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PROGRAM

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11:30 – 12:00	**Ivan Jakovac**, Faculty of Science, University of Zagreb *NMR in high magnetic fields and low temperatures: a study of quantum magnetism in m-NO_2PhBNO and $Ce_3Pd_{20}Si_6$* (invited talk)
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In-situ liquid and gas experiments in TEM

Janez Zavašnik, Ardita Kurtishaj Hamzaj, Uroš Cvelbar

Jožef Stefan Institute, Jamova cesta 39, SI-1000 Ljubljana, Slovenia

Abstract - Transmission electron microscopy (TEM) is one of the key experimental methods for characterization of nanomaterials, providing direct structural and chemical information down to the atomic scale. The conventional TEM allows us only a post-mortem analysis, where samples are analyzed only before and/or after synthesis, treatment, or operation. In-situ TEM overcomes this limitation by confining liquids or gases between electron-transparent membranes, enabling the direct observation of transformations and transient states of materials under controlled environments. Such experiments are especially valuable for following nanoparticle nucleation, growth, reshaping, dissolution, oxidation/reduction, and catalytic activation in real time.

In our contribution we will present fundamentals, limitations, and practical examples of in-situ liquid and gas experiments in TEM performed at F6-JSI. In liquids, particular attention will be given to liquid-flow cells, radiolysis, beam-induced chemistry, and the balance between spatial resolution, dose, and realistic reaction conditions, on example of anisotropic gold nanoparticles. For gas experiments, we will discuss in-situ reduction experiments on Fe-oxide nanoparticles exposed to hydrogen gas at elevated temperatures, where morphological and structural changes can be correlated directly with the surrounding reactive atmosphere. The comparison of liquid and gas-cell approaches show that both have common challenges, such as electron-beam effects and window scattering, while the gas-cell is especially useful for operando studies of functional nanomaterials.

Pick-Up of Organic Molecules by Mixed Ar Clusters: A Function of Gas Properties and Composition

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Clusters present an intriguing field of research, with their properties bridging the gap between isolated atoms/molecules and bulk matter. They also exhibit strong surface-related phenomena. Formation of clusters is relatively straightforward, requiring the expansion of pressurized gas into a vacuum, combined with cooling for some gases. Clusters can be studied as such, serve for sputtering of the surfaces, and act as substrates for dopant molecules located on or inside the cluster. The properties of dopants in such highly specific environments can be studied with their concentration and localization on/in the cluster, influenced by many factors, one of which is the composition of the cluster. [1] Doping of clusters can be performed during their formation via pre-mixing, whereas for solid compounds, the pick-up of the heated compound's vapors by already formed clusters is more common.

Our research on Ar clusters reveals that gas pressure and composition are crucial parameters that determine the pickup probability of evaporated adenine, uracil, glycine, and ascorbic acid molecules. Clusters were formed with a pulsed Even-Lavie valve, and the cluster beam was made to traverse a heated cell containing the target biomolecule. Analysis of clusters doped in this way was performed with a quadrupole mass spectrometer. For pure Ar expansion, the most intense molecular signals were observed at stagnation pressures between 10 and 30 bar. Adding up to 33 mol% of He or O_2 at fixed total pressure caused no change in the intensity of dopant and Ar oligomer signals. [2] The addition of N_2O or CO_2 resulted in a significant decrease in intensity. Signals from the molecule and Ar oligomers even disappeared above 3 mol% of N_2O or CO_2. [2] The opposite effect was observed with the Ar-H_2 mixture at 25 bar. Optimal results were obtained for H_2 concentrations between 40 and 50 mol% versus D_2 concentrations between 20 and 35 mol%. Substitution of Ar with an Ar-H_2 mixture caused signal intensities of dopants and Ar oligomers to increase by more than threefold. [2] A compound-specific minimal temperature was also required to provide molecular vapors of sufficient density for the H_2 effects to become apparent.

[1] Dvorak, M.; Müller, M.; Bünermann, O.; Stienkemeier, F. Size dependent transition to solid hydrogen and argon clusters probed via spectroscopy of PTCDA embedded in helium nanodroplets. *J. Chem. Phys.* **2014**, *140*, 144301.

[2] Ekar, J.; Plekan, O. Pick-Up of Organic Molecules by Mixed Ar Clusters: A Function of Gas Properties and Composition. *Molecules* **2026**, *31*, 553.

Platinum, silver, and gold-doped zinc oxide nanoparticles as a solid contact in nitrate-selective electrodes

Karolina Pietrzak[1], Julio Car[1], Rafaela Radičić[1], Klaudia Morawska[2], Cecylia Wardak[2], Nikša Krstulović[1]

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The use of ZnO nanoparticles doped with noble metals (Pt, Ag, Au) as a solid contact in ion-selective electrodes sensitive to nitrate ions was investigated. The nanoparticles were obtained as a result of a two-step synthesis combining the fabrication of targets using the pulsed laser deposition (PLD) technique (where thin layers of doping metals have been deposited on a zinc oxide bulk substrate) and production of doped nanoparticles (Pt:ZnO, Ag:ZnO, and Au:ZnO) by the pulsed laser ablation in liquid (PLAL) technique.

A series of physicochemical analyses was performed to characterize the obtained materials, and to assess the electrical and analytical properties of electrodes modified with these nanomaterials. The most effective modification was the addition of Pt:ZnONPs, as these ISEs exhibited the widest linearity range of 1×10^{-1} to 5×10^{-6} M and low detection limits (3.2 μM), despite having a characteristic slope higher than the theoretical (-62.5 mV dec^{-1}). The ISEs with Pt:ZnONPs achieved a capacitance of 22.18 μF (nearly four times higher than that of ISEs, with pure ZnONPs, 5.95 μF). Additionally, the charge transfer resistance for this electrode (0.58 MΩ) was nearly four times lower than that of the electrode based on undoped ZnONPs (2.18 MΩ).

Moreover, the obtained electrode has been tested for practical purposes and successfully used for the potentiometric determination of nitrate content in soil [1].

[1] Morawska K., Pietrzak K., Car J., et al (2026) A New Type of Nitrate Potentiometric Sensor Prepared Using Hybrid Metal Oxide/Metal Nanoparticles. Materials 19:847. https://doi.org/10.3390/ma19050847.

Multicomponent transition-metal alloys and oxides with photocatalytic and antibacterial properties

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Multicomponent transition-metal materials, including alloys and their derived oxides, represent a promising platform for the development of multifunctional systems with tunable photocatalytic and antibacterial properties. These materials address two pressing global challenges: the persistence of organic pollutants in aquatic environments and the increasing prevalence of antimicrobial resistance.

In this work, we investigated Fe- and Ti- based multicomponent transition-metal systems synthesized in both thin film and powder forms using complementary approaches, including magnetron sputtering, electrochemical anodization, and wet-chemical methods. Nanostructured oxide thin films were prepared via anodization of alloy thin film on FTO substrate, enabling controlled morphology, high surface area, and enhanced charge transport properties. Structural and morphological characterization was performed using X-ray diffraction (XRD), and Scanning electron microscopy (SEM) coupled with Energy dispersive X-ray spectroscopy (EDS).

Photocatalytic performance was evaluated through the degradation of Imidacloprid (neonicotinoid insecticide) under UV–visible irradiation, demonstrating that different surface morphology influences reaction kinetics and photocatalytic efficiency. In parallel, antibacterial activity of multicomponent oxides in powder and thin film form was investigated using representative gram-positive (Bacillus subtilis) and gram-negative (Escherichia coli) bacteria. The results indicate that tailored composition and surface chemistry enhance bacterial inhibition through combined effects of reactive oxygen species generation, ion release, and surface interactions.

By correlating synthesis parameters, structure, and functional properties, this study aims to establish design principles for multicomponent transition-metal materials with optimized photocatalytic and antibacterial properties.

From Processing to Function: PLLA Piezoelectric Platforms for biomedical applications

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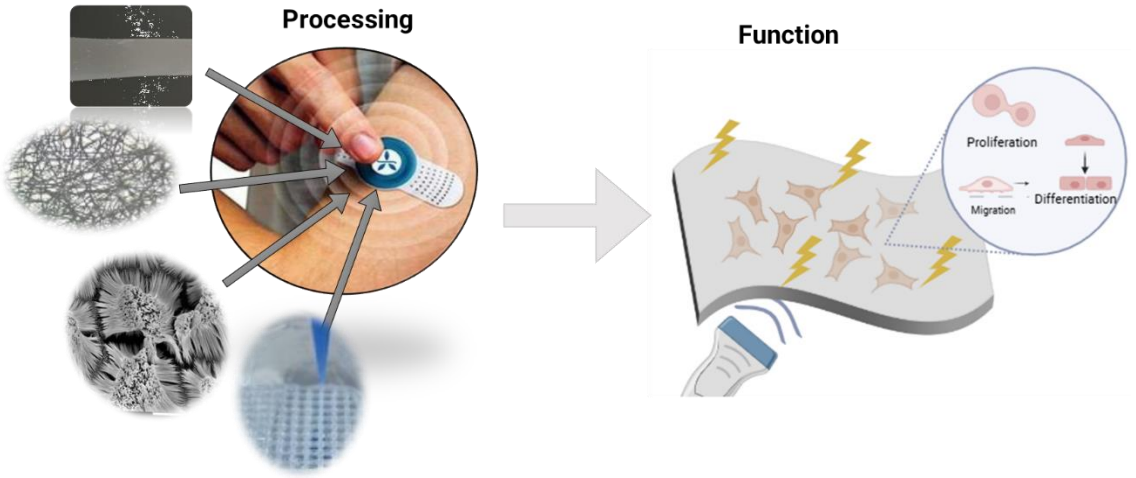
Poly (lactic acid) (PLA) is widely recognized as one of the most commonly used polymers in additive manufacturing because of its favorable mechanical properties and excellent processability. At the same time, it has a well-established role in biomedicine, where it is used in sutures, implantable devices, and other medical products due to its biocompatibility and biodegradability. Beyond its conventional role as a structural biomaterial, PLA also holds considerable functional potential. In its stereochemically defined form, poly (L-lactic acid) (PLLA) has helical molecular conformation that enables piezoelectric behavior. When appropriately processed, its molecular and crystalline organization can be tailored to induce piezoelectric behavior, enabling the material to generate electrical signals under mechanical deformation. This is particularly attractive for biomedical applications, where electrical cues are closely involved in cell signaling, tissue regeneration, and wound healing.

Using processing as the key design parameter, we developed PLLA-based piezoelectric platforms across multiple material formats, including films, fibers, nanotextured substrates, and 3D-printed constructs. By controlling processing conditions and the resulting architecture, we achieve enhanced piezoelectric performance while preserving the advantages of PLLA as a biodegradable and biocompatible material. Importantly, these platforms are not only structurally versatile but also biologically active: we confirmed their compatibility with cells and demonstrated favorable bioactivity, while also observing antibacterial effects that we associate with their electrically active nature.

As resorbable systems, PLLA-based platforms can provide temporary stimulation and support during healing, and then gradually degrade as they are replaced by newly formed tissue. Altogether, our results position PLLA as a versatile piezoelectric biomaterial whose function can be tailored through processing for advanced biomedical applications.



Hybrid Materials by ALD/MLD: Integrating Organic, Inorganic, and Structural Design Across Different Dimensionalities

Gabriela Ambrožić,[1,2] Iva Šarić,[1,2] Robert Peter,[1,2] Maria Kolympadi Marković,[1,2] Ivana Jelovica Badovinac,[1,2] Ivna Kavre Piltaver,[1,2] Mato Knez[3,4]

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Atomic layer deposition (ALD) and molecular layer deposition (MLD) offer a versatile platform for synthesizing hybrid materials from the gas phase, allowing precise control over composition, thickness, and surface chemistry. In this work, we present strategies for fabricating hybrid materials on nanoparticulate systems, flat surfaces, and three-dimensional architectures.

We demonstrate the use of MLD for targeted organic surface functionalization of inorganic materials through selective gas-phase click reactions.[1,2] ALD-deposited metal oxide thin films, such as Al_2O_3, can also serve as surface-activated substrates for solution-based organic modifications, imparting additional surface wetting properties or introducing specific functionalities, for example, in biosensor applications.[3] ALD has also been applied to complex and porous polymer fibers; conformal ALD-deposited Al_2O_3 and ZnO bilayers on cellulose impart antibacterial properties to the functional hybrid material.[4] Cellulose is also used as a sacrificial substrate for preparing three-dimensional ZnO structures with enhanced photocatalytic properties, demonstrating the advantages of ALD in building hierarchical architectures.[5]

These examples illustrate how ALD and MLD are effective approaches for designing hybrid materials, enabling the integration of organic functionality, inorganic stability, and structural complexity in substrate materials.

[1] I. Saric et al., *Chem. Commun.* 2019, **55**, 3109.
[2] I. Saric et al., *Appl. Surf. Sci.* 2021, **539**, 148254.
[3] G. Ambrožić et al. *J. Colloid Interface Sci.* 2020, **560**, 303.
[4] S. Mežnarić et al. *J. Environ. Chem. Eng.* 2022, **10**, 108095.
[5] R. Radičić et al., *Catalysts* 2026, **16**, 17.

3D Au nanoparticle lattices in MoO_3 for tunable optical and thermo-electrical properties

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Incorporating noble-metal nanoparticles into semiconductors offers a powerful means to tailor their functional properties. Here, we demonstrate that embedding ordered three-dimensional lattices of Au nanoparticles (Au NPs) into MoO_3 thin films via magnetron sputtering enables broad tunability of the optical and thermo-electrical behavior. The formation of regular Au NP lattices, with controlled particle sizes, interparticle separations, and ordering, is achieved through precise adjustment of the deposition temperature and layer thickness conditions. Localized surface plasmon resonances (LSPR) arising from Au
NPs-and their coupling at small separations-induce a strong modulation of the optical absorption across a wide spectral range. Simultaneously, the film's electrical resistance can be tuned by up to six orders of magnitude, while the activation energy and temperature coefficient of resistance (TCR) are reduced by up to fifty-fold compared to pure MoO_3. These findings offer relevant information for designing oxide–plasmonic hybrid materials, highlighting their potential for next-generation optoelectronic, sensing, and energy-harvesting devices.

Cold plasma seed treatment drives transgenerational microbiome changes in buckwheat

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Cold plasma (CP) seed treatment is increasingly explored as an environmentally friendly alternative to chemical seed treatments, yet its influence on seed-associated microbiomes under field conditions and across generations remains insufficiently understood. Here, we evaluated the effects of low-pressure CP treatment (50:50 O_2:N_2) on common (*Fagopyrum esculentum*) and Tartary (*Fagopyrum tataricum*) buckwheat by combining laboratory experiments (in vitro) and field performance assessments with shotgun metagenomic profiling of grain-associated bacterial and fungal communities across two successive generations. Our results showed that CP treatment delayed in vitro germination in both species and reduced the final germination of Tartary buckwheat by approximately 20%, but had a limited impact on its overall field performance. Notably, despite reduced seedling emergence, CP-treated plants exhibited substantially higher grain yields, increasing by 56% in Tartary and even 70% in common buckwheat relative to the control groups. Cultivation-based microbiological assays indicated a 30–50% reduction in viable fungal colonisation following CP exposure. Metagenomic analyses revealed significant shifts in the first-generation seed microbiome, including decreased relative abundance of Actinobacteria and increased relative abundance of Proteobacteria. Among fungi, the most notable shift was an approximately 10% reduction in Pleosporaceae. However, second-generation grains displayed pronounced restructuring of fungal communities, with Pleosporaceae abundance nearly doubling irrespective of parental CP treatment, suggesting strong environmental reassembly. Overall, CP treatment induced measurable but partially transient alterations in seed-associated microbiomes. While bacterial community shifts showed limited persistence across generations, fungal communities were largely reshaped by environmental factors in the second generation. These findings indicate that CP acts as a short-term ecological disturbance to the seed microbiome and underscore the importance of field-based, multigenerational approaches for evaluating microbiome responses to CP and similar physical seed treatments.

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We also thank Rangus Mill for providing us with buckwheat grains for our experiments. Ana Mezinec Urbanija, Neja Bizjak Štrus, Janez Trtnik and Matic Resnik are acknowledged for technical assistance and routine treatments.

Hydrogen and helium interaction with bcc metals and alloys

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Body-centred cubic (bcc) refractory metals and alloys are key candidates for plasma-facing and structural components in future fusion devices. Tungsten is the reference material for divertor applications because of its high melting point, low sputtering yield and favourable thermal properties. However, energetic-particle exposure produces defects that modify the interaction of the material with hydrogen isotopes and helium.

This contribution investigates irradiation-induced defect evolution in bcc metals, using tungsten as a model system, and explores how these defects influence the trapping, transport, and retention of light elements. Heavy-ion irradiation was used as a non-activating proxy for neutron-induced damage. Polycrystalline tungsten reference samples were irradiated with W ions at 800 K and 1000 K, with damage doses ranging from 0.02 to 0.8 dpa. At these temperatures, vacancies become mobile and can cluster, making the competition between dislocation loop formation, void nucleation, and defect annealing a key factor controlling the resulting microstructure. The damaged samples were characterized by combining X-ray diffraction, transmission electron microscopy and deuterium retention analysis using ^{3}He nuclear reaction analysis. Such multi-scale approach correlates average lattice distortion with direct imaging of nanoscale defects and quantitative hydrogen-isotope trapping. At low damage dose, dense distributions of small dislocation loops dominate the microstructure, while higher doses promote the formation of nano-sized voids. The deuterium concentration increases with increasing damage dose, demonstrating a clear connection between irradiation damage and hydrogen-isotope retention.

The results provide a basis for understanding how light elements interact with radiation-induced defects in bcc metals and alloys under fusion-relevant conditions, and contribute to predicting fuel retention, swelling, embrittlement and long-term performance of plasma-facing materials.

NMR in high magnetic fields and low temperatures: a study of quantum magnetism in m-NO_2PhBNO and $Ce_3Pd_{20}Si_6$

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Quantum magnetic systems with reduced dimensionality provide exceptional platforms for studying field-induced quantum phase transitions and the universal critical behavior. However, due to the underlying quantum nature, these phenomena frequently require high magnetic fields and low temperatures, which makes comprehensive studies challenging. Here, we investigate a quasi-one-dimensional Haldane system m-NO_2PhBNO (BoNO) and a cubic heavy-fermion compound $Ce_3Pd_{20}Si_6$ (CPS) using nuclear magnetic (NMR) and quadrupolar resonance (NQR) to reveal their low-temperature phase diagrams.

BoNO constitutes a novel approach to designing low-dimensional quantum magnets with readily accessible collective phases (B_{c1} = 1 T, B_{c2} = 34 T, $T_{N,max}$ = 3.3 K). Owing to its purely organic composition, BoNO exhibits remarkable magnetic isotropy, as corroborated by extensive magnetic susceptibility, ESR and NMR data. We present a complete phase diagram, determine the critical exponent ν at B_{c2}, and validate the theoretical framework across the Tomonaga-Luttinger regime, Bose-Einstein condensate phase, and quantum critical region. These findings are further supported by state-of-the-art computational methods, including density matrix renormalization group and quantum Monte Carlo simulations.

CPS presents a heavy-fermion system with high *Fm3m* symmetry, featuring two distinct Ce 4*f* magnetic moments. Neutron scattering data reveal two successive transitions into an antiferroquadrupolar (T_Q = 470 mK) and an antiferromagnetic (T_N = 250 mK) phase. Our ^{105}Pd NQR measurements shed light on the magnetic structure and the spin dynamics at dilution refrigerator temperatures down to 50 mK. We find no evidence of conventional magnetic order, although the NMR relaxation data suggests a possible onset of Kondo screening in the system. CPS also exhibits a Kondo-breakdown quantum critical point, where suppression of magnetic order coincides with a Fermi surface reconstruction. However, field-dependent NMR data do not corroborate this scenario, suggesting the absence of static magnetic order in CPS on the NMR experimental timescale.

New upgrades and capabilities at the new ion accelerator at Jožef Stefan Institute

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The Microanalytical Centre (MIC) at the Jožef Stefan Institute operates the only research ion accelerator facility in Slovenia. Its primary focus is Ion Beam Analysis (IBA) techniques, with increasing emphasis on ion implantation and irradiation in recent years. MIC began operation in 1997 with the installation of a 2 MV tandem accelerator (Tandetron) manufactured by High Voltage Engineering Europa (HVEE), initially equipped with two ion beam lines. Over the years, significant expertise has been developed in the operation and construction of ion beam systems. Since 2020, several major upgrades have been implemented; three of these will be presented in this contribution.

One of the key beamlines, operational since the early stages of MIC, is the microbeam system, which enables focusing of MeV ion beams down to micrometer dimensions. Increasing demand for sub-micrometer resolution led to the development of a new nanobeam beamline. This system is based on four thin quadrupole lenses configured into a user-friendly focusing setup, capable of focusing ion beams with magnetic rigidities up to 45 MeV/amu. The achieved beam size strongly depends on the brightness of the injected ion beam. Using a high-brightness H^- multicusp ion source [1], proton beams of 3 MeV were focused to sizes of 300 × 300 nm² at 5 pA and 80 × 120 nm² at a flux of 10,000 ions/s. With heavy ion sources, a 3.85 MeV $^{15}N^{2+}$ beam was focused to 600 × 600 nm² at 5 pA, and a 3 MeV $^{28}Si^{2+}$ beam to 700 × 700 nm².

A second major development is the construction of the UHV beamline coupled with the DeHydrAC (Defects and Hydrogen Analysis Chamber) experimental station. This system builds on experience gained in the INSIBA experiment [2,3], which investigates hydrogen isotope interactions in materials, primarily used for fusion-related applications. The new beamline is designed to provide a low-divergence ion beam, enabling IBA measurements in channeling mode and thus offering deeper insight into processes at the crystal lattice level and ion irradiation on large surface area.

After 28 years of operating the 2 MV accelerator, a new 3 MV Tandetron, also manufactured by HVEE, was installed in early 2026. Its higher terminal voltage and excellent stability (40 V at 3 MV) will enable the production of high-quality ion beams with energies up to 20.5 MeV. Together, these upgrades are expected to position the facility at the forefront of ion beam research in the coming decades.

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Hydrophobization of cellulose materials in hydrogen plasma

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Cellulose is a highly hydrophilic material due to its high content of hydroxyl groups. While in certain applications this is desirable (e.g., wound dressings, filter membranes, etc.), it is not in others (e.g., packaging materials, water-repellent fabrics, composite materials, etc.). One possible way to reduce the hydrophilic character is the treatment with hydrogen plasma to reduce hydroxyl groups. Here, we present an investigation of the hydrophobization of cellulose via hydrogen plasma treatment. The effects of treatment were studied using X-ray photoelectron spectroscopy (XPS) and water contact angle (WCA) measurements. Plasma was sustained in a glass tube by an inductively coupled radiofrequency discharge at the discharge powers of 35 and 120 W. The hydrogen pressure was set to 7 Pa. The plasma treatment times ranged from 10 ms to 10 s. XPS showed a decrease in oxygen concentration on the cellulose samples, down to approximately 30 at.%. Rapid hydrophobization was observed, as even 10 ms of treatment increased the WCA to approximately 110°.
This investigation was supported by the Slovenian Research and Innovation Agency (grant No. L2-70117 in L2-50078).

Martensitic stainless steels for MIC resistance: balancing composition and microstructure

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Hydroelectric power plants are an important component of a carbon-neutral energy system, offering significantly lower greenhouse gas emissions than fossil fuel-based technologies. Although they impact the environment, this can be mitigated through improved design and operation, such as enabling fish passage and optimizing flow regimes to support ecosystem recovery.

Corrosion remains a major challenge in hydroelectric facilities due to the aggressive aqueous environment. While corrosion-resistant stainless steels are widely used, they can still degrade under certain conditions influenced by water chemistry, microorganisms, flow conditions, temperature, and material selection. Understanding these factors is essential for effective corrosion control.

Microbiologically induced corrosion (MIC) is a particularly complex form of degradation driven by bacterial activity in natural waters and is a known issue across multiple industries, including hydropower. Resistance to localized corrosion, especially pitting, is critical for mitigating MIC. The pitting resistance equivalent number (PREN), defined as PREN = %Cr + 3.3(%Mo + 0.5%W) + 16%N, is commonly used to assess this resistance. Higher PREN values improve corrosion resistance, although increased alloying can promote the formation of deleterious phases. Alternative alloying approaches, such as the addition of copper, can enhance passive film stability while limiting such effects.

In this contribution, we present the development of martensitic stainless steels with increased PREN and evaluate their microstructure and corrosion resistance in MIC-relevant environments.

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Porous copper oxide/zinc oxide heterojunction films for solar-driven caffeine degradation

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The increasing contamination of aquatic environments by pharmaceutical micropollutants urgently demands efficient and sustainable water treatment solutions. Heterogeneous photocatalysis driven by solar light is a particularly attractive strategy due to its low energy requirements and potential for mineralisation of persistent organic compounds. Here, we present a method for copper oxide/zinc oxide heterojunction photocatalysts and evaluate their performance in degrading caffeine under simulated solar irradiation.

Porous copper oxide films were prepared by anodic electrochemical deposition from a 1 M H_3PO_4 electrolyte onto flat copper substrates (7.5 V, 0.9 A, 20–30 min, room temperature). The resulting films showed the red coloration characteristic of Cu_2O. ZnO thin films were then deposited by atomic layer deposition (ALD), enabling precise control of film properties. The close interfacial contact between the two oxide phases forms a type-II heterojunction, which facilitates efficient charge carrier separation, suppresses electron–hole recombination, and extends light absorption into the visible range.

Photocatalytic performance was evaluated using caffeine as a model pharmaceutical micropollutant under simulated solar illumination. The Cu_2O/ZnO heterojunction films exhibited superior degradation efficiency compared to both bare copper oxide and bare ZnO reference samples, confirming that the synergistic interaction at the heterojunction interface, rather than either component alone, is responsible for the enhanced activity. Building on these results, current work focuses on systematic optimisation of the copper oxide substrate, including control of film morphology, porosity, and phase composition, with the aim of further maximising photocatalytic performance.

Investigation of Ge/Ta quantum dot arrays in amorphous SiC and Si_3N_4 matrices for photosensitive device applications

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Semiconductor quantum dots, particularly germanium-based systems, exhibit strong quantum confinement effects due to the spatial restriction of charge carriers, enabling tunable electrical and optical properties through precise control of size and shape. Complex nanostructures such as core–shell quantum dots, consisting of a Ge core and a Ta metallic shell, are of particular interest, as confinement in both regions enables enhanced control of charge transfer, photoexcitation processes, and local electric field amplification. These properties make them promising candidates for photovoltaic and sensing applications.

In this work, we present thin-film materials based on core–shell Ge/Ta quantum dots embedded in amorphous silicon carbide (SiC) and silicon nitride (Si_3N_4) matrices. The influence of core size and shell thickness on optical, photoelectrical, and thermal properties is systematically investigated. We identify the optimal combination of core size, shell thickness, and matrix material for achieving the highest photoelectric response.

Simple photodetectors based on these structures demonstrate straightforward fabrication and broadband detectivity comparable to devices produced using more complex methods involving 2D materials or photolithography.

Cyclic organosiloxanes as precursors for plasma-assisted deposition of silicon dioxide

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The continuing miniaturisation of electronic devices and the evolution toward three-dimensional integrated circuit (IC) architectures have increased the demand for dielectric films with excellent uniformity and precisely controlled properties. Silicon dioxide (SiO_2) remains a key dielectric in micro- and nanoelectronics and other nanotechnology applications. Conventional deposition processes, such as chemical vapour deposition (CVD), physical vapour deposition (PVD), sputtering and electron-beam evaporation, struggle to deliver conformal SiO_2 layers on complex 3D structures and typically require high processing temperatures. These limitations motivate the search for alternative methods capable of producing high-quality films on temperature-sensitive substrates. Atomic layer deposition (ALD) and plasma-enhanced ALD (PEALD) overcome many of these drawbacks. Both rely on self-limiting surface reactions and can deposit ultrathin, highly conformal films with angstrom-level thickness and composition control at significantly lower temperatures than CVD. Nevertheless, standard Si precursors often exhibit low reactivity at low temperature and may release corrosive by-products or leave residual impurities in the films, and some precursors require stringent safety protocols due to toxicity or pyrophoricity. Organosilicon compounds, in particular organosiloxanes, provide attractive alternatives because they are typically liquid, chemically stable and easier to handle. Using plasma allows further tailoring of film chemistry by adjusting gas composition, plasma power and substrate temperature. Moreover, plasma activation enables the use of a broader range of precursors, including less reactive organosiloxane compounds.

We investigated the cyclic organosiloxanes 1,3,5-trivinyl-1,3,5-trimethylcyclotrisiloxane (V_3D_3) and 2,4,6,8-tetramethyl-2,4,6,8-tetravinylcyclotetrasiloxane (V_4D_4) as a precursor for the deposition of high-quality ultrathin SiO_2 films using PEALD. First, adsorption and surface reaction behaviour of the cyclic organosiloxanes on inorganic oxides were characterised. Thin films were then grown by combining the cyclic organosiloxanes with oxygen or nitrogen plasmas. The resulting films were examined for chemical composition, molecular structure, morphology, thickness and conformality using X-ray photoelectron spectroscopy (XPS), Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM) and transmission electron microscopy (TEM).

Emergent Nanoscale Phenomena in van der Waals MPX3 Materials

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Quasi-two-dimensional (quasi-2D) van der Waals (vdW) materials have emerged as fertile ground for the exploration of exotic optic, electronic and magnetic phenomena driven by reduced dimensionality, strong correlations and light–matter interactions, anisotropic dielectric response and variable interlayer bonding. Layered transition metal phosphorus trichalcogenides (MPX3) form a versatile family of van der Waals antiferromagnets spanning a wide range of electronic band gaps, magnetic anisotropies, and spin–lattice coupling strengths, making them an attractive yet largely unexplored platform especially for polaritonic and strain-driven phenomena.[1]

Here we utilize an advanced atomic force microscopy (AFM) – based techniques to study polaritonic and solitonic phenomena in specific MPX3 compounds, including $FePS_3$, $FePSe_3$, $CoPS_3$, $NiPS_3$ and $MnPS_3$. Using scattering-type scanning near-field optical microscopy (s-SNOM), we find signatures of propagating polaritonic modes in these materials, constituting, to our knowledge, the first experimental observation of polaritons in the MPX3 family. The measured interference fringes reveal guided optical modes in the visible spectral range, with propagation characteristics that vary across materials with different band gaps and dielectric response. In parallel, AFM, Kelvin probe force microscopy (KPFM), and conductive AFM (C-AFM) measurements reveal extended, line-like electronic and electrostatic features consistent with topological and structural soliton-like features at step edges induced by strain or stacking variations.

Our combined optical and scanning probe approach demonstrates how light–matter coupling and nanoscale electronic order intertwine in MPX3 materials, providing a platform for studying hybrid quasiparticles and solitonic excitations in correlated two-dimensional magnets.

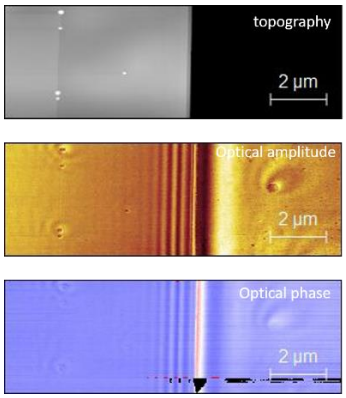

Figure 1: sSNOM measurements on $FePS_3$ on gold using a 633 nm excitation.

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Cu-doped ZnO thin films on porous anodized substrates for enhanced solar photocatalysis

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The development of efficient photocatalytic materials for water purification requires both high active surface area and strong photoresponse under solar irradiation. In this work, self-ordered porous substrates were prepared by electrochemical anodization to obtain well-defined nanoporous structures with significantly increased surface area. Subsequently, ZnO thin films were deposited by atomic layer deposition (ALD), while Cu doping was introduced in situ in order to extend the photocatalytic response of ZnO from the UV to the visible region.
The morphology and structural properties of the porous substrates and deposited films were investigated by scanning electron microscopy. Photocatalytic performance was evaluated through the degradation of methylene blue aqueous solution under UV and simulated sunlight irradiation. The porous architecture enabled a substantial increase in photocatalytic efficiency compared with flat substrates due to the larger number of accessible reaction sites. In addition, Cu doping improved visible-light absorption and enhanced photocatalytic activity under simulated solar light.
These results demonstrate that the combination of porous anodized supports and Cu-doped ZnO films represents a promising strategy for the design of reusable and highly efficient photocatalysts for environmental remediation.

Scanning X-ray microprobe PHI Genesis for advanced XPS surface and thin film characterization

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X-ray Photoelectron Spectroscopy (XPS) is a well-established and widely applied technique for analyzing surfaces and thin films. It provides quantitative information on elemental composition, as well as insights into the chemical and oxidation states and the bonding environment of elements in thin films and multilayer structures.
The new XPS instrument, model Genesis, was recently introduced at the Jožef Stefan Institute. It was manufactured by Physical Electronics, a division of ULVAC-PHI [1]. The scanning XPS microprobe instrument, Genesis, provides scanning X-ray-induced secondary electron images (SXI) generated by scanning a focused 5 μm X-ray beam across the sample. Just like an SEM, SXI's can be used to navigate to areas of interest and to select areas for analysis in real time. It is equipped with a monochromatic Al Kα X-ray source, a 32-channel energy analyzer for photoelectrons providing the energy resolution of 0.48 eV. A monoatomic Ar^+ ion gun serves for sputtering of inorganic materials and an Ar-cluster gas cluster ion beam (GCIB) source for organic materials. Additional capabilities include a Zalar rotation module for high-resolution profiling, an ultraviolet (UV) source for detailed valence-band analysis using Ultraviolet Photoelectron Spectroscopy (UPS), angular-resolved analyses (AR-XPS), and Low Energy Inverse Photoelectron Spectroscopy (LEIPS). An integrated heating module allows for in situ sample annealing. The system supports automated operation, enabling high-throughput analysis of multiple samples. The primary applications of the XPS spectrometer include surface chemical composition analysis, scanning X-ray imaging (SXI), identification of oxidation states, and depth profiling of elements in thin films. The instrument can be upgraded with a Cr X-ray source to analyze a deeper subsurface region 20 nm thick in HAXPES mode. The capabilities of the new instrument will be demonstrated through representative examples, including the analysis of oxide films, plasma-treated polymers, cellulose, multilayer thin-film structures, and corrosion-resistant coatings.

Acknowledgments: Slovenian Research and Innovation Agency – ARIS co-financed the acquisition of the new Genesis instrument through the program "Paket 21" in 2022

Reference: https://www.phi.com/surface-analysis-equipment/genesis.html

Determination of dielectric functions of colloidal silver nanoparticles in LSPR relevant wavelength range

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Dielectric functions play a pivotal role in the interaction of light with nanoscale matter. They determine all optical properties, including dispersion, absorption, scattering, reflection, transmitance, and polarization. In this study, we present a method for extracting dielectric functions from UV-Vis spectra of monodisperse colloidal silver nanoparticles, offering an alternative to standard experimental techniques like elipsometry within the constrained wavelength range of 400 to 600 nm. The approach utilizes a developed Mie scattering fitting function, incorporating additional conditions on the dielectric function behavior at the localized surface plasmon resonance wavelength. It enables the extraction of universal dielectric functions from UV-Vis data at localized surface plasmon resonance points by knowing absorbance and wavelength as well as concentrations of colloidal nanoparticles and optical path length. The universality of dielectric functions makes them applicable for fitting of UV-Vis spectra of colloidal silver nanoparticles of an a priori unknown sizes within the diameter range of 20 to 100 nm with possible extension to bigger sizes. Once determined, these dielectric functions can be directly applied to UV-Vis spectra to ascertain the size and concentration of monodisperse silver nanoparticles' colloidal solutions. Recently, this issue was addressed using machine learning approach [1]. Once known, dielectric functions can be used for reverse reconstruction of electron dynamics in nanoscale metals and compared to known dielectric model like Drude or Lorentz model. Also, they allow deeper analysis of light-matter interaction necessary for tailoring of nanoparticles for different applications like thermoplasmonics [2]. Since absorption cross section is dependent on cube of nanoparticles' size and temperature increase of nanoparticles when illuminated is linearly proportional to it, it is important to know dielectric functions precisely.

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Tailoring Strain in MoS_2 via Growth on Stepped Surfaces

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Strain plays an important role in tuning the properties of two-dimensional (2D) materials by modifying their electronic and mechanical behavior.1 However, optical and transport measurements used to study these effects are inherently averaging techniques and therefore cannot resolve strain-induced phenomena at the nanoscale.2 Scanning tunneling microscopy (STM) and spectroscopy (STS) are excellent tools for investigating strain effects locally, as they provide direct access to structural and electronic properties. Here, we introduce a novel approach for systematically inducing and probing strain in 2D materials at the nanoscale, based on growth on vicinal substrates. As model systems, we synthesize monolayer MoS_2 on pre-patterned surfaces, primarily focusing on graphene-covered Ir(332), with extension to Au(788), using molecular beam epitaxy (MBE) under ultrahigh vacuum (UHV) conditions. In our samples, monolayer MoS_2 islands bend over substrate step edges, resulting in the formation of uniaxial strain. To obtain optimal samples for investigation, we performed a growth study on gr/Ir(332) and found that post-annealing temperature strongly influences the size and shape of MoS_2 islands. Higher temperatures yielded islands with larger surface areas and more well-defined metallic edges, which are beneficial for STS measurements. STS measurements performed at 77 K on both gr/Ir(332) and Au(788) reveal variations in the electronic structure that correlate with the surface topography, as illustrated by the line STS map in Figure 1B, acquired along the dashed line indicated in Figure 1A. While the band edges generally follow the topography due to band bending, they do not shift completely rigidly. A small modulation in the band-gap size is also observed, likely arising from local strain effects. This work demonstrates a successful bottom-up approach for structurally modifying and straining MoS_2, providing a platform for nanoscale studies of strain-induced electronic and structural modifications.

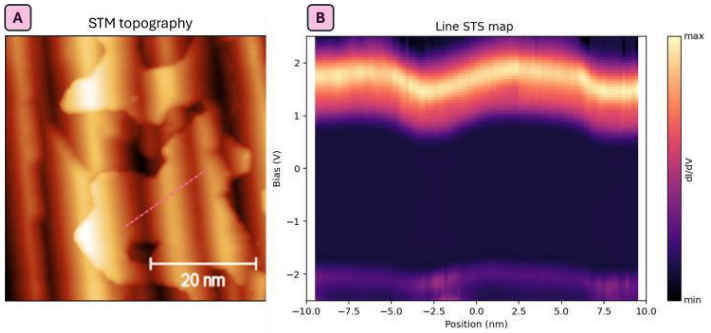

Figure 1: (A) Topography of the MoS_2 on gr/Ir(332) sample. The dashed line indicates where the line STS map in (B) was acquired at 77 K, showing local variations in the electronic structure that correlate with the topography.

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Colossal magnetoresistance in EuCd2As2

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We will present our recent work on Eu-based compounds, with a particular focus on $EuCd_2As_2$, a material widely regarded as a topological semimetal in which a Weyl phase emerges under an external magnetic field. However, a recent study [Phys. Rev. Lett. 131, 186704 (2023)] has challenged this view through a meticulous investigation of its properties. Our presentation will focus on our recent study of colossal negative magnetoresistance in $EuCd_2As_2$—comparable to that observed in manganites— and some related compounds, as well as the effects of isovalent substitution on its behavior.

Water treated with nitrogen plasma supported with a magnesium as a possible fertilizer of the future

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Climate change is expected to decrease global agricultural productivity by as much as 17% by 2050. To tackle this issue, developing new eco-friendly fertilizers is essential—ones that can boost crop yields while reducing environmental pollution.

Plasma-based technologies have already transformed industries such as semiconductors and medicine, and their range of applications is still growing. One particularly promising approach in agriculture is Plasma-Activated Water (PAW). It has been shown to support seed germination, enhance plant growth, stimulate enzymatic activity and protein synthesis, modify seed coats, improve fertilization, control pathogens, and aid in food preservation. I will show the production and characteristics of plasma-treated natural mineral water as a possible substitute for conventional fertilizers. Special attention will be given to magnesium and its influence on the physicochemical properties of the treated water. I will present measurements of pH, hydrogen peroxide (H_2O_2), nitrate (NO_3^-), and nitrite (NO_2^-), tracked from the time of production over several weeks. Our experiments included two types of water and three forms of magnesium (rods, turnings, and nanoparticles). The results show that hydrogen peroxide levels declined most rapidly in samples containing magnesium turnings, while mineral water with magnesium nanoparticles exhibited the highest concentration of nitrate (NO_3^-) ions. Overall, these results indicate that magnesium-enhanced plasma-treated natural water could be useful in analytical applications that require stable and well-controlled chemical properties over time, and it may also represent a promising solution for agricultural use.

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Swift heavy ion irradiation of silicon nanostructures: the role of energy dissipation

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We use Geant4 code with Microelectronics package to study the amount of energy that is retained in the silicon nanostructures after passing of the swift heavy ion. This open problem is of particular interest for processing of nanomaterials which might exhibit superior radiation hardness compared to classical (bulk) materials. Therefore, we used silicon ions with various kinetic energies (in a range between 2.8 MeV and 280 MeV) and simulated their passage through silicon nanostructures (nanocubes, nanowires and thin films). Additionally, we also investigated the case of swift heavy ion impact into the surface of silicon at grazing incidence angle. The presented results indicate that the amount of dissipated energy can be significant and should be considered when modelling changes in nanomaterials induced by swift heavy ion impacts, because primary electrons can escape easily.

Optical atomic clock frequency transfer

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For the past two decades, optical clocks have consistently outperformed traditional atomic clocks, such as the cesium clock, in both frequency stability and accuracy. This progress has spurred discussions about redefining the SI unit of the second. Further advancements in clock operation and time/frequency transfer and comparison techniques will accelerate this redefinition.

Our work focuses on developing techniques to transfer the atomic clock frequency between scientific institutions in Croatia using dark fiber. This effort is supported by the Croatian Quantum Communication Infrastructure project (CroQCI).

At the Institute of Physics in Zagreb, we are building an optical lattice atomic clock based on cold strontium atoms. The experiment requires ultra-high vacuum conditions with pressures below $10^{-10}\ mbar$. Hot atoms leaving the effusive oven are first transversely cooled and then slowed down using a Zeeman slower. Next, they enter a 2D magneto-optical trap (MOT) chamber and are pushed to a 3D MOT chamber. There, a blue and red 3D MOT will be used to cool the atoms. Once cooled, atoms will be confined in a multiplexed 1D lattice. Stabilization of red lasers is based on a low-noise 1550 nm Er:fiber frequency comb stabilized to a high-finesse optical cavity. The blue laser is stabilized using modulation transfer spectroscopy in warm Sr vapour.

Dark fiber is deployed between our institute and the Ruđer Bošković Institute (IRB) in Zagreb. The clock laser at 698 nm will be locked to the Sr-based clock transition and then referenced to the optical frequency comb, transferring the high stability of the optical reference to all comb modes. The laser for atomic clock signal distribution at 1542 nm will be referenced to the same frequency comb and transferred to IRB. Thermal and acoustic fluctuations in the fiber introduce phase noise, significantly reducing the stability of the transmitted frequency. To overcome this, we perform active phase noise compensation.

Machining Performance at Varying LCO_2 Flow Rates in Hard Turning of 42CrMo4 Steel Using TiAlN-Coated Tools

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TiAlN coating deposited by physical vapor deposition (PVD) is widely used in machining applications due to its high hardness, thermal stability, and oxidation resistance. Despite these advantages, coating degradation under severe thermo-mechanical loads remains a key limitation, particularly when machining hardened steels. Improving the utilization of such coatings using effective cooling strategies is therefore essential for enhancing tool performance.

In this study, machining performance of TiAlN-coated carbide cutting inserts was evaluated during hard turning of 42CrMo4 steel under varying liquid CO_2 (LCO_2) flow rates. Relationship between coating behavior – deposited in a cathodic arc evaporation unit – and thermo-mechanical conditions in the cutting zone was evaluated. Tool life, cutting forces, and cutting zone temperature were systematically analyzed for different LCO_2 flow conditions.

The results indicate that increasing LCO_2 flow rate enhances heat removal; however, excessive LCO_2 flow reduces the cooling effectiveness, leading to a reduced tool life. At flow rates above 400 g/min, tool life is even shorter than under dry turning conditions. In addition, higher flow rates increase machining costs without delivering corresponding performance benefits. Optimized flow rates slow down wear development, whereas excessive cooling of the workpiece can accelerate tool wear. These findings highlight the critical importance of optimizing the LCO_2 flow rate to achieve improved tool life, stable machining conditions, and cost-effective, sustainable manufacturing.

Hydrophilization of magnetic powder by precise dosing of oxygen atoms

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Powerful magnets used in electric vehicles are often made from magnetic powder densely distributed in a polymer matrix. The magnetic powder provides adequate magnetic properties of the powerful magnets, and the polymer matrix provides appropriate mechanical stability and helps prevent corrosion of the magnetic powder. The magnetic powder, particularly suitable for powerful magnets, is made from a neodymium-iron-boron alloy with the stoichiometry $Nd_2Fe_{14}B$. The material is synthesized by melt-spinning: a liquid alloy at high temperature is forced onto a spinning drum, where it rapidly cools to form a ribbon of amorphous (or nanocrystalline) material. The procedure takes place in the absence of oxygen, which would otherwise cause oxidation and thus inadequate magnetic properties. The as-synthesized ribbons are then crushed to obtain a powder of the desired particle size. During this procedure, adventitious carbon adsorbs onto the magnetic material, thereby degrading its wettability with all liquids except the most unipolar ones. The powder is mixed with polymer powder, and the polymer is melted in an extruder. The adventitious carbon acts as an interface between the magnetic material and the polymer, so the wettability for the melted polymer is inadequate, and the adhesion between the powder and the polymer matrix is poor, and so are the mechanical properties of the bonded magnet. A method for removing adventitious carbon is presented. The magnetic particles are exposed to atomic oxygen from a low-pressure oxygen plasma source. Wettability increases rapidly with increasing oxygen-atom dose and reaches a maximum in the range of about 10^{22} to 10^{23} m^{-2}. Larger doses were found to be inadequate due to wettability loss. In fact, the wettability became as bad as that of untreated samples after a dose of a few 10^{24} m^{-3}. The loss in wettability was explained by the selective oxidation of the magnetic materials.

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Electron localization in the presence of spin disorder in $Ca_{1-x}Gd_xMnO_3$ manganite

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Electric conduction in many novel quantum materials is determined by a complex interplay between interactions and disorder. Advanced theoretical studies use Mott-Anderson localization phenomenon to model behaviour of conducting electrons. Such approach indicates opening of an interaction-induced energy gap, which coexists with disorder-induced localized states at the Fermi level (EF). Experimental studies however have been unable to resolve an insulating state consistent with such band structure.

In this work we investigate electric transport in the manganite $Ca_{1-x}Gd_xMnO_3$ with $x \leq 0.2$, a canonical material with strong interactions and disorder. By performing detailed magnetic and transport measurements we show that electric transport within the insulating charge order phase takes place via two conduction channels, namely thermal activation across a mean-field-like energy gap and spin-dependent hopping among localized states at EF. Two conduction channels are associated with two magnetic phases: former with antiferromagnetic charge order, and the latter with disordered cluster spin-glass-like phase. To our knowledge this is the first time that multiple conduction channels are successfully disentangled providing clear evidence of the opening of the energy gap in the presence of localized states and thus confirming that electrical conduction in this material can be described by Mott-Anderson localization theory.

Preservation of historical artefacts through atmospheric pressure plasma jet treatment

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This study explores the application of a non-thermal atmospheric pressure plasma jet as an innovative disinfection strategy for the conservation of wooden cultural heritage artifacts. To evaluate its effectiveness, wooden test plates were deliberately inoculated with the brown rot fungal mycelium Coniophora puteana, a common biodeteriogenic species known for its ability to degrade lignocellulosic materials. Following inoculation, the samples were treated with an argon-based atmospheric-pressure plasma jet under controlled conditions. The progression of mycelial colonization on the plate surfaces was systematically monitored over seven days by quantifying the area covered by fungal growth.

The findings reveal that exposure to the plasma jet induces a pronounced stress response in the fungal mycelia, leading to the formation of calcium oxalate crystals. This biomineralization process appears to inhibit further fungal proliferation, effectively suppressing colonization. Importantly, complementary analyses confirm that the plasma treatment does not modify or degrade the chemical composition of sensitive decorative layers, such as gilded or lacquered surfaces. This highlights the method's suitability for removing atmospheric contaminants and biological deposits without compromising delicate artistic finishes. Overall, the cold argon plasma jet demonstrates strong potential as a safe and efficient tool for eliminating fungal contamination on wooden artifacts [1].

Beyond its immediate disinfection capabilities, this approach also opens pathways for future conservation technologies. In particular, the integration of antimicrobial ZnO nanoparticles into paper, textiles, or painted substrates represents a promising approach to enhancing the long-term stability and resistance of cultural heritage materials. Such hybrid plasma–nanomaterial strategies could significantly strengthen preventive conservation practices and contribute to more durable preservation solutions [2,3].

Keywords: Non-thermal atmospheric pressure plasma jet, coniophora puteana, calcium oxalate crystals, wooden artifact disinfection, ZnO nanoparticles for cultural heritage

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Plasma-Driven Photodegradation of Aflatoxins: Harnessing Vacuum UV for Rapid Food Decontamination

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Aflatoxins are highly toxic and chemically stable contaminants that pose significant health and economic risks in the agro-food sector. This study presents a rapid, nonthermal approach for aflatoxin degradation using vacuum ultraviolet (VUV) radiation generated by an inductively coupled hydrogen plasma. Experiments were conducted on both model quartz substrates and artificially contaminated maize grains to evaluate degradation efficiency. On smooth model surfaces, more than 90% of aflatoxins were degraded within 10 seconds of VUV exposure, demonstrating highly efficient photochemical decomposition. When applied to maize grains, up to 80% toxin removal was achieved within one minute; however, a residual fraction (~20%) persisted even after prolonged treatment. This limitation was attributed to the restricted penetration depth of VUV photons, preventing access to toxins embedded within surface crevices and pores. The results confirm that hydrogen-plasma-generated VUV radiation is a powerful tool for rapid surface decontamination, particularly for smooth substrates. However, scalability for bulk agricultural products is constrained by limited photon penetration and vacuum processing requirements. The study suggests that combining VUV treatment with complementary methods, such as mechanical agitation or enzymatic degradation, may offer a more effective and scalable solution for aflatoxin mitigation.

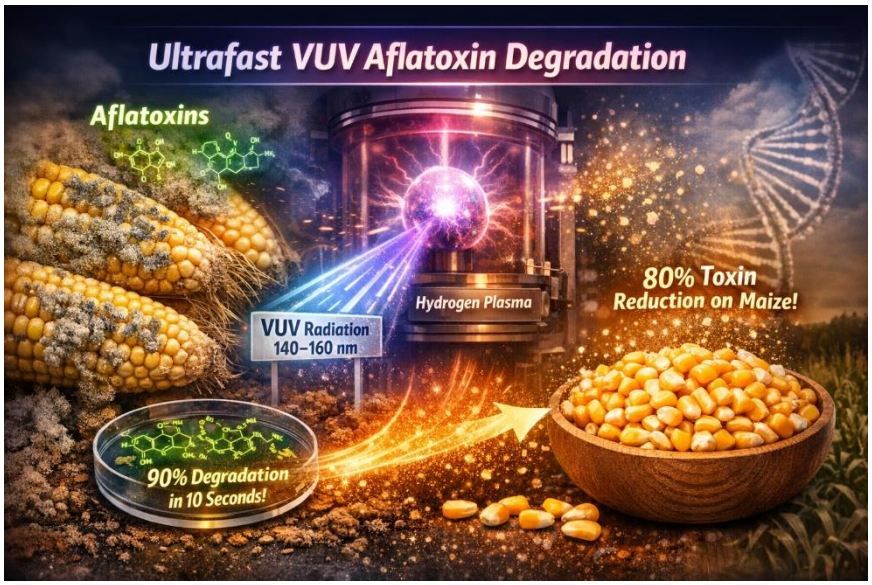

Figure 1: Plasma VUV degradation of aflatoxins.

Catalytic probe improvements with PE-CVD using carbon precursors

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We investigate heterogeneous surface recombination of neutral oxygen atoms. By utilizing surface heating via surface recombination, we can construct a fairly simple catalytic probe, and the choice of materials used in its construction is vital for detecting neutral atoms. Neutral atom density in the flowing afterglow and the recombination coefficient on several surfaces are measured.

The Eley-Rideal and Langmuir-Hinshelwood mechanisms explain recombination. The first mechanism describes the recombination process of an impinging atom and a physisorbed atom, while the second mechanism describes the recombination process of two physisorbed atoms. We investigate the factors influencing the recombination coefficient on a given surface, starting with the two most impactful parameters: surface temperature, which facilitates recombination, and surface morphology. Other parameters also influence the recombination process, such as the pressure in the experimental system and the surface chemistry of the studied surface.

We use calorimetry for measuring both the neutral atom density and the recombination coefficient. In our own experiments, we use the Šorli-Ročak method first to determine the absolute number density of neutral oxygen. Using this method along with a standard catalytic probe, we determine the recombination coefficient of oxidized nickel, cobalt, and cobalt covered with a layer of carbon nanowalls (CNW). We can control the thickness of the CNW layer via plasma-enhanced chemical vapor deposition (PECVD).

We use a gaseous plasma discharge with a gaseous carbon precursor for PECVD, with the thickness of the grown CNW layer increasing with deposition time and a growth rate of roughly 100 nm/s. By depositing CNW directly onto a catalytic probe, we can measure the recombination coefficient of CNW and how it varies with CNW layer thickness. In brief, we find that the recombination coefficient increases with surface temperature and decreases with pressure in our system, with an empirical formula that describes this dependence.

The variance of the recombination coefficient with respect to the thickness of the CNW layer is somewhat more complicated, as more factors are at play during deposition. Firstly, a non-structured layer of carbon, akin to soot, is deposited, thereby decreasing the recombination coefficient. Secondly, nanostructures begin to form, swiftly increasing the effective surface area of our probe, thereby increasing the recombination coefficient. This increase continues as the CNW layer thickens, with diminishing effect.

Enhanced Barrier and Antibacterial Performance of Oxygen Plasma-Treated PET Foils with Adhered Zinc Oxide Nanoparticles

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Polymers are widely used in food packaging due to their ease of processing, low density, flexibility, chemical inertness, and cost-effectiveness [1]. Polyethylene terephthalate (PET) is widely used because of its high transparency, dimensional stability, and favourable thermal and mechanical properties [2]. However, most low-cost polymers exhibit poor surface properties, including low surface energy, limited wettability, poor adhesion, and unsuitable surface morphology [3]. While nanoparticles are commonly incorporated via in situ or ex situ methods [4], plasma-assisted incorporation offers a more advantageous approach by enabling 2D NP localization on the polymer surface, which is crucial for enhancing properties such as antimicrobial activity and allows modification of com-mercially available polymers.
In this study, PET/ZnONP composites were fabricated using a novel two-step oxygen low-pressure plasma-assisted process applicable to commercially available PET films. PET substrates were pre-treated with oxygen plasma in an industrial-scale system, followed by drop-coating of ZnO NPs synthesized via pulsed laser ablation in water at varying concentrations. To assess the retention of ZnO NPs within the composite, which is an essential factor for applications such as food packaging, a leaching test was performed. Antimicrobial activity against Escherichia coli showed nearly complete efficacy at the highest ZnO NP concentration, at which barrier properties were also examined. Oxygen permeability decreased by 139-fold, while water vapor permeability remained largely unchanged. Shelf-life increased from approximately 13 hours for pure PET to about 84 and 76 days for plasma-treated PET and PET/ZnO composites, respectively, demonstrating strong potential for advanced food packaging applications.

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Effect of Cu nanoinclusions on the structural and photocatalytic properties of ALD-grown ZnO thin films

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Zinc oxide (ZnO) has emerged as a promising photocatalyst because it absorbs UV light well, is chemically stable, non-toxic, and allows efficient electron transport. However, it also has several drawbacks that limit its practical use. Its wide band gap (~3.3 eV) means it only absorbs UV light, while the fast recombination of photogenerated electron–hole pairs reduces its photocatalytic efficiency. In this study, we investigated ZnO thin films modified with copper nanoparticles (Cu NPs) as photocatalysts for solar-driven wastewater treatment. The ZnO@Cu films were prepared by incorporating Cu nanoparticles directly into ZnO during atomic layer deposition (ALD). Structural analyses (X-ray diffraction, X-ray photoelectron spectroscopy, and electron microscopy) confirmed that the ZnO retains its wurtzite crystal structure, while Cu nanoparticles with an average size of about 80 nm are embedded in the film. Photoluminescence measurements showed increase in the near-band-edge emission of the ZnO@Cu film, attributed to the coupling between the deep-level emissions of ZnO and the localized surface plasmon resonance of Cu nanoparticles. Kelvin probe force microscopy revealed changes in surface potential near the Cu nanoparticles, indicating electron transfer from ZnO to Cu and the formation of a Schottky-type barrier at their interface. The photocatalytic performance was tested by degrading methylene blue under simulated sunlight. The ZnO@Cu films showed significantly better performance than pure ZnO. This enhancement is explained by the injection of hot electrons from Cu nanoparticles into the ZnO conduction band, as confirmed by photoconductivity measurements showing nearly two orders of magnitude higher charge carrier generation. Overall, the results demonstrate that Cu nanoparticles improve charge generation and separation in ZnO, leading to enhanced photocatalytic activity under solar illumination.

Accredited calibration and measurement capabilities of the Institute of Metals and Technology in the field of reference leaks and helium leak detectors

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Institute of Metals and Technologies (IMT) is designated by the Metrology Institute of the Republic of Slovenia as the holder of Slovenian national standards for pressure and vacuum. In the vacuum area, we have also developed measurement capabilities for the characterization of reference leaks for various gases and the calibration of helium leak detectors.
In this paper, we will describe the measurement methods and accredited scope for reference leak calibrations that we can perform in our laboratory. In addition, we are also accredited for helium leak detector calibrations, which we can perform both in the laboratory and in the field at our customers' premises. In this paper, we will also describe our reference standard for field calibrations of helium leak detectors.

Microstructure and corrosion properties of refractory high-entropy alloy coatings and their nitrides

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In recent years, researchers have extensively studied refractory high-entropy alloy coatings and their nitrides due to their enhanced corrosion resistance. Despite the strong bonding between nitrogen and refractory metals and the chemical inertness of nitrides, it remains unclear whether nitrides provide better corrosion protection than their metallic counterparts. To address this question, we investigated the corrosion stability of three refractory high-entropy alloys (TiVCrZrNbMo, TiVCrHfTaW, ZrNbMoHfTaW) and their nitrides deposited by magnetron sputtering.

We characterized the structure by X-ray diffraction (XRD) and scanning electron microscopy (SEM), while we evaluated the corrosion properties by potentiodynamic polarization tests. The TiVCrZrNbMo and TiVCrHfTaW coatings exhibited an amorphous structure, whereas ZrNbMoHfTaW exhibited a body-centered cubic (bcc) structure. The TiVCrHfTaW coating showed a completely featureless cross-sectional morphology, whereas TiVCrZrNbMo was featureless in the lower part and showed subtle fiber-like features in the upper part. Similarly, the ZrNbMoHfTaW coating exhibited a featureless morphology in the lower part, while the upper part showed pronounced columnar growth, which is consistent with its crystalline structure. All three nitrides exhibited a face-centered cubic (fcc) structure with a columnar morphology.

The potentiodynamic polarization tests showed that the TiVCrZrNbMo and TiVCrHfTaW coatings have high corrosion resistance due to their amorphous structure. In contrast, the nitride coatings exhibited a higher corrosion current, which we attribute to the formation of a porous oxide layer.