DS 1: Thin Film Properties

Time: Monday 9:30–12:30 Location: H3

DS 1.1 Mon 9:30 H3

From ferromagnetic semiconductor to anti-ferromagnetic metal in epitaxial CrxTey monolayers — •Naina Kushwaha[1,2], Olivia Armitage[1], Brendan Edwards[1], Liam Trzaska[1], Jennifer Rigden[2], Peter Bencok[3], Deepnarayan Biswas[3], Tien-Lin Lee[3], Charlotte Sanders[2], Gerrit van der Laan[3], Peter Wahl[1,4], Phil D. C. King[1], and Akhil Rajan[1] — [1]University of St Andrews, UK — [2]Central Laser Facility, UK — [3]Diamond Light Source, UK — [4]Physikalisches Institut, University of Bonn , Germany

Two-dimensional (2D) materials can exhibit markedly distinct electronic and magnetic properties compared to their bulk counterparts [1]. Among these, the Cr-Te compounds are of particular interest. 1T-CrTe2, in particular, is a room-temperature ferromagnet in the bulk, but is only metastable, readily decomposing into self-intercalated compounds like Cr2Te3 [2]. Utilizing a nucleation-assisted molecular-beam epitaxy growth method [3], we achieve the growth of phase selective monolayer Cr2Te3 and 1T-CrTe2 with enhanced growth rates and uniformity. Characterization using X-ray magnetic circular dichroism, scanning tunneling microscopy, and angle-resolved photoemission spectroscopy reveals metallic antiferromagnetic behavior in 1T-CrTe2 and semiconducting ferromagnetic properties in Cr2Te3. These findings advance new understanding of the magnetic order in Cr-Te monolayers, and demonstrate routes to control this, of potential future interest for advancing 2D spintronics [1].

[1]Gibertini, et al., Nat. Nanotech. (2019), [2]Lasek, et al., ACS Nano (2020), [3]Rajan, et al. Adv. Mater. (2024).

DS 1.2 Mon 9:45 H3

In-situ and operando characterization of atomic layer deposited SnO_2 and SnO_2/CeO_2 heterostructures for gas sensing applications — •Rudi Tschammer, Carlos Morales, Karsten Henkel, and Jan Ingo Flege — Applied Physics and Semiconductor Spectroscopy, Brandenburg University of Technology, Cottbus, Germany

The amorphous and defective nature of atomic layer deposited (ALD) thin films results in material properties deviating from those of well-ordered and crystalline samples. For instance, we recently reported that ALD cerium oxide (CeO_2) ultrathin (<10nm) layers could be reduced under H_2/O_2 mixtures at room temperature without decoration with noble metals, thus opening the door to design miniaturized resistive sensors based on ALD-CeO_2 active layers. However, the remaining challenges include high electrical resistance (GΩ) and relatively long response and recovery times, which may be solved by combination with conductive oxides. In particular, tin oxide (SnO_2) has been shown to improve the sensing properties of CeO_2, tentatively explained by interface effects. Here, we present in-situ X-ray photoelectron spectroscopy (XPS) and operando spectroscopic ellipsometry measurements of ultrathin ALD-SnO_2 layers, highlighting a linear growth rate, an evolution of the Sn Auger parameter related to distinct chemical envioroments rather than different oxidation states, and changes in C and N residues with the ALD number of cycles. Lastly, preliminary results from structural and chemical characterization, as well as sensing capabilities, of ALD-SnO_2/CeO_x heterostructures are discussed.

DS 1.3 Mon 10:00 H3

RF sputtered growth of β-Ga_2O_3 on Ru(0001) films — •Aman Baunthiyal, Marco Schowalter, Martin Williams, Jon-Olaf Krisponeit, Thorsten Mehrtens, Alexander Karg, Andreas Rosenauer, Martin Eickhoff, and Jens Falta — Institute of Solid State Physics, University of Bremen, Germany

Gallium oxide (Ga_2O_3) is a leading candidate for high-power, high-frequency electronics due to its wide bandgap and high breakdown voltage. While its growth on insulating substrates like AlN and Al_2O_3 has been well-studied, research on metal substrates remains limited. This study investigates RF-sputtered growth of Ga_2O_3 thin films on Ru(0001) surfaces with varying roughness at temperatures from room temperature (RT) up to 600°C [1].

AFM measurements showed that surface roughness peaks at intermediate growth temperatures, then decrease at 600°C, suggesting a shift toward two-dimensional growth or increased surface diffusion. XRD revealed the amorphous nature of RT-grown Ga_2O_3 films but polycrystallinity in higher-temperature grown films. Films grown at 600°C exhibited minimal change on annealing due to pre-existing polycrystallinity. TEM confirms polycrystalline β-Ga_2O_3, with crystallite sizes of ≈ 10 nm for RT samples and ≈ 80 nm for samples grown at 600°C after annealing. These results highlight the impact of substrate morphology, growth temperature, and annealing on optimizing Ga_2O_3 films, supporting developments in Ga_2O_3-based vertical devices.

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

DS 1.4 Mon 10:15 H3

Molecule adsorption at Sc(x)Ga(1-x)N surfaces investigated by photo electron spectroscopy — •Fabian Ullmann[1,2] and Stefan Krischok[1,2] — [1]TU Ilmenau, Ehrenbergstraße 29, 98693 Ilmenau — [2]Zentrum für Mikro- und Nanotechnologien, Gustav-Kirchoff-Straße 7, 98693 Ilmenau

ScGaN can occur in various crystal orientations. The most important are wurtzite and rock salt formation. Depending on the scandium concentration, a phase transition between these orientations can be found. ScGaN surfaces with different scandium concentrations and orientations were grown by molecular beam epitaxy (MBE) to investigate the near-surface electronic structure. The interaction of gas molecules (oxygen and water) in vacuum were analyzed by X-ray (XPS) and ultraviolet photoelectron spectroscopy (UPS).

session break

DS 1.5 Mon 10:45 H3

Low temperature solid state dewetting of gold thin films on polystyrene nano structures — •Felix Lohmeyer and Jörg K.N. Lindner — Universität Paderborn, Department Physik, Warburgerstraße 100, 33098 Paderborn

Solid-state dewetting describes the breakup of a thin film into isolated objects due to surface energy minimization below the material's melting point. While well-studied for hard substrates, little research has been done on the dewetting of metal thin films on polymer substrates. This study shows that gold thin films can undergo dewetting at temperatures that preserve the underlying polymer substrate, with dewetting kinetics increasing with annealing temperature. Gold thin films (7 nm) were deposited on planar and nanostructured polystyrene (PS) substrates and thermally annealed at 100 to 120 °C, near the polymer's glass transition temperature ($T_{g,PS}$=100°C). Homogeneous spin coated PS films and nanostructured PS lamellae, created via block copolymer self-assembly, served as substrates. Dewetting was characterized using SEM, AFM, and TEM. On planar PS, dewetting was observed at any temperature and proceeded without incubation time, triggered by the initial non-uniformity of the gold film. On nanostructured PS, gold formed nanorods aligned with the polymer lamellae, breaking into particles while preserving the substrate pattern. These findings demonstrate the role of substrate morphology and temperature in dewetting and suggest a route to fabricating sub-10 nm gold structures for applications in sensing, catalysis, and nanoelectronics using BCP-based polymer templates.

DS 1.6 Mon 11:00 H3

Morphological characterization of Sub-10 nm surface patterns created by block-copolymer self-assembly — •Harikrishnan Venugopal, Janna X. Friebel, Julius Bürger, and Jörg K.N. Lindner — Universität Paderborn, Department Physik, Warburgerstraße 100

The microphase separation in block copolymers (BCPs) is a self-assembly process allowing to create ordered patterns on large substrate surfaces in short times and at low costs. Numerous applications of such patterns have been identified in the area of micro- and optoelectronics, data storage, catalysis, nanoporous membranes, and biomedical materials. If BCP self-assembly is used to create lithographic masks by removing one of the polymers selectively, for any targeted application it is important to characterise the morphology of polymer domains precisely at each processing step. In this work, we report on the morphology of silicon oxide nano structures fabricated by BCP self-assembly on Si substrates. A polystyrene-polydimethylsiloxane block copolymer (PS-b-PDMS) with a molar mass of 15 kg/mol and a PS volume fraction of 68.75 % was dissolved and spin coated onto silicon substrate. Microphase separation was initiated by solvent vapor an-

nealing and results in the formation of fingerprint like surface patterns. A high-power oxygen plasma treatment is done to selectively remove the PS domains while converting the PDMS to silicon oxide. TEM, SEM and AFM analyses were performed to understand why after the plasma treatment half-cylinder patterns are observed.

DS 1.7 Mon 11:15 H3

Sub-10 nm Nanostructures in Thin Films of a Cylinder-Forming PS-b-PDMS Block Copolymer — •Janna X. Friebel, Harikrishnan Venugopal, Julius Bürger, and Jörg K. N. Lindner — Universität Paderborn, Germany

Block copolymers (BCPs) with a combined Flory-Huggins parameter $\chi N > 10$ form ordered domains even at low degrees of polymerization (N), enabling sub-10 nm nanostructures suitable for e.g. nanomasks in microelectronics. However, interfacial energy effects in thin films complicate the direct application of the bulk phase diagram by Bates et al. [1].

This study investigates the morphology of thin PS-b-PDMS high-χ BCP films with $N_B/N_A \approx 0.25$, spin-coated onto silicon, titanium, and chromium substrates (all with their native oxides). The films were top coated with PVA, solvent vapor annealed, PVA stripped, and the PS phase was selectively etched. Cross-sectional TEM reveals hemispherical structures instead of the expected hexagonal arrangement of cylinders, as suspected from SEM and AFM investigation. The energetic reasons for this geometry are discussed.

[1] F. S. Bates et al., Physics Today 52 (1999) 32-38.

session break

DS 1.8 Mon 11:45 H3

Ultrathin-Film Y6 at Air-Water Interface via the Langmuir-Blodgett Technique for Optoelectronic Application — •Yisak Tsegazab Gerase[1,2] and Martin Presselt[1,2] — [1]Institute of Physical Chemistry, Jena, Germany — [2]Leibniz Institute of Photonic Technology, Jena, Germany

Supramolecular structures are critical to the optoelectronic properties of films. The Langmuir-Blodgett (LB) technique provides precise molecular assembly, enabling control and homogenization of the morphology of Y6 Langmuir films, which is essential for scalable fabrication and commercial production. Y6, a non-fullerene acceptor, has significantly improved the power conversion efficiency of organic solar cells. We monitored the in-situ formation of Y6 Langmuir films using Brewster angle microscopy, surface pressure isotherms, and fluorescence spectroscopy. Isotherms revealed high packing densities, while compression-expansion cycles showed increased stiffness due to intermolecular rearrangements. BAM images confirmed smooth, well-defined quasi-2D films, and in-situ fluorescence spectroscopy identified the existence of Y6 fluorophore at the air-water interface and with lateral compression growth in supramolecular structure were observed. In agreement with in-situ observations, these well-ordered morphologies were further characterized after deposition on solid supports. Y6 films used in organic thin-film transistors showed a mobility of about 0.007 cm2 /Vs as cast film, comparable to other deposition techniques.

DS 1.9 Mon 12:00 H3

Femtosecond Laser Ablation (fs-LA) - A New Approach to XPS Depth Profiling — •samir mammadov — Thermo Fisher Scientific, 1 The Feldbridge Centre, Imberhorne Lane, East Grinstead, West Sussex, RH19 1XP, UK

XPS depth profiling is a widely employed analytical technique to determine the chemical composition of thin films, coatings and multilayered structures, due to its ease of quantification, good sensitivity and chemical state information. Since the introduction of XPS as a surface analytical technique more than 50 years ago, depth profiles have been performed using ion beam sputtering. However, many organic and inorganic materials suffer from ion beam damage, resulting in incorrect chemical compositions to be recorded during the depth profile. This problem has been resolved for most polymers by using argon gas cluster ion beams (GCIBs), but the use of GCIBs does not solve the issue for inorganics. A prototype XPS depth profiling instrument has been constructed that employs a femtosecond laser rather than an ion beam for XPS depth profiling purposes. This novel technique has shown the capability of eradicating chemical damage during XPS depth profiling for all initial inorganic, compound semiconductor and organic materials examined. The technique is also capable of profiling to much greater depths (several 10s microns) and is much faster than traditional ion beam sputter depth profiling. fs-LA XPS depth profile results will be shown for selected thin films, coatings, multilayers and oxidised surfaces and the outlook for this new technique discussed.

DS 1.10 Mon 12:15 H3

Optimizing erbium luminescence for integrated photonics via ytterbium co-doping and thermal annealing — •Sören Lerner[1], Felix Mania[1], Jiale Sun[2], Zheru Qiu[2], Xinru Ji[2], Yang Liu[2], Tobias Kippenberg[2], and Carsten Ronning[1] — [1]Friedrich-Schiller Universität, Helmholtzweg 3, 07743 Jena, Germany — [2]École Polytechnique Fédérale de Lausanne, Switzerland

Erbium ions are promising candidates for enabling efficient optical amplification of signals in photonic integrated circuits, but their practicality is hindered by insufficient output power. To address this, we utilize ion implantation into ultralow-loss silicon nitride (Si_3N_4) thin films and investigate co-doping with ytterbium ions to enhance absorption and emission through resonant energy transfer. We systematically investigate the effects of doping concentration and subsequent thermal annealing parameters using photoluminescence measurements. These findings provide insights into optimizing erbium-based light emitters for integrated photonics.