GEORGI NADJAKOV INSTITUTE OF SOLID STATE PHYSICS
BULGARIAN ACADEMY OF SCIENCES

24th INTERNATIONAL SCHOOL ON CONDENSED MATTER PHYSICS

B O O K O F A B S T R A C T S

"Functional Materials for Sustainable Innovation and the Green Technology Transition: From Processing to Applications"

August 30th – September 4th, 2026
Varna, Bulgaria

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10:15-11:00	SAMO KRALJ, "Controlled Nanoparticle Targeting and Nanoparticle Assembling in Soft Matrices" ***Milko Borisov Memorial Lecture***
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12:20-12:40 JAKUB HOLOVSKY, "$Li_{1.66}CuSn_{3.33}S_8$ Thin-Film Prepared by Pulsed Laser Deposition as a Potential Photovoltaic Material"
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16:00-16:40 MARTIN LEDINSKY, "Universal Formation Mechanism of Halide Perovskite Thin Films"
16:40-17:20 ERDEM ALACA, "Surface-Modified Silicon Nanowires as Chemiresistive Sensors"
17:20-17:40 KAREKIN ESMERYAN, "Effect of Alcohol Temperature on the Quality Profiling of Commercial and Homemade Beverages Using Metal-phenolic Film-coated Quartz Crystal Microbalances"

18:00-19:00 **First poster session**
(coffee and refreshment drinks)

September 2nd (Wednesday)

08:30-09:00 *Registration*
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09:00-09:40 PHILIPPE VANDERBEMDEN, "Large-grain Bulk Superconductors Prepared by Single Direction Melt Growth (SDMG) Used as Efficient Materials to Trap or Shield Strong Magnetic Fields: How are Their Performance Affected by Time-varying Applied Fields?"
09:40-10:00 KRASTYO BUCHKOV, "High-Temperature Superconductivity: Four Decades of Exploration"
10:00-10:20 SCOTT WAITUKAITIS, "Adventitious Carbon Breaks Symmetry in Oxide Contact Electrification"

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11:00-11:40 ALBENA PASKALEVA, "Materials and Structures for Neuromorphic Computing"
11:40-12:20 NIKOLAY PETKOV, "Molecular Functionalization of Functional Semiconductor Devices for Chemical Sensing"
12:20-12:40 KRISTIYAN GROZDEV, "Development of a Methodology for the Control and Subsequent Optimization of the Actual Optical Thickness of a Multilayer Optical Coating"

12:40-16:00	*Lunch break*
16:20-17:30	**Chair: Aleš Iglič**
16:20-16:40	GEORGI TANKOVSKI, "Thermodynamic and Mechanical Evolution of Gelatin Biocomposites Under Varying Sweetener Ratios"
16:40-17:00	MARIA LYUDMILOVA, "Photothermally Triggered Drug Release from Gold Nanorod-Liposomal Complexes: Toward Precision-Controlled Drug Delivery"
17:00-17:30	ALLA REZNIK, "Process-Gas Control of Amorphous versus Polycrystalline Growth in Ion-Assisted PVD PbO Photoconductive Films for X-ray Imaging"
17:30-18:30	**Second poster session** (coffee and refreshment drinks)
20:00	***Farewell Dinner***

September 3rd (Thursday)

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09:40-10:00	GEORGE IVANOV, "Combination of Gravimetric and Electrochemical Signal Transduction in Chemical Sensors for PFOS Water Contaminant Detection"
10:00-10:20	ASEN DIMOV, "Langmuir and Langmuir-Blodgett Films from 20nm Sized Crystals of Metal-Organic Framework Material MIL-101(Cr)"
10:40-18:00	*Lunch break and Social event*

September 4th(Friday)

09:00-10:30	**Chair: Nikolay Petkov**
09:00-09:40	VERA MARINOVA, "2D Functional Materials for Next-Generation Optoelectronic and Photonic Devices"
09:40-10:20	VESELIN TONCHEV, "How many scales enter the description of the step bunches of Stoyanov"
10:20-11:00	DIMITRE DIMITROV, "ALD-grown Al-doped ZnO as a multifunctional ITO-free electrode for liquid crystal and PDLC devices"
11:00	**Closing Ceremony**

POSTER PRESENTATIONS

1. FIRST POSTER SESSION, September 1st (Tuesday)

1.1. S. BARANOVSKI, "Light-Induced Nucleation of Cesium"

1.2. M.STIFT, "Optical Characterization of Gold-Based SPR Chips by Spectroscopic Ellipsometry"

1.3. G. YANKOV, E. IORDANOVA, V. ATANASSOVA, "Modular System for Direct Air Capture of CO_2 Using Bioactive Membrane Modules"

1.4. M. ILIEVA, V. ATANASSOVA, "Multi-Element Analysis of Ceramic Artifacts from Northwestern and Southeastern Bulgaria by means of Inductively Coupled Plasma Optical Emission Spectrometry"

1.5. V. DONCHEV, "Optical investigation of epitaxial GaAs layers integrated on virtual Ge/c-Si substrates"

1.6. A. EUROSI, "Plasma-assisted Process for the Epitaxial Growth of III-V Materials and their Integration on epiGe/c-Si Virtual Substrates"

1.7. C. ZENG, "Numerical Investigation of Water-Overlayer-Induced Mueller-Matrix Variation in Plasmonic Au Nanostructures"

1.8. S. RAEISI, "In-situ spectroscopic ellipsometry study on the thermal stability of silk thin films"

1.9. G. SZÁNTÓ, "Finite-Element Study of Surface Roughness Effects in Spectroscopic Ellipsometry"

1.10. E. STOYANOVA, "Ellipsometric models for determination of depth dependent inhomogeneity in high-index thin layers"

1.11. G. VLADMIROV, "Optical Approach for Real-Time Detection of Microplastics In Aquatic Environments"

1.12. D. VASSILEV, "Photothermal Response of Plasmonic Nanoparticles: Characterization of Optical Absorption and Photothermal Conversion"

1.13. D. VASSILEV, "Surface Analysis of Sandblasted and Non-sandblasted 3D Printed CoCr alloy for dental applications"

1.14. A. TENEV, "Simulation and Elaboration of Chirped Dielectric Mirror for Femtosecond Laser Pulses at 1030 nm"

1.15. T. TENEV, "Spectrophotometric Determination of Thin Films Absorption in PVD Deposited Multilayer Resonant Structures"

1.16. T. ZAHARIEV, "Can We Control the Antenna-Effect in Luminescent Lanthanide Complexes, to Achieve Optimal Energy Conversion: Insights from Theoretical Modelling with Quantum Chemistry Methods"

2. SECOND POSTER SESSION, September 2nd (Wednesday)

2.1. E. KORUTCHEVA, "Urban Traffic for Energy Efficiency and Sustainability"

2.2. O. PIROUTEK, "Real-Time Insight into $FAPbI_3$ Crystallization Process"

2.3. H. SOLUNOV "Estimating the Width of the Relaxation Time Spectrum in Glass-Forming Liquids from Thermodynamics"

2.4. G. TANKOVSKI, "Influence of Sweetener Composition on the Electromagnetic and Optical Responses of Gelatin Matrices"

2.5. V. DULEV, "Investigation of Zinc Tin Oxide/Tin Sulfide Heterostructures for Efficient Thin-Film Solar Cells"

2.6. M. F. ASHRAF, "Structural, Magnetic, and Magnetocaloric Properties of Ti-Substituted $GdMnO_3$ Multiferroic Single Crystals"

2.7. Y. FEDCHENKO, "Probing the Capability of Metal-phenolic Film-coated Quartz Crystal Microbalances to Detect Sub-threshold Levels of Methanol as a Contaminant in Alcoholic Beverages"

2.8. T. STANCHEV, "Investigation of Charge Trapping Properties of HfO_2/Al_2O_3 Nanolaminated Dielectric Stacks"

2.9. D. SPASOV, "Effect of HfO_2/Al_2O_3 Charge Trapping Layer Structure on Memory Characteristics of Flash Cell Studied by TCAD"

2.10. E. HASAN, "Electrostatic Probe Diagnostics in Magnetized Plasmas"

2.11. V. VITKOVA, "Salt-dependent stability and structural properties of phosphatidylcholine vesicles: a MARTINI coarse-grained molecular dynamics study"

2.12. V. GEORGIEV, "Electrochemical Impedance Spectroscopy as a Quantitative Readout of Temporin-induced Membrane Perturbation"

2.13. A. GEORGIEV, "Analysis of the Efficiency of Partial Dealcoholization of Rosé Wine in Concentration Mode via Nanofiltration"

2.14. T. VLAKHOV, "Detection of Volatile Organic Compounds Using Impedance Spectroscopy with Phospholipid Langmuir–Blodgett Films"

2.15. M. LYUDMILOVA, "Biophysical Interactions of Ultrasmall Gold Nanoparticles with Archaeal Lipid-Based Biomimetic Membranes"

ABSTRACTS OF INVITED LECTURES

GEORGI NADJAKOV MEMORIAL LECTURE

Attractive Interactions Between Like-Charged Surfaces and Phagocytosis

A. Iglič [1*], E. Gongadze [1], S. Penič [1], S. Shubhadeep [2], R.K. Sadhu [3], N. Gov [2,4], V. Kralj-Iglič [5]

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It is shown that in the saturation regime close to the charged lipid surface, water dipole ordering and depletion of water molecules may result in a substantial local decrease of relative permittivity. An analytical expression for the osmotic pressure of the electrolyte solution between the zwitterionic lipid surface and a charged particle is derived. In addition, the theoretical description of the possible origin of the experimentally observed attractive interactions between like-charged membrane surfaces mediated by charged macroions with distinctive internal charge distribution is given. At the end the engulfment of rigid or soft objects/particles by giant lipid vesicle or cell membrane is theoretically described by using theoretical models and simulations, where the electrostatic forces are also taken into account.

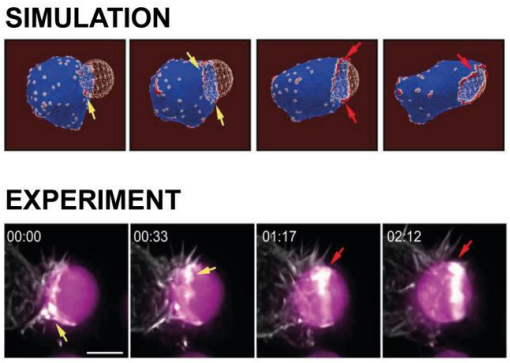

Figure 1. Monte Carlo (MC) simulation and experimental observation of membrane engulfment of spherical particle. The red colour in MC simulations denotes the curved protein complexes which are also the sites of the recruitment of actin polymerization and form a complete ring around the leading-edge rim during the final stages of the engulfment process, both in the simulations and the experiments. (adapted from [1]).

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MILKO BORISOV MEMORIAL LECTURE

Controlled Nanoparticle Targeting and Nanoparticle Assembling in Soft Matrices

Samo Kralj [1,2*]

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[2] *Faculty of Natural Sciences and Mathematics, University of Maribor, Maribor, Slovenia*

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We will present our study of controlled targeting of nanoparticles (NPs) and their self-assembling in liquid crystal (LC) media. We use LC matrices as NP hosts owing to their unique combination of (i) liquid character, (ii) orientational order, (iii) softness and (iv) optical transparency and anisotropy. These properties are advantageous for the following reasons. (i): Liquid character enables relatively simple immersion of different NPs. (ii): LC order can be described by relevant mesoscopic order parameter (OP) fields. In thermotropic LCs, which we use, different OP fields are established via temperature driven continuous symmetry breaking phase transitions. In such cases OP fields consist of two qualitatively different contributions: amplitude and phase fields. Amplitude fields measure the degree of established order formed in the transition. On the other hand, phase fields in bulk equilibrium determine a selected symmetry breaking direction among available degenerate states. In our studies regions exhibiting reduced amplitudes will serve as NP attractors. Furthermore, interaction of NPs with LC phase field components will enable tunable long-range elastic forces and consequent transport of NPs. (iii): Soft character arms LCs with sensitivity to external stimuli which could be exploited for needed local LC structural changes in particular applications. (iv): Finally, optic anisotropy will enable observation of NPs transport and structures of NP assemblies by using relatively simple optical methods.
We use nematic LCs in which we impose diverse disclination patterns (line topological defects). These topological defects (TDs) can serve as two-way directional pathways (to which we henceforth refer to as NP-roads) for specific NPs. We will present ways to remotely manipulate orientations and rewiring of NP-roads and NP directional transfer along them. Appropriate NPs or their assemblies (effective objects) are needed to enable their controlled transport.

INVITED LECTURERS

Archaeal Lipids as Building Blocks for Stable Functional Materials

Jan Kejžar [1] and Nataša Poklar Ulrih [1,*]

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The development of sustainable functional materials increasingly relies on bio-inspired design strategies that combine high performance, durability, and resource efficiency. Archaeal membrane lipids, originating from extremophilic microorganisms, represent a distinctive class of bio-derived materials whose ether-linked, branched isoprenoid architecture confers exceptional physicochemical stability compared to conventional ester-linked phospholipids [1]. These unique molecular features make archaeal lipids attractive candidates for enhancing the robustness of lipid-based soft materials without the need for synthetic stabilizers. In this contribution, we investigate polar lipids isolated from the hyperthermophilic archaeon *Aeropyrum pernix* K1 as functional modifiers of lipid assemblies. Building on recent studies demonstrating that low fractions of archaeal C25,25 lipids can substantially alter the physicochemical properties of sphingomyelin–cholesterol liposomes [1,2], we examine how archaeal lipids influence membrane organization, colloidal stability, and performance under biologically relevant conditions. Using complementary physicochemical characterization and *in vitro* assays, we show that incorporation of a small amount of archaeal lipids (≈2 mol%) stabilizes liposomes against calcium-induced destabilization, enables full recovery of vesicle morphology following chelation, and supports highly efficient active drug loading, reaching encapsulation efficiencies comparable to established clinical formulations [1]. Importantly, optimization at low archaeal lipid content preserves the favorable biological stability of sphingomyelin–cholesterol systems, avoiding the rapid aggregation and leakage previously observed for fully archaeal membranes composed entirely of C25,25 lipids [1,3,4]. This hybrid approach retains the intrinsic physicochemical resilience of archaeal lipids while maintaining compatibility with biological environments, highlighting a non-linear relationship between archaeal lipid content and membrane stability [1–4]. Overall, these findings position archaeal lipids as versatile, bio-derived building blocks for stable functional materials. By translating molecular design principles from extremophile membranes into applied soft-matter systems, this work contributes to the development of durable, resource-efficient materials aligned with green technology and sustainable innovation.

References

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UV Linnik interferometer for UV-visible-NIR local spectroscopy of materials: challenges and achievements

Paul C. Montgomery [1*], Farid Mahfoud [1,2], Sebastien Marbach [1], Noémie Gambaudo [1], Rémy Claveau [1], Jesse Schiffler [1], Olivier Felix [2], Matthias Pauly [2,3] and Manuel Flury [1]

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The development of new materials requires the use of advanced characterization methods. White light interference microscopy is one such technique used in optical metrology for the surface topography and depth characterization of opaque, transparent and semi-transparent materials. In past work, while we have successfully extended the use of this technique to local spectroscopy mapping in the visible to NIR range [1], it was found that the optical response measurements were restricted to a range of 460–780 nm, the response in the UV-blue region of the spectrum being weak due to losses in the optical elements and the low response of the camera at these shorter wavelengths. In this work, we present the challenges faced and the achievements of completely redesigning a UV Linnik interferometer to extend the measurement range down to UV wavelengths. By using x40 reflective objectives, a UV-optimized beamsplitter, a UV enhanced reference mirror and tube lens and a UV sensitive camera (Fig. 1(a)), the measurement range has been successfully extended to 300–900 nm [2, 3]. Quantitative reflectance data are acquired as spectral cubes, enabling detailed spectral and spatial analysis and thus allowing multi-modal measurement of topography, local spectroscopy and colorimetry at these wavelengths. The system performance for comprehensive UV-visible-NIR analysis is validated by making measurements on thin films of Au, Nd:SnO_2 (Fig. 1(b)), ZrO_2, SiO_2 and ITO deposited on silicon wafers.

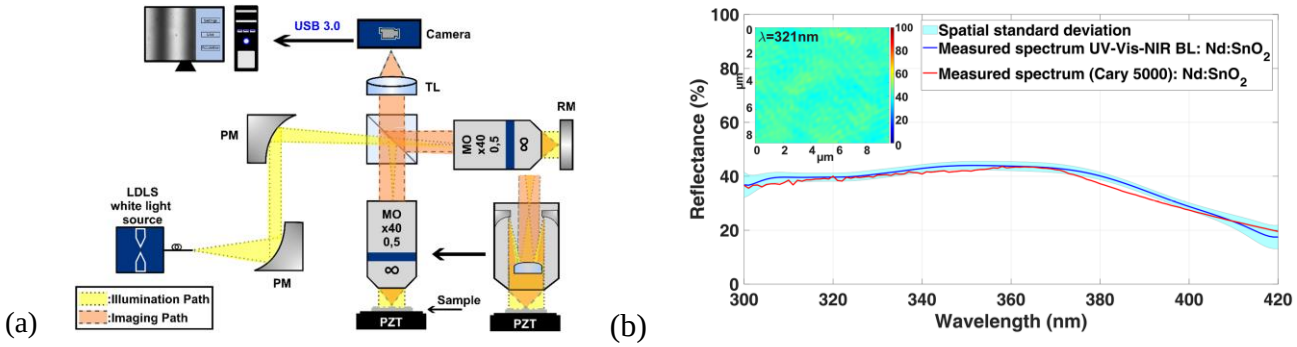

Figure 1: *Development of a UV Linnik interferometer: (a) layout of the system, (b) reflectance spectra and spectral map at 321 nm of Nd:SnO_2, compared to measurements with a standard spectrometer.*

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Acknowledgements

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Charge Transport in Organic Semiconductors for Device Applications

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Interest in the optoelectronic properties of organic crystalline and amorphous semiconductors has increased significantly over the past few decades. This is attributable to the successful current applications of such materials in thin-film transistors, light-emitting diodes, solar cells, sensors, and photorefractive devices, as well as to their potential for future applications [1,2].

The nature of charge transport mechanisms in organic semiconductors remains a subject of debate. The scientific literature presents various models for charge transport in organic materials, ranging from classical band-like conduction to the incoherent hopping of charge carriers between localized states arising from static and dynamic disorder as well as from electron-phonon interactions [3,4].

Theoretical models for description of charge transport in organic materials will be reviewed in the presentation. Particular attention will be given to material parameters responsible for the dependencies of charge carrier mobility on the intrinsic properties, such as molecular structure, on the extrinsic properties, such as the nature of defects and their concentration, and on the external parameters, such as electric field and temperature [5,6].

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Nano-scale Fabrication of 2D Material-based Devices

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2D materials-based devices represent a possible solution for the nanoelectronics of the future. Their functionality strongly depends on the shape of the layer itself. For example, some unpatterned 2D materials have no bandgap, being not suitable for the fabrication of many devices like the digital field effect transistors, because the "off state" could not be achieved [1]. While 2D materials enable absolute electrostatic gate control for extreme device scaling, three fabrication bottlenecks proved to be extremely important: high contact resistance, interface contamination and thermal budgets. The fabrication of such devices involves synthesizing atomically thin sheets, transferring them to target substrates, and patterning them into functional microelectronic circuits. In order to obtain their desired functionalities, the active layer is patterned at the nanoscale by various nano lithographic techniques, one of the most important being the electron beam lithography. It features ultra-high resolution and great flexibility, proving to be a very useful tool for shaping 2D materials with details in the sub 100nm range [2]. The main objective of this talk is to present precise fabrication using e-beam lithography for a series of devices like: graphene ballistic transistors producing negative differential resistance with large peak to valley ratio [3], graphene field-effect-transistors with nano perforated graphene channels [4], ultrathin SnS_2 and $SnSe_2$-based FETs [4] and MoS_2 self-switching diode, memristors and photodetectors [5]. The basics of e-beam lithography will be introduced, also pattern transfer, e-beam resists, material interaction, resolution limits, throughput, proximity effect correction and characteristics of different e-beam lithography tools, all these connected with the special requirements of deposition and etching processes.

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Solar Photovoltaics: Status in the mid-2020s

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Since its commercial origins in the 1950s as a satellite power source, solar photovoltaics (PV) has matured into a leading global supplier of renewable electricity [1]. While various thin-film alternatives have historically competed with crystalline silicon, monocrystalline silicon wafers maintained a market-leading 96% share in 2025, with cadmium telluride (CdTe) comprising most of the remainder [2]. Recently, synthetic metal-halide perovskites have emerged as a disruptive challenger. With a bandgap of approximately 1.5 eV and exceptionally low recombination losses, perovskite-based cells achieve a laboratory power conversion efficiency (PCE) exceeding 27% for single-junction cells and approaching 35% for perovskite-silicon tandems. Although commercial 30% PCE modules are anticipated, widespread deployment hinges on overcoming degradation, current-matching, manufacturing and environmental challenges [3]. Ultimately, these advancements will challenge incumbent silicon cell architectures like Tunnel Oxide Passivated Contact (TOPCon) and Silicon Heterojunction (SHJ), potentially paving the way for all-perovskite multi-junction dominance. This brief review is a personal perspective on the role of PV in the evolving global electricity mix. Beyond cell-level materials science and engineering, we evaluate the systemic bottlenecks facing the technology, the integration of grid-scale electricity storage [4] and the imperatives of inclusivity and design for sustainability [5] in securing a just energy transition.

Figure 1. Sheep grazing around a solar farm [6]

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Combinatorial, plasmonic and related process monitoring applications of ellipsometry

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Plasmonic nanostructures are widely used in sensing, photonics, and related fields, but they are difficult to model with standard ellipsometric approaches based on transfer matrices, effective media, first-principle oscillators, or analytical dispersion functions. This work presents modeling methods for characterizing various plasmonic and periodic nanostructures, including gratings [1], annealed nanoparticles [2], electrochemical systems, and combinatorial sputtered layers. Nanoparticle formation was monitored during annealing and electrochemistry using through-liquid and Kretschmann-Raether configurations. We studied gold layer growth, silk–analyte interactions, flagellar filament adsorption, and electrochemical sensing. The optical sensitivity of periodic and annealed gold nanostructures was evaluated experimentally and explained through simplified numerical and finite element models.

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Universal Formation Mechanism of Halide Perovskite Thin Films

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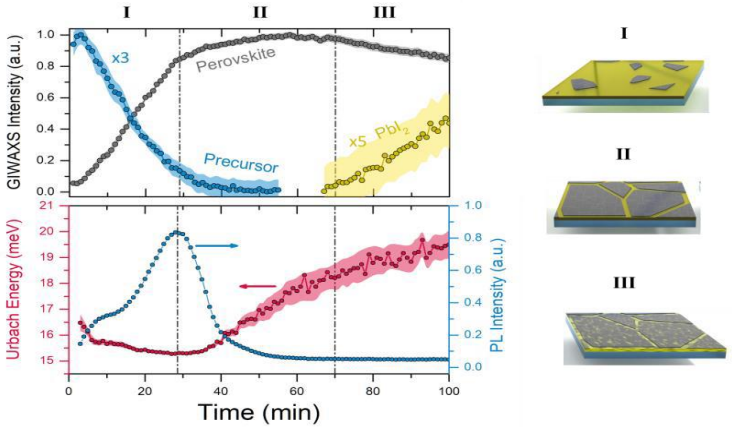
Metal halide perovskites (MHPs) have gained significant scientific interest due to their outstanding optoelectronic properties and high efficiencies in solar cell photoconversion. There are many ways to prepare MHPs of reasonable quality, the solution process is still the best in this manner. But the vacuum-based methods, which are relevant for industry and large area deposition, are not lacking far behind. The final product is always the MHP thin film of similar morphology and structure. The only substantial difference is the dimension of the grains, which used to be larger for solution processed films. Therefore, logical question arises, what are the differences in the MHP film formation? Recently, with the insight of in-situ photoluminescence (PL) and GIWAXS measurements, we have studied the MHP film deposition by solution processes [1]. Based on the results depicted bellow, we divided the MHPs growth into three stages. In short, we see fast growth of MHPs grains from GIWAXS in the first growth stage, accompanied by proportional increase in PL signal. However, in the second stage the growth speed significantly decreases, and the PL signal is highly quenched. This observation means that the free grown grains (stage I) are of low defect densities, but once they start to connect (stage II) the grain boundaries are formed, where defects are concentrated. This leads to rapid decrease of the PL signal. The last stage documents partial degradation at long deposition times only. Surprisingly, very similar observation was done by in-situ measurement of evaporated MHPs and films prepared by pizza oven deposition. Preliminary results shows the same tendencies for pulsed laser deposited MPHs as well. Deeper understanding to this universal formation mechanism of MPHs thin films give us a unique opportunity to enhance its optoelectronic quality. One critical aspect is formation of large grains, the second one is the passivation process mainly at the grain boundaries. In-situ PL characterization is able to guide us through these processes.



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Surface-Modified Silicon Nanowires as Chemiresistive Sensors

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Precise modification of surface states is critical for exploiting the full functionality of suspended silicon nanowires (Si NWs) in sensing and nanoelectronic applications. We report a noncontact metallization strategy that combines stencil lithography with high-accuracy registration and alignment to enable batch processing of suspended Si NW arrays [1]. The method achieves micro-scale placement precision across devices while preserving nanowire integrity [2]. By introducing metals of varying work function onto selected NW regions, the local electrostatic landscape can further be engineered, leading to systematic tuning of electrical transport characteristics. Furthermore, combining different metals at distinct locations along the same NW (Fig. 1) produces electrically distinguishable responses that depend on metallization layout and sequence. The results demonstrate a scalable approach for engineering functional heterogeneity in one-dimensional semiconductor structures and provide a foundation for the realization of addressable, low-power sensing and nanoelectronic platforms.

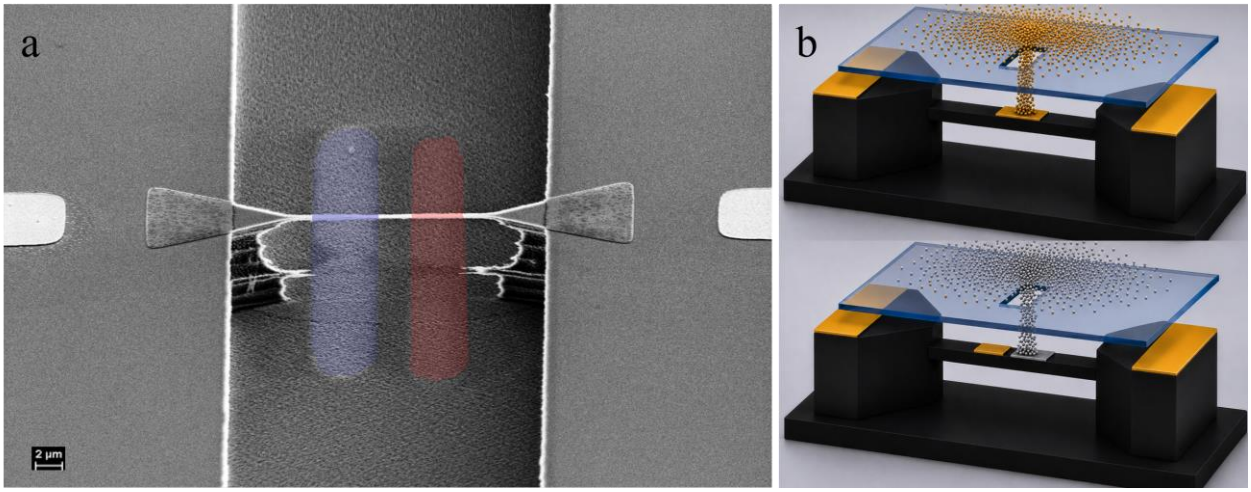

Figure 1. Surface metallization: a) SEM image of a dual metal patterned Si NW, b) Concept of multiple noncontact surface metallization by stencil lithography.

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Large-grain bulk superconductors prepared by Single-Direction Melt Growth (SDMG) used as efficient materials to trap or shield strong magnetic fields: how are their performance affected by time-varying applied fields?

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Large-grain bulk superconductors are characterized by a current-carrying ability significantly higher than 10^4 A/cm² at liquid nitrogen temperature (77 K) and can be routinely synthesized as disk pellets exceeding 2 cm³. These materials are therefore ideal candidates for two opposite applications: they can be used as (i) trapped field quasi permanent magnets, i.e. lossless current loops are trapped and generate a strong magnetic field (above a few teslas), or (ii) efficient magnetic shields / screens, i.e. lossless current loops are induced and generate a field that considerably reduces an external applied magnetic field. This work deals with bulk $GdBa_2Cu_3O_7$ superconductors prepared by the 'Single-Direction Melt Growth' (SDMG) method [1,2]. One significant advantage of this process, compared to previous processing techniques, is the notable improvement in the homogeneity of the trapped field distribution measured close to the top or bottom faces of the sample [3].

In several engineering applications, bulk superconductors are subjected to time-varying applied fields, e.g. during Pulsed Field Magnetization (PFM), when a trapped field permanent magnet is placed in the rotor of a rotating machine, or in a superconducting magnetic screen subjected to changing stray fields [4]. In this communication, we highlight the important parameters that can help predict how the performance of such bulk superconductors is affected when they are subjected to one cycle, or even repeated cycles, of the applied field. Focusing on magnetic screening applications, we first consider the low-frequency regime, for which self-heating can reasonably be neglected; in this case, the key parameters are therefore those related to magnetic relaxation. We then consider the medium-frequency regime and the parameters that influence the self-heating, which becomes crucial in this regime. We therefore characterize the thermal conductivity and specific heat of these samples and discuss the practical implications of the thermal property data by estimating analytically the self-heating of such a large-grain bulk superconductor used for magnetic screening.

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Materials and Structures for Neuromorphic Computing

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Remarkable advances in complementary metal–oxide–semiconductor (CMOS) technology have enabled the development of large-scale neuromorphic hardware platforms capable of emulating the information-processing mechanisms of biological neural systems. Unlike conventional digital computing platforms, neuromorphic systems are designed to mimic the operation of neurons, the fundamental functional units of the human brain. Through complex interactions mediated by synaptic connections, neurons form highly interconnected neural networks that enable cognitive functions such as information processing, adaptation, and learning. Several fundamental distinctions exist between conventional von Neumann computing architectures and neuromorphic systems. Conventional computing relies on sequential data processing, physically separated memory and processing units, and binary data representation. In contrast, neuromorphic architectures employ massively parallel information processing, co-localized memory and computation, and spike-based communication, thereby offering the potential for significantly improved computational efficiency. A notable example is the biologically inspired TrueNorth chip developed by IBM, which integrates approximately one million spiking neurons and 256 million programmable synapses on a single chip. Despite these achievements, CMOS-based neuromorphic systems remain several orders of magnitude less energy-efficient than the human brain, which performs complex cognitive tasks while consuming only about 20 W of power. Consequently, the development of novel materials, device concepts, and computing paradigms is essential to overcome the limitations of conventional CMOS technology and to achieve highly energy-efficient neuromorphic systems capable of approaching the performance and adaptability of biological neural networks. The talk will present the new materials and emerging memory concepts, which are currently investigated for the realization of compact circuits capable of emulating neuron and synapse functionalities. There are several major emerging memory technologies that hold the promise for neuromorphic computing - resistive random access memory (ReRAM), phase change memory (PCM), magnetoresistive random access memory (MRAM), ferroelectric random access memory (FeRAM). Increasing interest toward these novel device concepts results from their ability to store information at the nanoscale in an analogue and non-volatile way. The physical phenomena and operation principles as well as the materials and technologies to realize them will be presented.

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Molecular Functionalization of Functional Semiconductor Devices for Chemical Sensing

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Surface molecular functionalization of semiconductors is commonly performed to modify the electrical, physical and chemical properties of substrate materials for a diverse range of on-chip applications ranging from bio-chemical sensing [1], surface passivation and modification [2], thin film bonding [3], to molecular machines and quantum devices [4]. From a semiconductor device engineering perspective, the success of a semiconductor molecular functionalization step is normally seen by the final electrical or photonic device performance testing. Herein we review the main processes in chemical molecular modification of semiconductor surfaces, including surface oxide modifications using silane coupling reactions and direct covalent attachment to oxide—free Si and Ge surfaces[1]. Special attention is given to Si-nanowire field-effect transistors as (bio)chemical sensing, their fabrication, sensing principles and extremely high sensitivity [2]. Further we review the main techniques for characterizing the chemically functionalized surfaces and introduce a novel approach for spatially resolved quantification of the molecular functionalization, using energy dispersive X-ray (EDX) fluorescence on an electron microscope and molecular marker molecules. Taking advantage of the readily available mercapto-alkyl silane molecules having S-containing markers, and the detailed understanding of the e-beam interaction process at varying incident energies we obtain both spatially resolved and quantifiable information about the functionalization process. This is of particular importance when the specific semiconductor surface parameters altered, and the molecular functionalization strategy chosen depends on many experimental parameters that are sometimes part of multistep semiconductor process flow, hence reliable, direct and fast quantification immediately after functionalization is desirable. Finally, we cover some aspects of chemical separations and introduce the concept of chromatography on-a-chip, using CMOS compatible fabrications.

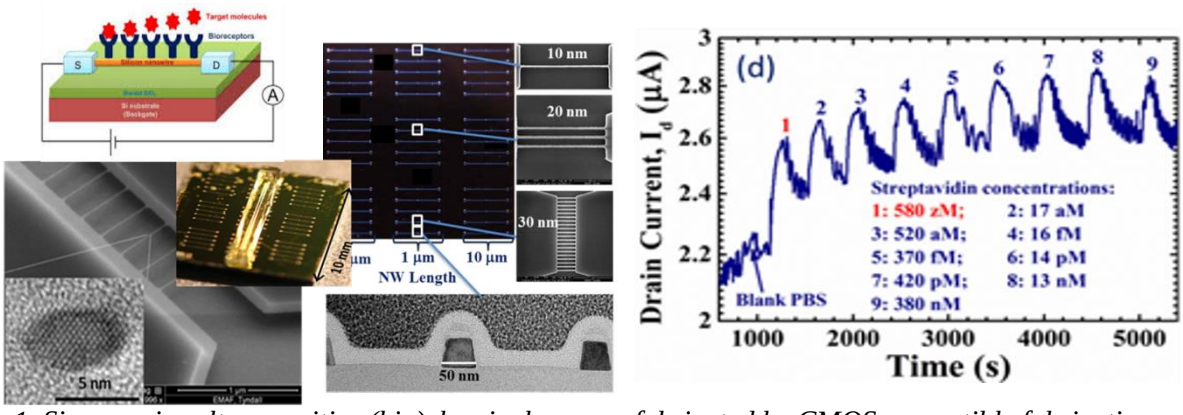

Figure 1. Si-nanowire ultra-sensitive (bio)chemical sensors fabricated by CMOS compatible fabrication using SOI substrates

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Process-Gas Control of Amorphous versus Polycrystalline Growth in Ion-Assisted PVD PbO Photoconductive Films for X-ray Imaging

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Lead oxide (PbO) is a high-Z (atomic number) photoconductor of strong interest for direct-conversion X-ray imaging because it combines high X-ray absorption with efficient charge generation [1]. Its performance, however, is highly sensitive to deposition-induced morphology, density, disorder, and charge transport. This requires a systematic study of how growth conditions control these properties. Here we compare two ion-assisted physical vapor deposition (PVD) techniques for PbO layers: reactive oxygen-ion-assisted thermal evaporation and inert argon-ion-assisted thermal evaporation. Regardless of the technology used, PbO layers are grown on indium-tin-oxide-coated glass substrates with a ~1 µm polyimide film that serves as blocking (dark current limiting) layer. Film structure and morphology were characterized by scanning electron microscopy and Raman spectroscopy, while detector-relevant response was evaluated via X-ray photoconductivity measurements, pulsed X-ray irradiation, and charge-transport analysis. It was shown that oxygen ion assistance promoted non-equilibrium amorphous growth, yielding dense, laterally uniform a-PbO layers with broad Raman features characteristic of highly disordered PbO; these films exhibited electron-hole pair creation energies $W_{\pm}$ of approximately 7.5–10 eV/ehp and effective hole mobility near 0.5 $cm^2/V{\cdot}s$. In contrast, argon ion assistance preserved polycrystalline growth while improving film continuity and temporal response, producing crystalline Raman signatures, needle-like surface crystallites, $W_{\pm}$ = 6 eV/ehp, and no measurable lag under 30 Hz modulated X-ray irradiation at 10 V/µm. These results identify the ion-assist process gas as a key functional parameter governing PbO growth mode and photoconductive behavior: oxygen assistance enables dense amorphous layers suited to uniform large-area coatings, while argon assistance provides a route to lag-free polycrystalline PbO with efficient X-ray-to-charge conversion. This tunability between amorphous and polycrystalline functional regimes, achieved solely through process-gas selection, offers a practical strategy for optimizing PbO-based photoconductors for next-generation X-ray detectors [1–6].

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Experimental Proofs About Existence of Cold Nuclear Fusion in Solids

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Successfully performed replicable experiments about cold nuclear fusion reactions in constantan specimens are reported. These experiments were performed thanks to the initial authors' research in the field of cold nuclear fusion as the corresponding results were partially published in [1, 2]. The experimental scheme consists of gas chamber where the constantan wire specimens were placed and where interaction of these specimens with injected deuterium gas having purity 99.995% took place. The pressure of the deuterium gas was maintained by mass-flow controller, and the temperatures (T) of the specimens were measured by pyrometer. The constantan wires were coiled on alumina rods and initial heating of the wires was performed by electrical power supply, whose heating current and voltage were controlled. Residual gas analyser was used for mass-spectroscopical determination of the nature and the pressures of the gasses in the chamber. Two types of experiments were conducted: with destroying of the specimen (initial T = 950 ^{o}C) and without destroying (initial T = 650 ^{o}C – 700 ^{o}C). The results of the first type are reported here as replicable experiments were performed at initial temperature 950 ^{o}C of the constantan wires. In all experiments, explosive evaporations of the wires occurred momentary after the beginning of the interactions of these wires with deuterium gas (D) injected in the chamber. Copper metal release was observed in the experiments (Fig.1). The released excess momentary energy was ~ 3648J, the energy density was 2280 J/g in terms of the constantan wire and the ratio <output power>/<input power> ≈ 16 and greater. The mass-spectroscopical analysis of the gasses in the chamber (Fig.2) shows: *i)* Release of significant amount of ^{3}He (column 3 and column 5 for ^{3}HeD); and *ii)* Release of D_2O (column 20) due to chemical burning of deuterium gas in the parasitic oxygen environment is almost negligible. The energy release and the mass-spectroscopic data show the nuclear origin of the interaction constantan-deuterium.

Figure 1. Destroyed specimen

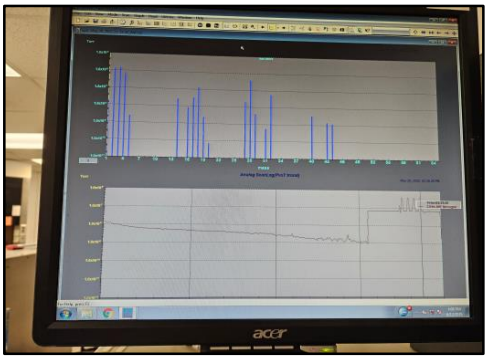

Figure 2. Helium release (especially ^{3}He isotope)

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2D Functional Materials for Next-Generation Optoelectronic and Photonic Devices

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Two-dimensional (2D) materials, including graphene and transition metal dichalcogenides (TMDCs) as WSe_2, $PtSe_2$, $MoSe_2$, MoS_2, etc., have attracted outstanding attention due to their strong in-plane covalent bonds and weak van der Waals forces which provide extraordinary electron mobility and extremely high anisotropic optical response. Their atomically thin nature, tunable bandgaps, and exceptional light-matter interactions mark them ideal candidates for high-performance, energy-efficient optoelectronics and photonics. For example, while p-type WSe_2 offers high hole mobility and strong visible-light excitonic absorption, group-10 $PtSe_2$ features low-temperature air-stable growth and a layer-dependent semiconductor-to-semimetal transition, and n-type $MoSe_2$ provides strong spin-orbit splitting with broad NIR-UV excitonic responses. Therefore, controlled, scalable growth on low-cost substrates remains a main challenge for practical device integration. Here, we report the critical pathway from the scalable, energy-conscious processing of these functional nanomaterials to their integration into advanced optoelectronic architectures and flat optics. We present a comparative investigation of WSe_2, $PtSe_2$, and $MoSe_2$ nanolayers synthesized via Thermally Assisted Conversion (TAC) and liquid-precursor chemical vapor deposition routes. Structural and spectroscopic characterizations (XRD, Raman, XPS, HRTEM) confirm highly crystalline, few-layer 2H or trigonal phase formations across the above systems. Optical spectrophotometry highlights high transparency in the NIR regime for $PtSe_2$ and WSe_2, enabling their successful application as transparent conductive electrodes in polymer-dispersed liquid crystal (PDLC) near-infrared light shutters, while $MoSe_2$ exhibits prominent A, B, C, D excitonic transitions ideal for photodetectors. Electrical transport measurements validate Ohmic behavior across converted layers with sheet resistance suitable for ITO-free optoelectronics [1]. As example, an application of graphene and $PtSe_2$ as transparent conductive electrode in display devices is demonstrated [2]. Besides the excellent phase modulation repeatability over the large-scale area, 2D layers exhibits great potential for future ITO-free integrated photonics and flat optics.

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How many scales enter the description of the *step bunches of Stoyanov*?

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We start with brief account of the material systems that show step bunching and attempt to classify these according to a recent classification scheme initiated by [1]. In order to answer the question in the title we use recent studies on the so-called *Step Bunches of Stoyanov* obtained in models of unstable vicinal sublimation [2]. Main role in this analysis plays a recently identified [3, 4] characteristic length l_Q deduced when imposing the principle of dimensional homogeneity on the scaling relation of the minimal distance in the bunch $l_{\min}$ with the number of steps in the bunch N [2]:

$$l_{\min} = l_Q \left(2/N\right)^{\gamma} \qquad (1)$$

Specifically, we obtain from a scaling analysis of a PDE equation (we call it ST-equation) [2] the two scaling relations that link the horizontal and vertical scale with the time scale. In total they contain 6 scales, 3 of them fixed from the beginning of the process – two spatial and a time scale... We show how the time dependencies of the bunch width and the bunch height obtained numerically fit in this frame. Thus, it is l_Q , a composite parameter, combination of the model parameters, that completes the set of two fixed spatial scales together with the mono-step height h_0. At the end of this part, which is tribute to Stoyan Stoyanov, we review briefly experimental results on the studies of lmin in various experimental systems. We conclude with applying the just developed approach to the case of unstable step flow growth, i.e. homoepitaxy [5].

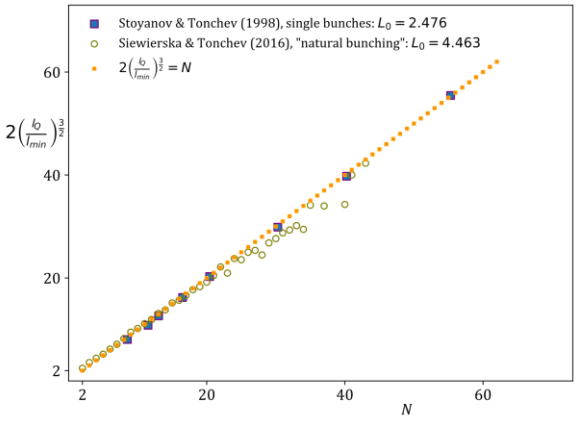

Figure 1. Graphical representation of (1), comparing results of two approaches to build step bunches, [2] and [6].

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Acknowledgements

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ALD-grown Al-doped ZnO as a Multifunctional ITO-free Electrode for Liquid Crystal and PDLC devices

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Indium-free transparent conductive oxides are a key enabler of next-generation liquid crystal (LC) photonics. We summarise our results on aluminium-doped zinc oxide (AZO) films grown by atomic layer deposition (ALD) from diethylzinc, trimethylaluminium and H_2O in a 24:1 supercycle, and on their integration into LC and polymer-dispersed LC (PDLC) devices. Films deposited at 100–200 °C on glass, PET and muscovite mica are compact and pinhole-free (100–210 nm) with a predominant wurtzite (100) texture, 80–90 % transmittance over the visible–NIR range and sheet resistance down to ≈66 Ω/sq ($\rho = 1.8\times10^{-3}$ Ω·cm, $\mu = 9.3$ cm²/V·s), giving a Haacke figure of merit of 0.89×10^{-3} Ω^{-1}, on par with commercial FTO. On flexible PET and mica the sheet resistance is stable over 1000 and 800 bending cycles (radii of 10 and 1.5 mm). Mechanically rubbed (100)-AZO combines an exceptionally low surface free energy with ~20 nm nanogrooves and therefore acts as electrode and alignment layer at once, giving uniform vertical alignment with a pretilt angle of 89.4°. AZO-based LC cells show a threshold voltage of ≈1.1 V and a response time of ≈500 ms, matching ITO and FTO references, while flexible AZO/mica PDLC devices switch from scattering to transparent at 5.8 V (saturation 16.6 V) with rise/decay times of 78/74 ms. ALD AZO thus offers a versatile ITO-free platform for rigid and flexible LC and PDLC devices.

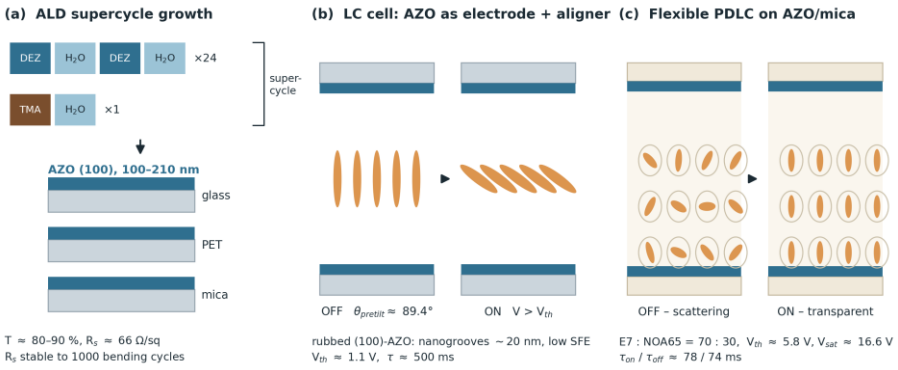

Figure 1. (a) ALD supercycle growth of AZO on glass, PET and mica; (b) vertically aligned LC cell with rubbed (100)-AZO as electrode and alignment layer; (c) flexible AZO/mica PDLC device, OFF and ON states.

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Internal Lattice Mechanics and Crystallography of Low-Dimensional Solids

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The Topology Conservation Theorem (TCT) imposes fundamental constraints on 2D atomistic lattice configurations [1], analogously to the Crystallographic Restriction Theorem for 3D crystals. However, TCT delineates structural boundaries without providing a predictive framework for quantitative investigation of lattice mechanics, deformation behavior, or electronic structure in low-dimensional systems. The validity of periodic boundary conditions cannot be assumed a priori for arbitrary 2D lattices, necessitating finite-flake electronic structure calculations to reveal intrinsic internal deformations free from artificial periodicity constraints. Such calculations inevitably convolve internal deformations with boundary effects, requiring rigorous disentanglement for reliable structural and mechanical analysis.

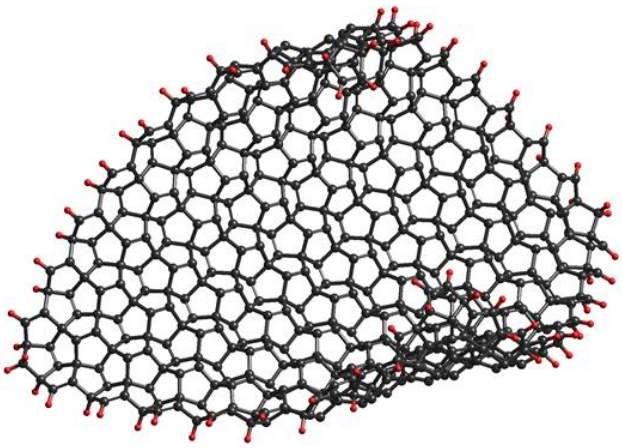

Figure 1. One-unit cell thick lattice of Cairo-Tilling carbon (4×4) flake.

We develop a continuous non-quantum catenary approach, combined with quantum simulations, to simultaneously analyze stabilization energies, deformations, and deformation forces arising from both internal lattice dynamics and edge effects in finite 2D flakes. To elucidate the role of lattice symmetries, we construct a series of structural models for two representative 2D lattices: Cairo-Tilling Carbon (CTC) and Transformed Cairo-Ring Carbon (TCRC). The methodology is validated by excellent agreement between the catenary model, augmented by edge-effect corrections, and quantum simulations, with both approaches yielding identical predictions for the types and directions of internal deformations.

The results reveal that the interplay between internal strain fields and boundary conditions produces distinct deformation patterns governed by crystallographic symmetry. The asymmetry of CTC, arising from non-equivalence of its top and bottom sp^2 sublattices, induces pronounced internal mechanical stress, whereas centrosymmetric TCR exhibits reduced distortion and enhanced planarity. A universal criterion, grounded in Föppl–von Kármán plate theory, is established for predicting lattice deformation types and topological stability, offering a practical tool for rational 2D materials design. Integration of continuum mechanics with atomistic electronic structure calculations provides a unified framework for understanding low-dimensional crystallography, internal mechanics, and deformation behavior of 2D crystals

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ABSTRACTS OF CONTRIBUTED LECTURES

Phase behavior of Twist-bend Nematic Phase

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We study theoretically the twist-bend nematic (Ntb) phase using Landau-de Gennes mesoscopic approach. The Ntb phase is commonly exhibited by curved mesogenic liquid crystalline (LC) dimers. Its basic structure is typically determined by the nematic director $\vec{n}$ which points along a local mesoscopic uniaxial molecular order, where the states $\pm\vec{n}$ are physically equivalent. In the Ntb phase $\vec{n}$forms an oblique helical pattern consisting of periodic twist-bend deformation. The configuration possesses a double degenerate handedness, has a typical pitch in the order of 10 nm and $\vec{n}$essentially forms spatially constant conical angle with respect to the direction of helix axis. The Ntb phase is typically formed by lowering the temperature from the conventional uniaxial nematic (N) phase. To describe the N- Ntb phase behavior, we use the Landau-de Gennes approach in terms of the nematic tensor order parameter Q and the electric polarization vector order parameter field p.We expand the free energy of the system in terms of order parameters up to the fourth order, considering symmetry restrictions. Our model predicts either a second-order or first-order N-Ntb phase transition. Moreover, we consider the Halperin-Lubensky-Ma effect taking into account pseudo layers mimicking the helicoidal Ntb pattern. We show that in the latter case the N-Ntb transition is always discontinuous. Furthermore, we study also the impact of different nanoparticles (NPs) on the phase behavior. We assume that the NPs exhibit either cylindrical or spherical symmetry and are homogeneously dispersed within the LC-NP mixture. We illustrate conditions for which NPs could introduce qualitatively different behavior with respected to the bulk LC reference.

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Salt-dependent Stability and Structural Properties of Phosphatidylcholine Vesicles: a MARTINI Coarse-grained Molecular Dynamics Study

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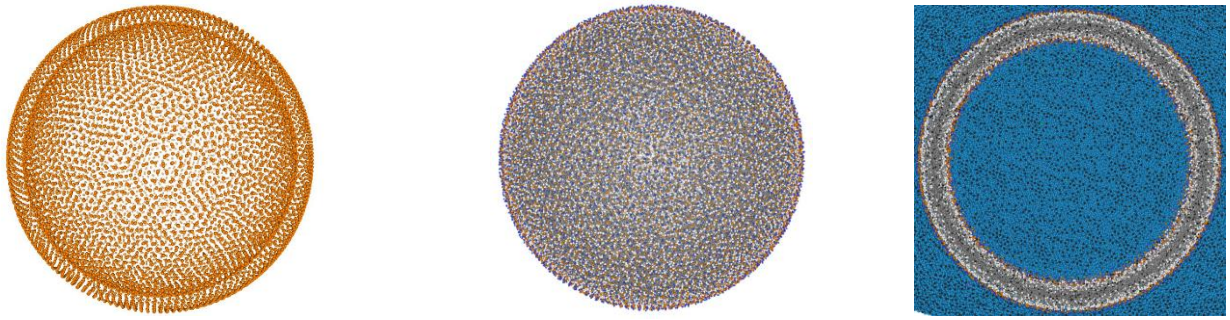
With the aid of CHARMM-GUI software within the Martini Vesicle Maker [1], the structure and properties of POPC (1-palmitoyl-2-oleoyl-*sn*-glycero-3-phosphocholine) vesicles of different radii have been studied in the NPT ensemble at T=300 K. We present the comparative analysis of our results using different Martini water models (standard and polarizable), varying Na^+ and Cl^- ions concentration and different Martini force-field parameterizations. Our research points out that vesicles with a radius of more than 20 nm preserve their spherical morphology throughout the simulation time in NaCl aqueous solutions at normal conditions (T=300 K and P=1 atm). Our data on vesicles stability are in agreement with available experimental observations [2]. Reliable coarse-grained models of POPC vesicles with radii above 20 nm were established over a range of NaCl concentrations and Martini parameterizations, providing validated starting configurations for subsequent multiscale calculations of membrane mechanical and electrical properties.



A **B** **C**

Figure 1. Representative snapshots of POPC vesicle systems: (A) POPC molecules only; (B) POPC molecules with Na^+ and Cl^- ions; and (C) POPC molecules with water and Na^+/Cl^- ions. Sodium and chloride ions are shown as blue and red spheres, respectively, lipid phosphate groups as orange spheres, and water molecules as light-blue spheres.

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Comparative Theoretical Study of Envelope-Induced Trapping, Longitudinal Acceleration and Effective Adiabaticity in Hydrogen and Noble Gases

Maria-Gabriela Zheleva [1*], Lubomir Kovachev [1,2], Ivan Angelov [1,2], Radostin Stefanov [1], Georgi Yankov [1], Ekaterina Iordanova [1], Victoria Atanassova [1], Alexandra Koleva [1]

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The interaction of ultrashort laser pulses with neutral atomic gases is commonly described through multiphoton and tunnel ionization driven by the rapidly oscillating electric field. Here, we investigate an additional pathway associated with the longitudinal nonstationary polarization optical force generated by the temporal variation of the electromagnetic energy flux. This force follows the femtosecond pulse envelope and vanishes in the continuous-wave regime [1]. A comparative theoretical model is developed for atomic hydrogen, helium, neon, and argon interacting with a propagating femtosecond laser pulse. The pulse evolution is described by an analytical solution of the linear 3D+1 paraxial equation, including diffraction and group-velocity dispersion. Species-dependent linear susceptibility, polarizability, atomic mass, refractive index, dispersion, and ionization potential are used to evaluate the longitudinal force and effective trapping potential. Classical equations of motion in the co-moving pulse-envelope frame are then solved to determine capture conditions, trapping times, longitudinal acceleration, and atomic trajectories. For each species, the carrier-envelope slip frequency is calculated from the difference between the phase and group velocities. The conventional Keldysh parameter is evaluated using the optical carrier frequency [2]. For atoms confined under the pulse envelope, an Envelope-Induced Effective Adiabaticity Parameter (EIAP) is introduced by replacing the optical carrier frequency with the substantially lower carrier-envelope slip frequency. EIAP is treated as a theoretical descriptor of envelope-confined dynamics rather than as a modification of conventional Keldysh theory. Tunnel-ionization rates and characteristic exit delays are considered using quasistatic and time-dependent approaches [3,4]. The study aims to identify the laser and atomic parameters that favor trapping and longitudinal acceleration, compare EIAP for H, He, Ne, and Ar, and assess whether the resulting effective adiabaticity is associated with enhanced tunnel-ionization probability within the finite interaction time.

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Laser-Induced Nuclear Reactions as a Potential Approach to Green Energy

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In recent years, the growing demand for clean and sustainable energy has significantly increased interest in nuclear fusion as one of the most promising technologies for the future of energy production. In addition to the conventional approaches based on magnetic and inertial plasma confinement, alternative methods for laser-induced nuclear fusion using ultrashort laser pulses are also being developed. This work presents the theoretical background and experimental investigations of nuclear reactions induced by high-intensity ultrashort laser pulses. The proposed approach is based on the trapping and acceleration of helium atoms by an ultrashort laser pulse, followed by the separation of their electrons by an external electric field. The resulting helium nuclei strike a cathode with a kinetic energy of approximately 1.88 GeV, leading to the decay of the nuclei and subsequent fusion reactions.

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Functionalization of Surfaces by Laser Induced Conductive Layers on Polyimide

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Surface functionalization of inexpensive and widely available polyimide adhesive films by laser induced carbonization is a simple technique to create thermally and electrically conductive layers that find wide range of applications in manufacturing electrical, optical and thermal devices [1]. In this work we present a comparative study of the processes behind laser induced carbonization of Polyimide (PI) by means of a continuous wave CW CO_2 laser (λ=10.6 nm) and a femtosecond laser in UV (λ=343 nm) and IR (λ=1030 nm). Our aim is to study how the characteristics of the produced layers change depending on the irradiation parameters, in attempt to optimize the thermal and electrical characteristics of the produced layers, and to maximally localize the carbonized region with minimal heat affected zone. Experiments are done with variable laser wavelengths, power and pulse duration, as well as different scanning speed and repetition. A data base of the optimal results observed is established and will be useful for further studies into direct laser writing on different polymers for applications in industry, medicine and aviation.

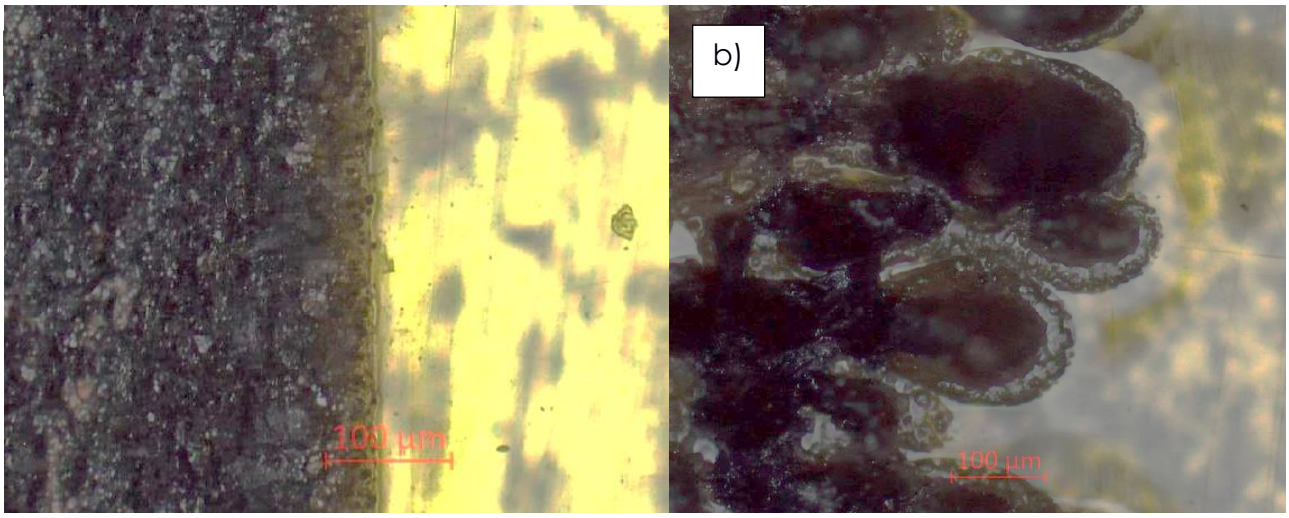

Figure 1. Confocal microscope image showing carbonized surface and HAZ of polyimide at laser irradiation of ablation threshold energy using a) femtosecond laser source of λ=343 nm and b) CW laser source of λ=10.6 nm.

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$Li_{1.66}CuSn_{3.33}S_8$ Thin-Film Prepared by Pulsed Laser Deposition as a Potential Photovoltaic Material

Naini Jain [1], Kristina Vlášková [1], Lucie Landová [1,2], Neda Neykova [1,2], Dmytro Vorontsov [2], Oleksandr Romanyuk [1,2], Lukáš Horák [3], Milan Dopita [3], David Bušek [1], Amalraj Peter Amalathas [4], and Jakub Holovský [1,2*]

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In the search for novel photovoltaic thin-film materials that are non-toxic and water-stable we explored a material with composition Li1.66CuSn3.33S8. To produce the thin film, we used pulsed laser deposition from a powder pellet with stoichiometric mixture [1]. The resulting layer was of brownish color demonstrating the existence of a bandgap, which was determined to be 1.55 eV by optical absorptance spectroscopy. Correspondingly, a measurable photoluminescence from bandgap edge was detected at 1.5 eV, which was an indication of non-negligible excess carrier lifetime. Moreover, the layer on glass exhibited weak photoconductivity, proving also a non-negligible carrier mobility. This allowed photocurrent spectroscopy measurements and the absorption edge obtained by photocurrent spectroscopy yielded Urbach energy EUrbach of 130 meV that was later reduced to 80 meV by optimization of the preparation process. The initial material was largely amorphous. After optimization of deposition parameters and optimization of powder preparation discrete crystalline grains with spinel phase formed, surrounded by residual amorphous phase [2]. Further optimization is needed to achieve phase pure polycrystalline thin films.

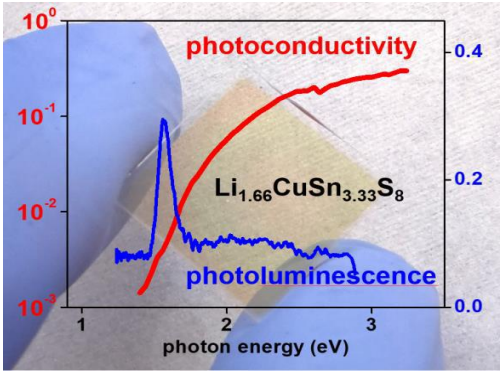

Figure 1. Historically first layer of lithium thiospinel – largely amorphous – thin film prepared by pulsed laser deposition. The layer exhibited already a weak photoluminescence and measurable photoconductivity – giving the steepness of absorption edge corresponding to EUrbach =130 meV.

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Simultaneous Time-Resolved Photoluminescence and Quantum Yield Measurement Using Random Fluctuating Light

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For the characterization of solar cell passivation and recombination processes at defect states, it is essential to employ time-resolved photoluminescence (TRPL) and photoluminescence quantum yield (PLQY). Standard TRPL presents two key limitations: the high peak intensity of the laser pulses (often reaching GW/cm²) and the long acquisition times. Since MHPs are intended for photovoltaic applications, the use of high-intensity, short laser pulses does not accurately replicate real-world solar irradiation conditions. Moreover, the "soft" nature of MHPs means such high peak intensities may alter the sample itself, potentially compromising the relevance of the results. To address these challenges, we employ RATS (Random Temporal Signals) [1,2], a method that measures PL lifetime under quasi continuum excitation conditions closely approximating the continuous solar irradiation in comparison with traditional pulsed laser excitation. We were able to directly combine the RATS with simultaneous measurement of PLQY, enabling the evaluation of radiative and non-radiative recombination rates in the studied material. The method employs a randomly fluctuating light intensity, fluctuating between 0% and 200 % intensity of a one-sun illumination, averaging to one-sun intensity (adjustable for intensity-dependent studies), to excite the sample. The PL response of the sample is given by the convolution of the excitation profile and the PL decay. The fluctuating random excitation provides a broad range of frequencies in Fourier space, allowing the decay to be calculated from a single dataset in a second. This approach offers a rapid, accurate, and non-destructive method for characterizing MHPs under realistic operating conditions, advancing both fundamental research and practical applications in photovoltaics.

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Effect of Alcohol Temperature on the Quality Profiling of Commercial and Homemade Beverages Using Metal-phenolic Film-coated Quartz Crystal Microbalances

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As an ancient dietary staple deeply embedded in cultural rituals, bridging evolutionary biology with social traditions, alcohol has a dual nature: serving as an industrial asset, but, at times, posing deleterious physiological implications to human body. The modern alcohol-driven innovations encompass sustainable energy production with a significantly lower carbon footprint, advanced manufacturing of agricultural waste-derived alcohol-based resins and nanotechnology in drug delivery for producing nanoemulsions. In parallel, alcohol is the primary driver of several societal challenges such as high premature mortality, domestic violence, criminal offences, and binge drinking. A contributing factor to this negative feature is the widespread distribution of counterfeit, low-quality alcohol.

The aroma, taste, mouthfeel and sensory profile of fermented and distilled beverages, basic markers of their quality, are determined by multiple volatile and non-volatile compounds formed and modified during the stages of raw material selection, fermentation, distillation and maturation. Real-time monitoring of alcohol quality is feasible via portable chemoresistive metal oxide sensors or chiral nematic liquid crystal-based devices, which regrettably are designed exclusively for methanol detection. Complex chemical analysis of various spirits (i.e., a range of chemical indicators and denaturants in alcohol) is possible using Raman spectroscopy, whose shortcoming, however, is the reduced resolution of the handheld spectrometer to beverages in darker bottles. Moreover, the real-life transferability of the proposed method is tested only on high alcohol-by-volume drinks purchased "off-the-shelf", so its applicability to beers, wines and homemade distillates (often produced in Southeastern Europe) remains unverified.

This proceeding addresses a critical literature gap by discussing how the chemical composition and different levels of ethanol within five reference alcoholic beverages affect the sensor signal of metal-phenolic film-coated quartz crystal microbalances – miniature, highly sensitive devices changing their oscillation frequency proportionally to the amount of absorbed chemical substance. The novel experimental findings reported herein correlate the resonance behavior of the sensors with the content of key chemical markers in the drinks across standard and refrigerated temperatures. This crucial, previously missing knowledge validates the capability of our devices to assess the quality of traditional alcoholic products. We reveal also that controlling the mixing order of ferric chloride and phenol directly influences the frequency response of quartz resonators.

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High-Temperature Superconductivity: Four Decades of Exploration

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In 2026, the physics community commemorates the 40th anniversary of the discovery of superconductivity in cuprate materials by J. Georg Bednorz and K. Alex Müller [1]. This breakthrough ushered the High-Temperature Superconductivity (HTSC) era and opened numerous novel scientific endeavors. The presentation outlines the timeline of the research progress, fundamental physical properties of the cuprates and other unconventional superconducting systems, the electronic phase diagrams and a particular focus on their complex electrodynamics, vortex matter phase transitions and pinning properties [2]. We will review also the contemporary technological status and challenges, exploration opportunities, and the plethora of open questions in the HTSC field.

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Adventitious Carbon Breaks Symmetry in Oxide Contact Electrification

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Insulating oxides are among the most abundant solid materials in nature. Of the many ways in which they influence natural phenomena, perhaps the most consequential is their capacity to transfer electrical charge during contact, yet what causes this remains unidentified. In work published in *Nature* [1], we show that adventitious carbonaceous molecules adsorbed from the environment are the symmetry-breaking factor in same-material oxide contact electrification (CE). We use acoustic levitation (Fig. 1) to measure charge exchange between a sphere and a plate composed of amorphous SiO2. Charging polarity is random for co-prepared samples, but we control it with baking or plasma treatment. Observing the CE relaxation afterwards, we see dynamics over a timescale of hours and connect this to adventitious carbon with time-of-flight mass spectrometry, low-energy ion scattering and infrared spectroscopy. We further find that adventitious carbon can even determine charge exchange among different oxides. Our results identify the symmetry-breaking parameter that causes insulating oxides to exchange charge in settings ranging from desert sands to volcanic plumes, while simultaneously highlighting an overlooked factor in CE more broadly.

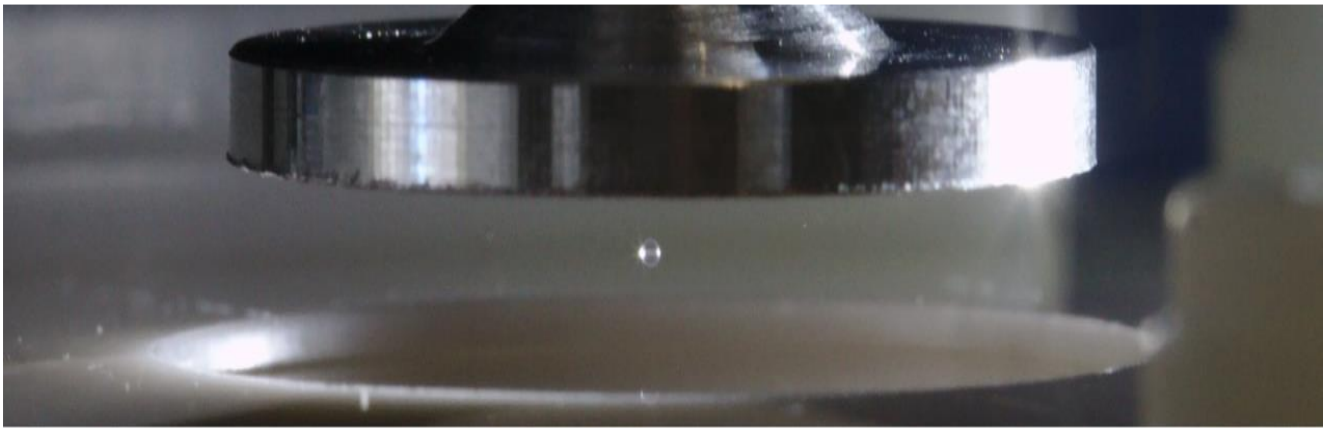

Figure 1. Using acoustic levitation to study the charge exchange as an SiO_2 sphere collides with a SiO_2 plate (below), we find that naturally occurring carbon-based molecules from the environment determine polarity and magnitude. These results, published recently in Nature [1]*, shed light on why particulate systems ranging from desert sands or volcanic plumes become electrically charged.*

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Development of a Methodology for the Control and Subsequent Optimization of the Actual Optical Thickness of a Multilayer Optical Coating

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Accurate control of the optical thickness of individual layers is essential for the realization of multilayer optical coatings with predefined spectral characteristics. In practical deposition processes, deviations from the designed optical thickness may occur due to variations in deposition conditions and the response of the monitoring system, leading to a shift of the resulting spectral response. In this work, the behavior of an optical monitoring system OMS 5000 is investigated with the aim of establishing a reliable approach for controlling and reproducing the optical thickness during thin-film deposition. The monitoring response is initially studied using TiO_2 single-layer depositions, where the reproducibility of the photometric curve and the termination point is evaluated. Based on the obtained behavior, monitoring strategies are applied to the deposition of multilayer dielectric coatings. The results demonstrate the applicability of the proposed approach for improving the reproducibility of optical thickness control and provide a basis for subsequent optimization of the deposited multilayer structures.

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Photothermally Triggered Drug Release from Gold Nanorod-Liposomal Complexes: Toward Precision-Controlled Drug Delivery

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Remote activation of liposomal drug delivery systems has attracted considerable interest as a strategy for achieving precise spatial and temporal control over therapeutic release. Gold nanorods (AuNRs) are particularly well suited for this purpose because of their efficient light-to-heat conversion, which can locally alter the physicochemical properties of lipid membranes. In this study, polyethylene glycol (PEG)-functionalized AuNRs were incorporated into SOPC liposomes to evaluate their influence on membrane structure and thermal behavior, and to assess their potential for use in light-responsive liposomal drug delivery systems.

The incorporation of PEG-functionalized AuNRs produced concentration-dependent changes in the thermotropic behavior of SOPC liposomes. Differential scanning calorimetry showed that samples containing 0.5%, 1%, and 2.5% AuNRs exhibited transition enthalpies of 0.269, 0.371, and 0.326 J g^{-1}, respectively. This implies that nanoparticle incorporation alters lipid packing in a non-linear manner, rather than simply inducing membrane fluidization. Functional consequences of such interactions were further evaluated through photothermal measurements under physiologically relevant conditions.

Upon laser irradiation, the AuNR-containing liposomes displayed pronounced wavelength- and power-dependent heating, with 515 nm excitation at 0.2 W cm^{-2} producing a temperature increase of approximately 38.9 °C after 10 min, whereas irradiation at 1030 nm generated a considerably smaller increase of approximately 7.2 °C. These findings demonstrate that PEG-functionalized AuNRs can both modify the thermodynamic properties of lipid bilayers and provide efficient, wavelength-selective photothermal activation. All of the above highlights their potential for the development of externally triggered liposomal drug delivery systems.

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Thermodynamic and Mechanical Evolution of Gelatin Biocomposites Under Varying Sweetener Ratios

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Gelatin composites are highly valued in food engineering because they are edible, cost-effective, and structurally tunable [1]. However, introducing different syrups and sweeteners does more than just alter flavor it affects the structural organization, water retention [2], and mechanical stability of the network [3]. This study investigates the thermodynamic and mechanical evolution of these materials by systematically varying gelatin concentrations alongside the weight ratios of different sweeteners.

To capture the physical hardening process, we tracked continuous gravimetric water loss during controlled desiccator storage until the sample variations were completely dehydrated. In parallel with these drying curves, the thermal behavior of the matrices was evaluated using Differential Scanning Calorimetry (DSC) providing information about thermal transitions and the stability of the gelatin network. We simultaneously conducted rigorous mechanical testing via Texture Profile Analysis (TPA) to quantify exactly how altering the sweetener composition impacts the structural rigidity of the gels.

By correlating the ongoing moisture evaporation with these thermal and mechanical shifts, we establish a clear link between specific sweetener formulations and macroscopic stability. These insights provide a practical framework for designing and optimizing gelatin-based edible structures, confectionery products, and functional foods where controlled texture and predictable shelf-life are critical.

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Combination of Gravimetric and Electrochemical Signal Transduction in Chemical Sensors for PFOS Water Contaminant Detection

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In the latest EU Directive on water intended for human consumption, a number of emerging contaminants were identified that must be monitored. Among them, the so-called "forever chemicals" PFAS have the lowest allowable concentrations. While the accredited method uses a combination of liquid chromatography and mass spectrometry, this is an expensive laboratory method not suitable for in-field deployment. Consequently, in a number of laboratories, work is underway on portable chemical sensors for PFAS detection, with no commercial success so far. We have suggested a completely different approach to the transduction of the sensing signal by using ultra-sensitive gravimetric detection with a 434 MHz two-port surface acoustic wave (SAW) resonator with gold electrodes. For the sensing layer, the Metal-Organic Framework (MOF) material MIL-101(Cr) was used, which was proven to be very selective in capturing one of the most dangerous "forever chemicals", PFOS. The sensing layer was deposited using one of the best methods in nanoarchitectonics – the Langmuir-Blodgett method [1]. The sensitivity was limited by the accuracy of the low-cost vector network analyzer used for gravimetry detection. With its improvement, this gravimetry method can easily go below the required accuracy. To increase the sensor selectivity on the same SAW device, electrochemical impedance spectroscopy (EIS) was performed. Its interdigitated microelectrodes increase the signal-to-noise ratio in the EIS measurements. The next step in this research is to use much smaller MIL-101(Cr) crystals to decrease the resonator load [2].

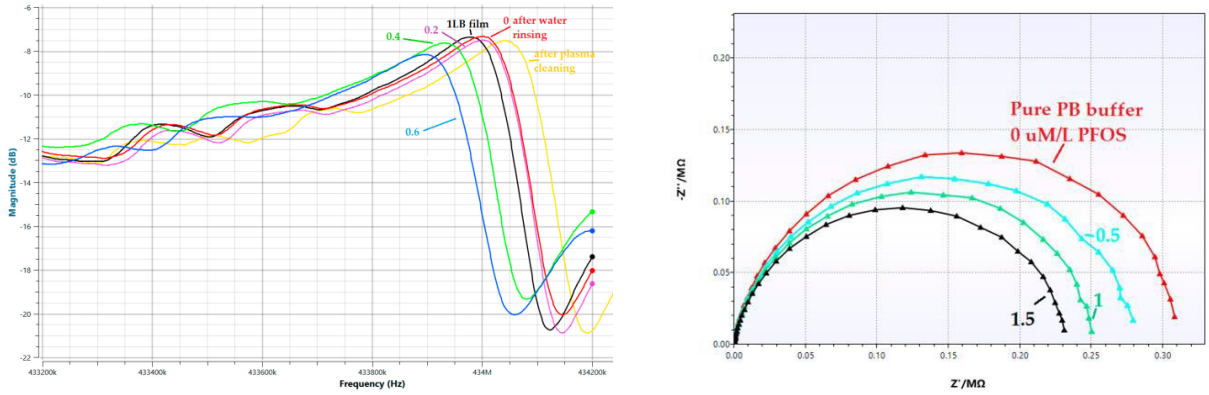

Figure 1. Resonance peak downshift in the gravimetric detection on increasing PFOS concentrations in μmol/L (Left); a Nyquist plot from the EIS data indicating a decrease in resistance on PFOS increase (Right).

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Langmuir and Langmuir-Blodgett Films from 20nm Sized Crystals of Metal-Organic Framework Material MIL-101(Cr)

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Metal-Organic Frameworks (MOFs) are a new class of smart materials composed of metal centers and organic linkers. Due to their high porosity, extremely high surface area, chemical and thermal stability, and numerous possibilities for chemical modification, they have a wide range of applications, including sensors, drug delivery, and supercapacitors. Among them MIL-101(Cr) is one of the most researched MOFs. It is very stable in water, which allows its investigation as an insoluble monolayer at the air-water interface (Langmuir film), followed by deposition on solid substrates as Langmuir-Blodgett (LB) monolayers. Previously we have demonstrated the use of a commercial material with around 300 nm sized crystal for chemical sensing of the emerging water contaminant PFOS. We combined ultra-sensitive gravimetric detection using 434 MHz two-port surface acoustic wave (SAW) resonators with electrochemical detection on the same device, using its interdigitated microelectrodes for impedance spectroscopy [1]. However, the large size of the crystals imposes a significant load on the resonator, strongly decreasing its Q-factor and, hence, its sensitivity. Much smaller, only 20 nm sized crystals material was synthesized, which adds much less mass to the SAW resonator. It was thoroughly investigated at the air-water interface with compression isotherms, surface potential measurements and Brewster angle microscopy [2]. Much more uniform packing was observed. LB monolayers were deposited on ultra-flat Si wafer substrates for AFM characterization and SAW resonators for gravimetric and electrochemical impedance studies of the adsorption of acetone and chloroform. On average, 6 times smoother surfaces were obtained, and the gas adsorption kinetics reveal information about the material's porosity.

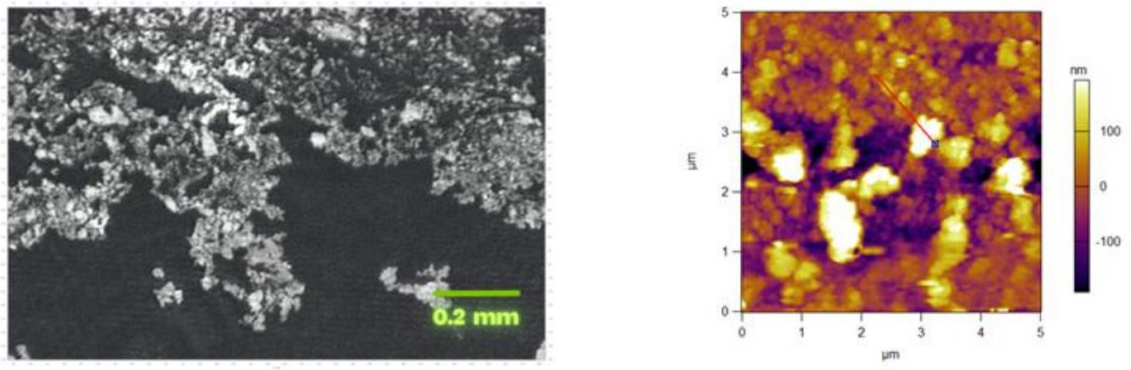

Figure 1. BAM of Langmuir film from 20 nm crystal sized MIL-101(Cr) at surface pressure of 0 mN/m (Left); and and AFM of a deposited as LB film on ultra-flat Si wafer at a surface pressure of 4 mN/m.

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Ion Transport Mechanisms in Doped Garnet-Type Solid-State Electrolytes for Energy Storage Applications

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Understanding ion transport in solid-state electrolytes is essential for the development of safe and efficient next-generation energy storage systems. In this work, we investigate lithium-ion conduction in a doped garnet-type oxide using density functional theory (DFT) combined with atomistic modeling. We focus on the role of aliovalent doping and lattice strain in modifying the local energy landscape and migration pathways. Our analysis shows that structural distortions induced by doping can facilitate the formation of more continuous low-energy diffusion channels for lithium ions. In particular, a systematic reduction in the migration barrier is observed, from 0.42 eV in the pristine material to 0.28 eV in the doped configuration.

This reduction is accompanied by a significant enhancement in ionic transport properties, with the estimated room-temperature ionic conductivity reaching the order of 10^{-3} S/cm. The results highlight the sensitivity of ion transport to coupled effects of defect chemistry and lattice strain, suggesting that targeted structural engineering can be an effective strategy for optimizing solid-state electrolytes. Overall, this study provides a detailed atomistic perspective on ion migration mechanisms in garnet-type materials and contributes to the broader understanding of structure–transport relationships in functional energy materials.

ABSTRACTS OF FIRST POSTER SESSION

Light-Induced Nucleation of Cesium Vapor

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The effect of photoinduced condensation in supersaturated cesium vapor is investigated using an upward thermal diffusion cloud chamber [1]. A pronounced influence of light absorption on the nucleation rate is revealed. Figure 1 compares the spectral dependence of the nucleation rate with the absorption and ionization spectra of cesium vapor [2]. The data demonstrate that the structure observed in the nucleation spectrum at photon energies above the ionization threshold correlates strongly with both the absorption spectrum and the light-induced ionization spectrum of cesium dimers.

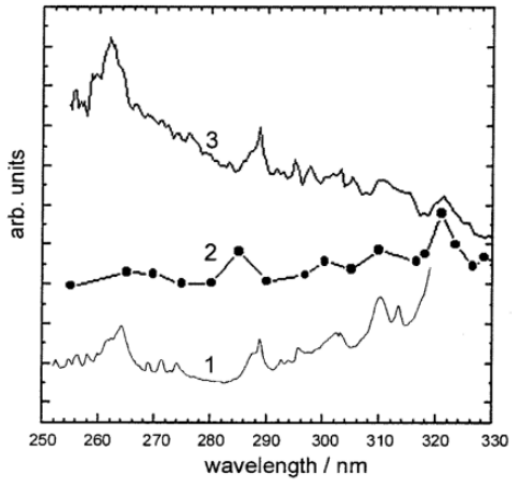

Figure 1: 1- Absorption cross-section of saturated cesium vapor at T = 767 K; 2 – photoionization crosssection of cesium dimers from Ref. 4; 3 – the nucleation rate spectrum. The observed effect is similar to that in supersaturated mercury vapours [3]. The rate of nucleation is greatly enhanced when the supersaturated vapour is illuminated with the light absorbed by gas molecules. Theoretical interpretation of the observed phenomenon is straightforward based on the close analogy with the well-established mechanism of ion-induced nucleation [2–4]. In both cases, particles tend to form growing clusters of vapor atoms, thereby reducing the excess energy associated with either ionization or optical excitation. This decrease in excess energy provides the driving force for the nucleation process.

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Optical Characterization of Gold-Based SPR Chips by Spectroscopic Ellipsometry

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Surface plasmon resonance (SPR) chips based on thin gold layers are widely used in optical sensing [1]. Spectroscopic ellipsometry has proven to be a powerful tool for the characterization of plasmonic structures and sensing-related optical configurations [2,3]. In this work, we present a spectroscopic ellipsometry study of gold-based SPR chips in several experimental configurations, including direct measurements on the sample surface and Kretschmann-cell measurements under different conditions. Measurements were carried out in the 300–1000 nm wavelength range at multiple angles of incidence in order to evaluate the influence of geometry, alignment, optical coupling, and chip condition on the recorded ellipsometric response. The comparison of different configurations revealed clear changes in the resonance-related spectral features and in the stability of the optical fits, indicating that both the optical arrangement and the state of the gold layer have a strong impact on the measured response. These results provide a practical basis for selecting robust measurement conditions and for improving the optical characterization of SPR chips intended for sensing applications. The study contributes to the development of reliable ellipsometric protocols for the evaluation of plasmonic chips and for future in-situ optical sensing experiments.

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Modular System for Direct Air Capture of CO_2 Using Bioactive Membrane Modules

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The increasing concentration of atmospheric carbon dioxide (CO_2) and its impact on global climate have intensified the search for sustainable carbon capture technologies. While conventional direct air capture (DAC) approaches rely predominantly on physicochemical processes, biological systems offer an attractive alternative due to their ability to assimilate CO_2 under ambient conditions with comparatively low energy requirements.

This study presents the development of a modular system for biological direct air capture based on bioactive membrane modules containing photosynthetically active microorganisms. The research focuses on the integration of biological and material components into a functional gas–membrane interface capable of supporting carbon assimilation from air. Particular attention is given to the selection of membrane materials, the maintenance of biological activity, and the establishment of operating conditions suitable for long-term performance.

A laboratory-scale prototype was constructed and evaluated under controlled conditions. Preliminary investigations demonstrated stable operation of the system and measurable CO_2 uptake by the bioactive membranes, confirming the feasibility of the proposed approach. The obtained results provide a foundation for further optimization of membrane formulations and operational parameters, as well as for the future development of scalable biological DAC technologies.

Acknowledgements

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Multi-Element Analysis of Ceramic Artifacts from Northwestern and Southeastern Bulgaria by means of Inductively Coupled Plasma Optical Emission Spectrometry

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The present research applies the method of Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) for the determination of trace and minor elements in ceramic fragments from Northwestern (Baley, Vidin region) and Southeastern Bulgaria (Perperikon, Kardzhali region).

Sample preparation involved a two-stage microwave-assisted pressure digestion using HNO_3, HCl, HF followed by H_3BO_3 masking. Measurements were performed on an Agilent 5800 spectrometer, using the IntelliQuant software package for rapid full-spectrum semi-quantitative screening routine and identification of anomalous and rare elements. A comparative profiling of the micro-component composition was carried out between the two geographical locations, revealing distinct differences in elements such as Eu, Cr, Ni, As, V, and Sr. While measurable Eu contents were recorded for one matrix from Baley, both samples from Perperikon fell below the limit of quantification (< LOQ). Concurrently, Perperikon demonstrates a higher geochemical baseline for Sr (up to 256.3 ppm) and a pronounced internal divergence in V levels.

The study confirms the reliability of the method for trace-element-driven profiling and geographical differentiation of ceramic materials.

Plasma-assisted Process for the Epitaxial Growth of III-V Materials and their Integration on epiGe/c-Si Virtual Substrates

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III–V semiconductors are key materials for next-generation optoelectronic and photonic devices, yet their large-scale integration, especially in the photovoltaic sector, remains limited by high production cost arising from both (i) expensive equipment (CAPEX) and (ii) the use of expensive substrates (IIIV and c-Ge). This work highlights the potential of Remote Plasma–Vapor Phase Epitaxy (RP-VPE) [1] as an innovative and cost-effective approach for the growth of high-quality III–V semiconductor materials on epiGe films on c-Si substrates (virtual substrates). RP-VPE addresses these limitations through low-temperature (≤ 450 °C) plasma-assisted growth. In particular, the use of a remote plasma dicharge, minimizes ion bombardment at the substrate while enabling efficient precursors dissociation at intermediate pressure (0.1-1 mbar) [2] with respect to MOCVD. In addition, the plasma environment enables in-situ surface treatments and interface engineering prior to growth, offering additional flexibility for substrate preparation and growth optimization. This approach, first developed on GaAs substrates (homoepitaxy) was then transferred to c-Ge substrates as a preliminary step toward the more challenging implementation on epiGe/c-Si virtual substrates for low-cost III–V integration [3]. The resulting layers were characterized in terms of crystalline quality and morphology via Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). Overall, these results highlight the potential of RP-VPE for low-temperature III–V integrationon Sicompatible platforms, including photovoltaic applications.

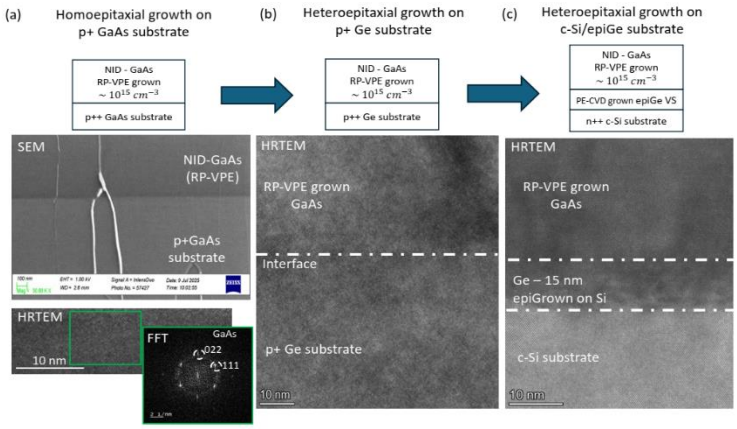

Figure 1. (a) SEM and HRTEM with FFT images for RP-VPE homoepitaxial grown GaAs. HRTEM images for RPVPE heteroepitaxial grown GaAs on (b) p+Ge substrate and (c) epiGe/c-Si substrate.

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Optical investigation of epitaxial GaAs layers integrated on virtual Ge/c-Si substrates

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Investigations were conducted on GaAs/Ge/Si heterostructures for photovoltaic applications, produced via PECVD using Remote Plasma Vapour Phase Epitaxy (RP-VPE), a newly developed low-thermal-budget technique compatible with low-cost integration [1]. The GaAs layers were deposited on virtual substrates comprising an ultrathin Ge buffer layer on a c-Si wafer. For comparison, structures with homoepitaxially grown GaAs absorber layers were also examined.

The electronic and optical properties of the structures were investigated using surface photovoltage (SPV), Fourier-transform photocurrent (FTPS) and photoluminescence (PL) spectroscopies, enabling evaluation of the bandgap energy and defect-related electronic states.
The SPV amplitude and phase spectra in the reference homoepitaxial samples revealed a negative SPV with intensity- and frequency-dependences corresponding to the expectations.

The heteroepitaxial structures exhibited lower SPV amplitudes than the homoepitaxial samples. FTPS revealed higher Urbach energies, with sub-bandgap absorption from defect states consistent with the SPV spectra. These results indicate inferior crystalline and electronic quality in the RP-VPE-grown GaAs layers on Ge/cSi substrates, attributed to enhanced carrier recombination and reduced carrier collection due to structural defects and interface states at the GaAs/Ge interface. The SPV amplitude and phase recorded at a fixed wavelength (828 nm) show intriguing intensity- and frequency-dependence, driven by contributions of opposite sign from the GaAs surface and back interface.

The obtained results provide insight into the electronic properties and interface-related limitations of low-temperature-grown GaAs heterostructures and contribute to the optimisation of low-temperature GaAs-based solar-cell architectures compatible with silicon integration.

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Numerical Investigation of Water-Overlayer-Induced Mueller-Matrix Variation in Plasmonic Au Nanostructures

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We present a COMSOL-based numerical study of the polarization-resolved optical response of Au nanostructures covered by an ultrathin water molecular overlayer, with emphasis on the Mueller-matrix element M_{33} and its differential response $\boldsymbol{\Delta M_{33}}$. Both 2D and 3D finite-element models were constructed to investigate how he equivalent deposited mass and the related interparticle spacing and nanoscale interfacial dielectric loading influence the spectral behavior of the plasmonic system[1].For the aligned configuration ($\boldsymbol{dx = dy = 0}$, $\boldsymbol{R = 25\ nm}$), both 2D and 3D simulations show a clear resonance-like feature in $\boldsymbol{M_{33}}$. With increasing adsorbed water-layer thickness, the resonance-related spectral feature gradually evolves in both wavelength position and amplitude, revealing the sensitivity of the plasmonic polarization response to nanoscale interfacial dielectric loading [2]. After introducing an ultrathin water overlayer ($\boldsymbol{dx = dy = 2\ nm}$), differential features appear in $\boldsymbol{\Delta M_{33}}$, particularly in the wavelength range of approximately 570–650 nm. These results suggest that nanometer-scale dielectric loading near the metal surface can perturb the polarization-resolved optical response. The response is mainly associated with near-field redistribution and resonance modulation induced by the interfacial water layer. A comparison between the 2D and 3D simulations shows that the two models reproduce broadly consistent spectral trends, including similar resonance evolution and comparable $\boldsymbol{\Delta M_{33}}$features. Small quantitative differences are observed in the resonance position, amplitude, and spectral line shape, which can be attributed to differences in model dimensionality, near-field distribution, finite-particle geometry, and radiative loss channels. These results indicate that 2D simulations are useful for rapid trend analysis and parameter screening, while 3D simulations provide a more complete description of the physical nanostructure response. Overall, this study clarifies how ultrathin interfacial water layers modulate Mueller-matrix observables and provides a theoretical basis for the design of sensitive plasmonic sensing platforms.

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In-situ Spectroscopic Ellipsometry Study on the Thermal Stability of Silk Thin Films

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As silk-based materials have emerged as a versatile platform for advanced optics and photonics due to their exceptional transparency and tunable structural properties [1], this study investigates the thermal stability of cross-linked silk thin films (~100 nm) deposited on 45-nm gold layers, forming a multilayer structure designed for plasmonic applications [2]. We employ in-situ spectroscopic ellipsometry using a Woollam M-2000DI instrument to monitor the real-time optical response of the silk layer within a specialized heating cell. The experimental procedure involves linear heating ramps at a rate of 1°C/min up to target temperatures of 150°C and 300°C, followed by a 30-minute isothermal hold period to ensure structural equilibrium.

Optical modeling is performed using Complete EASE software, where the silk film is represented by a non-absorbing Cauchy dispersion relation ($n(\lambda) = A + B/\lambda^2$). By fitting the thickness and refractive index as time-dependent variables, we track the dynamic evolution and structural rearrangement of the film throughout the thermal cycles. This research provides essential baseline data for defining the thermal operational limits and structural transitions of silk-based coatings in high-sensitivity optical sensors.

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Finite-Element Study of Surface Roughness Effects in Spectroscopic Ellipsometry

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Ellipsometry is a widely used, non-destructive optical technique for characterizing surfaces and thin-film layers, with surface roughness commonly represented by a Bruggeman effective-medium approximation (EMA) layer [1]. Here, the relationship between true three-dimensional surface morphology and the effective roughness thickness extracted from EMA fitting is investigated using finite-element simulations of Gaussian-correlated rough interfaces. Synthetic ellipsometric spectra, Ψ and Δ, are generated for metallic, semiconducting, and dielectric substrates, namely gold, silicon, and silicon dioxide, with systematically varied RMS roughness and lateral correlation length. Increasing roughness produces clear changes in Ψ and Δ. Also, plasmonic features appear in the ellipsometric response of gold. Comparison with EMA surface-layer models allows the fitted EMA thickness to be directly related to the physical RMS roughness. In contrast to the empirical linear relationship often used [2], and consistent with indications from earlier FEM-based studies [3], the EMA thickness is found to scale approximately quadratically with RMS roughness over the simulated parameter range. The proportionality constant is material-specific and only weakly affected by correlation length. These results provide a practical route for estimating RMS roughness directly from routine ellipsometric measurements, reducing reliance on AFM or other profiling methods, while highlighting material-specific sensitivity limits and signal floors.

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OPTICAL APPROACH FOR REAL-TIME DETECTION OF MICROPLASTICS IN AQUATIC ENVIRONMENTS

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The growing presence of microplastics in aquatic ecosystems requires faster and more reliable monitoring methods. Conventional laboratory techniques are often expensive, time-consuming, and difficult to apply for continuous environmental assessment. This work presents an optical approach for real-time, in-situ detection of microplastic particles in water based on multispectral transmission analysis in the visible spectral range. Pulsed coherent radiation interacts with water and suspended particles within an active sensor volume, and the resulting transmission response is evaluated at multiple wavelengths. The study considers common polymers, including polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET), with particular emphasis on the influence of particle composition, shape, and structure. Initial laboratory proof-of-concept experiments demonstrate the feasibility of rapid optical identification of microplastics in aquatic environments. The results support the further development of compact sensing systems for continuous environmental monitoring and water-quality assessment.

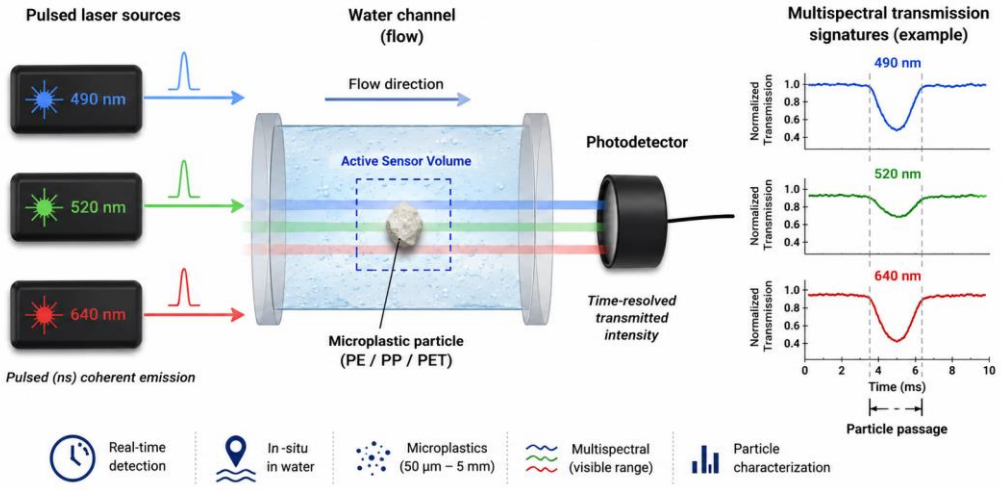

Figure 1. Schematic representation of the multispectral optical approach for real-time detection of microplastic particles in an active sensor volume.

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Ellipsometric Models for Determination of Depth Dependent Inhomogeneity in High-index Thin Layers

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One of the main problems in the field of thin film optics is the nontrivial analysis of the spectrophotometric spectra and the ambiguous solution of the inverse problem for finding optical constants from reflection and transmission spectra.

In this work depth dependent inhomogeneity in high-index thin layers is investigated, using spectroscopic ellipsometry. Thin layers of Hafnium dioxide – HfO_2, Niobium pentoxide – Nb_2O_5 and Tantalum pentoxide – Ta_2O_5 were deposited by electron-beam evaporation under two different deposition regimes – with ion-assisted deposition (IAD) and without ion assistance. The two types of processes have been selected to densify and homogenize the layers. The layer thicknesses were selected to clearly define the layer properties and enable their analysis using spectrophotometric methods – 50 nm, 100 nm, 200 nm and 400 nm. The optical constants (refractive index n and extinction coefficient k) were determined by combined analysis of spectrophotometric measurements and spectroscopic ellipsometry in two spectral ranges 330–1000 nm and 380-1000 nm. The two ranges was chosen for greater reliability of the results.

Particular emphasis is placed on the evaluation of refractive index inhomogeneity along the film thickness and its impact on the optical performance. The common program Complete EASE was to analyze the thin film layers. The data was fitted and studied with the four gradient models implemented in the program.

Furthermore, the obtained inhomogeneity will be incorporated as an optimization parameter in the design of an antireflection coating, providing an additional validation of its physical relevance.

Acknowledgements

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Photothermal Response of Plasmonic Nanoparticles: Characterization of Optical Absorption and Photothermal Conversion

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Optical absorption is a key parameter in terms of governing the photothermal performance of plasmonic nanoparticles, particularly the photothermal efficiency. It indicates the fraction of incident laser energy converted into heat. To determine the absorption, a series of experiments were performed for two types of gold nanoparticles, nanospheres and nanorods, for three laser wavelengths: 343 nm, 515 nm, 1030 nm and for each of them respectively, at laser power densities of 0.1W/cm^2 and 0.2W/cm^2. All experiments were conducted using a Pharos PH2-10W femtosecond laser (Light Conversion, Vilniaus, Lithuania). Results for optical absorption are presented for both types of gold nanoparticles after performing laser power measurements. Absorption coefficient was determined from the Beer-Lambert law after corrections for the transmission losses of an empty cuvette. The acquired data reveal strong wavelength-dependent absorption, and with that most prominent retention in the UV-visible spectral region and a pronounced decrease at 1030 nm. The aforementioned is then used to evaluate photothermal efficiency, using the theoretical approach of Kumar and Vikas [1, 2]. The results show gold spheres have photothermal efficiency that decreases proportionally while increasing laser wavelength: from 85.2% (343 nm), through 71.2% (515 nm) to 62.7% (1030 nm), all at 0.2W/cm^2. Similarly, for the same power density, gold nanorods' efficiency drops from 72.8% (343 nm) through 71.5% (515 nm) to 32.1% (1030 nm). All of the above data support the further development of photothermal therapy dependent on metal nanoparticles.

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Surface Analysis of Sandblasted and Non-sandblasted 3D Printed CoCr Alloy for Dental Applications

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The LPBF-printed CoCr alloy is widely used in the dental industry because of its durability, biocompatibility and corrosion resistance [1, 2]. To better understand its surface and enable improvements in the planning for further surface modification, two CoCr LPBF-printed samples were studied: one in a built-in condition and one additionaly sandblasted with aluminum oxide (Al_2O_3) particles.

Both samples were examined with confocal microscopy, acquiring multiple z-stacks from different regions. The images were then processed by surface-metrology software to generate the primary (leveled), roughness and waviness surfaces, and areal height parameters (Sa, Sq, Sp, Sv, Sz, Ssk and Sku) which meet the ISO 25178 standard.

The results show that the sandblasting process increases the Sa and Sq form 2.19 ± 0.2 to 7.82 ± 0.54 and 2.82 ± 0.29 to 9.58 ± 0.66 respectively. The averages of Sp, Sv and Sz go from 13.16 ± 1.11µm (peak 14.93 µm), 13.70 ± 2.24 µm (peak 17.52 µm) and 26.86 ± 3.31 µm (peak 32.45 µm) to 30.26 ± 3.76 µm (peak 35.42 µm), 36.49 ± 6.08 µm (peak 42.59 µm) and 66.75 ± 5.98 µm (peak 73.00 µm) respectively. The Ssk and Sku go from -0.33 ± 0.22 and 3.77 ± 0.42 to -0.50 ± 0.38 and 2.91 ± 0.66 respectively. These results characterize the changes caused by the sandblasting process and provide basis for better engineering of surface modification of CoCr alloy for dental applications.

Keywords: CoCr alloy, dental metallic alloy, confocal microscopy, laser powder bed fusion, LPBF, topography, ISO 25178

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Simulation and Elaboration of Chirped Dielectric Mirror for Femtosecond Laser Pulses at 1030 nm

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A multilayer dielectric high-reflectivity (HR) coating for laser pulse compression, with a target GDD of −350 fs² over the 980-1080 nm range, was designed and fabricated. The mirror structure was numerically optimized using OptiLayer software, and several designs employing different material combinations and deposition strategies were evaluated. The final design consisted of 66 alternating Ta_2O_5 and SiO_2 layers. The electric-field distribution and standing-wave intensity within the coating were analyzed to evaluate the potential laser-induced damage threshold (LIDT). Because the high-index Ta_2O_5 layers are less environmentally stable than the low-index SiO_2 layers and may therefore exhibit reduced resistance to laser-induced damage, the multilayer design was further optimized by minimizing the electric-field intensity within the high-index layers.

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Spectrophotometric Determination of Thin Films Absorption in PVD Deposited Multilayer Resonant Structures

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Optical characterization of thin films using UV–VIS spectrophotometry is an important analytical method for determining their optical properties, including the refractive index and absorption coefficient. However, extracting optical constants from spectrophotometric data is an inverse problem that can be non-unique, particularly for multilayer structures in which interference effects strongly influence the measured spectra.

In resonant multilayer structures, the transmission and reflection spectra can exhibit very sharp resonant features. Even weak absorption in one of the constituent materials can significantly modify the resonance depth, linewidth, and spectral profile. This enhanced sensitivity is particularly useful for the characterization of weakly absorbing materials, since the resonant structure effectively increases the optical interaction length within the absorbing layer.

In this work, we investigate the determination of very low absorption in a material incorporated into a PVD-deposited multilayer resonant structure using spectrophotometric measurements of transmission, $T(\lambda)$, and reflection, $R(\lambda)$. The optical response of the complete multilayer system is calculated using the transfer-matrix method (TMM), taking into account multiple reflections and interference in all layers. The measured spectra are then fitted by varying the complex refractive index, $n(\lambda)+ik(\lambda)$ of the investigated material.

Using narrowband optical filters as representative resonant structures, we demonstrate the sensitivity of the method to weak absorption and estimate the order of magnitude of the extinction coefficient $k(\lambda)$ in the vicinity of the resonance. The results show that, provided an appropriate dispersion model is used for the investigated material, the accuracy of the extracted absorption is determined predominantly by systematic errors in the measured spectrophotometric data rather than by the transfer-matrix model itself.

The proposed approach provides a practical method for estimating weak optical absorption in thin films incorporated into resonant multilayer structures using conventional spectrophotometric (*R/T*) measurements.

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Can We Control the Antenna-Effect in Luminescent Lanthanide Complexes, to Achieve Optimal Energy Conversion: Insights From Theoretical Modeling with Quantum Chemistry Methods.

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Lanthanide-based compounds, utilizing Ln^{3+}-ions, are indispensable in modern innovative technologies due to their exceptional photoluminescent properties [1]. Unlike conventional materials, they offer line-like emission with high color purity, narrow absorption and emission bands, long excited-state lifetimes, and low susceptibility to photobleaching. These distinct advantages make lanthanides essential for developing smart optical materials used in lighting, telecommunications, displays, lasers, security inks, molecular thermometers, sensors, bioimaging, and immunoassays. Because direct light absorption by Ln^{3+}-ions can be inefficient, their luminescence is strategically enhanced through complexation with sensitizing chromophores, commonly referred to as 'antenna' molecules [2]. When irradiated with UV light, the antenna absorbs energy and initiates a sequence of relaxation processes. This pathway involves intersystem crossing between singlet and triplet excited states followed by a nonradiative ligand-to-metal energy transfer, which efficiently populates the 4f-excited state of the metal ion. Binding lanthanide ions to these antenna groups provides remarkable flexibility, allowing fine-tuning of both luminescence quantum efficiency and yield. To further optimize these materials, researchers employ quantum chemistry methods to resolve the individual steps of the sensitization mechanism. The present work summarizes results from several theoretical studies [3-5], performed with a combination of quantum chemistry methods. The key steps of electronic relaxation process after UV irradiation is described with the help of first principles (DFT/TDDFT) and *ab intio* (CASSCF) methods. Judd-Ofelt theory, along with the framework introduced by Malta [6] and Freire [7] is applied to evaluate the rates of ligand-to-metal energy transfer, the corresponding quantum efficiencies and quantum yields. The obtained results are validated through comparison with available experimental data. The leading factors, influencing the efficiency of the antenna-effect are examined and potential strategies to optimize the process, are proposed.

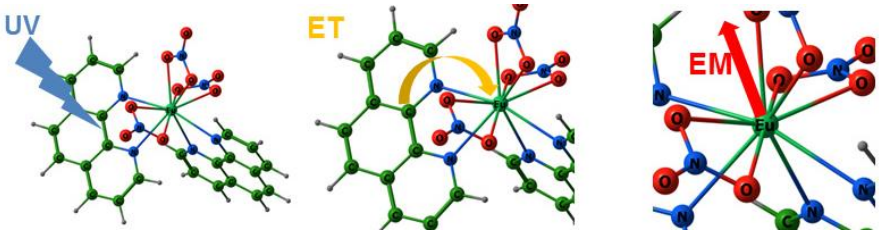

Fig 1. A schematic representation of the antenna-effect. ET-energy transfer, EM-emission

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ABSTRACTS OF SECOND POSTER SESSION

Real-Time Insight into $FAPbI_3$ Crystallization Process

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Rapid progress in silicon solar cell technology has driven widespread adoption across commercial sectors, largely due to their long-term operational stability. However, single-junction silicon photovoltaics are limited by their maximum power conversion efficiency of 29.4 %. This barrier can be significantly exceeded by adding a second solar cell, an approach known as a tandem solar cell. Lead halide perovskites represent a promising candidate material for such a top junction paired with silicon, offering a near ideal bandgap along with strong optical absorption, defect tolerance, and long charge-carrier lifetimes. Achieving high-quality perovskite thin film requires an understanding of the governing formation mechanisms. Direct insight into how these materials form allows for the optimization of crystallization parameters across their wide range, helping to accelerate research progress. Combination of in situ photoluminescence (PL) and wide-angle X-ray scattering (WAXS) provides an option for real-time insight into the crystallization process. Fast changes in the material, such as phase transformation, defect formation and grain growth, can be effectively captured by the evolution of PL spectra and WAXS diffractograms.

In this work, we systematically investigate the influence of crystallization temperature on the formation behaviour of $FAPbI_3$ thin films. By measuring in situ PL and WAXS during crystallization and conducting ex situ X-ray diffraction, we identified a threshold crystallization temperature of 140 °C, that separates two distinct material states. Films crystallized below the threshold temperature exhibit limited stability of photoactive α-phase. Whereas higher-temperature crystallization leads to the formation of a qualitatively different material with markedly improved structural stability and optical properties. Real-time PL measurements provide reliable indicator of the final film quality. This development features a transient minimum in PL intensity for samples crystallized above 140 °C and a simultaneous maximum in the obtained Urbach energy, signalling recrystallization process of already formed α-$FAPbI_3$. This thermally driven recrystallization step with activation energy $E_A = (0.53 \pm 0.02)$ eV is needed for prolonged stability of the α-phase. Films lacking this characteristic PL evolution exhibit accelerated degradation.

In situ PL and WAXS reveal a characteristic signature for films crystallized at temperatures higher than 140 °C. Observed recrystallization of these films is essential for stabilizing the photoactive α-$FAPbI_3$ phase.

Acknowledgements: We would like to acknowledge the support of projects 24-11652S (GACR) and PVKSC 9F23003 (MEYS). We also acknowledge the use of the CzechNanoLab research infrastructure supported by the MEYS (LM2023039).

Optimizing Urban Traffic for Energy Efficiency and Sustainability

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Currently, the transportation sector accounts for approximately one-quarter of global final energy consumption [1]. Urban traffic is a particularly critical sector, as congestion and high annual vehicle mileage lead to an increased dependence on fossil fuels and harmful environmental pollution. Although various mitigation strategies have been tested this study proposes an intervention based on the classic four-step travel demand model [2]. This macroscopic model was applied as a case study to the city of San Francisco, a well-documented benchmark for urban traffic congestion, with recommended parameter values [3]. As illustrated in Figure 1, a significant share of employment is concentrated within a single region representing 18% of the total traffic flow (red dark node). Consequently, morning commute networks experience severe bottlenecking.

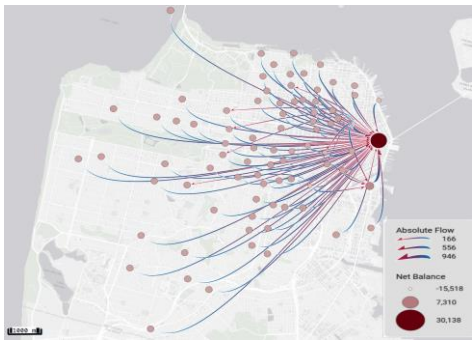

Figure 1. Graphical diagram of commuting patterns in San Francisco. The flow represents the number of transported individuals. Node sizes and colors are proportional to the net worker balance in the area.

To address this, we propose a simultaneous strategy. First, relocating a fraction of employment opportunities to the centers of mass of four urban partitions generated via the K-Means clustering algorithm. Second, systematically analyzing the required percentage of traffic diversion from the saturated zone. The system exhibits a behavior akin to a phase transition around 40% of the zone inflow. This diversion policy reduces the average morning peak-hour travel time from 17.60 to 15.30 minutes by re-routing merely 7,2% of the city's overall traffic. Third, extending the study to a Machine learning analysis incorporating climate data. Furthermore, this approach promotes the creation of jobs outside the highest-income districts, potentially fostering greater social equity and sustainability in general.

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Estimating the Width of the Relaxation Time Spectrum in Glass-Forming Liquids from Thermodynamics

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The relaxation functions in glass-forming liquids are inherently non-exponential and are commonly described by the Kohlrausch–Williams–Watts (KWW) decay function. The fractional exponent parameter, β (where $\beta < 1$), in this function serves as a metric for the width of the spectrum of relaxation times. Investigations of self-diffusion in supercooled liquids reveal a distinct decoupling between translational and rotational diffusion. This observation has been widely interpreted as evidence of spatial heterogeneity in the dynamics of glass-forming liquids. Consequently, β the parameter in the KWW distribution function is often chosen as a metric for this spatial heterogeneity. At the molecular level, spatial heterogeneity is attributed to the formation of molecular clusters, with the correlation length of these clusters serving as a second metric for heterogeneity. Adam and Gibbs related the temperature dependence of relaxation times with the thermodynamics via the configurational entropy—the difference between the entropy of the liquid and the solid states. They defined a cooperatively rearranging region (CRR) as a cluster of molecules that rearranges as a single block, alternating between two configurations: one before rearrangement and one during. Therefore, their theory is related to Debye relaxation (implying a single relaxation time), an explicit equation for the size of the cooperative cluster was not suggested. The present author has proposed an extension of the Adam–Gibbs theory to the molecular level [1,2]. Through this framework, an equation for the CRR was obtained and interpreted as the number of sub-molecular units, termed "beads," that rearrange during the relaxation time. The size of these CRRs can be determined experimentally from thermodynamics. While beads were initially introduced empirically into thermodynamics, methods for quantifying the partitioning of molecules into specific numbers of beads have since been established [2]. Applying these methods to various substances reveals that molecular partitioning is strongly dependent on molecular structure. For instance, shifting a single chemical group from the second position in 2-methylpentane to the third position in 3-methylpentane results in partitioning into the different number of beads. In this work, a direct relationship between the thermodynamic size of the cooperative cluster and the KWW β parameter is suggested. Hence, linking the thermodynamic size of the CRR to the width of the relaxation spectrum. Because the cooperative cluster and its constituent beads can be identified, a molecular interpretation of the phenomenological β parameter is successfully deduced.

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Influence of Sweetener Composition on the Electromagnetic and Optical Responses of Gelatin Matrices

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Gelatin based composites offer highly tunable properties, yet the exact ways that different syrups and sweeteners alter their microscopic structure and electromagnetic response remain complex [1]. This study explores how shifting the sweetener composition directly impacts the fundamental light-matter interactions and charge transport mechanisms within the gelatin network.

To isolate the specific contributions of these additives, we systematically varied the gelatin concentrations alongside the weight ratios of different sweeteners. The optical response of these varying formulations was quantified by measuring the refractive index across three distinct laser wavelengths. This approach allowed us to map exactly how compositional shifts influence light propagation and optical dispersion behavior [2].

Simultaneously, we applied impedance spectroscopy over a broad frequency range to evaluate the overall dielectric response of the samples. This non-destructive technique provided insight into the underlying charge transport mechanisms, polarization effects, and molecular mobility within the matrix [3]. By tracking how these broader electrical properties shift, we gained a direct look at how the physical density of the internal network adapts to varying sweetener concentrations. Ultimately, correlating these dielectric and optical shifts establishes a clearer picture of how specific additives dictate the fundamental electromagnetic behavior of complex functional soft materials.

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Investigation of Zinc Tin Oxide/Tin Sulfide Heterostructures for Efficient Thin-Film Solar Cells

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The growing demand for sustainable and high-efficiency photovoltaic technologies has intensified research into environmentally friendly and cost-effective semiconductor materials. This study focuses on the engineering of thin-film heterostructures using tin sulfide (SnS) as the photoactive semiconductor paired with Molybdenum Oxide (MoO_3). The suitability of SnS stems from its earth-abundant constituent elements (Sn, S), an ideal direct bandgap (~1.3 eV), and a high absorption coefficient (>10^4 cm^{-1}). SnS thin films were deposited on indium-tin-oxide (ITO) substrates by thermal evaporation. Molybdenum Oxide layers were deposited by magnetron sputtering of a MoO_3 target in Ar +O_2 atmosphere. Kelvin probe measurements established work-function values in the range of 4.6 - 4.8 eV for the SnS absorber layers and 5.2 eV for the sputtered MoO_3 film. Surface photovoltage (SPV) measurements in air atmosphere show a clear photo effect for the Molybdenum Oxide (MoO_3) and the Tin Sulfide (SnS) thin films. The fabricated heterostructure followed an ITO/SnS/MoO_3/Ag architecture. Current-voltage *J-V* characteristics of the completed device demonstrate diode behavior and efficient carrier selectivity across the heterojunction, validating SnS/MoO_3 as an effective pairing for charge extraction layers and heterojunction interfaces in photovoltaic applications.

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Structural, Magnetic, and Magnetocaloric Properties of Ti-Substituted $GdMnO_3$ Multiferroic Single Crystals

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$GdMnO_3$ came to the attention of the scientists due to the discovery of multiferroicity in this compound. It crystallizes in the orthorhombically distorted perovskite structure; space group *Pnma*; Gd ions are located on 4*c*; Mn ions on 4*b* and oxygen anions are located on 4*c* and 8*d* crystallographic sites. The compound orders into antiferromagnetic phase below T_N ~ 40 K [1] and then undergoes order-to-order magnetic phase transition into low temperature canted magnetic phase at T_{lock} (~ 20 K). $GdMn_{1-x}Ti_xO_3$ ($0 \leq x \leq 0.1$) compounds were synthesized by the floating zone method to understand the role of Ti substitution on structural, magnetic, and magnetocaloric properties. Raman spectroscopy and X-ray diffraction, along with Rietveld refinement, confirm the pure phase of all compositions having an orthorhombic perovskite structure (space group; Pnma). The Neel temperature T_N is not visible on magnetization measurements; however, from the combination of zero-field-cooled; field-cooled magnetization data and hysteresis loops M(B), we concluded the decrease of T_N from 42 K (x = 0) to roughly 30 K (x = 0.1). T_{lock} has been also shifted from ~20 K (x = 0) to ~2 K (x = 0.1). In the temperature interval $T_{lock} < T < T_N$ the M(B) curves show simple antiferromagnetic behavior, however, below T_{lock} the character of M(B) curves changed from complicated butterfly-type (x = 0) to simple ferromagnetic one (x = 0.1). This suggests that Ti destabilizes the magnetic structure or at least prevents the Gd sublattice from ordering. Magnetic entropy change (ΔSM) is extremely sensitive to the direction of the applied field and can be negative (normal MCE) or positive (inverse MCE). The Gd ordering induces an inverse MC effect along '*c*' and '*b*' axes, whereas it's not seen along the '*a*' axis, revealing complex anisotropic magnetic ordering. The magnetic entropy change displays a broad peak at T_1 ~ 13 K with -ΔSM = 11.35, 8.05, and 7.77 J/kg-K and corresponding relative cooling power (RCP) = 197.72, 164.70, and 166.78 J/kg for x = 0.0, 0.05, and 0.1, respectively, under 5 T. A sharp -ΔSM = 0.55 J/kg-K (0.5 T) appears at T_{lock} = 20 K (x = 0.0), which is shifted to higher temperatures with a magnetic field. The large cryogenic MCE suggests these compounds are promising for low-temperature magnetic refrigeration applications.

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Probing the Capability of Metal-phenolic Film-coated Quartz Crystal Microbalances to Detect Sub-threshold Levels of Methanol as a Contaminant in Alcoholic Beverages

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Although alcohol is an integrated part of modern industry, the excessive consumption of alcoholic beverages may be dangerous, because it affects brain function within six minutes, reduces body temperature via vasodilation and induces anxiety due to the accumulation of the toxin acetaldehyde. Alcohol is responsible for significant health burdens, including 4.1% of global cancer cases in 2020, as well as contributing to domestic violence, sexual harassment and workplace productivity losses. Additionally, the industrial production of alcohol is resource-intensive, contributing to a rapidly warming climate, water scarcity, and biodiversity loss. The problem is further aggravated by the fact that excessive drinking imposes massive healthcare expenditures. Low-income people suffer far higher rates of alcohol-related illness, hospitalization and death compared to wealthier groups, despite the similar or lower levels of consumption (the so-called "alcohol harm paradox"). The reason behind these worrying statistics is related to the production of adulterated alcohol, so finding reliable methods for point-of-use alcohol analysis is a current societal challenge.

Quartz crystal microbalances (QCMs) are ideal as portable, high-resolution sensors for on-site applications to restaurants, drinking establishments or residential buildings. Depositing selective adsorbents on the upper electrode of quartz crystals results in a linear decrease in resonance frequency upon gas sorption and if QCMs are functionalized with a metal-phenolic film, they are capable of accurately detecting trace methanol in whiskey (2.7 μL/100 mL). By adjusting the sorptive layer's thickness and chemistry, QCMs detect methanol concentrations up to 1000 times lower than regulatory standards under equilibrium vapor pressure, rendering unnecessary the equipment delivering the analyte-of-interest and revealing potential for the fabrication of a lab-on-a-chip system. The rigidity and hydrophobicity of metal-phenolic films endow quartz resonators with negligible cross-sensitivity to changes in ambient temperature and humidity (~5.6 Hz/°C/%RH), while ensuring selective sorption of low molecular weight alcohols at the expense of water, petroleum ether and ammonium hydroxide. However, the daily use of metal phenolic film-coated quartz crystal microbalances (MPF-QCMs) would be hindered if they cannot discriminate sub-threshold methanol contamination in various low and high alcohol-by-volume products. This is particularly challenging across varying serving temperatures such as for beers (~3–7 °C) and white wines (~7–13 °C).

In this proceeding, we represent a pioneering study concerning the capability of MPF-QCMs to discriminate 0.25-0.5-1-2.5 mL methanol in five reference alcoholic drinks, thus sticking to real scenarios where the black market tries to trick the consumers and sell them low-quality alcohols.

Acknowledgements:

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Investigation of charge trapping properties of HfO_2/Al_2O_3 nanolaminated dielectric stacks

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Recently, the HfO_2/Al_2O_3 ternary system has been widely studied as a promising charge-trapping medium for non-volatile memory devices. In this work, we report the obtained results on the memory windows of atomic-layer-deposited HfO_2/Al_2O_3 nanolaminates (with a thickness of 16.5 nm) under different write/erase voltage amplitudes and pulse durations, depending on the annealing temperature. Test samples in the form of metal–insulator–silicon structures were employed. Two types of stack configurations were studied: a single HfO_2/Al_2O_3 nanolaminate on n-Si and a 20 nm Al_2O_3/ HfO_2/Al_2O_3 nanolaminate on n-Si. In the latter case, the additional 20 nm alumina layer serves as a blocking oxide (BO), preventing charge injection from the metal gate. The effect of rapid thermal annealing (RTA) in O_2 at three different temperatures was also investigated. An illustration of the results is presented in Fig. 1a for selected programming pulse voltages, while Fig. 1b shows a comparison between the charge-trapping-induced shifts for stacks with and without a BO layer, respectively. Despite the higher observed voltage shifts for BO-equipped stacks, the amount of trapped charge is approximately the same (~1.4×10^{13} cm^{-2}) because of the lower capacitance of the stacks with BO. Nevertheless, the BO layer confines the injected electrons within the HfO_2/Al_2O_3 trapping layer and slightly improves the trapping dynamics and the maximum trapped charge. However, this effect depends on the annealing temperature. It was observed that, in as-grown stacks, the effectiveness of the erase operation is extremely low (Fig. 1). One possible interpretation concerns the availability of holes in n-Si under negative erase pulses. It was found that, after RTA, capacitors with a BO layer exhibit a large initial negative charge, which inverts the Si surface and supplies more holes for the erase operation. Charge trapping in the stacks was additionally explored using the constant-current-stress method for two current densities: 0.1 and 1 μA/cm^2.

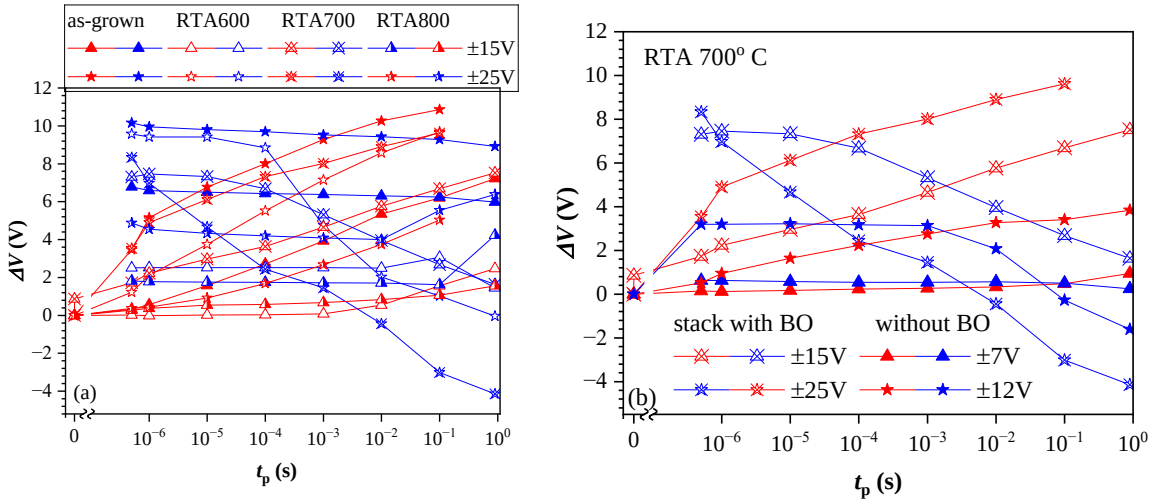

Figure 1. Flat-band voltage shift dynamics for capacitors with BO as a function of annealing temperature (a); comparison between flat band voltage shifts for structures with and without BO (b).

Acknowledgements: the work is supported by Chip Centre of Competence Bulgaria C3BG, Project ID 101217573, under Digital Europe Program DIGITAL-Chips-2024-SG-CCC-1

Effect of HfO_2/Al_2O_3 Charge Trapping Layer Structure on Memory Characteristics of Flash Cell Studied by TCAD

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Charge-trapping non-volatile (flash) memories have recently attracted significant interest due to the introduction of novel high-*k* oxide dielectrics as replacements for Si_3N_4. For significant boosting of the device characteristics ternary or even quaternary material systems are proposed [1]. The standard deposition method for these new substitutes is atomic layer deposition (ALD). Because of ALD work-principles, the resulting multicomponent layer has a structure that resembles superlattice – a sublayer sequence of different high-*k* oxides, where the component ratio is controlled by sublayers thicknesses. Apart from the change of trap density and traps parameters, alignment of materials with different band structure could in principle amend carrier transport in the film. Inserting sublayers with lower electron affinity into main matrix could lead to relaxation of the injected carriers, thus increasing the trap efficiency [2]. Here we compare simulation results for two types of HfO_2/Al_2O_3 ALD films with approximately the same overall thickness and Al/Hf ratio, but with different structure of the composite film - nanolaminated case which employs 5× repeated 2.8 nm HfO_2/0.5 nm Al_2O_3 bilayer block and doped one 25×(0.56 nm HfO_2/0.1nmAl_2O_3). The doped layer is treated as a single homogeneous layer. The simulations are performed with TCAD extending based on standard incorporated SANOS ($Al_2O_3/Si_3N_4/SiO_2$) model. Fig. 1 depicts obtained threshold voltage shifts at 25 V programming voltage, which clearly indicate an enhancement of trap efficiency for nanolaminated stack. The influence of other parameters such as band gaps; electron and hole mobilities and trap cross sections; and trap energy depth are also traced.

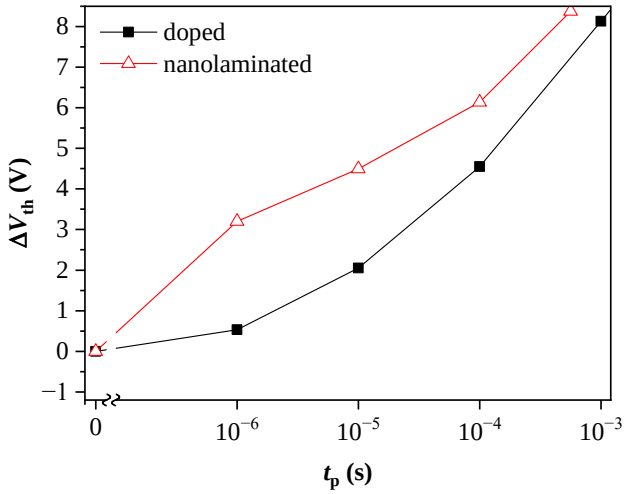

Figure 1. Threshold voltage shifts for nanolaminated and doped HfO_2/Al_2O_3 for +25V programming pulse, all other relevant parameters of the doped and nanolaminated stacks are the same.

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Electrostatic Probe Diagnostics in Magnetized Plasmas

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Electrostatic probe diagnostics remain among the most widely used techniques for measuring local plasma parameters in laboratory and fusion plasmas. In this work, probe methodologies are investigated in two complementary experimental environments, ranging from low-temperature magnetized plasma discharges to tokamak divertor plasmas.

A DC gas discharge tube equipped with Helmholtz coils was developed in order to study plasma behavior in the presence of low magnetic fields [1]. The experimental setup enables investigations of the influence of magnetic field intensity and probe orientation on Langmuir probe measurements. Single probes aligned parallel and perpendicular to the magnetic field lines were used in argon discharges for magnetic fields up to 800 G. These experiments provide an important platform for validating probe diagnostics in magnetized plasmas and for studying modifications of the probe characteristics caused by magnetic confinement effects.

In parallel, a retarding field energy analyzer (RFEA) was installed in the divertor region of the WEST tokamak in order to perform direct measurements of the local ion temperature under different plasma operating regimes [2]. The design and operational principles of the diagnostic system are presented together with preliminary experimental results obtained during the initial experimental campaigns. The measurements demonstrate that the ion temperature can significantly differ from the electron temperature commonly inferred from Langmuir probe measurements. In attached divertor plasmas, ion temperatures up to 80 eV were measured, exceeding the electron temperature by factors of 3–6 in several cases.

These results demonstrate the importance of direct ion temperature measurements for accurate evaluation of plasma–surface interaction processes, heat fluxes, and material erosion in tokamak divertors. The combined laboratory and tokamak investigations contribute to the validation and development of electrostatic probe diagnostics for future fusion devices and provide important insight into edge plasma physics relevant to ITER and DEMO-class reactors.

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Electrochemical impedance spectroscopy as a quantitative readout of temporin-induced membrane perturbation

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The increasing resistance of microorganisms to conventional antibiotics has intensified the search for effective alternatives, among which antimicrobial peptides (AMPs) such as temporins A and F have attracted considerable attention because of their potent antimicrobial and antiproliferative activities [1-3]. As biomimetic membrane models, lipid bilayers interact with AMPs through mechanisms that may alter their structural integrity, dielectric properties, and permeability, thereby governing the balance between therapeutic efficacy and cytotoxicity. Quantitative assessment of membrane stability is therefore essential for elucidating peptide-membrane interactions and supporting the rational design of safer peptide-based therapeutics.

In this work, we investigate the effects of temporins A and F, as well as a series of analogues modified at position 7 with the non-proteinogenic amino acids ornithine, citrulline, 2,4-diaminobutyric acid, and 2,3-diaminopropionic acid on the structural and dielectric stability of phosphatidylcholine bilayers. Electrochemical impedance spectroscopy was employed to determine membrane capacitance and resistivity as sensitive indicators of bilayer integrity. The results reveal different degrees of membrane perturbation induced by the studied peptides and identify sequence modifications associated with reduced perturbation of the lipid bilayer. These findings provide molecular-level insights into how subtle sequence modifications modulate peptide-membrane interactions and membrane stability, offering a physicochemical framework for the future optimization of temporin-derived peptides.

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Detection of volatile organic compounds using impedance spectroscopy with phospholipid Langmuir–Blodgett films

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We report the development of an impedance-based gas sensor that uses a phospholipid Langmuir–Blodgett monolayer (LB) as the active sensing element for detecting volatile organic compound (VOC) vapors. A 6-nm-thick molecular monolayer of dipalmitoyl-phosphatidylethanolamine (DPPE) was fabricated using the Langmuir–Blodgett deposition technique. The nanolayer was deposited on interdigitated electrodes. The sensor was designed to monitor various VOCs, including methanol, ethanol, hexane, cyclohexane, chloroform, tetrachloromethane, and petroleum ether, which can pose significant risks to the environment and human health due to their high volatility and potential toxicity even at low concentrations. The electrical response of the sensor was investigated using electrical impedance spectroscopy (EIS) in the frequency range from 0.1 Hz to 1 MHz at room temperature. The interaction between the phospholipid monolayer and VOC molecules led to significant changes in the impedance characteristics, manifested by a marked decrease in impedance values. The experimental results obtained indicate that DPPE monolayers prepared using the Langmuir–Blodgett method exhibit high sensitivity to VOC vapors. The combination of phospholipid Langmuir–Blodgett nanofilms with impedance spectroscopy provides a promising platform for the development of compact, portable, and real-time VOC monitoring devices for environmental control, safety systems, and ecological applications.

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Analysis of the efficiency of partial dealcoholization of rosé wine in concentration mode via nanofiltration

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Wine dealcoholization is becoming an increasingly important topic due to the growing demand for healthy alternatives to alcoholic beverages. Membrane nanofiltration is a highly effective technology for the partial dealcoholization of wine and the concentration of valuable bioactive compounds. This study provides an efficiency analysis of nanofiltration processes applied to a Bulgarian rosé wine produced and bottled by "Black Sea Gold" winery, Pomorie utilizing a MaxiMem PS Prozesstechnik GmbH filtration system equipped with an Alfa Laval NF99HF polyester membrane (MWCO 200 - 300 Da). To evaluate process performance, experiments were conducted in concentration mode at a constant temperature of 18°C, regulated by a Lauda Alpha RA8 thermostatic cooling bath. The efficiency of ethanol removal was assessed across transmembrane pressures of 10, 20, 30, 40, and 50 bar at a tangential flow rate of 1.2 l/min. To determine the optimal flow rate for partial dealcoholization, additional comparative trials were performed at a constant pressure of 20 bar using flow rates of 0.8 and 2.0 l/min. The systematic variation of these operating parameters successfully identified the optimal conditions for maximizing dealcoholization of the rosé wine.

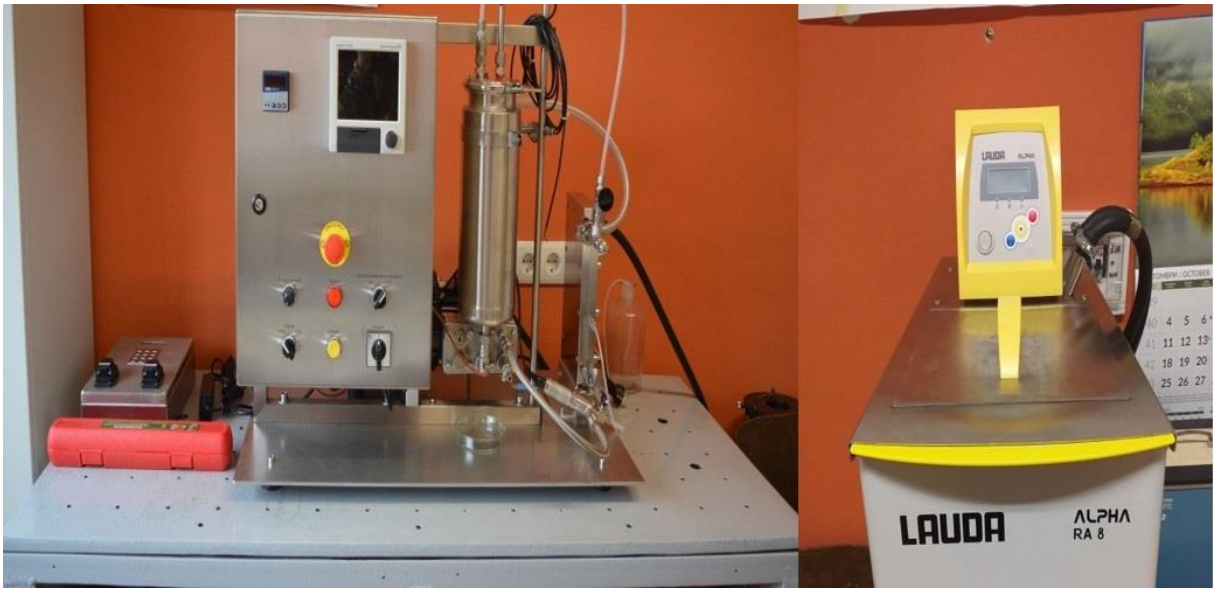

Figure 1. [Membrane filtration system MaxiMem and cooling bath Lauda Alpha RA 8.]

Biophysical Interactions of Ultrasmall Gold Nanoparticles with Archaeal Lipid-Based Biomimetic Membranes

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Understanding nano–bio interactions is essential for the development of safe nanomaterials for biomedical applications [1,2]. In this context, the present study investigates the biophysical interactions of dodecanethiol-functionalized ultrasmall spherical gold nanoparticles (AuNPs) using archaeal lipid-based biomimetic membranes. Liposomes composed of pure DPPC and DPPC–archaeal lipid mixtures (97:3 mol%) encapsulating 1 wt% ultrasmall spherical AuNPs were characterized by transmission electron microscopy (TEM), dynamic light scattering (DLS), zeta potential measurements, attenuated total reflectance Fourier-transform infrared (ATR-FTIR) spectroscopy, and Raman spectroscopy to evaluate nanoparticle–membrane interactions and their effects on membrane structure and molecular organization. TEM analysis revealed uniformly distributed spherical AuNPs with an average diameter of 2–3 nm, while DLS and zeta potential measurements confirmed the formation of stable liposomal dispersions. ATR-FTIR and Raman analyses showed subtle shifts in methylene and carbonyl vibrational bands without significant perturbation of phosphate headgroup vibrations, indicating preservation of bilayer integrity. These findings demonstrate that ultrasmall plasmonic AuNPs interact favorably with archaeal lipid-containing membranes while preserving membrane structural integrity, highlighting their potential for drug delivery, bioimaging, and photothermal nanomedicine.

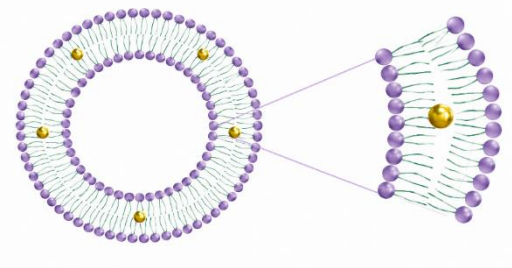

Figure 1. Schematic illustration of liposomes entrapped with ultrasmall gold nanoparticles.

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