# DS 10: Thin Film Application

Time: Wednesday 15:00–18:15 Location: A 060

DS 10.1 Wed 15:00 A 060

**Investigation of interfacial spin transport in chiral RhSi epitaxial thin films** — •Surya Narayan Panda[1], Edouard Lesne[1], Qun Yang[1], Anastasios Markou[2], Binghai Yan[3], and Claudia Felser[1] — [1]Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Str. 40, 01187 Dresden, Germany — [2]University of Ioannina, Greece — [3]Weizmann Institute of Science, Israel

The rise of nonmagnetic chiral topological semimetals as a uniquely attractive playground for the observation and control of various spin-orbit effects has ushered in the promising field of topological spintronics. In this work, we have investigated the spin-to-charge interconversion through spin pumping and inverse-spin Hall effect(ISHE) in sputter-grown epitaxial RhSi thin films and its subsequent transport across RhSi/Py interface. From the observed modulation of Gilbert damping parameter and ISHE voltage with RhSi thickness, the spin-Hall angle of RhSi and interfacial spin transparency of RhSi/Permalloy interface is determined. A stark variation of spin Hall angle and interfacial spin transparency is observed with ambient temperature in this heterostructure. The spin Hall angle and spin Hall conductivity is found to be maximum of 1.4% and 252 ($\hbar$/e) Ωˆ(-1) cmˆ(-1), respectively. A spin-mixing conductance and interfacial spin transparency as high as 34.7 nm-2 and 88% is attainable in these heterostructures. This study expands the horizon of topological spintronics and highlights the controlled spin-charge interconversion and interfacial spin-transport process in chiral semimetal/ferromagnet heterostructures.

DS 10.2 Wed 15:15 A 060

**Functionalization of SiC diodes for soft X-ray optics** — •Simone Finizio[1], Massimo Camarda[2], Joakim Reuteler[3], and Jörg Raabe[1] — [1]Swiss Light Source, Paul Scherrer Institut, Villigen PSI, Switzerland — [2]SenSiC GmbH, Villigen PSI, Switzerland — [3]ScopeM, ETH Zürich, Zürich, Switzerland

Synchrotron light sources are a vital tool for the scientific community that has allowed for several critical discoveries. Amongst the quiver of techniques offered by synchrotrons, X-ray microscopy and spectroscopy are two of the most popular ones. A critical requirement for such techniques is the reliable and reproducible positioning of the X-ray beam, and the measurement of its intensity, to avoid measurement artefacts that can affect the quality of the acquired data. The integration of X-ray beam position and intensity sensors in measurement conditions as close as possible to those experienced by the sample under investigation is therefore of interest. In this presentation, we will show the fabrication and integration of SiC diode sensors with soft X-ray spectro-microscopy beamlines, in particular with geometries ranging from pinholes, center stops, and thin membrane films.

DS 10.3 Wed 15:30 A 060

**Piezoelectricity enhances MoSe2 nanofowers adsorption of the antibacterial dye malachite green under sonication** — •Jinzhu Wu — Harbin Institute of Technology, Harbin, China

Nanoscale piezoelectrics have recently found applications in radios, switches, tweezers, sensors, actuators, feld efect transistors and piezoelectric-gated diodes. Piezoelectrics may also be used to adsorb and efciently degrade pollutants, yet knowledge is actually scarce. Two-dimensional transition metal dichalcogenides were recently found to be piezoelectric. Here, MoSe2 nanofowers were synthesized by the hydrothermal method then used to adsorb the malachite green dye, an antifungal and antibacterial agent for aquaculture. Results show very high dye adsorption, of 85% within 5 s under sonication, with a theoretical maximum adsorption capacity of 208.3 mg/g.This is explained by spontaneous physisorption via pai-pai stacking interactions between aromatic malachite green and electron-rich MoSe2 nanofowers. For the frst time, this work clarifes that the piezoelectric efect of the few-layered MoSe2 nanofowers triggered by the ultrasonic vibration is a driven force for outstanding adsorption.

DS 10.4 Wed 15:45 A 060

**Innovative Strategies in CZTS Solar Cells: Unravelling the Potential of Metal Substituted CZTS Thin Films** — •Yusuf Selim Ocak[1,2], Ahmet Tombak[3], Mustafa Fatih Genisel[4], and Omer Celik[2,5] — [1]Institute of Nanotechnolgy, JUST, Jordan — [2]Smart-Lab, Dicle University, Turkey — [3]Department of Physics, Batman University, Turkey — [4]SESAME, Allan, Jordan — [5]LDMRC, University of Malaya, Malaysia

Copper zinc tin sulfide (CZTS) thin films are gaining traction in solar cell applications due to their abundance and favorable optoelectronic properties. This presentation provides a comprehensive exploration of CZTS thin films, focusing on strategically substituting metals to customize their optical, structural, and morphological traits.

We systematically examine the influence of metal substitutions like Si, Ge, Cd, and Ti on the structural properties and bandgap engineering of CZTS, shedding light on their potential as absorber materials. Additionally, we offer a detailed characterization of solar cells crafted from Cd- and Ti-substituted CZTS. The incorporation of various deposition techniques underscores the versatility of our approach, providing insights into how fabrication methods impact thin film properties.

This study enhances the fundamental understanding of CZTS thin films, emphasizing their practical significance in advancing solar cell technologies through tailored metal substitutions. The findings, supported by relevant literature, pave the way for the development of efficient and sustainable thin-film solar cells with enhanced performance characteristics.

DS 10.5 Wed 16:00 A 060

**Tailoring gas permeation of carbon nanomembranes via the structure of molecular precursors** — •Daniel Hüger[1], Anna-Laurine Gaus[2], Vladislav Stroganov[1], Julian Picker[1], Christof Neumann[1], Max von Delius[2], and Andrey Turchanin[1] — [1]Friedrich Schiller University Jena, Jena, Germany — [2]University of Ulm, Ulm, Germany

Carbon nanomembranes (CNMs) are molecular nanosheets with a thickness of about 1 nm. They are synthesised via electron irradiation of aromatic self-assembled monolayers (SAMs), which enables to flexibly tailor their physical and chemical properties by choice of the molecular precursors. Among others, the permeation properties of CNMs make them promising for applications in energy storage and conversion. Here we present a study of the permeation of helium and water vapours through a series of CNMs synthesised from pyrene-1-thiol, anthracene-2-thiol, phenanthrene-2-thiol and 4'-nitro-4-biphenylthiol SAMs. We demonstrate that the introduction of functional groups on the CNM surface and tuning the precursors' structure significantly impact the permeation properties and therefore the selectivity of the permeating species.

DS 10.6 Wed 16:15 A 060

**Reversible Photoalignment of Azobenzene inside the pores of thin MOF films** — •Tillmann Koehler[1,2], Alexander Mundstock[3], Jürgen Caro[3], and Frank Marlow[1,2,4] — [1]Max-Planck-Institut für Kohlenforschung — [2]Universität Duisburg-Essen — [3]Leibniz Universität Hannover — [4]Center for Nanointegration Duisburg-Essen

Integrating molecular switches within the cavities of metal-organic frameworks (MOFs) represents a promising avenue for achieving all-optical switching - a crucial approach to address the escalating energy demands of contemporary internet and communication technologies. Our primary focus centers on employing azobenzene and its derivatives as guest molecules within these frameworks. Azobenzene can undergo photochemical switching between the stable trans-isomer and the metastable cis-isomer. As hosts, we utilize thin films of MOFs, a hybrid material class composed of metal centers interconnected by organic linkers. They are synthesized via liquid phase epitaxy by alternating exposition to metal and linker. The state of the isomers and their orientation inside the pores can be analyzed using linearly polarized UV/Vis spectroscopy. Our findings reveal that azobenzene encapsulated within the pores of MOF type HKUST-1 not only undergoes efficient isomerization, leading to reversible changes in optical properties, but also exhibits the uncommon phenomenon of photoalignment [1]. Results for higher loadings and more perfect films are shown. [1] J. Phys. Chem. Lett. 2021, 12, 36, 8903*8908

**15 min. break**

DS 10.7 Wed 16:45 A 060

**Photosensitive silicon oxynitride doped silicon containing**

**wearable Bragg gratings against counterfeit applications** — •Ali Karatutlu[1], Timuçin Emre Tabaru[1,2], Umut Taylan[1,3], Zehra Gizem Mutlay[1], Hamid-Reza Bahari[1], Esra Kendir Tekgül[1], Doğukan Hazar Özbey[1], Engin Durgun[1], and Bülend Ortaç[1] — [1]UNAM–Institute of Materials Science and Nanotechnology, Bilkent University, Ankara, 06800-Turkey — [2]Sivas University of Science and Technology, Mecnun Otyakmaz Street No:1 Sivas 58100, Türkiye — [3]Empa, Swiss Federal Laboratories for Materials Science & Technology, Laboratory for Advanced Materials Processing, Feuerwerkerstrasse 39, CH-3602 Thun, Switzerland

Bragg gratings are utilized in different advanced applications, including lasers, sensing, and spectrometers. This study demonstrates a synthesis of photo-sensitive silicon oxynitride-doped silicon containing distributed Bragg gratings (BGs) on a flexible substrate as a wearable material and utilization of this flexible material in the information storage inscribed by a femtosecond laser light. The BGs were designed and fabricated to possess a unique hyper-spectral reflection behavior from ultra-violet to near-infrared region. To make it user-friendly, the inscribed message *L* can be observed in an indoor or outdoor light at certain viewing angles, such as 45° with respect to the normal surface of the flexible BG. Furthermore, the message can also be observed at certain polarizations. Furthermore, we will show in the framework of ab initio calculations the first-time formation of silicon oxynitride crystals from Si3N4 crystals present in Si layers.

DS 10.8 Wed 17:00 A 060

**Photoresponsive Nanoporous Metal Organic Framework Films with Switchable Unpaired Electron** — •Yidong Liu and Lars Heinke — Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany

Photoresponsive materials enable the dynamic remote control of their inherent properties. The integration of photochromic molecules within nanoporous metal organic frameworks (MOFs) offers a distinctive avenue for tailoring material attributes, including the interplay between the MOF host and guest molecules within the pores. In our study, a MOF film of HKUST-1 type with embedded hexaarylbiimidazole (HABI) photoswitches show reversible light-induced reactions between a stable HABI dimer state and a meta-stable radical state. The transitions between the dimeric and radical forms are characterized through infrared, UV-vis and electron paramagnetic resonance (EPR) spectroscopy. Through transient uptake experiments utilizing ethanol and methanol as probe molecules, we demonstrate that the dimer-radical switching profoundly influences the host-guest interaction, particularly altering the uptake amount and the diffusion rate of the guest molecules.

DS 10.9 Wed 17:15 A 060

**Growth study of $\beta$-$Ga_2O_3$ on Ru(0001) substrates for resistive switching applications** — •Aman Baunthiyal, Martin Williams, Alexander Karg, Marco Schowalter, Thorsten Mehrtens, Martin Eickhoff, Andreas Rosenauer, Jon-Olaf Krisponeit, and Jens Falta — Institute of Solid State Physics, University of Bremen, Germany

$\beta$-$Ga_2O_3$ is in demand for high-power electronics, sensors, and UV devices. While $Al_2O_3$ and AlN are common substrates, this study aims for a metallic substrate serving as bottom electrode in vertically stacked resistive switching (RS) devices [1]. Here, we utilize Ru, which is also considered a promising replacement for Cu interconnects in CMOS technology due to its stable resistivity at high temperatures and excellent electromigration resistance.

After sputter deposition of Ru(0001) on $Al_2O_3$(0001) substrates at 450 °C, the subsequent growth of $Ga_2O_3$ was systematically studied with respect to growth temperature (room temperature to 600 °C) and film thickness. Raman spectroscopy unveiled that the growth of $\beta$-$Ga_2O_3$ growth starts at 200°C. Atomic force microscopy revealed an initial increase in roughness up to 400 °C and indicates a transition to a two-dimensional growth mode in the upper-temperature range. Finally, RS devices were created by deposition of Al top electrodes, featuring excellent stability with a consistent ON/OFF ratio exceeding $>10^4$ over extended retention and endurance cycles.

[1] Baunthiyal *et al.*, Appl. Phys. Lett. **123**, 213504 (2023).

DS 10.10 Wed 17:30 A 060

**Laser scanning induced phase transitions in $V_2O_3$ thin-films** — •Stefan Guénon[1], Theodor Luibrand[1], Farnaz Tahouni-Bonab[1], Lorenzo Fratino[2], Amihai Kronman[3], Yoav Kalcheim[3,4], Marcelo Rozenberg[2], Ivan K. Schuller[4], Dieter Koelle[1], and Reinhold Kleiner[1] — [1]Physikalisches Institut, Center for Quantum Science (CQ) and LISA$^+$, Eberhard Karls Universität Tübingen, 72076 Tübingen, Germany — [2]Université Paris-Saclay, CNRS Laboratoire de Pysique des Solides, 9105, Orsay, France — [3]Department of Materials Science and Engineering, Technion - Israel Institute of Technology, Technion City, 32000 Haifa, Israel — [4]Department of Physics and Center for Advanced Nanoscience, University of California - San Diego La Jolla, CA 92093, USA

There is a growing interest in strongly correlated insulator thin films in the emerging field of neuromorphic computing. Previous studies on the prototypical Mott-insulator $V_2O_3$ reported a strain induced spontaneous phase separation into metal-insulator herringbone domains during the Mott transition. Here, we used low-temperature optical microscopy to investigate the effect of laser scanning irradiation. We found that the response depends on the thermal history: When the film has been heated starting at a temperature below the Mott transition, the laser predominately induces a metallic phase. On the contrary, when the thin film has been cooled beginning at a temperature above the transition, the laser beam remarkably causes an insulating phase. Very likely this behavior is due to superheating and supercooling effects. Funding: Technion: ERC-2031938

DS 10.11 Wed 17:45 A 060

**Non-volatile electro-thermal memristive behavior in planar $NdNiO_3$ thin film devices** — •Farnaz Tahouni-Bonab[1], Matthias Hepting[2], Theodor Luibrand[1], Georg Cristiani[2], Gennady Logvenov[2], Bernhard Keimer[2], Dieter Koelle[1], Reinhold Kleiner[1], and Stefan Guénon[1] — [1]Physikalisches Institut, Center for Quantum Science (CQ) and LISA$^+$, Eberhard Karls Universität Tübingen, 72076 Tübingen, Germany — [2]Max Planck Institute for Solid State Research, Heisenbergstraße 1, 70569 Stuttgart, Germany

Memristive two-terminal devices are heavily investigated in the emerging field of neuromorphic computing as building blocks for artificial neural network hardware, particularly for storing the synaptic weights via non-volatile resistive switching. Here, we report on a non-volatile electro-thermal memristive effect in a planar $NdNiO_3$ (7 nm thick) thin-film device due to its characteristic thermodynamic properties. This behavior was investigated by electrical transport measurement and simultaneous optical imaging. We found resistive switching via multiple persistent states, which can be directly related to the spatial geometry of the metallic shunt. These results can be understood by considering the electro-thermal instability caused by the resistance vs. temperature dependence.

DS 10.12 Wed 18:00 A 060

**Developing neural networks for designing optical thin films** — •Elena Stoyanova, Krassimir Panayotov, Tihomir Tenev, and Ilko Miloushev — Institute of Solid State Physics, Bulgarian Academy of Sciences, 72 Tzarigradsko chaussee, Sofia 1784, Bulgaria

Almost every optical device is made up of a number of optical surfaces that guide and modify light as it passes through them. Optical coatings are produced as thin-film multilayers of different materials, using specialized deposition processes. Coatings are applied to optical components to guide and modify light as it passes through them and to use them at desired wavelength regions. Artificial Intelligence as neuron networks is included in the process of construction the thin films. Neural networks can learn and simulate complicated, nonlinear connections between input and output data. A computer program on Python is written, which investigates different layered structures in the spectral region between 0.2 *m and 2 *m. Film parameters values are given.