, and beyond. By linking synthesis, processing, and functionality, this overview underscores the transformative role of 2D materials in future electronic and energy technologies.

Biography

Prof. Zdenek Sofer is a tenured professor at the University of Chemistry and Technology Prague in the Czech Republic since 2019. He earned his PhD at the University of Chemistry and Technology Prague, Czech Republic, in 2008. During his doctoral studies, he spent one year at Forschungszentrum Julich and completed a postdoctoral stay at the University of Duisburg-Essen, Germany. Prof. Sofer's research interests focus on 2D materials, including crystal growth, chemical modifications, and derivatization. His research spans various applications of 2D materials, such as energy storage and conversion, electronics, catalysis, and sensing devices. Prof. Sofer has received several awards. He has authored over 700 articles, which have garnered over 40 000 citations (with an h-index of 102).

Knowledge Increase of 20 Years Research on High Entropy Alloys

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The denomination high entropy alloys (HEA) was published first in 2004 by Prof. J.-W. Yeh and in parallel by Prof. B. Cantor. Research picked up exponentially since then, leading to more than 2,200 (!) papers listed in Web of Science containing "high entropy alloy" within the title in the year 2023.

Due to this number, it is impossible to discuss all research results in detail. The focus of this presentation is on mechanical strength. Four core effects, resulting from an increased configurational entropy, have been proposed: decrease in Gibb's free energy at higher temperatures, lattice distortion, sluggish (slower) diffusion and cocktail effect.

Within this presentation, there will be a clear distinction between single-phase HEA (at the designated application temperature) and two- or more-phase alloys. Due to this distinction, it will be possible to clearly separate into well-known strengthening effects. The probability of staying single-phase is decreasing with the number of elements since intermetallic phases can form, decreasing the Gibb's free energy more than the configurational entropy does. Therefore, only a handful of single-phase, equi-atomic, 5-component HEA are known by now. They can be distinguished by crystallographic structure and located in groups within the periodic table. To name some of them: fcc or Cantor alloy, fcc of precious metals, bcc or Senkov alloy, hcp or Feuerbach alloy. With respect to mechanical strengthening the only classical strengthening mechanism is solid solution strengthening.

On the other hand, the number of two- or more-phase compositionally complex alloys (CCA) is countless, and all options of precipitate hardening are available (e.g., internal stresses, Orowan bowing, locally strong increase of dislocation density, cutting of precipitates) additionally to solid solution strengthening.

Single-Ion Polymer Electrolytes and Novel Polymer Architectures for Enhanced Stability and Performance for Next Generation Batteries

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Metallic lithium, boasting an exceptional specific capacity (3860 mAh g^{-1}) and the lowest redox potential (−3.04 V vs. SHE), is the ultimate negative electrode material for next-generation high-energy batteries. However, its practical deployment is severely hindered by persistent challenges: lithium dendrite formation, inhomogeneous solid electrolyte interphase (SEI) formation, and poor coulombic efficiency. Single-Ion Polymer Electrolytes (SIPEs) offer a promising solution by immobilizing anions within a polymer matrix, achieving a lithium transference number close to unity and effectively suppressing dendrite growth. This presentation reviews the different classes of SIPEs—both in dry and gelled states—highlighting their unique advantages and inherent drawbacks. Despite their promise, SIPEs still react with metallic lithium, forming thick, inhomogeneous SEI layers that increase interfacial resistance and compromise lithium reversibility. To address these issues, this study focuses on improving lithium reversibility and SEI formation in SIPEs through targeted doping with additives such as $LiNO_3$. Electrochemical tests demonstrate that doped SIPEs enable more homogeneous and smooth lithium deposition, lower interfacial resistance, and reduced polymer degradation. Furthermore, to overcome the limitations of widely used poly(ethylene oxide) (PEO)-based polymer electrolytes—such as narrow electrochemical stability windows and poor compatibility with high-voltage cathodes—this work introduces a novel class of dry solid-state polymer electrolyte based on poly(butyl malonate) (CPBM). Compared to PEO-based systems, CPBM electrolytes deliver comparable ionic conductivity, higher lithium transference numbers (>0.6), and a wide electrochemical stability window (up to 4.7 V vs. Li/Li^+).

Long-term cycling stability is demonstrated through lithium stripping/plating tests and full cells with LFP, LMFP, or NMC electrodes at high current densities, underscoring the potential of these materials for future battery applications.

Keywords: lithium metal batteries, single-ion polymer electrolytes, poly(butyl malonate), electrochemical stability, solid-state electrolytes

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Eco-Design of polyester for recycling and Valorization of textile Waste

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Over the past years, textile industry has been pointed as a major contributor to global plastic production, consumption, and consequently environmental plastic pollution. Global fiber production has almost doubled from 58 million tons in 2000 to 113 million tons in 2021. These numbers are still expected to grow up to 149 million tons by 2030. Polyester fibers (polyethylene terephthalate or PET) account for 54% of the market share, being the most used fiber worldwide. However, textile recycling remains a challenge due to the low cost of virgin fibers and clothing collects issues, but also the fact that most of actual clothes are composed by blended fibers. Therefore, 70% of the textile waste is either incinerated either landfilled [1].

The introduction of dynamic bonds to thermoplastics represents a promising approach to valorize textile waste in order to obtain high-value recycled products with enhanced properties. PET-based CANs were elaborated through reactive extrusion by adding bisphenol A diglycidyl ether (DGEBA) as crosslinking agent and the nature of transesterification catalyst was explored. A comparative study between $Zn(acac)_2$ and zinc-based ionic liquid was conducted, showing the impact of ionic liquid catalyst on the relaxation time, thermal stability and different relaxation modes. Besides the use as catalyst, this work presents the synthesis of innovative and autocatalytic systems using a new generation of epoxidized ionic liquids [2].

Finally, the elaborated CANs were used as building blocks in the mechanical recycling of PET. Different PET/CAN blend compositions were produced and the rheological and mechanical properties were studied in order to obtain a new generation of polyester fibers.

Keywords: Polyethylene Terephthalate ; Textile ; Recycling ; Vitrimers ; Transesterification; Ionic Liquids.

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Biography

Prof. Jannick Duchet-Rumeau got a PhD diploma of University of Lyon in Macromolecular Materials & Composites in 1996 focused on modelling of the interface in a polyethylene / glass system tuned by the grafting connecting chains to improve the adhesion properties. She has had a post PhD position in Louvain La Neuve (Belgium) where she worked on processing and characterization of polymer nanotubes. In 1998, she got an assistant professor position then a full professor position in 2010 in the laboratory ‘Ingénierie des Matériaux Polymères’ UMR CNRS #5223. She manages the National CNRS Network (GDR #3585) dedicated to Ionic Liquids and Polymers gathering 40 academic laboratories. Her research activities are dedicated to multiscale relationships between architecture and physical properties of polymer materials involving i/ nanocomposites materials ii/ mesoporous materials iii/ self assembled materials onto inorganic surfaces iv/ ionic materials from Ionic Liquids and v/ the multi-phased materials : polymer blends and fiber based composites. She is author of two hundred papers in international journals, 7 book chapters and 200 communications in international conferences. She has supervised 60 phd students. Since 2021, she has being managed the IMP Lab gathering 200 permanent and non permanent staff. Since 2025, she is the co-director of French National Program PEPR dedicated to Recycling, recyclability and Re-Use of materials.

Design of Nitroxides: Stability Issues in Aqueous Organic Flow Batteries

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The development of safe and sustainable stationary storage systems is essential for large-scale renewable energy integration. In aqueous organic redox flow batteries (AORFBs), nitroxide radicals are attractive posolytes owing to their fast electron-transfer kinetics and reversible nitroxide/oxoammonium redox chemistry. However, their performance is often limited by the instability of the oxidized oxoammonium form. We explore two complementary molecular strategies: a five-membered ring derivative (3-TMA PROXYL) [1] and a fused isoindoline-based nitroxide (PPO) [2]. Both exhibit high formal potentials in aqueous media (up to 1.16 V vs SHE) and solubilities above 3 M. Flow cell evaluation shows increased cell voltages relative to TEMPO-based systems. Nevertheless, cycling and spectroscopic analyses reveal contrasted stability behaviors, with more pronounced intrinsic degradation for the isoindoline derivative.

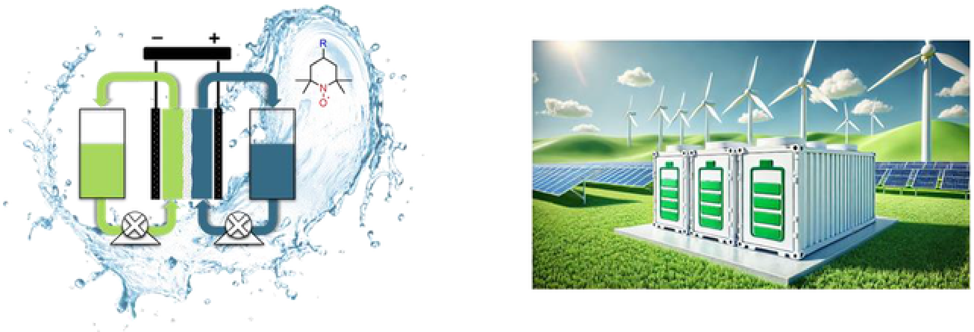

Figure 1. Nitroxide-based aqueous organic redox flow battery for renewable energy storage.

Keywords: Nitroxide radicals electrochemistry; Aqueous redox flow batteries.

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Biography

Dr. Steven Le Vot is an associate professor at the University of Montpellier (ICGM) specializing in electrochemical energy storage. His research focuses on electrode materials, surface functionalization, and interfacial electrochemistry for batteries and supercapacitors.

Atomic Redox Centers in Metal Oxide Host Matrices as Alkali Metal-Ion Electrodes for Rechargeable Batteries

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The unique combination of exceptional energy and power density along with the continuous decrease in cost have made lithium-ion batteries the electrochemical energy storage technology of choice for small-scale and large-scale applications.[1–3] However, the use of graphite as active material for the negative electrode is intrinsically limiting the possibility to rapidly charge these batteries.[4] Herein, a new class of active materials is presented that provides comparable charge storage capacities at much faster rates. This new class of materials is based on the introduction of highly redox-active atomic centers into stable metal oxide host matrices. These host matrices are well preserved upon continuous lithium cation insertion and deinsertion following a solidsolution-type mechanism, while the introduction of these highly redox-active atomic centers allows for the duplication and triplication of the charge storage capacity compared to the nanoparticulate metal oxide host matrices alone. Remarkably, the redox centers are reversibly reduced to the metallic state at the atomic level without affecting the surrounding crystal structure. When replacing lithium cations by sodium or potassium cations, essentially the same mechanism is observed, apart from the expected "size effect", highlighting the exceptional versatility of this new class of battery electrode materials.

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Material-related problems of neuromorphic technologies

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Advancements in materials science have been instrumental in the progression of neuromorphic technologies. However, existing neuromorphic hardware often relies on rigid and energy-intensive fabrication processes. There is an urgent need for innovative materials and device architectures that can bridge this gap while ensuring scalability and eco-friendliness. The inevitability of a revolution in electronic technologies is dictated by the emergence of new paradigms of electronics which cannot be implemented on existing hardware. Traditional computing architectures struggle with energy efficiency, scalability, and adaptability, particularly as AI and data-intensive applications demand greater computational power. In the past decades, electronics and telecommunications have become a new global energy consumer. Machine learning tends, in the limit, to consume all the power produced in the world, and this development model is costly, inefficient and unsustainable. Neuromorphic computing, inspired by biological neural networks, presents a promising alternative by enabling real-time, low-power processing. Crucial for this development is the ability of materials to implement bioinspired functions. However, existing neuromorphic hardware often relies on rigid and energy-intensive fabrication processes, limiting material flexibility, integration potential, and environmental sustainability. There is an urgent need for innovative materials and device architectures that can bridge this gap while ensuring scalability and eco-friendliness.

Thus, the presentation is dedicated to the material problems of neuromorphic technologies and aims to review a wide range of theoretical and experimental results in this field.

Keywords: materials, neuromorphic, memristors, reservoir computing

Biography

Nikolai A. Sobolev is currently a Professor Jubilado at the Department of Physics, University of Aveiro, Portugal. He received the MS and Dr. rer. nat. degrees in Physics from the Friedrich Schiller University of Jena, Germany. He worked as a Scientist and Professor in the Soviet Union, Belarus, Germany, Russia and Portugal. He held Visiting Professor and Invited Scientist positions at the Universities of Berlin, Gdansk, Jena, Moscow, and Ulm. N.A.S. is the author/co-author of more than 200 research papers, four book chapters and seven USSR / Russian Federation patents. His book chapter “Radiation Effects in Quantum Dot Structures” (DOI: 10.1016/B978-0-08-046325-4.00013-X) has more than 1,600 reads on ResearchGate. He has coordinated multiple national and international research projects and supervised several successful PhD projects. His current research interests are focused on material science aspects of neuromorphic technologies.

Invited Talks

Compostability and Ecotoxicological Assessment of a Functional Cellulose-Based Laminate: Challenges and Opportunities for Sustainable Materials

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Assessing environmental safety during material disposal is essential to prevent ecotoxicological risks to soils, plants, and ecosystems [1]. Even materials labeled as biodegradable can release contaminants that impair plant development [2,3]. Residency time is critical: slow degradation increases waste accumulation and ecological impacts [4]. Conversely, rapid disintegration under controlled conditions, such as thermophilic composting, reduces landfill pressure and environmental risks. Combining accelerated degradation with the absence of toxic effects is key to circular economy goals [3]. This study evaluated a cellulose-based packaging material functionalized for temperature regulation, containing molybdenum (Mo) and fluoride (F) above the limits of European regulations. After 45 days of thermophilic composting, complete disintegration occurred faster than that of conventional paper. The compost showed maturity indicators: neutral pH, no odor, and reduced volatile solids, confirming mineralization of organic elements [1]. Seed germination and growth tests on barley, wheat, sunflower, tomato, and onion revealed species-dependent effects. Wheat and sunflower exhibited germination rates above 100%, suggesting a fertilizing effect, while barley showed moderate phytotoxicity in the germination test (GI≈60%) and induced chlorosis and necrosis in the plants. Root length reduction in barley was significant ($p<0.01$). Despite Mo exceeding normative limits, phytotoxicity remained within safe ranges for food crops [3]. Findings indicate that, although compostable and valuable as organic amendments, functionalized cellulose materials may pose ecotoxicological hazards, particularly due to fluorides [2]. Interspecies variability underscores the need for comprehensive testing before agricultural use to ensure environmental safety and compliance with circular economy principles [3].

Keywords: Cellulose-based material; Compostability; Environmental Safety; Phytotoxicity

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Microfluidics as Versatile Tools for the Synthesis of Engineered Metal Nanoparticles

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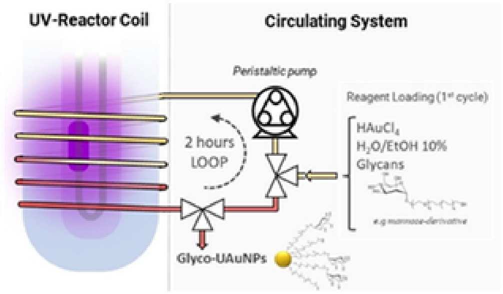
Nanomedicine and the applications of nanomaterials in life and health sciences have yet to reach their full potential and fulfill the promises of their beginnings. In fact, despite the interesting and promising properties of nanoparticles (NPs), the full implementation of NPs in the current practice remains a challenge. One of the main obstacles is the lack of reliable, reproducible, and scale-up protocols for the preparation of these materials.[1] Flow chemistry is a privileged pathway to synthesize NPs employing reproducible, and scaling-up protocols. Once optimized, continuous synthesis is more reliable, productive, and less expensive than wet synthesis.[2] In this context, we have developed innovative and versatile microfluidic platforms for synthesizing advanced nanomaterials such as gold NPs,[2-4] platinum NPs [5] and hybrid NPs.[6]

These versatile flow protocols are based on tubular reactors working at room temperature coupled with bench-top syringe pumps [2,4,5] or peristaltic pumps.[3,5] The metal reduction could be photo-induced by a UV lamp or chemical promoted by mild reduction agents, in the presence of peculiar smart ligands (e.g. glycans)[3] or without stabilizers.[5] These platforms could also be used to produce hybrid systems as gold-titania nanostars.[6] By exploiting these protocols, we have successfully synthesized several advanced functional nanomaterials i.e. glyco-Au/Pt NPs, anisotropic gold nanostars, and ultra-small ligand-free Pt NPs with enhanced catalytic properties.

Keywords: microfluidics, gold nanoparticles, synthesis, hybrid nanoparticles, photo-induction



Platform for the synthesis of engineered ultra-small AuNPs

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Topologically Protected Interlayer Excitons in Core-Shell WS_2@ReS_2 Multiwalled Nanotubes

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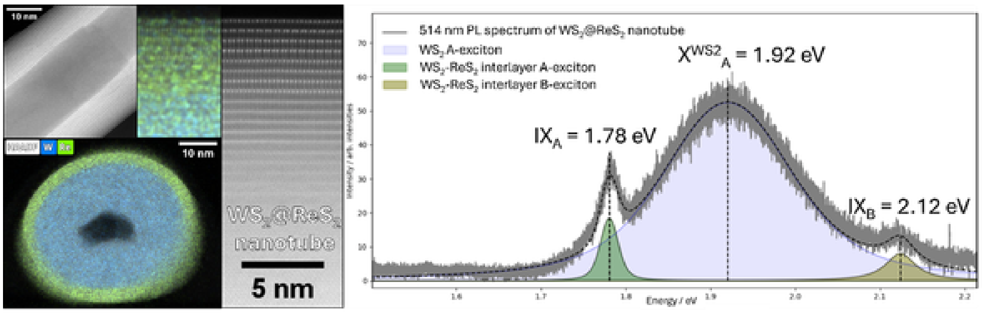
Transition-metal dichalcogenides (TMDCs) are key building blocks for next-generation atomically thin electronics and optoelectronics, where device performance critically depends on the quality of the interfaces. In planar heterostructures, lattice mismatch leads to uncontrolled stacking and Moiré effects, severely limiting reproducibility at scale. Nanotube geometries offer a fundamentally different approach, enabling the alignment of noncommensurate lattices by tuning curvature to accommodate unit-cell mismatches. Here, we demonstrate this concept using WS_2@ReS_2 core–shell nanotubes grown by van der Waals epitaxy.[1–3] Advanced high-resolution electron microscopy and 4D-STEM reveal a well-aligned curved interface and a complex diffraction response arising from multiple crystallographic projections in the core-shell nanotube. Photoluminescence and STEM-Cathodoluminescence measurements show bright interlayer excitons, with electrons localized in ReS_2 and holes in WS_2. Two interface excitons (IX_A and IX_B) appear at identical energies across different nanotubes, indicating topological protection imposed by the nanotube geometry. Their micrometer-scale length, nanoscale thickness, and chemically protected interfaces make these heteronanotubes promising platforms for quantum transport and nanoelectronics devices.



Keywords: Core-Shell Nanotube, Rhenium Disulfide, Tungsten Disulfide, Interlayer Exciton

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Ultrathin metal nanoparticles with novel electronic structure stabilized by their interaction with 2D crystals

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Metallic platinum is the best and most widely studied catalysts for hydrogen evolution. A transition from a metallic to a nonmetallic electronic structure is generally expected, as the size of metal nanoparticles is reduced. However, opening an energy gap in metal nanoparticles, turned out rather challenging, leaving the properties of metal nanoparticles with nonmetallic electronic structure, largely unexplored. Here, we show that 2D transition metal chalcogenide (TMC) crystals can stabilize metal nanoparticles with a novel atomic structure, corresponding to two- or even single- atomic layer thickness. We found that when the thickness of metal nanostructures is reduced below their Fermi wavelength, a sizeable bandgap (0.3 – 1 eV) opens in their electronic structure. Remarkably the intrinsic catalytic activity towards the hydrogen evolution reaction is substantially enhanced for such semiconducting ultrathin metal nanoparticles, compared to their conventional metallic nanoparticle form [1]. Our findings evidence that engineering the electronic structure of catalyst nanoparticles is essential for unlocking their full potential.

Keywords: 2D Materials, metal nanoparticles, hydrogen evolution reaction, electronic structure, scanning tunneling microscopy

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Biography

Levente Tapasztó is a Research Professor at the HUN-REN Centre for Energy Research and the Budapest University of Technology and Economics. His main area of expertise is nanoscale materials science and engineering, with particular focus on 2D materials and scanning probe microscopy techniques. He is the Head of the Nanostructures Department, and recently has been elected as member of the Hungarian Academy of Sciences.

Thermal Conductivity in 2D Materials

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Thermal properties of materials are crucial for heat-related technologies, ranging from efficient heat spreading in nanotransistors to low thermal conductivity requirements in thermoelectric generators. To control heat and harness its benefits, scientists aim to understand extreme regimes of thermal transport. Two-dimensional (2D) materials provide an ideal platform to explore the thickness limit, in which a material is reduced to a one- to few-atom-thick layer derived from layered van der Waals crystals.

In this talk, I will present the general scope of research on thermal conductivity in 2D materials and van der Waals heterostructures. I will discuss state-of-the-art results and key experimental techniques used to study thermal properties in these systems. In particular, I will address the challenges and opportunities associated with frequency-domain thermoreflectance (FDTR) and optothermal Raman methods. Furthermore, I will demonstrate that thermal transport can be drastically modified by combining atomically thin conductors and highlight applications of Raman thermometry for measuring the temperature of operating 2D nanotransistors.

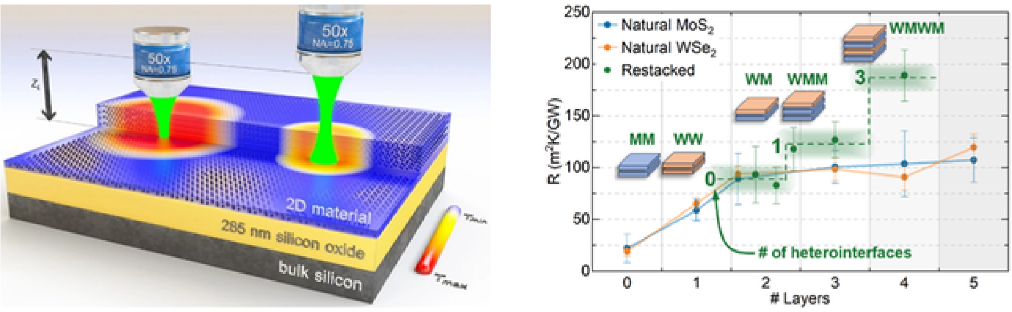

Figure 1. Left: Raman-based method for measuring thermal conductivity. Right: heterointerface-driven large thermal resistance between two monolayer semiconductors.

Keywords: 2D materials, thermal conductivity, interfaces, FDTR, Raman spectroscopy

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Biography

A. P. Gertych, PhD, Assistant Professor at the Faculty of Physics, Warsaw University of Technology. Scientific interests include the production of 2D materials and heterostructures via metal-assisted exfoliation and transfer, as well as the use of Raman spectroscopy as an advanced characterization tool for temperature-related phenomena in 2D materials and van der Waals heterostructures.

TEM characterization of 2D compound semiconductors

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The synthesis of 2D InN by MOCVD growth on graphene coated SiC is reported and the grown layer is characterised by atomic resolution electron microscopy, spectroscopy as well. The bandgap is measured and is substantially different from the bulk one.

Recently, the growth of transition metal dichalcogenides (TMDs), such as MoS2, on wide bandgap semiconductors (for example on GaN) has attracted increasing interest for heterojunction diodes and UV photodetectors applications. We report on a simple method which allows us to cover large surface of the substrate by a few layer of MoS2. In the case of GaN we managed to deposit a single layer of MoS2, which is confirmed by electron microscopy and Raman analysis as well. The electrical data are in agreement with the observed structure as well.

In both subjects the control of the process needs TEM investigations due to the very small dimensions.

Interplay of Kinetic Limitations and Precursor Disintegration: Selective Growth of Hexagonal Boron Nitride and Borophene Monolayers on Metals

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The CVD growth of bi-elemental 2D-materials by using molecular precursors involves complex formation kinetics. Kinetic limitations for diffusion and nucleation cause a high density of small domains and large number of grain boundaries. Naively, these are overcome by increasing the growth temperature and decreasing the growth rate. In contrast, molecular precursors exhibit limited thermal stability which can result in dissociation and preferential desorption. We demonstrate these constraints in a combined LEEM, m-diffraction, and high-resolution LEED study by examining the selective formation of single layer hexBN [1] and borophene [2] on Ir(111) using a borazine precursor. We derive a temperature−pressure phase diagram and apply classical nucleation theory to describe our result. We find a large critical nucleus $i^* > 8$ resulting in an almost linear dependence of island- or grain density n_{hexBN} with dosing pressure p_{dose} [3]. Considering the competing processes, we find an optimum growth temperature for hexBN of T_g = 950 °C. At lower temperatures, the hexBN island density is increased, while at higher temperatures the precursor disintegrates and borophene is formed [3]. Studying the kinetics of borophene formation through segregation from subsurface Ir bulk regions during cool-down shows that surface steps are bunched during the borophene formation, resulting in elongated and extended borophene domains with exceptional structural order [2].

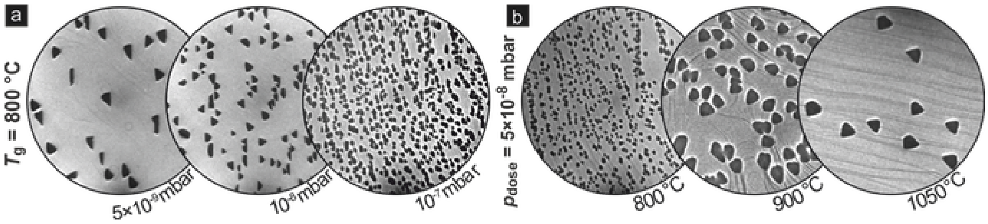

Figure 1:LEEM images of hexBN islands on Ir(111) as function of p_{dose} and T_g.

Keywords: CVD of 2D-materials, hexBN, borophene, LEEM, LEED

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Biography

M.H.v.H. holds the Chair of Surface Science at the Duisburg-Essen University. His research focuses on CVD of 2D materials, ultrafast electron and structural dynamics, and MBE of hetero films.

Hot carrier diffusion in 2D Materials for Quantum Optoelectronics

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Two-dimensional semiconductors provide a versatile platform for exploring hot carrier transport. However, rapid energy dissipation remains a fundamental challenge for their implementation in next-generation optoelectronic and quantum technologies. In this talk, I will present our recent progress in modulating hot carrier diffusion and extraction through systematic control of interface, dielectric screening, and dimensional confinement. By tailoring the semiconductor-metal interface and employing a high- dielectric environment, we demonstrate screening-stabilized and interface-governed hot carrier transport in MoS_2, characterized by suppressed carrier scattering and prolonged non-equilibrium carrier populations. Moreover, atomic layer thickness control enables access to quasi-ballistic transport regimes with minimal energy loss. These results offer physical design strategies for harnessing the hot carrier effect in ultrafast, energy-efficient, and quantum optoelectric systems.

Biosensing using graphene within and beyond the Debye length

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Due to its 2D structure, graphene offers extraordinary electronic properties useful in the context of biosensing. Electrical biosensing based on field effect transistors (FETs) is label-free and can be used to study the dynamics of target molecules without interference from labels. However, progress in the development of such measurement platforms has been hindered by several issues, the perhaps most important one being the Debye length that limits charge sensitivity in a physiological buffer to a distance of ~ 1 nm. Furthermore, usually the detection depends on a molecule binding to a specific anchor site so that the same transistor cannot be reused to detect a different type of molecule, thus limiting the usability of a device. Finally, encapsulation that is necessary for long lifetime of the devices reduces the yield of functioning devices dramatically.

In my talk, I will first show how we build reusable graphene FETs for biosensing of membrane-associated proteins [1,2] and what we did to increase the yield after encapsulation. I wioll present a new mechanism that allows for sensing beyond the Debye length based on noise measurements. To demonstrate the high sensitivity regarding binding of proteins, we focused on the prenylated Rab7 GTPase Ypt7 and its interacting HOPS tethering complex using liquid-gated GFETs combined with low-frequency noise spectroscopy. Current-voltage (I–V) transfer measurements reveal no or only very small changes upon binding of Ypt7 and after addition of HOPS. In contrast, noise analysis reveals pronounced flicker (1/f) noise level growth after Ypt7 binding, most likely due to conformational dynamics of Ypt7. Recruitment of the HOPS complex by Ypt7 to membranes inhibits these fluctuations, suggesting structural stabilization of Ypt7 via HOPS binding [3]. Altogether, our findings highlight the potential of combining lipid monolayer modification of GFETs with graphene-based noise spectroscopy as a highly sensitive approach for probing protein–membrane as well as protein-protein interaction.

Keywords: GFET, graphene, biosensing

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Biography

PD Dr. habil. Carola Meyer is head of the Electronic Transport group at the University of Osnabrück. Throughout her academic career she investigated the physics of carbon nanostructures. During her postdoc with Prof. Kouwenhoven at TU Delft, she studied properties of carbon nanotubes (CNTs) in quantum transport. In 2005, Dr. Meyer started a young researcher group on CNTs functionalized with magnetic molecules at the Peter Grünberg Institute at Research Centre Jülich and received tenure in 2008 for her work on quantum- and low-temperature transport. Moving to Osnabrück in 2017, she started new work on biosensing, first with CNTs, but soon adding graphene to her portfolio. Dr. Meyer did her habilitation on molecular and spin interactions in carbon nanotube-based electronic devices.

Exploring mono- and multilayers of Graphene, Silicene and their oxides with soft X-ray spectroscopy and DFT calculations

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We study the hexagonal honeycomb of Si atoms – referred to as Silicene [1] – deposited on Ag(111) with synchrotron-based soft X-ray spectroscopy (XAS & XES) at the Si L-edge. When compared to our electron density functional theory calculations, we unambiguously show that the Si valence and conduction states are continuous across the Fermi energy, i.e. that the silicene overlayer is indeed metallic [2]. If Si-monolayers are to come into use, they must be all at once isolated from their substrates. One suggested way of achieving these characteristics is to produce a multilayer of silicene on the Ag(111) surface.

Our DFT calculations predict a stable, AA-stacked silicene bilayer on Ag(111). Unfortunately, DFT calculations predict a similar electronic structure as that of the monolayers, namely metallic and bound to the Ag(111). Our measurements indicate a transition to forming bulk Si beginning shortly after the completion of a third monolayer [3].

For Graphene oxide it turns out that the distribution of functional groups is as important as type and number. It is necessary to include epoxide and hydroxyl group to achieve good agreement between exp. & theory [4].

Keywords: Soft X-ray spectroscopy (XAS & XES), DFT, Graphene, Silicene, Density of States

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Biography

Alexander Moewes is a professor and Canada Research Chair in Materials Science with synchrotron radiation. His group studies a wide range of novel materials from LEDs to transition metal nitrides and 2D-materials.

Integration of Graphene Photonics with Silicon Nitride Waveguides in a 200-mm Pilot Line

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This study presents a comprehensive examination of the design, integration, and performance of graphene photonic devices on SiN waveguides, which were manufactured using a 200 mm pilot line. In the context of fabricating graphene-based components within a 200-mm CMOS Si environment, several processing stages—namely, growth, passivation, and contacting—emerge as being of paramount importance. The electrical characteristics of graphene devices, including sheet resistance and contact resistance, were initially evaluated. The fabrication of SiN waveguide photonic platform components, encompassing bottom/top cladding layers, grating couplers, and waveguides, was undertaken for the implementation of Graphene photonic circuits. The measured 3dB bandwidth of 15 GHz of a dual-layer graphene modulator demonstrates the viability of graphene-based photonic devices for high-speed communication applications.

Keywords: *Graphene, Photonics, Integration, Pilot line*

Acknowledgements

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101120938 (GATEPOST) and under grant agreement 101189797 (2D-PL).

Biography

Dr. Mindaugas Lukošius received M.Sc. degree in Inorganic Chemistry in 2006 from the University of Vilnius, Lithuania. The PhD degree in Chemistry was obtained from the Carl von Ossietzky University Oldenburg, Germany in 2010, in the field of CVD depositions and developments of high-k MIM capacitors. In 2015 he joined the Graphene research group and since 2018 he is leading the 2D materials team in the Materials Research department at IHP and focuses on the development and integration of novel graphene photonic modules into the BiCMOS pilot line.

In Situ Development of Phosphate Glass Fillers with High Aspec Ratio in Polymer Composites

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The versatility of processing methods for fiber-reinforced thermoplastic composites is limited, as fillers cause a significant increase of the material viscosity. We thus investigated the feasibility of creating polymer composites reinforced with phosphate glass (P-glass) fillers of which a high aspect ratio was produced in situ. The elegant approach is to take benefit of the very low and adjustable glass transition temperature of P-glass (Tg~100°C-200°C) [1]. In the example given, the matrix was a Polybutylene Succinate (PBS) being processable at 160°C. Thus, at a processing temperature above the P-glass Tg, the filler can adopt an elongated shape due to large stresses during processing. However, if P-glass is kept for long time at a temperature above Tg, it can crystallize, making it non-deformable. This led us to prepare the polymer/P-glass blends in powder form, without the high-temperature holding stage that is unavoidable in the case of a conventional melt mixture. Figure 1 shows the morphology for injected parts obtained with blends prepared in the molten state using an internal mixer and in powder form. Besides, the difference of filler aspect ratios obtained with the two methods led to a 50% higher Young's modulus for the composite prepared by powder mixing, in agreement with the prediction of the Halpin-Tsai model [2].

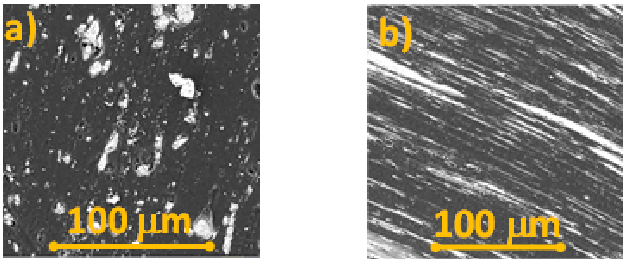

Figure 1: SEM pictures of injected parts. Composites prepared in melt state (a) or in powder state (b).

Keywords: Polymer Composite, P-glass, Fibers, Injection molding.

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Biography

René Fulchiron has been a full professor at Claude Bernard Lyon 1 University (UCBL) since 2017 (Associate Professor between 1994 and 2017). His is member of the laboratory 'Polymer Materials Engineering'. His PhD thesis (1992) focused on the rheological behavior of molten polymers and its links to the spinning process. His accreditation to supervise research (2004), concerned the structuring of thermoplastic polymers under stress (shear, elongation, pressure). His current research works focus on the structuring induced by the process and the resulting properties of polymer materials and composites. He co-supervised 34 PhD theses and he is co-author of over 100 peer-reviewed publications, 4 patents and 1 book chapter.

How Gas Dissolves in Water: Insights from Transmission Electron Microscopy

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[2] Institute of Mathematics for Industry, Kyushu University, Fukuoka, Japan.
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Dissolution of gases in liquid water is a general and fundamental phenomenon. Conventionally it has been assumed that dissolved gas molecules are well dispersed as monomers, even when water is gas-supersaturated. Our transmission electron microscopy (TEM) study of gas-supersaturated water encapsulated in graphene liquid cells (GLCs) at room temperature revealed the presence of a novel type of mesoscopic clathrate hydrate structures (often 100-1000 nm in lateral size) (Fig. 1a) [1]. A few discrete sets of strong diffraction spots were observed. The major constituent of the clathrate structures is water, and the d-spacings (interplanar spacings) of the crystalline structures are not different for different gases, suggesting that water molecules form the crystalline structures that produce diffraction spots. Dark-field TEM imaging of the clathrate structures has indicated that water molecules form crystalline structures surrounding or between gas-filled cages (typically 2–4 nm in diameter). Almost identical clathrate structures were observed when ethanol-water (EW) mixtures at ~10% volume fraction ethanol, which is also gas supersaturated, were encapsulated in GLCs [2]. The presence of the mesoscopic clathrate structures explains many long-standing puzzles for dissolution of gas in water as well as EW mixtures. Electron diffraction patterns recorded on this clathrate state indicated that the crystalline water structure has a d-spacing of 4.5–4.8 Å [1,2], which has not been reported for any other water ice or clathrate hydrate structure.

We derived the crystalline water structure in this novel clathrate state by recording and analyzing various in-zone electron diffraction patterns (IZEDPs) (Fig. 1b,c) and by performing first-principles calculations [3]. Fig. 1d shows the derived structure; all water molecules are hydrogen-bonded to four others, and some distortions from the perfect tetrahedral structure are evident. The structure comprises only five-membered rings of hydrogen-bonded water molecules, in contrast to the six-membered rings in hexagonal ice. Because the samples were prepared under ambient conditions, the results offer insights into the local structures of ambient liquid water. Even though the mesoscopic clathrate hydrate structures were observed inside GLCs, several previous works suggest the presence of these structures in bulk water as well as in aqueous solutions. The present findings challenge conventional concept of dissolution of small hydrophobic solutes in water. The new understanding may resolve many mysteries regarding ambient water as well as gas in water.

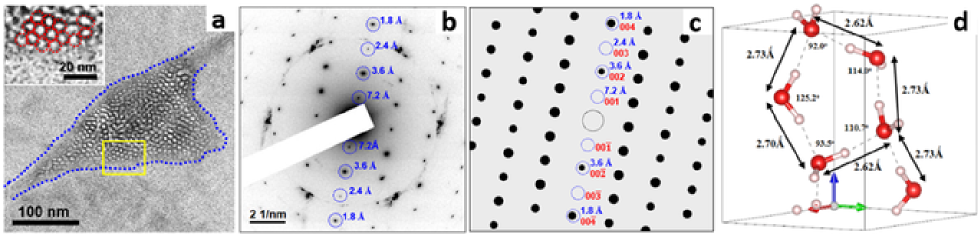

Fig. 1 (a) Bright-field TEM image of a mesoscopic clathrate hydrate structure. (b) A type of IZEDPs recorded on a mesoscopic clathrate hydrate structure. (c) Simulated IZEDPS for comparison with (b). (d) Unit cell of the derived crystalline water structure with a = 5.40 Å, b = 5.40 Å, c = 7.12 Å, α = 90°, β = 90°, and γ = 120°. The space group of the structure is $P2_1$.

Keywords: water, gas, clathrate hydrate, graphene liquid cells, transmission electron microscopy

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Biography

Ing-Shouh Hwang completed his PhD degree in 1993 from Harvard University. He joined the Institute of Physics, Academia Sinica in 1994 and is currently a Research Fellow. He received Young Investigator Award of Academia Sinica in 1999, Outstanding Research Award of National Science Council of Taiwan in 2000, Outstanding Nanotechnology Research Award of Taiwan Nanotechnology Industry Development Association in 2006, and JSPS Invitational Fellowships for Research in Japan in 2022. His main research interests regard surface and interface science, surface phase transitions, nucleation and growth mechanisms, solid-water interfaces, gas in water, mechanism of gas bubble nucleation in water, development of microscopy and spectroscopy based on coherent electron beams emitted from thermally stable single-atom tips or nanotips, and development of various gas field ion sources emitted from several types of thermally stable single-atom tips.

New Insights into Photochemical Processes of the Carbon Nanotubes-Based Composites

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Composites of the type conducting polymers/carbon nanotubes and metal oxide semiconductors /carbon nanotubes have attracted special attention in the field of photovoltaic[1] and optoelectronic devices[2], biosensors and fluorescent probes[3], and last but not least photocatalysis[4]. In most of the studies reported in the case of composites, the carbon nanotubes were used as mixtures of metallic and semiconductor tubes. The development of techniques for separating metallic tubes from semiconductor ones has allowed the understanding of various photochemical processes[5]. This fact allowed a better understanding of the role of each type of carbon nanotube, metal and respectively semiconductor in the optical processes specific to these composite materials. The communication will present the role of semiconducting carbon nanotubes in comparison with that of the mixture of metallic and semiconducting carbon nanotubes in the case of composites of the type: a) metal oxide semiconductor /carbon nanotubes in order to improve the photocatalytic properties for the elimination of pollutants from wastewater; and b) the conducting polymer/carbon nanotubes in order to understand the photoluminescence quenching processes of the macromolecular compound.

Keywords: semiconducting single-walled carbon nanotubes, metal oxide semiconductors, composites

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Biography

Mihaela Baibarac completed her doctoral studies in Bucharest University, faculty of Physics, Romania. She spent a postdoctoral period at Institut des Materiaux Jean Rouxell in France and Institut de Ciencia de Materials de Barcelona, Spain. At present, she is senior researcher first degree at National Institute of Materials Physics, Romania. Her research is focused on the composite materials based on carbon nanoparticles and inorganic/organic compounds for the water management and the energy storage.

Possible Mechanisms of Phase Transformation in Oxide Dispersion Strengthened 316L Stainless Steel in Spark Plasma Sintering Procedure

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Oxide dispersion strengthening (ODS) of 316L stainless steel with alumina additives is a widely used method for improving mechanical performance of steel alloys. In this work, ODS alloys were fabricated by attrition milling followed by spark plasma sintering (SPS) [1], a technique that applies pulsed electric current at elevated temperature and pressure. SPS offers rapid heating, controlled grain growth, and efficient densification. However, phase transformations occurring during SPS remain insufficiently understood. ODS 316L stainless steel composites containing 0.33 wt% and 1 wt% Al_2O_3 were sintered at 900 °C. After milling, alumina particles were located at grain boundaries. Despite the relatively low sintering temperature, the original α-Al_2O_3 additive fully transformed into a chromium-rich spinel phase [2], surrounded by amorphous silica. This unexpected transformation is attributed to diffusion of chromium and silicon from the steel matrix during SPS. Chromium oxide may form on steel grain surfaces during milling and sintering, subsequently reacting with dispersed alumina to form Cr–Al spinel. The presence of amorphous silica appears to promote spinel formation, consistent with reports from geological systems and annealed glass composites. Local temperature increase at grain boundaries, caused by the concentration of pulsed electric current at interparticle contacts, may further enhance diffusion and reaction kinetics.

Keywords: spark plasma sintering, phase transformation, spinel, cation exchange

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Biography

Zsolt Czigány received PhD in 1999 in physics. Since 2013 he is Doctor of Hungarian Academy of Sciences. As a materials scientist, specialized in transmission electron microscopy of thin films, nanocomposites and nanostructured materials. Co-author of more than 140 peer reviewed papers and received more than 3500 citations. In 2010 he received the Outstanding Paper Award of the European Microscopy Society.

Structural Characterization and Design of High-entropy Thermoelectric Materials via Advanced Transmission Electron Microscopy

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Thermoelectric materials, which enable direct heat-to-electricity conversion, have attracted considerable attention over the past decades. Among recent advancements, the high-entropy strategy, incorporating multiple principal elements, has shown great promise in significantly enhancing thermoelectric performance, which is primarily governed by the composition and structure. Herein, advanced transmission electron microscopy, featuring sub-angstrom spatial resolution and various analytical techniques, has been employed to elucidate the atomic structure and chemical composition of high-entropy thermoelectric materials. Using atomic-resolution STEM-EDS combined with a novel noise-reduction algorithm, we have not only clearly resolved atomic location of all constituent elements in high-entropy thermoelectric materials, but also accurately quantified the concentration of each element in lattice sites. This offers a clear atomic-scale picture of multiple-element distributions and also promotes to identify the respective contributions of different element characteristics on the local chemical fluctuation. The electronegativity and mass have a comparable influence on the fluctuations of constituent elements, while the radius make a slight contribution. By varying the constituent elements in GeTe-AgSbX (X=Sn, Mn and Pb) high-entropy materials, the local chemical fluctuation can be further tailored to induce large lattice distortion and strong strain fluctuation, which effectively reduces the lattice thermal conductivity from 0.88, 0.73 to 0.61 W/mK at room temperature. Structural disorder induced by high entropy and local chemical fluctuation suppresses the propagation of transverse phonons, resulting in phonon localization and largely depressed lattice thermal conductivity.

Beyond phonon transport, we also observe unconventional electronic behavior that the power factor of high-entropy GeTe-AgSbPb is much larger than the pristine GeTe. This is attributed to the altered electron distribution, as revealed by atomic-scale charge density mapping using the DPC-STEM technique. While pristine GeTe shows localized electrons within short Ge–Te bonds, the high-entropy sample exhibits delocalized electrons between Ge sites and surrounding Te sites. By simultaneously tuning phonon and electron localization through the high-entropy strategy, we have enhanced the figure-of-merit (ZT) of GeTe-AgSbPb material to 2.7 and achieved a record-high conversion efficiency of 13.3% in a segmented module.

Keywords: Thermoelectric materials; High entropy; Transmission electron microscopy; Phonon and electron localization

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Shock response of additively manufactured Ni-based superalloys

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Although additive manufacturing rapidly expands to various application areas, some of which may involve severe high-rate deformation (e.g. within aircraft engines in case of in-service failure, blade loss, bird strike or particle ingestion), very limited data can be found yet on the potential effects of this process on the dynamic behavior of the materials thus produced [e.g. 1, 2]. In this context, we present an experimental study of the shock response of the high-performance Rene 65 Ni-based superalloy, widely used in the latest generation of aero-engines. Specimens were either additively manufactured (AM) by laser powder bed fusion or cast and wrought for comparison. To evaluate the anisotropic character of deformation and fracture, the AM samples were shocked in two directions, either parallel or normal to the building direction. In order to explore a wide range of pressures and strain rates, up to about 4×10^{6} s^{-1}, two loading techniques were used: planar impact of a laser-accelerated flyer [3] and direct irradiation by a high-intensity laser pulse [4].

Hugoniot elastic limit and spall strength values inferred from time-resolved velocity measurements are both high, typically about 2.5 GPa and 7 GPa, respectively. They are found to be similar in the AM material and its wrought counterpart within the scatter. On the other hand, extensive post-recovery observations including X-ray micro-tomography and Electron Back-Scattering Diffraction reveal a strong dependence of the initiation and propagation of spall damage on the rich and complex microstructures inherited from the manufacturing routes and heat treatment conditions.

Keywords: Ni-based superalloys, shock loading, spall damage, high strain rate, additive manufacturing

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Biography

Thibaut de Rességuier is a Senior Researcher at the French Centre National de la Recherche Scientifique (CNRS). He works on the dynamic behavior of materials at extremely high strain rates, using various loading techniques including laser driven shocks.

Transition Metal Dichalcogenides:
Microstructure as a Challenge and an Opportunity

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In modern electronics, the active material is often only a few atoms thick, which makes defects a key factor in determining device properties. For instance, in field-effect transistors (FETs) with silicon channels, carrier mobility typically decreases as channel dimensions shrink, mainly due to the high density of dangling bonds at the silicon surface.

In the search for alternative channel materials, two-dimensional (2D) systems have gained considerable attention. Thanks to their van der Waals structure, they can be fabricated with uniform thickness down to three atomic layers, ideally without strain or dangling bonds.

Among them, transition metal dichalcogenides (TMDCs) such as MoS_2 and WS_2 are particularly promising. In their monolayer form, they become direct semiconductors with band gaps in the visible range, enabling numerous optoelectronic applications. Yet, their performance is strongly governed by their microstructure. While this presents challenges, it also opens opportunities for optimized or even novel devices, as well as for defect engineering strategies [1-3].

Keywords: 2D materials, transition metal dichalcogenides, defects, microstructure, optoelectronics, defect engineering

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Biography

Professor Dr. Marika Schleberger is Professor of Experimental Physics at the University of Duisburg-Essen and Deputy Scientific Director of CENIDE, the Center for Nanointegration Duisburg-Essen. Her research is centered on surface physics with a focus on two-dimensional (2D) materials and ion–solid interactions. She is Principal Investigator and board member of the DFG International Research Training Group IRTG-2038 “Scalable 2D-Materials Architectures”. After completing her Ph.D. at the University of Osnabrück, she held research positions in Germany, France, Australia, and Switzerland.

Modeling Ultrafast Dynamics in Excited Materials

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Ab initio molecular dynamics simulations based on (excited-state) potential energy surfaces obtained via constrained density-functional theory [1] offer detailed insight into the coupled electron-nuclear dynamics of excited systems and enable the quantitative modeling of excitation processes. In this talk, I will illustrate the power of this approach with three intriguing examples:

1. **Ultrafast insulator–metal transition:** Photoholes localized at the Brillouin zone boundary of the In/Si(111)(8×2) surface trigger an ultrafast transition from insulating to metallic behavior [2,3].

2. **Polaron formation in lithium niobate:** Bound polarons form on the femtosecond timescale and have a profound impact on both the linear and nonlinear optical response of the material [4].

3. **Exciton transfer across organic/Si interfaces:** Triplet excitons generated by singlet fission in organic overlayers are efficiently transferred into silicon solar cells via interface-localized dangling bond defects. The vibrations of Si surface atoms modulate the defect state energies, effectively facilitating exciton shuttling across the interface [5].

These case studies demonstrate how a combined treatment of electronic excitations and lattice dynamics can uncover microscopic mechanisms and greatly assist in the interpretation of experimental data.

Keywords: Excitons, Polarons, Phase Transitions, DFT, AIMD

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Biography

Prof. Dr. Wolf Gero Schmidt studied physics in Jena and received his PhD in 1997 under the supervision of Friedhelm Bechstedt. This was followed by a postdoctoral stay with Jerry Bernholc at North Carolina State University. Upon returning to Jena, he led the research group Computational Materials Science. In 2001, he was appointed Adjunct Assistant Professor at North Carolina State University. In 2005, he became Associate Professor at Massey University in Auckland, before accepting a chair in theoretical physics at Paderborn University in 2006. Since 2018, Prof. Schmidt has been Dean of the Faculty of Science at Paderborn University. His research interests focus on the understanding and development of energy materials, quantum systems, and optical materials.

Pixel-Level Design Considerations for Next-Generation SWIR Image Sensors Based on Monolithic Thin-Film Photodiodes on CMOS

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Short-wave infrared (SWIR) imaging (1,000–2,000 nm) enables enhanced material discrimination and improved penetration through obscurants compared to visible wavelengths, making it attractive for applications such as autonomous systems, industrial inspection, and biomedical imaging. However, most high-performance SWIR sensors rely on InGaAs photodetectors hybridized to silicon readout integrated circuits (ROICs), which increases fabrication complexity and cost. In contrast, recent advances in thin-film photodiode (TFPD) technologies, including quantum-dot (QD) and organic photodiodes, enable monolithic integration directly on CMOS ROICs, offering greater cost-effective ways toward high-resolution SWIR imaging.

Despite these advantages, monolithically integrated QD- and organic-photodiode–based SWIR image sensors introduce distinct pixel-level design challenges, including reliability, dark current suppression, external quantum efficiency (EQE), power-supply noise rejection, and dynamic range (DR). This work addresses these challenges from a pixel-centric design perspective, highlighting the role of material properties, device architecture, and pixel-level co-design in achieving scalable and cost-effective SWIR image sensors.

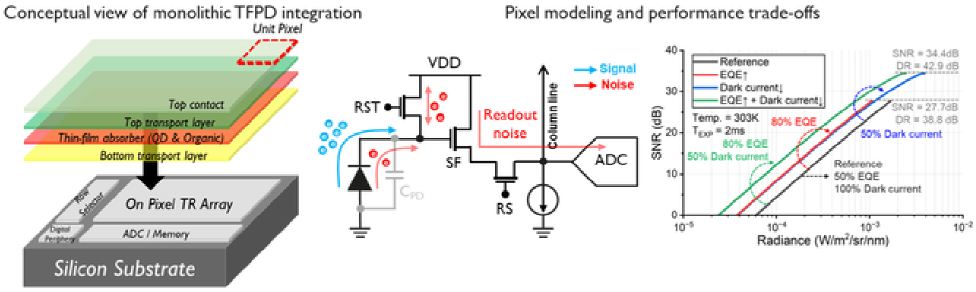

Figure 1. Conceptual view of monolithic TFPD integration and pixel-level performance trade-offs in SWIR image sensors.

Keywords: Short-Wave Infrared (SWIR) Image Sensors, Monolithic Integration, Quantum-Dot and Organic Photodiodes, Pixel-Level Design, Infrared Optoelectronics

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Electron correlation effects in highly-doped single-layer graphene

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Since the discovery of graphene – a single layer of carbon atoms arranged in a honeycomb lattice – much attention has been devoted to the investigation of its distinctive electronic properties as well as to their controlled manipulation. In particular, there is significant interest in realizing strongly correlated ground states absent in pristine graphene, such as superconductivity (SC) or charge density waves (CDW), driven by both fundamental and possible application aspects. The strength of electron correlations in graphene tends to scale with the number of available states at the Fermi surface. A substantial increase of the latter can be achieved, for example, by electron doping via metallic atom intercalation up to a saddle-point singularity, known as Van Hove singularity (VHS), where the density of states (DOS) diverges. This, in turn, can lead to significant warping of the Fermi surface, resulting in an almost non-dispersing flat band at the Fermi level, referred to as extended VHS. The emergence of such a flat band was recently reported for Yb-intercalated graphene [1] and is also observed for the intensely studied magic-angle twisted bilayer graphene, known for its superconductivity and correlated insulating states.

Here we report a detailed study of the atomic structure and local electronic properties of Ytterbium (Yb)-intercalated monolayer graphene on SiC(0001) by means of low-temperature scanning tunneling microscopy and spectroscopy. Several different intercalation phases/structures were identified, that host two possible CDW states, characterised by a $(9/2 \times 9/2)R30^\circ$ and (3×3) modulation of the graphene lattice. Quasi-particle interference (QPI) pattern analysis indicates that all intercalation structures are heavily n-doped close to VHS. Upon bias-dependent inaging, the $(9/2 \times 9/2)R30^\circ$ superstructure shows contrast inversion upon switching between filled and empty states, along with almost perfect Fermi surface nesting (FSN), both hallmark characteristics of a CDW state described by a Peierls-type mechanism. The (3×3) superstructure displays contrast inversion around ± 175 meV, which can be explained considering the possibility of a second charge modulation with an additional gap opening away from the Fermi level. We further discuss the possible driving mechanisms of the CDW formation in both structures.

Keywords: Graphene, intercalation, scanning tunneling microscopy, charged density wave, Fermi surface nesting, electron correlation

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Extrusion of various polymer compositions for positive electrodes and electrolytes in all solid-state batteries

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The climate emergency requires to review our lifestyles, particularly those related to transport. Electric vehicles are part of the solutions, provided that efficient energy storage is achieved. The choice of all solid-state batteries on a polymer basis stands out for its ability to combine autonomy, safety and ease of process. The challenge of all solid-state batteries is to ensure the ionic conductive properties through pathways within the matrix via the addition of various constituents depending on the type of electrolyte (polymer and ionic conductor) or electrode (carbon fillers, lithium salts, active materials for Li intercalation).

The research presented in this field targets the formulation of electrolytes or electrodes that could be processed and shaped in a melt blend process. The development aims at obtaining ionic conductivity (and electronic conduction in positive cathode) by controlling the blend morphology and the electrolyte or electrode geometry during processing by extrusion. Ionic and electronic conductive properties require the addition of a large amount of various fillers. Therefore, parameters such as torque and temperature are clues to the flow of the final material during its processing especially in view of the extrusion of solid positive electrodes. Scientific bolts arising from the extrusion of all solid-state batteries (ASSB) are presented through various examples of electrolyte and positive electrode formulations. The electrolytes were prepared following strict conditions to limit humidity intake of the salt or the solid superconducting filler. After electrolyte formulation, the positive electrodes were processed and the effect of successive additions of the active filler (lithiated nickel-manganese-cobalt oxide type) and carbonaceous conductive additive was studied. Obtained results varied depending on the studied system and have shown in some cases to be similar to systems prepared through more conventional ways. These studies present results for the extrusion of ASSB, leading to new challenges and research prospects.

Keywords: electrolyte, positive electrode, extrusion, dispersion, all solid-state batteries.

Biography:

Melinda Desse is an associate professor at Université Jean Monnet in Saint-Etienne, working in the IMP (Engineering of Polymer Materials) laboratory. Her research topics are mainly the relation between structure and properties of processed polymers, in the fields of polymers for energy storage and biopolymers.

Shock Compression, Release And Spall Fracture Along The Closest Packed [111] Crystallographic Direction In Single Crystal Iron

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Understanding the microphysical processes that underline the shock compression and release behavior and subsequent spall fracture of solid materials is a scientific challenge relevant for both fundamental and industrial applications [1,2]. Such processes can be characterized at the atomic level by using large-scale Molecular Dynamics simulation, which now gives access to spatial and temporal scales comparable to those available in experiment [3]. Thus, in this work, Non-Equilibrium Molecular Dynamics (NEMD) simulations have been used to study the coupling between phase transitions and spall damage in single crystal iron when a shock wave propagates along the closest packed [111] crystallographic direction. The modified version of the Ackland potential was used [4].

Consistent with the literature [5], no plastic deformation was observed under compression before the phase transition. Then, both direct bcc to hcp and reverse hcp to bcc phase transitions occur at onset pressures that increase with shock pressure. The microstructure behind the incident release wave is mainly composed of defects such as dislocations, with some residual hcp and fcc atoms within the matrix of the released bcc phase. In contrast to the high symmetry [001]-direction [6], no release shock wave was observed to form upon unloading, leading to large-width Gaussian tensile pulses upon reflection from the free surface. Voids nucleation sites are found to be directly correlated with the bcc to hcp phase transition under compression, since they are located where both phases coexisted before the arrival of the reflected rarefaction wave. On the other hand, the spall strength evaluated from the acoustic approximation is systematically higher than that measured within the maximum tensile plane, which is also higher than that evaluated at the weak sites plane.

Keywords: Shock compression, Release, Spall fracture, Phase transition, Rarefaction shock wave, Iron, Molecular Dynamics

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Biography:

Nourou Amadou is a Full Professor at the Faculty of Sciences and Technologies of the Abdou Moumouni University in Niamey and an affiliated researcher at the Pprime Laboratory, ENSMA, Poitiers, France. He holds a master's degree from the University of Bordeaux 1 and a Ph.D. from the “Ecole Polytechnique” of Paris, France.

Simple Scaling Function Unites Micro to Nano Deformation Structures for Strength in fcc and bcc Metals/Alloys

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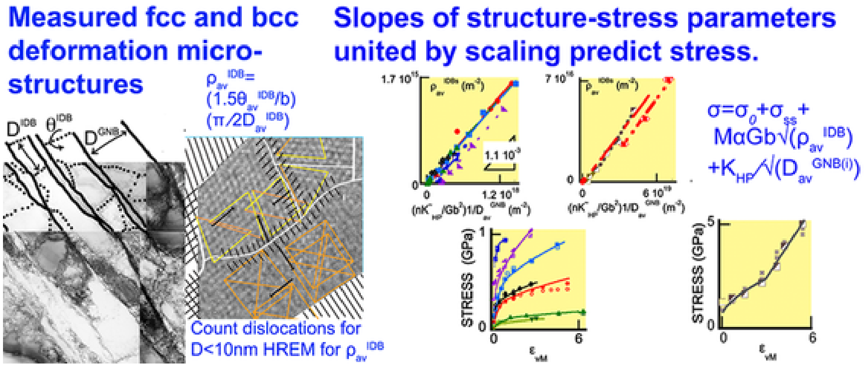
Quantitative and statistical measurements of deformation microstructures utilizing transmission and high resolution electron microscopy were analyzed in a new scaling law and successfully used to predict flow stress from tensile data. Data as a function of stress and strain represent a diverse range of ~monotonic cold deformation modes, from simple tension to nominally flat plate sliding friction, in cell and non-cell forming fcc and bcc metals and alloys (including a high carbon pearlitic steel). Two structure-strength parameters within the hierarchy of universal grain subdivision scale linearly and collapse into a single slope:1/D_{av}^{GNB} versus rho$_{av}^{IDB}$, i.e. the inverse spacing of geometrically necessary boundaries versus the dislocation density in incidental dislocation boundaries and Taylor lattices. Scaling constants utilize physical material constants that include both the number and magnitude of glide Burgers vectors, shear moduli, and Hall-Petch constants (modified units). Extremes of stress/strain for Cu+Fe add a/2<100> glide Burgers vectors. Scaling encompasses > 5 orders of magnitude in strain rate, > 4 in strain and rho$_{av}^{IDB}$, >3 in deformation induced crystallite sizes to < 3 nm, and > 2 in stress to ~5 GPa. Scaling simplifies estimates of stress in an additive strength law and illuminates mechanisms for a cooperative structural evolution.



Keywords: Stress, Mehanical Properties, Dislocations, Scaling, High Resolution Electron Microscopy, Modeling

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Biography:

D. A. Hughes spent her career at Sandia National Laboratories, Livermore CA, USA after gaining her PhD. from Stanford University. Her major contributions and seminal papers center on the mechanical and physical properties of metals and alloys. She is the expert on deformation microstructures formed from very small to extreme strains and the prediction of flow stress. Her collaborations have included colleagues from the U.S., Europe, and China.

Bio-innovative modification of polyester using Amano Lipase and Chitosan

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University of Zagreb, Croatia

Polyester accounts for almost 80 % of the total production of synthetic fibers, of which poly(ethylene terephthalate), PET, is the most common. Development of bio-innovated polyester materials aimed for use in a hospital environment was investigated using Amano Lipase and Chitosan. The activation of the surface of PET fabric by hydrolysis with emphasis on the sustainability was investigated by using the process of alkaline hydrolysis at reduced temperature with the addition of an accelerator (cationic surfactant hexadecyltrimethylammonium chloride, HDTMAC) and hydrolysis with the environmentally friendly enzymes Amano Lipase from Pseudomonas fluorescens (ALAK). The chitosan was applied on the activated fabric surface by pad-dry-cure method with a homogenized chitosan solution in acetic acid. To determine the durability of the treatment, the antimicrobial efficacy of the functionalized fabrics was tested after 10 adapted industrial washing cycles. The enzymatically hydrolysed and functionalized PET fabric shows higher efficacy compared to the alkaline hydrolysed and chitosan-functionalized PET fabric, as it is also effective against micro fungi and the functionalization persists after multiple washing cycles. Such fabric can be used in the hospital environment as a replacement for disposable protective clothing.

Phase transformations and deformation mechanisms in nanocrystalline high entropy alloys

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High entropy alloys (HEA) and their variations (non-equiatomic HEAs, multi-phase HEAs, medium-entropy alloys and some others) embracing the broad family of complex concentrated alloys attract growing attention thanks to wide possibilities to tune their properties according to specific requirements. Their complex chemical composition allows multiscale microstructure design including formation of grain boundary segregations and various phases, concurrently precipitating depending on the concentration of particular alloying elements. Furthermore, the possibility to play with the stacking fault energy allows switching of deformation mechanisms from planar dislocation slip to twinning and faulting. In some cases deformation induced martensite formation and transformation induced plasticity effect can be achieved [1]. Moreover, grain size of the multicomponent solid solution can be easily refined to nanoscale range by application of severe plastic deformation [2]. In this presentation, the possibility to achieve remarkable mechanical properties in non-equiatomic nanocrystalline CoCrFeMnNi and Fe60Co15Ni15Cr10 thanks to microstructure design will be demonstrated.

Keywords: nanocrystalline, high entropy alloys, transformation-induced plasticity, mechanically driven phase transformations

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Biography

Yulia Ivanisenko graduated with a Diploma in Mechanical Engineering from Ufa State Aviation Technical University and received her PhD in applied physics at the Institute for Metals Superplasticity Problems of Russian Academy of Sciences in Ufa, Russia in 1990 and 1997, respectively. In 2001, she came to Germany as an Alexander-von-Humboldt fellow to work with Prof. H. Fecht at Ulm University. Since September 2003, she is affiliated at the Institute for Nanotechnology, Karlsruhe Institute for Technology, where she leads a research group. The research of Dr. Ivanisenko's is mostly in the areas of severe plastic deformation, mechanical properties of nanostructured materials and mechanically driven phase transformations.

Gastric Fluid-Powered Galvanic Cells as Self-activating Biobatteries for Ingestible Devices

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Ingestible devices are attracting potential research attention these days as it opens up a new way to access the gut conditions [1]. The main challenges behind the safe clinical translation of these devices are the requirement for reliable and safe power sources that can operate within the complex gastrointestinal environment [2]. Typically, batteries are regarded as the primary power source for these devices. However, their inherent toxicity and limitations of space and shelf life make them less suitable. One of the alternatives can be harvesting energy inside the body using the biobattery concept [2]. Gastric fluid-powered galvanic cells function as self-activating biobatteries, presenting a possible alternative to traditional batteries by directly harvesting energy from the stomach environment.

In this work, we present a novel Zn and MnO_2 nanoparticles-based galvanic cell integrated into an ingestible capsule and evaluated under in vitro gastric conditions. The galvanic cell utilizes zinc as the anode and manganese dioxide nanoparticles as the cathode, with simulated gastric fluid serving as the electrolyte. The system was fully assembled inside a capsule and tested using an in vitro setup that replicates key gastric parameters. Electrochemical performance was characterized in terms of open-circuit voltage, power output, and stability over time under continuous operation, which suggests the practical utility of the system. Under in vitro conditions, only one galvanic cell capsule can provide a stable voltage of 1.05 V. Moreover, all components exhibit biocompatibility, indicating their suitability for in vivo applications. This approach eliminates the necessity for pre-charged batteries and creates new possibilities for autonomous sensing and diagnostics in the gastrointestinal tract.

Keywords: Ingestible Devices, Gastric Fluid, Galvanic Cell, Nanoparticles

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Biography

Dr. Santanu Patra is currently working as a Postdoc at the Technical University of Denmark. He received his PhD from the Indian Institute of Technology (ISM), Dhanbad. His research is centered on materials chemistry, with a focus on integrating functional materials across macro-, micro-, and nanoscale systems. His current work involves developing advanced nanotechnological approaches for innovative sensing and energy-harvesting technologies aimed at healthcare and biomedical applications.

Achieving strength-ductility synergy of steels through partial recrystallisation and stress introduction

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In order to use less materials and to achieve lightweighting, high strength steels are in high demand. There are different strengthening methods (including grain size, phase balance, precipitation, cold work and solid solution strengthening) that can be used to increase the strength of steel. Most of these, however, come with a strength ductility trade-off.

Recovery and partial recrystallisation, also known as ‘back annealing’, has been used to retain as much as possible of the hardening due to cold rolling while gaining ductility by controlled low temperature heat treatment (lower than the full anneal temperature). It has been shown that the process window of partial recrystallisation can be very narrow and difficult to control in a conventional continuous annealing process line (CAPL).

In this study, 2 model steel alloys, Fe-30Ni austenitic steel and an extra low carbon ferritic steel, are used to study the influence of annealing temperature (affecting amount of recrystallisation) and subsequent second reduction or other stress introduction on the final mechanical strength. The austenitic steel and ferritic steel were selected to represent steels with different numbers of active slip systems and different levels of recovery before recrystallisation, both in single phase microstructures (avoiding any complexity caused by the existence of multi-phases). A low-temperature long annealing process is used to increase the size of the process window for partial recrystallisation and its controllability. The steels are hot rolled, cold rolled (85% reduction) and annealed at different peak temperatures, covering no recrystallisation (just recovery), partial recrystallisation and full recrystallisation, before a small stress is introduced. It is known that in hetero-structured materials the back stress acts on the soft regions and the forward stress acts on the hard regions, and this can promote a strength-ductility synergy. In this work, it is found that for the steels with certain partial recrystallisation percentage, if a certain small stress is introduced, a strength-ductility synergy can be achieved. Flat dog-bone tensile specimens were used to test the mechanical properties of the material. Scanning Electron Microscope (SEM) with Electron Backscatter Diffraction (EBSD) detector is used to analyse the microstructure of the steels at different stages, including KAM mapping, grain size and recrystallized grain distribution, to determine the mechanisms behind the strength-ductility synergy.

Keywords: Strength-ductility synergy, strengthening, partial recrystallisation, batch anneal

Engineering Functional Thin Films for Next-Generation Solar Photocatalysis

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The increasing scarcity of clean water resources, combined with the continuous release of emerging contaminants such as pharmaceuticals, dyes, and microplastics, represents a significant societal and environmental challenge. These chemically persistent contaminants are not adequately removed by conventional wastewater treatment technologies, creating an urgent need for sustainable, energy-efficient remediation strategies. Solar-driven photocatalysis provides a powerful approach to advanced oxidation processes, harnessing renewable solar energy to degrade recalcitrant organic pollutants [1].

Despite its long-standing role as a benchmark photocatalyst, titanium dioxide (TiO2) remains fundamentally limited by its wide band gap and restricted visible-light utilisation. Overcoming these intrinsic limitations requires a shift towards precision materials engineering, in which composition, morphology, and optical and electronic properties are controlled at the atomic scale. Due to its ability to precisely control thin-film thickness, composition, and defect chemistry, atomic layer deposition (ALD) is a suitable approach for this research [2].

In this study, pure and nitrogen-doped TiO2 thin films were synthesised on silicon substrates using thermal ALD. Titanium isopropoxide and water vapour were employed as the titanium and oxygen precursors, respectively, while ammonia gas served as the nitrogen source during the ALD cycles. Post-deposition calcination at 550 °C was carried out to enhance crystallinity and activate photocatalytic sites. The structural, morphological, and chemical properties of the resulting thin films were systematically analysed using X-ray diffraction, Raman spectroscopy, scanning electron microscopy, and X-ray photoelectron spectroscopy, enabling direct correlations between deposition parameters, material structure, and optical properties.

Photocatalytic performance was evaluated through the degradation of methylene blue under simulated solar irradiation. Nitrogen-doped TiO2 thin films exhibited enhanced photocatalytic efficiency compared with undoped TiO2, attributed to improved visible-light absorption and reduced charge-carrier recombination. These results highlight the effectiveness of nitrogen incorporation and atomic-scale thin-film engineering in tuning photocatalytic properties.

This research will emphasise structure–property–performance relationships in ALD-grown photocatalytic thin films and demonstrate how precision at the nanoscale can deliver stable, efficient, and scalable materials for solar-driven advanced oxidation processes. By integrating sustainable materials design, renewable energy utilisation, and advanced thin-film engineering, this research addresses global challenges in the provision of clean water and advances the transition towards a circular, water-resource-efficient economy, directly supporting the United Nations Sustainable Development Goals, with particular focus on SDG 6, 7, 9, and 12.

Keywords: thin film, atomic layer deposition, solar photocatalysis, wastewater purification

Acknowledgment

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Biography

Dr. Martina Kocijan defended her PhD in 2023 at FAMENA, University of Zagreb. In 2024, she became a Senior Assistant on the POMERI project at the Faculty of Physics, University of Rijeka. Her research focuses on functional nanostructured materials, solar photocatalysis, and advanced characterization techniques to develop sustainable solutions to environmental challenges. Her work addresses pollutant degradation in water and promotes clean water conservation through the 3Rs: Reduce, Reuse, and Recycle. She has a strong international profile, evidenced by projects funded through competitive fellowships in the UK, Hungary, Slovenia, and Portugal. She has published 12 peer-reviewed articles and delivered more than 40 conference presentations. She serves on editorial boards and programme committees, and has been a guest editor for two Special Issues in the journal Water. She organizes the annual international workshop Small Molecules, Big Problems, bringing together students, young researchers, and experts to present novel research and key innovations.

Formation of reverted austenite in martensitic stainless steels

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The influence of the heat treatment on an essentially interstitial free, martensitic stainless steel with approx. 15 mass %Cr and 5 mass %Ni is investigated. After austenitization and quenching, the phase transformations during the subsequent tempering regime are characterized using in-situ X-ray diffraction. The maximum isothermal tempering temperature ranges from 200 to 750°C. Reverted austenite forms at tempering temperatures above 500°C. A high mass fraction of reverted austenite is linked to a high toughness. Austenite remains stable during cooling for tempering temperatures up to 600°C, but partially transforms back to martensite at higher tempering temperatures (see Fig. 1a and 1b). Additionally, it is found that the mass fraction of austenite depends on tempering time (Fig. 1a, compare 2h and 10h tempering). Deviation from equilibrium and compositional inhomogeneities are obviously present for medium tempering temperatures (500°C - 600°C) and not too long tempering times. A kinetic model was developed to describe the non-equilibrium conditions inherent in reverted austenite formation. Based on this model the complex phase transformation kinetics is captured qualitatively. The retransformation to martensite is prevented by a relatively high mass fraction of Ni and Ni-gradients in the austenite when tempering temperatures are below 650°C. At higher tempering temperatures, a lower and more uniformly distributed mass fraction of Ni in austenite permits the retransformation to martensite.

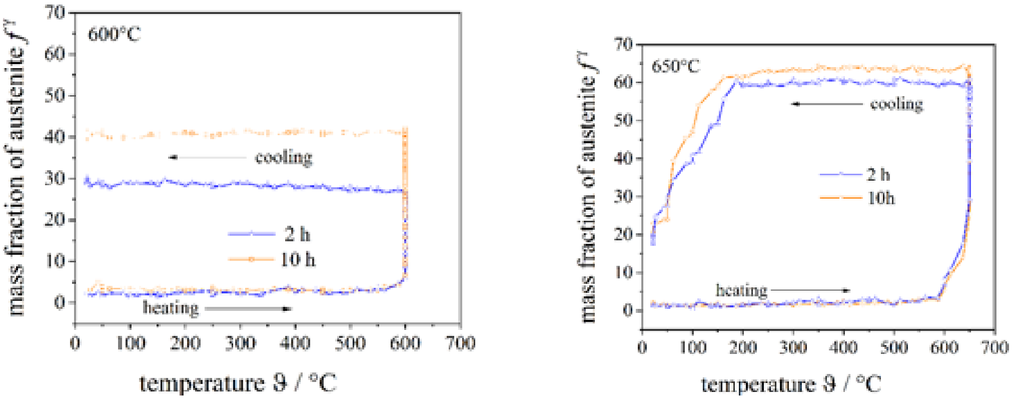

Fig. 1: Evolution of the mass fraction of austenite during heating, holding at the tempering temperature and cooling deduced from X-ray diffraction. (a) Tempering at 600°C, (b) Tempering at 650°C.

Keywords: Martensitic stainless steel, kinetics of phase transformations, reverted austenite, in-situ X-ray diffraction, non-equilibrium thermodynamics.

Bi_2Se_3 for broadband photodetectors

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Bismuth selenide (Bi_2Se_3) belongs to the class of layered topological insulators (TIs) showing unique electronic state of quantum matter with bulk semiconducting behaviour and Dirac topological surface state (TSS). Bi_2Se_3 with its narrow band-gap (0.3 eV) has gained an increasing attention as a popular material for photodetection applications, exhibiting optical absorbance from ultraviolet (UV) to infrared (IR) radiations. [1,2] Its topologically protected surface states prevent backscattering and make it ideal for both efficient charge transport and collection. However, pure Bi_2Se_3 based on its Dirac TSS have been reported to give rise to devices with large dark current. Therefore, several materials have been proposed to fabricate heterojunction with Bi_2Se_3. In this respect, of particular interest, is the Bi_2Se_3/Si one, because of the possibility to obtain photodetectors (PDs) exploiting the Si-technology while extending the Si spectral band toward the IR and the near UV. [2] In addition, the high mobility Dirac TSS of the Bi_2Se_3 is expected to reduce the response time and to increase the responsivity (R) and the detectivity (D) of the device as for the graphene/Si PDs. [2,3]

Unfortunately, Bi_2Se_3/Si PDs present reduced performances in the IR range because of the much lower optical absorbance of Bi_2Se_3 with respect to the visible region and the absence of the contribution of the Si photocharges. On the other hand, Te is a two-dimensional material with thickness dependent bandgap which extends from 0.3 eV for bulk material up to 1.2 eV in the case of a monolayer. Since the optical absorbance of Te films is higher than that of Bi_2Se_3 with the same thickness, these films are expected to increase the PD response in the IR region. In this talk, we present the results of a study on Bi_2Se_3/Si and Te/Bi_2Se_3/Si PD performances, which have been realized to exploit the Si-technology while extending the Si spectral band toward the IR and the near UV as well as making such broadband PDs faster than the commercial ones. [2,3]

Keywords: Photodetectors, van der Walls heterostructures

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Building New Metal Oxide Architectures: Novel Ir and Ru Cluster Discovery

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A key structural feature across the stannate clusters is the formation of MSn_6-octahedra filled with different transition metals, forming either isolated or one-dimensional endless chains through shared corners and edges of the $[MSn_6]$-octahedra [1]. As the transition metal to tin ratio decreases, the coordination state of condensation increases systematically. Compounds like $RuSn_6[(Al_{1/3-x}Si_{3x/4})O_4]_2$, $Fe_4Si_2Sn_7O_{16}$ and $FeMn_3Ge_2Sn_7O_{16}$, where $[MSn_6]$-octahedra do not condense, have been identified [2-4]. The novel cluster compounds $RuIn_6Sn_6O_{16}$[5] and $Ru_4In_2Sn_{20}O_{21}$[6] have recently been discovered, which exhibit new types of structures with proposed In^{+} and In^{3+} sites in addition to the possible oxidation states of Sn^{2+} and Sn^{1+}. $RuIn_6Sn_6O_{16}$ contains highly ordered Sn/In sites with an alternating discrete $Ru(Sn)_6$ octahedra encapsulated in an indium oxide layer and additional substructure formed by indium occupying a site of sevenfold coordination. $Ru_4In_2Sn_{20}O_{21}$ show the formation of isolated and condensed clusters $RuSn_6$ clusters in the same compound for the first time. So far, only either isolated or condensed clusters could be found in a compound. $Ru_4In_2Sn_{20}O_{21}$ could be seen as a combination of $Ru_3Sn_{15}O_{14}$ and a (hypothetical) $RuSn_6[SnO_4]O_4$.

The presentation will summarize the preparation and properties of these interesting novel materials.

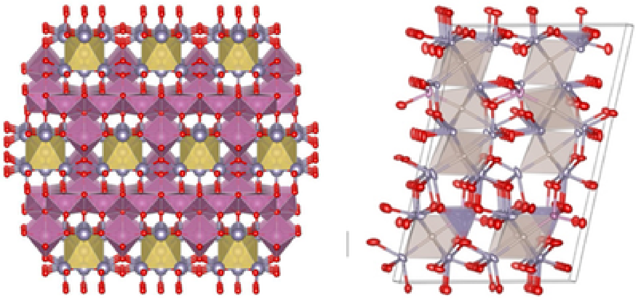

Figure 1. The crystal structure of $RuIn_6Sn_6O_{16}$ (left): discrete $Ru(Sn)_6$ octahedra (gold) and $In(O)_6$, $In(O)_7$ polyhedra (purple); $Ru_4In_2Sn_{20}O_{21}$ (right) showing discrete and condensed $Ru(Sn)_6$ octahedra.

Keywords: Ru clusters, Sn-In Mixed main group clusters, Catalysis, Photoluminescence

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Biological constraints and design strategies for advanced bacterial cellulose-based Engineered Living Materials

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Komagataeibacter spp., native producers of bacterial nanocellulose (BC), are attractive chassis for biological engineered living materials (bioELM). However, their use beyond laboratory demonstrations is constrained by intrinsic biological limitations that are still poorly understood. Here, we present two interconnected lines of investigation that together define these constraints and outline a path toward more robust and programmable Komagataeibacter-based bioELMs.

A central challenge in BC-based bioELM design is biopolymer functionalization. While Komagataeibacter is typically used as a structural scaffold producer, functionalization is delegated to auxiliary secretion hosts1. We show that this separation can be overcome by engineering signal peptide-mediated recombinant protein secretion directly in Komagataeibacter via its native Sec-translocase2. Using two structurally and functionally distinct proteins, we demonstrate strong signal peptide-cargo context dependence. While this establishes a secretion-enabled bioELM chassis, routine agitation reproducibly induced a transition from BC-producing cells to non-producing mutants.

This phenotypic transition is widely recognized within the research community3. However, current understanding of Komagataeibacter biology has largely focused on gene content rather than genome dynamics. To address this gap, we investigated the genome-wide mutational dynamics under agitated conditions4. Population-level sequencing revealed both structural variations (SVs) and non-structural variations (NSVs). Importantly, BC impairment was not consistently driven by large-scale genome rearrangements across the genus, as previously assumed3. Instead, the accumulation and selection of NSVs emerged as equally critical contributors. In addition, genomic signatures implicated that both genetic and regulatory layers contribute to the disruption of BC synthesis.

Together, these studies highlight genome stability as a key constraint for implementing advanced bioELM functionalities and inform strategies for engineering Komagataeibacter as a more predictable and scalable living material platform.

Keywords: Komagataeibacter, bacterial nanocellulose, biological engineered living materials, genome shuffling

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Biography

Rahul Mangayil is an Academy Research Fellow and Assistant Professor of Bioprocess Engineering at Aalto University, Finland. His research focuses on engineering non-model, industrially relevant microorganisms for sustainable biochemical and biomaterial production. His work spans synthetic biology, microbial physiology, and bioprocess engineering, with research themes ranging from investigating the metabolic landscape of acetogenic bacteria under mixotrophic fermentation to developing robust microbial platforms for circular bioeconomy applications.

A major research focus of Dr. Mangayil's group is on Komagataeibacter, a native producer of bacterial nanocellulose. His work aims to transform these biomaterial-producing bacteria into programmable cell factories that can functionalize the material as it is being formed, rather than as a downstream process. To achieve this, his group combines synthetic biology tool development with population-level genome biology to understand and engineer genome stability, secretion capacity, and functional robustness. Through this integrated approach, his research advances Komagataeibacter as a chassis for advanced biomaterials.

Sliding friction measured over individual covalent bonds

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Unveiling the dynamics and energy dissipation involved in atomic scale motion is key to understanding surface catalysis, molecular motors, and single molecule manipulation. Despite significant progress in nanoscale friction studies, due to challenges in atomistically defining the sliding surfaces, there are outstanding problems regarding reproducibility, isolating nonconservative interactions, and in general reconciling atomistic theory with experimental results. This has prompted investigations with precise control at the single atom scale. We use a single atom asperity as one sliding surface. High spatial resolution allows us to investigate individual chemical bonds and address the question of how the nature of a chemical bond affects sliding friction. Surprisingly, we find a large variety in sliding friction over covalent bonds. Density functional theory-based simulations yield excellent agreement with the data and reveal that sliding friction is correlated to bond order. Finally, we show that over hydrogen bonds, the maximum magnitude of sliding friction can be similar to friction over covalent bonds, however that interaction is not with a bond (increased electron density between the atoms). These findings offer new insights into atomic-scale motion and show that the frictional properties of advanced materials and nanodevices can be tuned by selecting the nature and order of chemical bonds at surfaces.

Keywords: Scanning probe microscopy, Lateral force microscopy, Energy dissipation, Single molecule, friction

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Biography

Shinjae Nam is a postdoc in physics at the center for QNS, South Korea. She specializes in atomic-scale microscopy and imaging techniques. Her research focuses on lateral force measurements with single-atom resolution, particularly investigating various factors contributing to friction over surfaces. She has extensive experience with cryogenic UHV systems, STM/AFM instrumentation, and sensor fabrication.

Posters

Vacuum-Based Synthesis and Structural Characterization of $AgBiS_2$ Thin Films for Sustainable Optoelectronics

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Silver bismuth sulfide ($AgBiS_2$) is a promising semiconductor material for optoelectronic applications due to its suitable bandgap, non-toxicity, and favorable absorption characteristics [1].

In this study, we present a simple and effective approach for the synthesis of $AgBiS_2$ thin films. First, the films were prepared via magnetron sputtering of metallic Ag and Bi layers, followed by post-deposition sulfurization at temperatures ranging from 250 to 450 °C. The synthesized $AgBiS_2$ films exhibit optical bandgap values around 1.0–1.1 eV, which are suitable for photovoltaic and photodetector devices. The films showed an enhanced photoresponse, with a pronounced photocurrent under visible light illumination. The results highlight that the proposed synthesis route provides good control over film composition and ensures the essential structural and optoelectronic properties of $AgBiS_2$ thin films, making them highly suitable for use in future reproducible, non-toxic energy and optoelectronic applications. This work demonstrates a fast, reproducible, and energy-efficient route to high-quality $AgBiS_2$ thin films with uniform morphology and targeted optoelectronic properties. Our findings suggest that $AgBiS_2$ is a promising candidate for next-generation optoelectronic and photovoltaic materials and highlight the potential of scalable vacuum-based synthesis methods.

The research was funded by the Economic Recovery and Resilience Facility “New Generation Lithuania” (Project No. 10-38-T-0293).

Keywords: Green materials, magnetron sputtering, thin films.

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Biography

V. Pakstas is a Senior Researcher at the Center for Physical Sciences and Technology, Department of Characterization of Materials Structure. He has co-authored 117 scientific papers (h-index 19). His research focuses on thin-film materials for renewable and solar energy applications, with particular expertise in XRD, XRF, and AFM techniques for micro- and nanoscale materials characterization. His work supports the development of efficient and sustainable energy technologies.

Synthesis Methods of Calcium Phosphates and Their Impact on Cellular Response

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Calcium phosphate (CaP) ceramics are widely recognized for their excellent biocompatibility, bioactivity, making them highly valuable in biomedical applications [1]. They are used in tissue engineering, implantology, and as reinforcing phases in composite materials for 3D printing, where they improve both mechanical properties and biological performance of scaffolds [2]. The biological activity of CaPs is strongly influenced by their structure, chemical composition, and synthesis route. In this study, CaP powders were synthesized using three wet-precipitation methods: ANP ($NH_4H_2PO_4$ + $Ca(NO_3)_2$), ABP (H_3PO_4 + $Ca(OH)_4$), and ACP (Na_2HPO_4 + $(CH_3COO)_2Ca$), with Ca/P molar ratios between 1.5 and 1.67. Cytocompatibility was assessed using L-929 fibroblasts and hFOB 1.19 osteoblasts. ACP powders showed the broadest cytocompatible concentration range (1–0.1 mg/mL) for L-929 cells, while ACP 1.5 was most effective for hFOB 1.19 cells. A concentration of 0.1 mg/mL ensured ≥70% metabolic activity across all samples. Notably, ACP powders with Ca/P ratios of 1.0 and 1.5 activated the NF-κB pathway at non-toxic concentrations. Certain formulations offer both high biocompatibility and the ability to activate cellular signaling pathways, highlighting their potential for future use in regenerative medicine and bioactive, 3D-printed composite materials.

Acknowledgement: The authors gratefully acknowledge the financial support of the project: “Bioactive composite granules with potential for 3D printing LIDER14/0266/2023”.

Keywords: calcium phosphate, regenerative medicine, cytocompatibility, bone

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Biography

Dagmara Słota – PhD student in materials engineering, conducting innovative and interdisciplinary research on polymer-ceramic composites for bone and cartilage regeneration. Her work focuses on bioactive carriers for regenerative medicine.

Effect of Synthesis Methods on the Physicochemical Properties of Calcium Phosphate Ceramics

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Calcium phosphate ceramics (CPCs) are commonly used in bone tissue engineering due to their biocompatibility, osteoconductivity, and similarity to natural bone [1]. Advances in 3D printing have enabled the production of porous, patient-specific implants that support osseointegration and biodegradation. The final properties of CPCs, however, are strongly influenced by synthesis and processing methods [2]. To improve mechanical performance, they can be combined with thermoplastics to form tougher, more durable composites [3].Calcium phosphate powders were synthesized using the wet precipitation method under carefully selected reaction conditions, employing Acid-Base Precipitation (ABP), Acetate Precipitation (ACP), and Ammonium Nitrate Precipitation (ANP). The influence of synthesis parameters was assessed using Fourier transform infrared spectroscopy (FT-IR), X-ray diffraction (XRD), and scanning electron microscopy with energy-dispersive spectroscopy (SEM-EDS) to analyze functional groups, phase composition, elemental content, and morphology. Morphological analysis revealed distinct differences between samples: ANP powders formed large, irregular agglomerates; ABP powders were smaller and more uniform; ACP powders exhibited cauliflower-like structures. Elemental mapping confirmed the presence of calcium and phosphorus, while XRD analysis indicated the formation of hydroxyapatite. The results demonstrate that synthesis methods strongly influence the physicochemical properties of calcium phosphate powders, making them suitable for bone tissue engineering applications.

Acknowledgement: The authors gratefully acknowledge the financial support of the project: “Bioactive composite granules with potential for 3D printing LIDER14/0266/2023”.

Keywords: calcium phosphate, regenerative medicine, cytocompatibility, bone

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Biography

Karina Niziołek – MSc, PhD student in materials engineering, specializing in polymer-ceramic biomaterials for bone and cartilage regeneration. Her research focuses on developing active substance carriers for regenerative medicine.

Bioactive granules based on PEEK for 3D printing biomaterials.

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The paper presents the process of obtaining composite granules for use in 3D printing technology, based on a polyetheretherketone (PEEK) matrix with the addition of apatite ceramics. The obtained granules were subjected to a preliminary assessment of their functional and biological properties in the context of their potential use as a biomedical material for the production of personalised implants. Due to its excellent properties, PEEK is sought after in implantology, while apatite ceramics exhibit bioactive properties that are extremely important in the context of biomaterials [1]. The mechanical properties of the granules were determined on the basis of hardness measurements. The biological evaluation was carried out using mouse fibroblast (L929) and human osteoblast (hFOB 1.19) cultures, determining both cytotoxicity and metabolic activity of the cells. The biological activity analysis showed no negative effect of the composite on fibroblast viability and a favourable effect on osteoblast metabolism, indicating the potential osteoconductive properties of the material. In addition, the surface structure of the granules was characterised by scanning electron microscopy (SEM), which allowed observation of the topography and phase distribution of the composite. The results indicate that the obtained granules are characterised by favourable mechanical properties, adequate bioactivity and a microstructure predisposing them to further application research in the field of implantology and regenerative medicine.

The authors gratefully acknowledge the financial support of the project: “Bioactive composite granules with potential for 3D printing LIDER14/0266/2023”.

Keywords: filament, biomaterials, PEEK, apatite ceramic, 3D printing, mechanical testing

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Biography

Julia Sadlik is a PhD student at the Cracow University of Technology, Faculty of Materials Science and Engineering. She works on a team that specializes in biomaterials, focusing primarily on bone tissue and skin. Her research interests includes the sintering of titanium alloys and bioprinting.

Eco-Active Antimicrobial Films: Functionalized Polycaprolactone for Sustainable Infection Control

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The development of biodegradable polymer materials with antimicrobial properties is of increasing importance in the context of environmental safety and infection control. The aim of this study was to develop polycaprolactone (PCL) films modified with benzimidazole and to comprehensively evaluate their biological and environmental properties.

PCL-based films containing benzimidazole were prepared and subjected to detailed characterization. Antibacterial and antifungal activity was assessed against selected reference strains. Diffusion-contact assays demonstrated a clear reduction in microbial growth in the vicinity of modified samples compared to the unmodified control. The antimicrobial effect was dependent on the concentration of the additive, indicating its effective role in limiting surface colonization. Visual analysis of culture plates revealed a decreased number of colonies and reduced formation of compact biofilm structures around benzimidazole-containing films.

Environmental safety was examined through mutagenicity testing and analysis of the effect of benzimidazole-containing materials on seed germination and early plant development. The results indicate that benzimidazole-modified PCL films exhibit promising antimicrobial activity while maintaining an acceptable environmental safety profile. These findings suggest that biodegradable PCL films functionalized with benzimidazole may serve as a sustainable alternative for antimicrobial applications.

Keywords: biodegradable polymers, polycaprolactone, benzimidazole, antimicrobial materials

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Viscoelastic characteristics of plant tissue on the example of sugar beet root tissue

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Identification and evaluation of the mechanical properties of biological materials, especially fruits, vegetables and industrial plants, can be carried out through commonly used stress relaxation tests. The tests are of particular significance because their results make it possible to propose a mechanical model of studied material. The aim of the study was to determine the effects of initial deformation and deformation velocity on the parameters of generalised Maxwell model during stress relaxation in sugar beet root. Tests were performed with texture analyser at three deformations: 2 mm, 3.5 mm and 5 mm and four deformation velocities: 1 mm/s, 2 mm/s, 10 mm/s and 20 mm/s. The cut sugar beet samples used for the experiment were cylindrical in shape, with 9.5 mm in diameter and 20 mm in height. The samples were initially compressed along the vertical axis in the state of uniaxial stress and constant deformation was maintained while recording the force response for 35 seconds. Two-branched generalised Maxwell model with an additional elastic element was used to describe the experimental force response curves. Dimensions of the sample as well as initial deformation velocity were taken into consideration in the model formula. Two relaxation times of the model decreased with the increase of deformation velocity and increased with the increase of deformation value. The relaxation times were related to the process of gas and liquid flows in the intercellular spaces. Changes of model parameters in the function of deformation velocity could testify the appearance of internal micro damages in the material during deformation. The increase in the peak force response along with the increase of deformation velocity shows typical viscoelastic behaviour of sugar beet root flesh.

Environmental safety was examined through mutagenicity testing and analysis of the effect of benzimidazole-containing materials on seed germination and early plant development. The results indicate that benzimidazole-modified PCL films exhibit promising antimicrobial activity while maintaining an acceptable environmental safety profile. These findings suggest that biodegradable PCL films functionalized with benzimidazole may serve as a sustainable alternative for antimicrobial applications.

Keywords: stress relaxation, generalized Maxwell model, viscoelasticity, sugar beet root

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Enhancing Breakdown Strength of Atomic Layer Deposition-deposited TiO_2 Thin-Films for Si Capacitor Applications

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TiO_2 thin film has attracted significant attention for Si capacitor applications owing to its relatively high permittivity ($\varepsilon_r \approx 30–75$), compared to that of a commercial SiO_2 ($\varepsilon_r \approx 4$)-based one. However, TiO_2-based thin-film capacitors typically suffered from low breakdown strength (BDS), primarily attributed to the narrow bandgap (~3.2 eV) and high concentration of oxygen vacancies.[1]Here, we explore atomic layer deposition (ALD)-grown TiO_2 thin-film capacitors incorporating with an Al_2O_3 interlayer to overcome intrinsically limited BDV strength. The insertion of Al_2O_3 interlayer into TiO_2 results in a substantially enhanced BDV strength (≈11 V), compared to those of pristine TiO_2 capacitor (BDV < 1 V). To further enhance BDS, Al was doped into the TiO_2 in conjunction with Al_2O_3. The resultant device exhibited a further increase in BDV (≈14 V) along with a significantly reduced leakage current density (~5.24×10^{-6} A/cm²) at the rated voltage (~3.6 V). These results are attributed to the suppression of interfacial reaction between defects in TiO_2 and metals, driven by wide bandgap of Al_2O_3 interlayer and Al doping.

Keywords: TiO_2 thin film, Al_2O_3 interfacial layer, Breakdown Voltage, Si capacitor

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Biography

S. H. Kim is a master's student at GNU and KICET, working on ALD-based TiO_2/Al_2O_3 dielectrics for MIM capacitors. S. Y. Kim is working on thin-film capacitor application at GNU. S.-S. Chee and Y. Je are working on passive components at KICET.

Development of Nanostructured Biocement Based on Tricalcium Silicate and Niobium Pentoxide: Evaluation of Physical-Chemical Properties and Biocompatibility

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Clinkerization, the traditional method for C_3S synthesis, requires elevated temperatures (~1430 °C), multiple grinding steps, and inevitably produces unwanted secondary phases (CaO and C2S), resulting in reduced purity. Citrate- nitrate combustion synthesis overcomes these limitations, producing high-purity biocements in a single step. This work evaluates a C3S-based biocement incorporating niobium pentoxide (Nb2O5) as an innovative radiopacifier, replacing toxic bismuth oxide (Bi2O3), synthesized by citrate-nitrate combustion method ($\chi = 7$) at 600 °C with 1000 °C heat treatment. Four formulations (pure C3S and C3S with 15, 20, 25 wt% Nb2O5) were synthesized. Characterization included structural analysis (TGA/DSC, XRD with Rietveld refinement, SEM, FTIR), and surface analysis (BET/BJH). Clinical properties included radiopacity, setting time, pH (1–28 days), and apatite deposition in simulated body fluid. Biological assays included hemolysis (ASTM E2524-08) and cell viability (MTT) On fibroblasts. Combustion synthesis produced 99.2% monoclinic C3S (22.78 nm). The C3S-20 wt% Nb2O5 formulation exhibited ideal properties: radiopacity 3.54 mm Al (>3 mm Al ISO 6876), setting time 8.37 min, pH 11.5 (28 days), and carbonate apatite deposition. Hemolysis was negligible (<1%) at physiological concentrations (20–40 µg/mL), and cell viability exceeded 70% at all concentrations. Nb2O5 emerges as a superior radiopacifier enabling high-purity, nanometric C3S-based biocements for periapical repairs and endodontic regeneration.

Keywords: Tricalcium silicate, niobium pentoxide, combustion synthesis, biocompatibility, biocements, nanotechnology.

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[3] A. V. Bernardi, F. Raupp-Pereira, N. M. Possolli, S. Arcaro, O. R. K. Montedo, M. A. P. M. Nunes, J. Therm. Anal. Calorim., 147, 2083–2090, (2022)

Biography

Giovane Betinelli is a Materials Science Ph.D. student at UNESC, Brazil, specializing in combustion synthesis of endodontic biocements. He has published in Ceramics International and holds a patent for high-purity nanostructured tricalcium silicate. Betinelli actively collaborates with Instituto Politécnico de Viana do Castelo, Portugal, on biomaterials research.

Biocement with Zinc Oxide Combustion: Validation of Mechanisms of Action in Endodontic Bioceramic Cements

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The search for materials with superior performance in endodontic repairs drives the development of new formulations with high purity and nanometric size. This work presents combustion synthesis as a possible strategy for obtaining nanostructured tricalcium silicate (C3S)-based cements, exploring the mechanisms of interaction between biocement and zinc oxide (ZnO), as a radiopacifier, in different proportions for application as a material in dentistry. The nanostructured biocement was synthesized by the self-ignition combustion method (600 °C) using citric acid as fuel, calcium nitrate as oxidant, and tetraethyl orthosilicate (TEOS) as a source of silica. Subsequently, the material was heat treated at 1000 °C. Four formulations (pure C3S and C3S with 20, 25, and 30 wt% ZnO). Characterization was performed by TGA/DSC, XRD with Rietveld refinement, TEM, SEM, and FTIR. Additionally, setting time, radiopacity, flow, mechanical compressive strength, and cell viability were determined. From the combustion synthesis, the C3S phase of the monoclinic polymorph was obtained with a purity of 99.2% and a nanometric crystallite size of 23 nm, confirming the high purity and reactivity of the biocement. The 80%C3S-20%ZnO composition had a reduced setting time (8.5 minutes), meeting the clinical requirements for endodontic materials, as well as a flow of ∅18.03 mm, indicating potential use as a repair material. The biocement also presented adequate radiopacity (3.83 mm Al). In addition, it showed no cytotoxicity in murine fibroblast assays. Combustion synthesis proved to be an efficient route for obtaining nanostructured endodontic biocements with superior properties compared to traditional synthesis methods. The 80% C3S-20%ZnO formulation resulted in a biocement with high potential for clinical applications in dentistry, particularly in endodontics, and mainly as a material for tissue regeneration.

Keywords: Tricalcium silicate, zinc oxide, combustion synthesis, biocements, biocompatibility.

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Biography

Giovane Betinelli is a Materials Science Ph.D. student at UNESC, Brazil, specializing in combustion synthesis of endodontic biocements. He has published in Ceramics International and holds a patent for high-purity nanostructured tricalcium silicate. Betinelli actively collaborates with Instituto Politécnico de Viana do Castelo, Portugal, on biomaterials research.

Effect of Surface Treatment and Resizing on the Interfacial Bonding Properties of PA6 with Recycled Carbon Fibers for Upcycling

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In this study, recycled carbon fibers (rCFs) recovered from waste carbon fiber–reinforced plastics (CFRPs) were upcycled through chemical desizing, surface treatment, and resizing processes. The effects of treatment temperature and time on mechanical and chemical properties, as well as oxygen functional group evolution, were investigated to enable the reuse of rCFs with performance comparable to commercial carbon fibers.

Chemical desizing with acetone at 60 °C for 0.5 h completely removed the sizing agent, and subsequent nitric acid treatment at 100 °C for 1 h provided optimal surface modification without degrading tensile properties, whereas prolonged treatment led to mechanical deterioration. Functional group analysis indicated that increased treatment time promoted the formation of oxygen-containing functional groups, resulting in changes in interfacial bonding strength.

For resizing, optimal surface coating was achieved using a PA6-based sizing agent at 1 wt.% for 10 s, significantly enhancing interfacial adhesion. Under these conditions, the interfacial shear strength reached 32 MPa, approximately 15% higher than that of commercial carbon fibers, demonstrating the potential of upcycled rCFs for high-performance composite applications.

Keywords: Recycled carbon fiber, Upcycling, Surface treatment, Resizing, Interfacial adhesion, PA6

Biography

Daeup Kim received his Ph.D. in Metallurgical Engineering. He is currently a researcher at the Korea Institute of Industrial Technology (KITECH). His research interests include metal and composite materials, surface modification, interfacial properties, and sustainable materials processing, with a particular focus on recycling and upcycling technologies.

Data-Driven Optimization of More Sustainable High Entropy Perovskites for Oxygen Evolution Catalysts

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This work presents a data-driven strategy for developing low-Ru, high entropy La(RuwNixMnyFez)O3 Perovskite (w+x+y+z=1) catalysts for the Oxygen Evolution Reaction (OER), aimed at reducing dependence on critical and expensive noble metals. An initial library of thirty compositions was synthesised via a two-step process involving Continuous Hydrothermal Flow Synthesis (co-precipitation),[1,2] followed by heat-treatment (8 h, 800 °C in air). Structural/compositional analysis confirmed phase-pure orthorhombic LaFeO3-type (Pnma) had been formed in all but one case (with the most Ru-rich sample showing minor extra rutile RuO2 impurity peaks). Electrochemical screening identified two initial performance champions: La0.94Ru0.46Ni0.10Mn0.16Fe0.34O3 (moderate Ru content, onset at 358 mV at a current density of 10 mA·cm-2) and La1.00Ru0.16Ni0.30Mn0.22Fe0.32O3 (low Ru content, onset at 325 mV at a current density of 10 mA·cm-2, with excellent stability of 70 h at 10 mA·cm-2 with only 4% decay). Subsequently using the data from the first round of synthesis and electrochemical screening, Machine Learning (ML)-guided synthesis (round 2) was used to predict the composition of twelve high performing samples (split into moderate vs. low Ru content). Consequently, this produced significantly better OER performance; In round 2, the champion samples were La1.00Ru0.10Ni0.38Mn0.18Fe0.34O3 (329 mV, Tafel slope 79 mV·dec-1, 93% retention after 106 h at 10 mA·cm-2; durable to 30 mA·cm-2) and La1.02Ru0.16Ni0.36Mn0.12Fe0.34O3 (269 mV, Tafel slope 62 mV·dec-1, > 90% retention after 85 h at 10 mA·cm-2 and with outstanding stability with 92% retention after 45 h at 30 mA·cm-2).

Overall, this combined experimental and ML-guided approach accelerates the discovery of cost-effective, stable, and sustainable OER catalysts with reduced noble-metal content. By integrating machine learning with sustainable composition design, the work aligns strongly with the Energy & Harvesting Materials theme, while also contributing to Advanced and Novel Materials through the development of compositionally complex, data-driven perovskite catalysts.

Keywords: high entropy oxides, Perovskites, oxygen evolution reaction, Ruthenium minimisation, continuous hydrothermal flow synthesis, AI-guided materials discovery

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Interfacial Characteristics of Carbon Fiber Composites Using Micro-mechanical and Acoustic Emission Technique

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Interfacial characteristics of carbon fiber reinforced composite (CFRP) for wind turbine blades were evaluated using Acoustic Emission(AE). Micro-mechanical failure patterns and the acoustic characteristics of CFRP were analyzed as function of the failure-induced source. Various AE signals were classified using the K-means clustering algorithm[1].

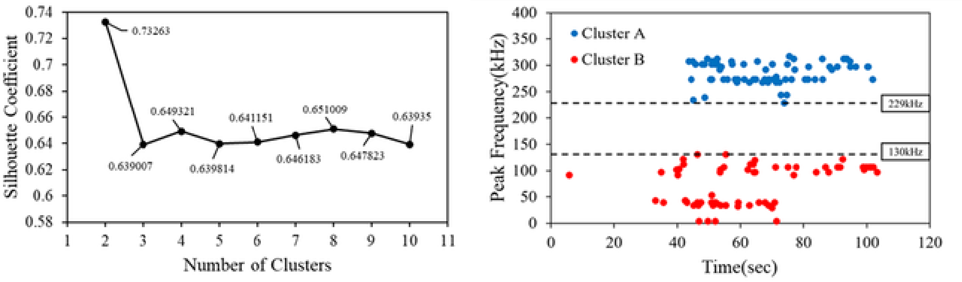

Fig 1. K-means clustering results of single carbon fiber composites

The classification criteria for failure-induced signals of CFRP were investigated. In this study Effective approach of damage patterns analysis in Wind blade composites materials could be provided.

Keywords: Acoustic Emission, Composite Materials, Wind Turbine Blades, K-means clustering

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Acknowledgement

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Bi content-driven Dielectric Permittivity of BiZnNbO Ceramics governed by Locally Structural Distortion

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Dielectric materials with high permittivity and low loss are essential for miniaturized energy strorage devices. $Bi_xZn_yNb_zO_y$ (BZNO) exhibits a high theoretical dielectric constant (~200), low dielectric loss, and high breakdown strength.[1] Bi content in BZNO influences its dielectric properties, but the underlying mechanism remains still unclear. Here, Bi content in BZNO was systematically varied to examine its inflluence on defects and dielectric behavior. The dielectric constant increased with increasing Bi content, reached 159.4 at 1.5 mol, and gradually decreased to 138.2 for 1.66 mol of Bi content. This trend results from Bi-induced changes in oxygen vacancies and microstrain. Although all samples retained a pyrochlore phase, balanced defect and lattice distortion at 1.5 mol enhanced dielectric performance, whereas imbalance reduced it. Our study show that dielectric behavior in BZNO is governed by defect-straininterplay interplay rather than phase variation, suggesting a defect-engineered strategy for high-permittivity capacitors.

Keywords: BiZnNbO, Dielectric permittivity, Pyrochlore, local distortion

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Biography

J. H. Lee is a master’s student at KU and KICET, working on pyrochlore BZNO dielectrics for ceramic capacitors. Prof. S. J. Oh is working on ceramic-based electrical application at KU. Dr. H. S. Shin and Dr. S.-S. Chee are working on high-k ceramic-based passive components at KICET.

Mechanochemical Synthesis of Poly(arylacetylene)s and the Effect of Additives on Molecular Structure

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Mechanochemical (MC) synthesis has emerged as a sustainable, eco-friendly methodology that minimizes solvent use. We previously reported that solid additives serve as effective cushioning agents, suppressing scission of polymer chains and unintended cis-to-trans isomerization of the polyacetylene main chain during MC synthesis of helical poly(arylacetylene)s[1]. Based on these results, the present study investigates how the molecular structure of alcohol additives influences the precise control of the helical conformation and the optical properties of poly(2-ethynylnaphthalene) (P2EN) obtained via a Rh-catalyzed MC process with various linear alcohols (Scheme 1). Additive-free synthesis produced brown polymers due to pressure-induced cis-trans isomerization, whereas the addition of alcohols maintained a high cis-content (Table 1). Remarkably, the polymer color shifted from yellow to red as the alkyl chain length of the alcohol increased, indicating a transition in helical pitch of the main chain. Comparative solution polymerizations consistently yielded yellow polymers regardless of the alkyl chain length of the alcohol used. This result confirms that controlling helical structures via additive structure is a phenomenon unique to the mechanochemical environment[2].

Scheme 1. Mchanochemical synthesis of **P2EN**.

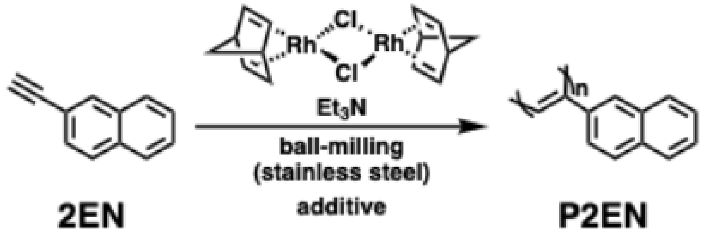
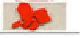


Table 1. Polymerization results of **2EN**[a].

Entry	P2EN	$H(CH_2)_nOH$	Yield (%)	Color
1	**PN(M)**[b]	-	77	
2	**P1(M)**[b]	1	88	
3	**P2(M)**[b]	2	96	
4	**P4(M)**[b]	4	94	
5	**P8(M)**[b]	8	93	
6	**P12(M)**[b]	12	91	
7	**P16(M)**[b]	16	97	
8	**P22(M)**[b]	22	75	

[a] Reaction time is 30 min. [b] Conditions of mechanochemical method: Mole ratio(**2EN**/Rh cat./Et_3N) is 100/1/50. The weight of the **2EN** and additive are 300 mg and 600 mg, respectively.

Keywords: polyacetylene, isomerization, helix, mechanochemical reaction, solid state, color

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Biography

Haruki Ikushima is a Ph.D. candidate at Muroran Institute of Technology. His research focuses on the synthesis and structural analysis of helical poly(arylacetylene)s. He is currently a research fellow under the SPRING program.

LCST-like Phase Separation Behavior of Alkyl Gallates with Oligoethylene Glycol Chains

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Thermo-responsive smart windows (TRSW) are expected to serve as energy-saving technology by adjusting light transmittance in response to ambient temperature. Materials exhibiting lower critical solution temperature (LCST)-like phase separation have recently gained attention as a potential active layer in TRSW.[1] Aqueous solutions exhibiting LCST behavior undergo phase separation when uniformly dissolved solutes are heated above the cloud point (T_{cp}). We found that gallic acid derivatives (GAD) bearing short oligo(ethylene glycol) (OEG) chains show LCST-like phase separation around room temperature. This study examines the relationship between the molecular structures of GAD and T_{cp}, and investigates the aggregation state responsible for turbidity. GAD modified with hydrophobic alkyl chains and amphiphilic OEG units (Et-DEG, Pr-DEG, Bu-DEG, and Pr-TEG) were examined. Aqueous 3 wt% solutions were evaluated by monitoring transmittance at 500 nm as the temperature increased. T_{cp} decreased with longer alkyl chains, whereas it increased with longer OEG chains. This structure–property trend provides insight into the phase-separation behavior of GADs and highlights their potential as tunable, thermoresponsive materials.

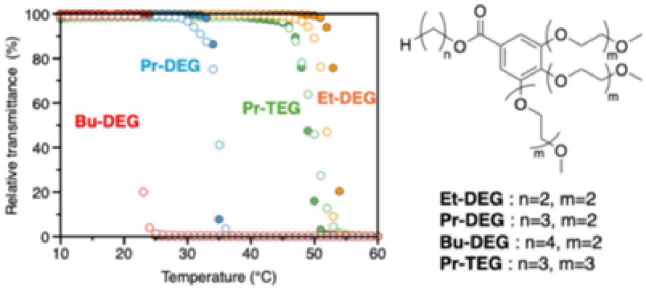

Figure 1. Transmittance curve for 3 wt% aqueous solutions of alkyl gallates measured at 500 nm. The temperature was varied at a rate of 1 ℃/min between 10 and 60 ℃. Solid and white circles indicate results during temperature increase and decrease, respectively.

Keywords: lower critical solution temperature, gallic acid, thermo-responsive smart window

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Biography

Keigo Urushidate is a Ph.D. candidate at Muroran Institute of Technology. His research focuses on the synthesis and structural analysis of temperature-responsive materials.

Probabilistic Mechanical Property Evaluation of Basalt Fiber Composites using Homogenization Analysis and Machine Learning

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Sustainable energy technologies are increasingly important for achieving carbon neutrality and mitigating climate change, with wind power emerging as a key solution. Wind turbine blades commonly use glass fiber reinforced polymer (GFRP) composites, which face challenges due to poor recyclability and environmental impacts during disposal. Basalt fiber reinforced polymer (BFRP) composites have gained attention as eco-friendly alternatives with superior life-cycle performance. BFRP also offers excellent corrosion resistance and strong potential for offshore wind energy applications. However, research on the mechanical properties and probabilistic reliability of BFRP remains limited.

In this study, tensile and shear tests were conducted on basalt fibers, epoxy resin, and BFRP laminates in accordance with ASTM standards. Based on the experimental results, homogenization analysis was employed to predict the effective mechanical properties of the composites. Monte Carlo simulations were further applied to account for variability and uncertainty in material properties. To alleviate the high computational cost associated with repeated homogenization analyses, machine learning techniques were introduced to accelerate the prediction and validation of effective properties. The integrated analytical framework proposed in this study provides a foundation for evaluating the mechanical reliability of BFRP for wind turbine blade applications.

Keywords: Wind blade, Basalt fiber reinforced plastic, Homogenization Method, Machine Learning, Probabilistic analysis

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Acknowledgments

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Obtaining and Investigation of Ceramic Composite Materials Reinforced with Basalt Fibers

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The accelerated pace of life in the modern world and the large-scale development of industrial production is significantly increasing the need for the creation of new composite materials, which in extreme conditions, including a wide temperature range, multiple thermal cycling, chemically aggressive environment, in conditions of high radiation and mechanical loads, will maintain high physical-mechanical characteristics during the long-running operation. Due to its low cost, availability of raw materials and good combination of physical-chemical properties, corundum ceramics is the most used material for creating construction nodes and products for various purposes. Composites based on aluminum oxide with specified properties are used in various fields, including Aerospace, Automotive, Energy, Biomedical, Electronics, Catalysis and Armor.[1-3]. However, these materials are less plastic and as a result have lower toughness. In order to increase plasticity, ceramics are reinforced with various additives.

In the present paper we offer simplified technology for obtaining Alumina-Based Composite materials reinforced with metal oxides and basalt fibers using local raw materials, where modification of the final powder composite - α-alumina with a reinforcing component were implemented during its synthesis, which was ensure their homogeneous spatial distribution, which increase the crack-resistance and bending strength. In the implementation of this work, modern instrumental methods were applied: Electronic and optical microscopy, X-ray structural and granulomere analysis, IR spectroscopy. Determination of physical-mechanical characteristics were performed according to International Standards (ISO and ASTM).

Keywords: Alumina, basalt fibers, ceramic materials, characterization, hot-pressing.

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Innovative antibacterial elastomeric materials with the addition of graphene oxide or its compositions with other substances.

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Graphene oxide is known for its antibacterial properties. A study was conducted on an elastomer: acrylonitrile-butadiene rubber (NBR) with graphene oxide and a graphene oxide composition with basic natural ingredients, i.e., lactic acid and chitosan, to determine their effect on the properties of the elastomer. Antibacterial additives were synthesized and added to the elastomer. Antibacterial and physicomechanical properties were tested. The tested samples demonstrated antibacterial activity against Escherichia coli (ATCC 8739) and Staphyloccocus aureus (ATCC 6538P) according to the ISO 22196:2011 standard. Antibacterial properties were observed when graphene oxide was connecting with lactic acid and chitosan, compared to graphene oxide alone. Compared to the control samples, a reduction of Escherichia coli (91.4%) and Staphyloccocus aureus (90.7%) was observed, while no reduction was observed for graphene oxide alone.

All additives improved some of the physicomechanical properties of acrylonitrile-butadiene rubber.

Keywords: graphene oxide, acrylonitrile butadiene rubber, antibacterial, lactic acid, chitosan

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Biography

Katarzyna Rucińska, PhD, Eng., is a Chief Specialist at the Łukasiewicz Research Network – Institute of Polymer Materials. In 2019, she earned a PhD in biodegradable polymer chemistry from the Faculty of Chemistry, Warsaw University of Technology. Her doctoral thesis title is "Inorganic-organic composites containing lactic acid oligomers." She currently specializes in antimicrobial elastomeric materials, a field in which she publishes and patents. She is a member of the Polish Society of Biomaterials and the Polish Chemical Society.

Phase-Engineered Low-Loss SiO_2-Based LTCC Substrates for Millimeter-Wave RF Filter Applications

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Millimeter-wave (mm-wave) frequency bands above 30 GHz require substrate materials with low dielectric constant and low dielectric loss due to severe propagation losses. SiO_2-based low-temperature co-fired ceramic (LTCC) substrates are promising candidates; however, systematic studies on phase-dependent properties remain limited. [1,2]

In this study, SiO_2-based LTCC substrates with different crystalline phase compositions were developed, and the effects of phase variation on dielectric, thermal, and mechanical properties were investigated for RF filter applications. Phase evolution was analyzed by X-ray diffraction, and dielectric properties were measured at 1 MHz and 15 GHz. Thermal and mechanical properties were evaluated using thermo-mechanical analysis, laser flash analysis, and three-point bending tests. An optimized SiO_2 crystalline phase exhibiting superior high-frequency performance was identified. An RF filter fabricated using the optimized LTCC substrate showed favorable insertion loss, return loss, and bandwidth, demonstrating the feasibility of phase-engineered SiO_2-based LTCC substrates for mm-wave applications.

Keywords: LTCC, RF filter, SiO_2, mm-wave, low dielectric loss, phase

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Biography

Hyo Soon Shin received the Ph.D. degree in Engineering and is a Principal Researcher at the Korea Institute of Ceramic Engineering and Technology (KICET). His research interests include LTCC, MLCC, SOFC, and advanced ceramic materials for electronic applications.

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Aptamer-Functionalized Niosomes for Co-Delivery of Doxorubicin and Harrisonia perforata Extract

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Chemotherapy is widely used in cancer treatment, but is often limited by systemic toxicity and poor tumor selectivity. To address these issues, targeted drug delivery systems have emerged as promising alternatives. This study investigates the co-delivery of doxorubicin (Dox) and Harrisonia perforata extract (HP-C) using aptamer-decorated niosomes to improve cancer therapy. Niosomes were prepared using cholesterol and Tween 20. Their morphology, characterized by transmission electron microscopy (TEM), showed predominantly spherical vesicles with smooth surfaces, while dynamic light scattering (DLS) indicated an average particle size of ~250 nm and a zeta potential between -6 and -4 mV. HP-C was encapsulated in the niosomes, and released ~40% over 120 hours. The successful aptamer attachment via a polyelectrolyte approach was evidenced by gel retardation, and Dox loading was confirmed by fluorescence quenching. MTS assays showed that aptamer-functionalized niosomes co-loaded with Dox and HP-C markedly reduced SW480 cancer cell viability while sparing normal cells. This targeted nanocarrier demonstrates strong potential to enhance efficacy and minimize side effects in cancer therapy.

Keywords: Aptamer, Doxorubicin, Harrisonia perforate, Niosomes

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Biography

Pichayanoot Rotkrua is an Assistant Professor of Biochemistry in the Faculty of Medicine, Thammasat University, Thailand. She earned her PhD in Molecular Oncology from Tokyo Medical and Dental University, Japan, where her doctoral research identified key roles of microRNAs in gastric carcinogenesis. Rotkrua's work integrates bioactive herbal extracts, DNA/RNA-based therapeutics, and biodegradable nanoparticle carriers to create treatment strategies that enhance drug uptake while reducing systemic toxicity.

Utilization of Fly Ashes from Co-Combusting Solid Refuse Fuel and Coal as Construction Materials

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To promote waste utilization and address environmental challenges associated with climate change, many countries around the world have introduced low-carbon fuel policies that emphasize waste reuse as supplementary fuel. Solid Recovered Fuel (SRF), produced from combustible waste such as plastics, rubber, wood, and paper, has garnered significant attention for its ability to reduce dependence on traditional fossil fuels and lower carbon emissions. However, the fly ashes produced by co-combusting coal and SRFs exhibit distinct characteristics that are different than regular fly ashes obtained from boilers purely burning coal. Some SRF constituents contain aluminum metal, and the combustion process in circulating fluidized bed (CFB) boilers often involves the use of limestone as a desulfurizing agent. Consequently, the co-combustion of SRF and coal in CFB boilers produces fly ash that contains metallic aluminum and free calcium oxide (f-CaO), which can lead to significant expansion when used in making concrete.

This study investigates the material characteristics and the potential of co-combustion fly ash as construction materials, with a particular focus on ashes exhibiting expansion potential. A detection protocol for assessing the risks of possible expansion as concrete-making materials was developed. Ashes showing expansion potential are subjected to stabilization processes including mixing with water for hydration and cement solidification. The results indicate that a qualitative analysis can preliminarily detect the presence of aluminum and f-CaO, based on water bubbling and temperature rise in the alkaline solution, respectively. When combined with quantitative measurements of metallic aluminum and f-CaO contents, the overall detection process becomes more effective and efficient. The expansion behavior varies under different conditions. In cases where aluminum is present and the f-CaO content exceeds 2%, the ash slurry may lose plasticity prematurely, impeding hydrogen release from the aluminum and thereby intensifying expansion issues. Hydration treatment is a low-cost and effective method for stabilization. However, its performance diminishes when the aluminum content is high. In terms of utilization, the cement solidification process demonstrates the feasibility of utilizing co-combustion ash in maritime engineering. Additionally, the production of aggregates by cement solidification and crushing thereafter yields materials with favorable physical properties. The particle size of these aggregates can be adjusted based on the crushing method, making them suitable for use as highway bases/subbases and structural fills.

Keywords: Co-combustion Fly Ash, Solid Refuse Fuel, Aluminum content, Free Lime, Concrete

Fatigue Crack Growth Behavior of Adhesively Bonded Hybrid Composite Joints in Wind Turbine Blades

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Adhesively bonded joints are critical to the structural integrity of wind turbine blades and are vulnerable to fatigue-induced debonding under long-term cyclic loading. In hybrid composite blades, damage often initiates at bonded regions such as spar–web joints where complex stress states develop under flapwise bending. This study investigates the fatigue crack growth behavior of adhesively bonded biaxial/triaxial hybrid composite joints using combined experiments and numerical simulations.

Mode I fatigue crack growth tests were performed on double cantilever beam specimens under displacement-controlled cyclic loading. The relationship between fracture energy rate and fatigue crack growth rate was quantified, and propagation parameters were identified from the test data. These parameters were implemented into a VCCT–XFEM model to simulate progressive debonding.

The validated model was applied to a representative wind turbine blade joint configuration under constant-amplitude cyclic loading. Results show that crack initiation and growth are strongly governed by local stress redistribution and adhesive fracture properties, producing distinct propagation trends within bonded joint regions. The proposed approach supports damage-tolerance assessment and durability-oriented design of wind turbine blade adhesive joints.

Keywords: fatigue crack growth; adhesive joint; hybrid composite laminate; VCCT-XFEM; wind turbine blade; debonding

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Manufacturing Constraints Reveal Coordination-Governed Alternative Iron Oxide Nanoparticle Materials Library

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Biocompatible iron oxide nanoparticles (IONP) are conventionally organized in crystalline spinel phases that impart magnetic interactions that promote aggregation in colloidal systems[1,2]. To address magnetic-driven aggregation under scalable, automation-compatible synthesis constraints, spinel lattice formation was intentionally disrupted. In this work, we report that when spinel ferrite design is intentionally defective and co-precipitation-based synthesis is constrained to be automation-compatible, crystallinity can cease to be the primary organizing outcome. The result is a gold-colored suspension of unaggregated, stable, 45nm hydrodynamic diameter iron-oxide:magnesium (9:1) nanoparticles formed under an aqueous, single-pot synthesis over 140 minutes. Sixty-two milligrams of colloid produce ~2x10^{13} biocompatible, functionalized, zwitterionic free-thaw stable particles with a Zeta potential of ~ -25mV, and a PDI of < 0.3.

In-process controls have yielded insights. Under oxygen-limited conditions, out-of-specification yet stable colloids formed with reduced magnesium and low MW dextran, indicating their concurrent integration during particle formation rather than as dopants or coatings. Multi-dentate iron coordination ligand additions during formation govern colloidal integrity under these constraints. Optical characterization of in-process samples demonstrates kinetics inconsistent with crystalline spinel ferrite signatures, with time-dependent spectral evolution showing the emergence of a locked colloidal state at 140 minutes.

Together, this work indicates that under automatable, one-pot synthesis conditions, multi-dentate iron coordination ligands can govern colloidal stabilization without enforced crystallinity, enabling a standardized iron oxide nanoparticle materials library that expands the available design space for combinatorial discovery as well as downstream therapeutic applications.

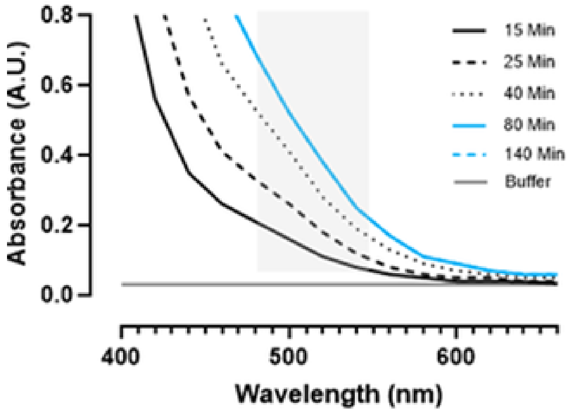

Figure 1. Alternative IONPs: Optical Evidence of Colloidal Locking During Fe^{3+} Iron Oxide Synthesis. Time-resolved UV–Vis absorbance spectra collected over a 140-minute aqueous synthesis show smooth, monotonic spectral decay without discrete optical features. The shaded region (≈480–550 nm) indicates the wavelength range typically associated with crystalline spinel ferrite signatures, which are not observed at any time point.

Keywords: Colloidal nanoparticles, Materials Library, Magnetism suppression, Coordination chemistry, Colloidal stability, Alternative IONP

Conflict of Interest. This work was supported by internal research funding from Paretor LLC.

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Biography

Dustan Bonnin is an inventor whose work examines how imposed manufacturing constraints alter fundamental assumptions in nanoparticle systems. His current research focuses on iron oxide colloids, where suppression of magnetic interactions reveals coordination chemistry as a key stabilizing factor when crystalline lattice formation is intentionally disrupted. Mr. Bonnin's background spans early wet-lab research in immunology and molecular biology, followed by extensive work in nanoparticle and polymer system design across academic and industrial settings. Formally trained in the study of history, he is an author on peer-reviewed publications and patents covering peptides, vaccines, and nanoparticle-based constructs. Mr. Bonnin is the founder of Paretor, where he develops automatable single-pot aqueous synthesis architectures to study stability, phase behavior, and reproducibility in iron oxide nanoparticle systems under process-defined constraints.

Rheological Properties of Earthenware Ceramic Body: An Analysis of Viscosity, Hardness and Plasticity

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The plastic earthenware ceramic body is a multiphase ceramic material primarily composed of clay powder and water and may include organic or inorganic additives that affect its rheological and mechanical behaviour. Its behaviour during the shaping, drying, and handling steps is controlled by three key interrelated properties: viscosity, plasticity, and hardness, all of which are highly dependent on water content. Moisture plays a central role in balancing workability and mechanical stability. The ceramic paste was characterised through plasticity, green hardness, and viscosity tests, which are essential for its performance during forming and drying. Plasticity was evaluated using the Pfefferkorn method to determine the optimal moisture content that ensures adequate deformation, cohesion, and dimensional stability without cracking. Green hardness was measured using penetration resistance tests, which provided an indirect estimate of mechanical strength before firing and identified the moisture range that balances deformability and resistance. Viscosity was assessed with a rheometer to analyse the paste's rheological behaviour. The results confirmed pseudoplastic behaviour, suitable for robocasting, as viscosity decreases with increasing shear rate, facilitating extrusion and shape retention. Together, these tests defined the optimal processing window for additive manufacturing while minimising defects.

Keywords: Plastic earthenware, rheology, plasticity, viscosity, green hardness.

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Biography

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