DS 12: Gaede-Jubiläumssitzung

The Gaede Prize was founded 40 years ago by Dr Manfred Dunkel and is awarded annually for outstanding scientific work in basic research and application, for which the use of vacuum is relevant. To mark this anniversary, Selina Olthof (2019 prizewinner), Philip Willke (2022), Philip Hofmann (2011), and Andreas Waag (1998) from the illustrious list of prizewinners will give presentations in this session, covering a broad spectrum from the prize-relevant fields of thin films, surface science, semiconductor physics, and nanotechnology.

Time: Thursday 16:15–18:30 Location: H3

Invited Talk DS 12.1 Thu 16:15 H3

Probing the Electronic Structure of Halide Perovskites — •Selina Olthof — Department of Chemistry, University of Cologne — Chair of Material and Surface Analysis, University of Wuppertal

Halide perovskites are a novel class of thin film semiconductors that have revolutionized the field of photovoltaics, nowadays even surpassing in record efficiency the conventional silicon-based cells. Their remarkable defect tolerance, solution-based processability and tunable band gap make them highly promising for next-generation optoelectronic technologies.

This talk will provide a brief introduction to halide perovskites, highlighting the origins of their exceptional material properties. Next, I will introduce UV photoelectron spectroscopy (UPS) as well as reflection electron energy loss spectroscopy (REELS) as powerful tools to gain deeper insight into device relevant material properties. Specifically, I will discuss our investigations into the valence and conduction band density of states in tin and lead-based 3D perovskites. By combining photoelectron spectroscopy results with density functional theory, we identified the roles of atomic positions, bond hybridization, and lattice distortions in shaping the electronic properties.

Additionally, I will introduce our recent work on reduced-dimensionality perovskites (2D layers), which are gaining attention for their potential to optimize interfaces and enhance solar cell efficiencies. Here, I will present a systematic study using alkyl-based organic cations with varying chain length, which we used to track effects of interlayer spacing on the electronic and optical properties.

Invited Talk DS 12.2 Thu 16:45 H3

Quantum Science with Single Atoms and Molecules on Surfaces — •Philip Willke — Physikalisches Institut, Karlsruhe Institute of Technology, Karlsruhe, Germany

The quantum nature of a physical system often emerges from its fundamental building blocks and demands a deep understanding to leverage its benefits for future quantum devices. In this talk, I introduce the combination of electron spin resonance (ESR) and scanning tunneling microscopy (STM) as a new platform for coherent control of spins on surfaces (1). This technique enables for instance the addressing of individual atoms on surfaces with exceptional energy resolution. It allowed for high-resolution magnetic sensing, for instance by resolving their hyperfine interaction between the electron and nuclear spins. Recently, we have extended this technique to achieve spin resonance on individual molecules (2), which is particularly exciting as it extends ESR-STM into the realm of molecular quantum technologies: Promising new avenues involve organizing spins through molecular self-assembly into larger structures, alongside the application of on-surface chemistry techniques. As an example, we demonstrate how constructing new complexes through tip-assisted on-surface assembly can lead to spin systems with improved dynamic spin properties (3), that can be coherently controlled. (1) Chen, Y. et al., Advanced Materials, 35 (27), 2107534 2023. (2) Zhang, X. et al. Nat. Chem., 14, 59-65 2022. (3) Huang, W. et al. arXiv.2410.18563 2024.

session break

Invited Talk DS 12.3 Thu 17:30 H3

Gallium Nitride Technology - the second pillar of microelectronics — •Andreas Waag — Nitride Technology Center NTC, TU Braunschweig

The highly efficient radiative recombination makes GaN ideally suited for microLEDs with dimensions as small as 1 μm and even below. Besides display applications, their capability to produce optical patterns with high resolution, which can be modulated at extremely high frequencies, makes them suitable for numerous other applications.

Besides chip-based microscopy and highly efficient sensing, we explore these exciting properties for a new highly significant application: utilizing microLEDs in optical processing units for artificial intelligence workloads.

The talk will focus on technological challenges of chip processing and hybrid integration with silicon CMOS microelectronics. For all these applications, nitride technology and the exciting properties of GaN semiconductor devices are a key.

Invited Talk DS 12.4 Thu 18:00 H3

Ultrafast X-ray photoelectron spectroscopy and photoelectron diffraction — •Philip Hofmann — Department of Physics and Astronomy, Aarhus University, Denmark

X-ray photoelectron spectroscopy (XPS) is an experimental tool capable of accurately determining the core level binding energies of atoms. This energy is not only element-specific but also provides detailed information on the atoms' oxidation state and chemical environment, making XPS an essential tool for studying catalytic processes. XPS line shapes have also attracted considerable interest, leading to the development of many-body theories to study the solid's electronic and vibrational properties. Finally, the core level photoemission intensity can be interpreted as a diffraction pattern that gives access to the emitting atom's local geometrical environment in an experimental approach called X-ray photoelectron diffraction (XPD).

The increasing availability of ultrafast X-ray sources at free electron lasers now opens the opportunity to take XPS and XPD into the ultrafast time domain and this talks will give two recent examples. For graphene, it is shown that a study of the time-dependent XPS line shape can reveal detailed insight into the excitation of the system, directly giving access to parameters such as the electronic temperature. A demonstration of XPD is given in which the motion of surface atoms of the topological insulator Bi_2Se_3 is tracked after the excitation of a coherent optical phonon.