SenDiSo Workshop:

Bridging between Materials Research and Advanced Sensor and Detector Technologies, Vol II.

Date: May 28th 2026
Venue: "Sál A. Kochanovské" - část A (podium) Solid/1.NP/P.23/1**,** FZÚ, Na Slovance 1999/2, 182 00 Praha 8 (entrance from Pod Vodárenskou Věží 1)
Directions: https://www.fzu.cz/en/about-fzu/main-building-na-slovance-site.
Registration link: : https://indico.fzu.cz/e/sendiso-workshop-may2026

Program

9:30 – 10:00	Get together, coffee
10:00 – 10:10	Welcome and introduction, **Jakub Dostalek** (FZU)
10:10 - 10:30	Surface Modification of Thermoplastic Lab-on-a-Chip Devices with Polymer Brushes via SI-ARGET ATRP, **Volkan Cirik** (FZU, WP2)
10:30 - 10:50	Interactions of Antifouling Polymer Brushes with Biological Systems, **Alina Šleichertová** (FZU, WP2)
10:50 - 11:10	Multiphoton lithography for spatially controlled preparation of biointerfaces, **Guillermo Israel Garcia Delgadillo** (FZU, WP5)
11:10 - 11:30	Charge Dependent Trapping of Biomolecules in Confined Nanofluidic Geometries, **Taha Nasir** (FZU, WP5)
11:30 - 11:50	Layer-Defined Graphene/Polyaniline/MXene Heterostructures as Mechanistic Interfaces for Gas Sensing and Charge Storage, **Michal Jakl** (Heyrovsky, WP4)
12:00 - 13:00	Lunch
13:00 - 13:20	Nanostructured black palladium films fabricated by pulsed laser deposition for hydrogen sensing, **Jan Kejzlar** (FZU, WP4)
13:20 - 13:40	Scintillation Performance of InGaN/GaN Heterostructures Grown by Metal Organic Vapor Phase Epitaxy, **Tomáš Hubáček** (FZU, WP3)
13:40 – 14.00	Photogating-enhanced Direct X-ray Detection in Ultrathin Graphene/$CsPbBr_3$ Nanocrystal Heterostructures, **Oleksandr Volochanskyi** (Heyrovsky, WP3)
14:00 – 14.20	Correlating Growth Parameters, Layer Morphology, and Excitonic Dynamics in CVD-Grown MoS_2 Thin Films**, Akanksha Agarwal** (FZU, WP1)
14:20 – 14.40	Beyond Ink: Aerosol Jet Printing of Diamond Layers, Functional Coatings and Conductive Electrodes, **Michal Kočí** (FZU, WP1)
14:40 – 15.00	Investigating the thin film growth of $[Ni(Hvanox)_2]$ by microscopic and spectroscopic techniques, **Atharva Sapre** (FZU, WP4)
15:00 – 15.10	Wrapping up (J. Dostalek)
15:10 – ….	Informal discussions, coffee

Zoom link for online participation:

https://bokuvienna.zoom.us/j/67774117355?pwd=QlBPnnu943tWWPOIVQu4Hsj56yrr9C.1

Co-funded by the European Union

Ministry of Education, Youth and Sports of the Czech Republic

Sensors and Detectors for Future Information Society – SENDISO reg.n. CZ.02.01.01/00/22_008/0004596 is co-funded by the European Union

Abstracts:

Surface Modification of Thermoplastic Lab-on-a-Chip Devices with Polymer Brushes via SI-ARGET ATRP

Volkan Cirik[1,2], Markéta Kubíčková[1, 2], Oleksandr Romanyuk[1], Hana Lísalová[1],Nicholas Scott Lynn Jr.[1]

1) *Institute of Physics of the Czech Academy of Sciences, Na Slovance 1999/2, 182 00 Prague, Czech Republic, info@fzu.cz*
2) *Charles University, Faculty of Mathematics and Physics, Ke Karlovu 2027/3, 121 16 Prague, Czech Republic, mff@matfyz.cuni.cz*

Thermoplastic lab-on-a-chip (LOC) devices made from PMMA, PP, and PC are gaining popularity due to their biocompatibility, gas permeability, and good optical properties. Their mass-production capability lowers manufacturing costs, making them suitable for disposable LOCs.[1] However, without surface modification, these materials can lead to flow disruption and biomolecule fouling.

A polymer brush (PB) is a structure consisting of densely packed ultrathin polymer chains, one end attached to a solid surface.[2] The SI-ARGET (Surface Initiated Activators Regenerated by Electron Transfer) ATRP (Atom Transfer Radical Polymerization) technique offers an environmentally and oxygen-friendly approach to synthesize PBs on solid substrates. The resulting PBs allow tailored hydrophilicity, enhance flow stability and reduce biofouling, which improves device reliability.[3]

Here we will present several synthesis strategies for PB grafting on thermoplastics, along with their characterization using IR, XPS, and contact angle goniometry. IR and XPS results demonstrate successful PB growth, and contact angle measurements that indicate an increase in hydrophilicity.

References:

[1]Shakeri, A. *Materials* **2022**, *15*, 6478. https://doi.org/10.3390/ma15186478
[2] Zhao, B. Progress in Polymer Science, 2000. 25(5): p. 677-710. doi:10.1016/S0079-6700(00)00012-5
[3] Barbey R. Chem Rev. 2009 Nov;109(11):5437–527. doi: 10.1021/cr900045a.

Interactions of Antifouling Polymer Brushes with Biological Systems

Alina Šleichertová

FZU - Institute of Physics, Czech Academy of Sciences, Na Slovance 2, Prague, 182 21, Czech Republic

Institute of Physics, Faculty of Mathematics and Physics, Charles University, Ke Karlovu 3, Prague, 121 16, Czechia

sleichertova@fzu.cz

Antifouling polymer brushes (PBs) represent versatile biointerfaces for biomaterials and biosensing applications, where performance is governed by interactions at the solid–liquid interface. This presentation highlights recent results on zwitterionic and nonionic PBs, with a particular focus on poly(carboxybetaine methacrylamide) (pCBMAA), poly(sulfobetaine methacrylamide) (pSBMAA), poly[N-(2-hydroxypropyl) methacrylamide] (pHPMAA), and functionalizable CBMAA/SBMAA/HPMAA terpolymer brushes. These coatings combine strong antifouling properties with tunable biological functionality.

First, recent findings on the effective charge of low-fouling polybetaine brushes will be presented. Although pCBMAA and pSBMAA brushes exhibit negative zeta potential above their isoelectric point, this apparent negative charge does not necessarily correspond to a functionally negative surface charge governing macromolecular interactions. These results show that zeta potential alone is not sufficient to predict the interaction behavior of antifouling PBs. [1]

Second, the presentation will show how fine-tuning the composition of functionalizable terpolymer brushes based on CBMAA, SBMAA, and HPMAA enables control over antifouling and biological performance. The optimized

terpolymer coating reduced protein adsorption by 98% in serum-rich medium and suppressed Staphylococcus epidermidis and Pseudomonas aeruginosa adhesion by 99%. It also enhanced macrophage motility and phagocytic activity and, after RGD functionalization, promoted osteoblast-like SaOS-2 cell adhesion while maintaining antifouling efficacy. [2]

Together, these results highlight the importance of charge balance, hydration, and molecular architecture in the design of advanced antifouling polymer-brush biointerfaces for biological and biomedical applications.

References:

[1] Pilipenco, A.; Forinová, M.; Černochová, Z.; Kolská, Z.; Fekete, L.; Vaisocherová-Lísalová, H.; Houska, M. The Effective Charge of Low-Fouling Polybetaine Brushes. Langmuir 2025, 41, 15307–15318.

[2] Pilipenco, A.; Subbiahdoss, G.; Forinová, M.; Romanyuk, O.; Houska, M.; Spasovová, M.; Covato, C.; Scheberl, A.; Reimhult, E.; Vaisocherová-Lísalová, H. Fine-Tuned Functionalizable Terpolymer Brush Nanocoating Resists Protein Adsorption and Bacterial Adhesion while Promoting Macrophage Activity and Osteoblast Proliferation. ACS Applied Materials & Interfaces 2025, 17, 65399–65410.

Multiphoton lithography for spatially controlled preparation of biointerfaces

Guillermo Israel Garcia Delgadillo

FZU - Institute of Physics, Czech Academy of Sciences, Na Slovance 2, Prague, 182 21, Czech Republic

Institute of Physics, Faculty of Mathematics and Physics, Charles University, Ke Karlovu 3, Prague, 121 16, Czechia

The possibility of achieving spatial control over affinity capture target molecules in plasmonic biosensors is crucial for fully exploiting electromagnetic field enhancement at plasmonic hot spots [1,2]. Here, we investigate femtosecond laser-induced multiphoton photochemistry on planar and plasmonic gold substrates using engineered thermoresponsive poly(N-isopropylacrylamide) (pNIPAAm) – based polymers in order to prepare large binding capacity binding matrix. The material system is photoactivated through benzophenone-mediated multiphoton absorption and subsequently functionalized via EDC/NHS chemistry for selective biomolecule immobilization.

To enable precise micro/nanostructuring, we developed a custom optical lithography system combining a femtosecond pulsed laser, high-precision stage control, and dedicated software for tailored writing routines. Different fabrication parameters and plasmonic architectures, including nanocylinder arrays and bull's-eye structures, were investigated to study their influence on photocrosslinking. Distinct photocrosslinking thresholds were observed for flat gold substrates and plasmonic nanocylinder arrays, while bull's-eye structures promoted the formation of complex localized geometries. Our results demonstrate that the spatial distribution of the enhanced electromagnetic field governs the localization and efficiency of hydrogel photocrosslinking near the metal interface, highlighting the potential of plasmon-assisted multiphoton fabrication for localized biofunctionalization and plasmon-enhanced fluorescence biosensing.

References

[1] Plasmon-Enhanced Multiphoton Polymer Crosslinking for Selective Modification of Plasmonic Hotspots
Morozov, Y. M.; Quilis, N. G.; Fossati, S.; De Laporte, L.; Gusenbauer, C.; Weber, A.; Toca-Herrera, J. L.; Wiesner, F.; Jonas, U.; Dostalek, J. *J. Phys. Chem. C* **2024**, *128* (43), 18641–18650.

[2] Microstructuring of Thermoresponsive Biofunctional Hydrogels by Multiphoton Photocrosslinking
Morozov, Y. M.; Wiesner, F.; Grün, J. J.; Pertiller, M.; Fossati, S.; Schmidt, K.; Quilis, N. G.; Gusenbauer, C.; Zbiral, B.; Toca-Herrera, J. L.; Klees, S.; Thiagarajan, C. R. V.; Jonas, U.; Dostalek, J. *Adv. Funct. Mater.* **2024**, *34*, 2315578.

Charge Dependent Trapping of Biomolecules in Confined Nanofluidic Geometries

Taha Nasir[1,2], Tereza Roesel[1], N. Scott Lynn Jr. [1], Barbora Špačková[1]

[1] *FZU - Institute of Physics of the Czech Academy of Sciences, Na Slovance 1999/2, 182 21 Prague, Czechia*
[2] *Charles University, Faculty of Mathematics and Physics, Ke Karlovu 2027/3, 121 16 Prague, Czech Republic, mff@matfyz.cuni.cz*

Understanding the transport dynamics of proteins and other nanosized particles in nanofluidic confinement is important for manipulating, detecting, and characterising matter in fluids. In these systems, transport is strongly influenced by electrostatic interactions arising from surface charge, electric fields, and ionic distributions. However, experimentally probing the dynamics of single proteins in their native solution state remains challenging and has often relied on labelling strategies.

Nanofluidic Scattering Microscopy (NSM) enables label-free detection of single biomolecules in solution [1], providing a platform to study such electrokinetic effects directly. In this study, we investigate molecular trajectories through electrostatic traps formed in SiO_2-based nanofluidic channels with spatially varying geometrical constrictions. When filled with an ionic solution, regions of different EDL overlap generate localised electrostatic trapping potentials without the need for externally applied electric fields [2].

Using thyroglobulin as a model protein, we observe that varying the concentration of phosphate-buffered saline (PBS) alters molecular transport dynamics within these traps. Finally, we explore how this electrokinetic behaviour could be extended toward label-free measurements of single-biomolecule charge in solution, adding charge as a third independent biomolecular characteristic accessible by NSM, alongside mass and hydrodynamic radius.

References:
[1] Špačková, B., Klein Moberg, H., Fritzsche, J. *et al. Nat Methods* **19**, 751–758 (2022). https://doi.org/10.1038/s41592-022-01491-6
[2] Ruggeri, F., Zosel, F., Mutter, N. *et al. Nature Nanotech* **12**, 488–495 (2017). https://doi.org/10.1038/nnano.2017.26

Layer-Defined Graphene/Polyaniline/MXene Heterostructures as Mechanistic Interfaces for Gas Sensing and Charge Storage

Michal Jakl, Martin Mergl, Michal Bláha, Martin Kalbáč

HIPC-J. Heyrovský Institute of Physical Chemistry, Czech Academy of Sciences, Dolejškova 2155/3, Prague 8, 182 23, Czech Republic

michal.jakl@jh-inst.cas.cz

Two-dimensional hybrid materials are promising for gas sensing and electrochemical energy storage, but most reported MXene/polymer/carbon systems are random composites in which individual interfacial contributions are difficult to resolve. Here, we propose a layer-defined heterostructure consisting of Si/SiO_2-supported CVD single-layer graphene, a quasi-monolayer of polyaniline (PANI), and dielectrophoretically assembled few-layer $Ti_3C_2T_x$ MXene flakes. Graphene is used as a field-effect transduction channel, PANI as a redox- and protonation-active molecular interlayer, and MXene as a conductive, surface-terminated adsorption and pseudocapacitive layer. The concept builds on recent evidence that graphene/PANI interfaces exhibit electron donation from graphene to protonated PANI, *p*-type doping of graphene, stabilization of polaronic charge carriers, and measurable shifts in the Dirac point [1]. Coupling this interface with $Ti_3C_2T_x$ MXene introduces –O, –OH and –F surface terminations relevant for room-temperature gas sorption and charge-transfer-based transduction [2,3]. A key methodological aspect is the controlled preparation of quasi-monolayer interfaces: PANI will be formed by a suppressed bulk-polymerization strategy on graphene, while dielectrophoresis will be used to position dispersed few-layer MXene flakes with tunable coverage. This is critical because partial MXene coverage may preserve graphene field-effect sensitivity, whereas excessive percolation could screen the graphene channel. Related studies have already demonstrated large-area MXene monolayer assemblies and electrically continuous flake networks [4].

The charge-storage relevance of this architecture is supported by MXene/PANI systems in which PANI interlayers suppress MXene restacking, open ion-transport pathways and enhance pseudocapacitive performance [5]. In contrast to thicker composite electrodes, the present platform is designed as an ultrathin mechanistic interface in which Raman spectroscopy, XPS, SEM, AFM, GFET measurements, cyclic voltammetry and impedance spectroscopy can be correlated. By linking Dirac-point shifts, Raman/XPS signatures of PANI redox states, MXene surface chemistry and electrochemical response, this project connects practical sensor and microsupercapacitor concepts with fundamental studies of molecular interactions in layered 2D hybrid materials.

References:
[1] M. Bláha et al., *Adv. Compos. Hybrid Mater.*, 2025, 8(5), 381
[2] H. Qin et al., *Nanoscale*, 2026, 18(7), 3513-3536
[3] S. Yu et al., *Small Methods*, 2025, 9(10), 2402179
[4] M. Mojtabavi et al., *ACS Nano*, 2021, 15(1), 625-636
[5] X. Wang et al., *ACS Appl. Mater. Interfaces*, 2021, 13(26), 30633-30642

NANOSTRUCTURED BLACK PALLADIUM FILMS FABRICATED BY PULSED LASER DEPOSITION FOR HYDROGEN SENSING

J. Kejzlar[1,2], M. Hruška[1], S. A. Irimiciuc[2], S. Chertopalov[2], M. Vondráček[2], P. Fitl[1,2], M. Novotný[1,2], J. Lančok[2], M. Vrňata[1]
[1] Department of Physics and Measurements, University of Chemistry and Technology, Prague, Technická 5, Praha 6, CZ16628, Czech Republic
[2] Institute of Physics of the Czech Academy of Sciences, Na Slovance 1999/2, 18200
10 Prague 8, Czech Republic

Hydrogen (H_2) detection at low concentrations is crucial for safety and environmental monitoring, particularly as hydrogen becomes increasingly adopted as a clean energy source of the future [1]. A wide range of strategies has been developed to achieve sensitive, reliable, and economically viable hydrogen sensing, especially in the critical concentration range below 4% and down to ppm levels required for leak detection [2]. Advances in nanostructured materials have revealed that highly porous surface morphologies can markedly improve sensing performance by providing a larger number of active sites for the analyte. Among these materials, black metal nanostructured thin films exhibiting fractal-like morphology and black-body optical behaviour have emerged as especially promising candidates. Although these materials have been known for decades, their potential for gas sensing applications has only recently attracted significant interest [3,4]. Earlier work demonstrated that black gold films can detect hydrogen concentrations below 1% [5], encouraging further exploration of other black metal systems.

In this study, we investigate the hydrogen sensing properties of annealed black palladium films fabricated by pulsed laser deposition (PLD). While black metals are traditionally produced by thermal evaporation, PLD provides an attractive alternative, allowing the preparation of black metal coatings even from refractory and noble metals that are difficult to evaporate using conventional methods. In the present work, low-density Pd films were deposited under high-fluence conditions promoting fractal-like growth and subsequently annealed at 300 °C for 16 h, resulting in the formation of a Pd/PdO core–shell structure. As demonstrated here, this architecture contributes to stabilising the sensor response and improving the hydrogen sensing performance. The sensing characteristics were examined in the 100 - 800 ppm hydrogen concentration range at room temperature (23 ± 0.5 °C), where a stable and measurable response was observed even at 100 ppm H_2.

To evaluate the environmental stability of the sensor, measurements were carried out under controlled ambient-like atmospheres with relative humidity values of 0%, 20%, 45%, and 60%. The annealed Pd/PdO nanostructures showed stable, repeatable, and humidity-resistant sensing behaviour under all tested conditions. Importantly, even at 60% relative humidity, the sensor response remained unaffected, preserving consistent dynamic performance throughout the entire calibration range.

References
1. Z. Abdin, et al., "Renewable hydrogen for sustainable energy transitions", Renew. Sustain. Energy Rev., 120 (2020), 109620.

2. T. Hübert, et al., “Hydrogen sensors – A review”, Sens. Actuators B: Chem., 157/2 (2011), 329–352.
3. M. Hruška, et al., “Surface Enhancement Using Black Coatings for Sensor Applications”, Nanomaterials, 12/23 (2022), 4297.
4. J. Kejzlar, et al., “Black gold layers: preparation via thermal evaporation, material and optical properties, and application potential for gas sensors”, Mater. Adv., 6/10 (2025), 3280–3292.
5. M. Hruška, et al., “Hydrogen sensing capabilities of highly nanoporous black gold films”, Appl. Surf. Sci., 647 (2024), 158618.

Scintillation Performance of InGaN/GaN Heterostructures Grown by Metal Organic Vapor Phase Epitaxy

Tomáš Hubáček

FZU-Institute of Physics, Czech Academy of Sciences, Cukrovarnická 112/10, Prague, 162 00, Czech Republic

hubacekt@fzu.cz

Nitride semiconductors (GaN, InN, and AlN, as well as their alloys) are well-known direct wide-bandgap materials with fast near-band-edge emission and good thermal, chemical, and radiation resistance [1]. While these materials are best known for their applications in optoelectronics, such as blue light-emitting and laser diodes [2, 3], and in high-power and high-frequency electronics [4], their intrinsic physical properties also make them highly attractive for detecting ionizing radiation, including α and β particles, soft γ-rays, and even neutrons [5]. Nitrides are distinctive within the domain of novel scintillation nanomaterials, primarily due to their ultra-fast decay time. Nitrides’ decay time can be reduced to 1 ns while maintaining adequate luminescence efficiency, a property that is particularly advantageous for time-of-flight applications [6]. The drawbacks of nitride scintillation detectors include the limited thickness of semiconductor epitaxial films, the complexity of preparation, and the quenching of luminescence via defects, dislocations, and other non-radiative centers.

This work focuses on the preparation of InGaN/GaN multiple quantum well (MQW) structures with different architectures to obtain thick MQW region as much as possible while maintaining ultra-fast decay time. Structures are prepared by metal organic vapor phase epitaxy (MOVPE). The preparation of structure with 2.6 µm thick MQW region and 1.24 ns mono-exponential decay time is discussed, as well as the ways to obtain decay time below 1 ns or how to increase luminescence efficiency of MQW region. Comparison of scintillation performance of these structures to YAP:Ce or BGO is also shown. Finally, the growth of MQW region on the non-polar planes on the GaN microcolumns is also discussed. These structures exhibit extremely fast decay time due to the absence of internal electric field inside the non-polar MQW region.

[1] H. Morkoc, Springer Series in Materials Science, 1999, ISBN 978-3-642-63647-9.
[2] S. Nakamura et al., Jpn. J. Appl. Phys. 1993, 32 (1A).
[3] S. Nakamura et al., Jpn. J. Appl. Phys. 1998, 37 (3B).
[4] A. Talukder et al., e-Prime – Adv. Electr. Eng. Electron. Energy 2025, 13, 101059.
[5] J. Wang et al., Appl. Phys. Rew. 2015, 2, 031102.
[6] A. Hospodková et al, Nanotechnology 2014, 25, 455501.

Photogating-enhanced Direct X-ray Detection in Ultrathin Graphene/CsPbBr$_3$ Nanocrystal Heterostructures

Oleksandr Volochanskyi

J. Heyrovský Institute of Physical Chemistry, Czech Academy of Sciences, Dolejškova 2155/3, Prague, 182 23, Czech Republic oleksandr.volochanskyi@jh-inst.cas.cz

Ultrathin, low-bias direct X-ray detectors are highly desirable for next-generation imaging and dosimetry. Conventional X-ray detectors typically rely either on relatively thick scintillator screens, for which greater thickness improves absorption at the expense of spatial resolution and noise,[1] or on direct-conversion semiconductors operated under strong electric fields, creating practical trade-offs between sensitivity, miniaturization, and integration.[2] In the present work, a graphene/$CsPbBr_3$ nanocrystal heterostructure is shown to overcome these limitations by exploiting interfacial photogating to amplify the electrical response of an ultrathin absorber. Visible-light phototransport reveals trap-limited gain and charge transfer to the graphene channel, allowing to reach responsivity of $\sim 2 \times 10^{7}$ A W^{-1}, whereas time-resolved photoluminescence and transient absorption spectroscopy show strong excited-state quenching on graphene and sub-100-ps interfacial depopulation,[3] consistent with rapid charge separation that seeds a long-lived electrostatic gating state.[4] Under 8.04 keV irradiation, the same gain mechanism enables direct X-ray readout from a sub-50-nm $CsPbBr_3$ nanocrystal film despite intrinsically low absorption, yielding areal charge sensitivity up to $\sim 1.46 \times 10^{6}$ μC Gy_{air}^{-1} cm^{-2} at low bias voltage, outperforming state-of-the-art thick-film detectors.[5] Radioluminescence quenching on graphene further supports direct interfacial harvesting of X-ray-generated charge carriers. These results establish a unified framework linking ultrafast interfacial charge transfer, visible-light photogating, and gain-enhanced direct X-ray conversion in ultrathin graphene/$CsPbBr_3$ nanocrystal heterostructures, offering high sensitivity and low-bias detection.

References:
[1] A. Howansky et al., *Med. Phys.* 2019, 46, 4857–4868.
[2] S. Kasap et al., *Phys. Status Solidi B*, 2009, 246, 1794–1805.
[3] N. C. Maurya et al., *Phys. Rev. B*, 2023, 108, 155417.
[4] G. Konstantatos et al., *Nat. Nanotechnol.*, 2012, 7, 363–368.
[5] W. Qian et al., *Matter,* 2021, 4, 942–954.

Beyond Ink: Aerosol Jet Printing of Diamond Layers, Functional Coatings and Conductive Electrodes

Kočí Michal

FZU-Institute of Physics, Czech Academy of Sciences, Cukrovarnická 10/112, Prague, 162 00, Czech Republic

kocim@fzu.cz

Precise control of material deposition is a fundamental prerequisite for the fabrication of high-performance diamond-based sensor architectures. Aerosol jet printing represents a non-contact, mask-less additive manufacturing technology in which an ultrasonic atomizer generates a polydisperse aerosol from a liquid ink feedstock. The resulting aerosol stream is transported to a flow cell, where it is co-axially focused by an annular sheath gas and collimated through a series of aerodynamic lenses before deposition, enabling feature resolutions ranging from 10 to 1000 μm line width. In contrast to inkjet printing, which relies on thermal or piezoelectric droplet ejection and is constrained to narrow ink viscosity windows and strictly planar substrate geometries, aerosol jet printing accommodates functional inks across a substantially broader rheological envelope — including metallic nanoparticle suspensions, polymeric matrices, and biological agents. The inherent standoff between the nozzle and substrate, combined with aerodynamic focusing rather than direct fluid contact, enables aerosol jet printing on topographically complex surfaces, such as nanocrystalline diamond (NCD) films, without requiring lithographic steps that would compromise carefully engineered surface terminations and chemistry. In this work, utilizing the IDS NanoJet Free Standing aerosol printing platform equipped with ultrasonic aerosolization, interchangeable ink cartridges, and three-axis motion control, aerosol jet printing is demonstrated across three functional domains critical to diamond-based sensor technology. First, conductive silver nanoparticle electrodes are directly printed onto rough NCD surfaces, establishing continuous conductive pathways while fully preserving substrate surface chemistry and termination. Second, site-selective deposition of active functional layers enables the realization of multiplexed sensor arrays on a single diamond substrate, facilitating parallel multi-analyte detection within a compact footprint. Third, spatially controlled printing of diamond nucleation layers permits selective CVD diamond growth on heterogeneous substrate materials, extending integration strategies beyond conventional diamond-on-diamond architectures. This photolithography-free, additive approach eliminates exposure to aggressive chemical etchants and photoresists, safeguarding the physicochemical integrity of underlying functional layers and providing a scalable, materials-agnostic route toward next-generation diamond-based sensing and electronics platforms.

References:
[1] M. Kočí et al., Diamond and Related Materials, 2026, vol. 162, 113307
[2] P. Kulha et al., Journal of Electrical Engineering, 2016, vol. 67, 61-64.
[3] IDS NanoJet Aerosol Printing, available at: https://www.idsnm.com
[4] V. Povolný et al., NANOCON, 2025, 194-200
[5] A. Laposa et al., IEEE Sensors Journal, 2019, vol. 20(3), 1158 – 1165

Correlating Growth Parameters, Layer Morphology, and Excitonic Dynamics in CVD-Grown MoS_2 Thin Films

Akanksha Agarwal

FZU-Institute of Physics, Czech Academy of Sciences, Cukrovarnická 10/112, 162 00, Prague 6, Czech Republic

akanksha@fzu.cz

Two-dimensional molybdenum disulfide (MoS_2) is a highly promising transition metal dichalcogenide for optoelectronic applications due to its indirect to direct band gap transition and strong excitonic band gap. However, achieving large-area growth with controlled morphology and understanding its optical properties remains challenging. In this work, we present a comprehensive study that connects CVD growth parameter optimization with the morphological and excitonic properties of layered MoS_2 films on Si/SiO_2 substrates. MoS_2 thin films were synthesized using a dual-zone thermal CVD system with solid MoO_3 and sulfur as precursors. We investigated the influence of growth parameters on morphology and thin film deposition. Optical microscopy, scanning electron microscopy (SEM), and X-ray photoelectron spectroscopy (XPS) reveal that vertical substrate orientation under atmospheric pressure yields relatively continuous, near-stoichiometric MoS_2 ($S/Mo = 2.0$) with well-defined triangular domains, while horizontal placement produces inhomogeneous, bulk-like crystals. We investigated the layer-dependent excitonic properties of CVD-grown MoS_2 flakes (bilayer to ~15 layers). Raman spectroscopy confirmed the number of layers from the frequency difference (Δ) between the E_{2g} and A_{1g} phonon modes, ranging from 21 cm^{-1} (bilayer) to 26 cm^{-1} (multilayer). Room-temperature photoluminescence (PL) spectroscopy revealed a redshift of ~0.04 eV in the excitonic emission with increasing layer number, consistent with the direct-to-indirect bandgap transition. Multi-component Gaussian fitting of the PL spectra resolved the A exciton, A^- trion, and B exciton contributions, enabling extraction of the trion binding energy and electron density as a function of thickness. This interplay is attributed to the combined effects of dielectric screening, disorder-induced doping, and bandgap renormalization in layered MoS_2.

References:
[1] S. Z. Butler et al., *ACS Nano*, 2013, 7, 2898–2926
[2] S. Manzeli et al., *Nature Reviews Materials*, 2017, 2, 17033
[3] K. F. Mak et al., *Physical Review Letters*, 2010, 105, 136805
[4] S. Golovynskyi et al., *Journal of Physical Chemistry C*, 2021, 125, 17806–17819

Investigating the thin film growth of $[Ni(Hvanox)_2]$ by microscopic and spectroscopic techniques.

Atharva Sapre

FZU-Institute of Physics, Czech Academy of Sciences, Na Slovance 2, Prague, 182 00, Czech Republic

sapre@fzu.cz

Thin films of transition metal complexes are widely studied for their tunable properties in optoelectronics, sensing, and molecular electronics. Surface roughness plays a crucial role in determining their functional performance by increasing surface area and enabling unique interactions. Controlled fabrication of films with tailored roughness has therefore become essential for understanding and optimizing film growth mechanisms and enhancing the overall efficiency of these materials in various applications.

In this work we investigate the controlled deposition and structural growth of thin films of the nickel(II) complex, [Ni(HVanox)$_2$], derived from *o*-vanillin oxime (H$_2$vanox = *o*-vanillin oxime).[1] Low-pressure experiments to prepare thin films were conducted at temperatures between 120-150°C to optimize the deposition rate for uniform films. Thin films of increasing thickness (16-336 nm) have been prepared on various substrates and were characterized in detail using microscopic and spectroscopic methods: scanning electron microscopy (SEM), atomic force microscopy (AFM) and transmission electron microscopy (TEM). FT-IR and Raman analyses confirmed the preservation of the molecular structure after evaporation, demonstrating the chemical integrity of the films. UV–Vis spectroscopy revealed charge transfer transitions and optical band gap.

Microscopy revealed a rough surface with a dense arrangement of elongated, rod and needle-like nanocrystals with random orientation. AFM images revealed the surface with a high degree of roughness, varying with different thicknesses. Microscopic characterization also helped us to understand the growth mechanism of the film by observing a seeding layer, which grows in parallel to the surface of the substrate, upon which long needles or grass-like crystals grow perpendicular to the substrate.

X-ray photoelectron spectroscopy (XPS) was used to confirm the elemental composition of the films along with the square-planar environment around the Ni(II) center. XRD data revealed the phase purity of the thin films, with additional Rietveld refinement of the XRD data leading to refined lattice parameters which are in good agreement with the structure of [Ni(Hvanox)$_2$][2]. These complexes will be further investigated for gas sensing applications.

References:

(1) Sapre, A. U.; Vlček, J.; de Prado, E.; Fekete, L.; Klementová, M.; Vondráček, M.; Svora, P.; Cuza, E.; Morgan, G. G.; Honolka, J.; Kühne, I. A. Investigating the Thin Film Growth of [Ni(Hvanox) 2] by Microscopic and Spectroscopic Techniques. *Nanoscale Adv* **2025**, *7* (7), 2083–2091. https://doi.org/10.1039/D4NA01021C.

(2) Li, B. W.; Zeng, M. H.; Ng, S. W. Bis(2-Hydroxy-Imino-Methyl-6-Methoxy-Phenolato-2 O 1,N)Nickel(II). *Acta Crystallogr Sect E Struct Rep Online* **2009**, *65* (3), m318–m318. https://doi.org/10.1107/S1600536809005996/SJ2577ISUP2.HKL.