KFM 5: Instrumentation for Micro-/Nano-Analysis and Lithography/Structuring (joint session KFM/DS/O)

Time: Monday 15:00–16:30 Location: PHY 5.0.21

Invited Talk KFM 5.1 Mon 15:00 PHY 5.0.21

On-surface synthesis by atomic manipulation studied with AFM — •Leo Gross — IBM Research - Zurich, Säumerstr. 4, 8003 Rüschlikon, Switzerland

Elusive molecules can be created using atomic manipulation with a combined atomic force/scanning tunneling microscope (AFM/STM). Molecules that are highly reactive and short-lived under ambient conditions can be stabilized at low temperature on inert surfaces. Employing high-resolution AFM with functionalized tips provides insights into the structure, geometry, aromaticity and bond orders of the molecules created and into the reactions performed [1].

We created radicals, diradicals [2], non-Kekulé molecules [3], antiaromatics [4], and polyynes [5] and studied their structural and electronic properties. We recently showed that the reorganization energy of a molecule on an insulator can be determined [6]. In addition, we expanded the toolbox for the synthesis of molecules by atomic manipulation, demonstrating reversible cyclisation reactions [2], skeletal rearrangements [5] and controlled reactions on insulating substrates by electron attachment/detachment [7].

References: [1] L. Gross et al. Angew. Chem Int. Ed 57, 3888 (2018). [2] B. Schuler et al. Nat. Chem. 8, 220 (2016). [3] N. Pavliček et al. Nat. Nano. 12, 308 (2017). [4] Z. Majzik et al. Nat. Commun. 9, 1198 (2018). [5] N. Pavliček et al. Nat. Chem. 10, 853 (2018). [6] S. Fatayer et al. Nat. Nano. 13, 376 (2018). [7] S. Fatayer et al. Phys. Rev. Lett. 121, 226101 (2018).

KFM 5.2 Mon 15:30 PHY 5.0.21

Additive laser fabrication of silver and silver-composite 3D micro-structures — •Erik H. Waller[1] and Georg von Freymann[1,2] — [1]Physics department and State Research Center OPTIMAS, Technische Universität Kaiserslautern, Kaiserslautern — [2]Fraunhofer Institute for Industrial Mathematics (ITWM), Kaiserslautern

We present direct laser writing (DLW) of silver and silver-composite microstructures via photoreduction in liquid resists. Several photoresist compositions are compared based on visual inspection of 2D and 3D test structures complemented by EDS and spectral resonance measurements.

Compared to common approaches for additive manufacturing of 3D metallic structures, e.g., selective laser melting or sintering, DLW is a very precise fabrication technology allowing sub-micrometer feature sizes. However, structures fabricated by DLW are usually made of polymers. Renewed interest in DLW of metallic microstructures has emerged due to their potential, e.g., in plasmonics. The underlying principle of metal DLW is photo-induced reduction of a precursor to neutral metal within the laser focus. The metal particles subsequently agglomerate to form the building block of a structure. Adverse effects are mainly heating of and scattering by the evolving structure as well as low quantum yield and slow speed of the reaction. Thus, we here test different photoresist compositions with respect to the above mentioned criteria and identify key parameters to best control these photoreactions.

KFM 5.3 Mon 15:50 PHY 5.0.21

Hard X-ray Photoelectron Diffraction in Graphite — •Olena Fedchenko[1], Sergey Chernov[1], Katerina Medjanik[1], Sergey Babenkov[1], Dmitry Vasilyev[1], Aimo Winkelmann[2], Hans-Joachim Elmers[1], and Gerd Schönhense[1] — [1]JGU, Institut für Physik, Mainz — [2]Laser Zentrum, Hannover

A new high-energy momentum microscope (kinetic energies up to >7 keV) allows full-field imaging of the (k_x-k_y) photoelectron distribution with a large field of view (up to 20 $Å^{-1}$ dia.) in momentum space and ToF energy recording. Avoiding symmetry-varying rotation of sample and/or analyser, "full-field k-imaging" provides an ideal means for X-ray photoelectron diffraction (XPD) studies. High-resolution ($< 0.1°$) diffractograms can be recorded within minutes thanks to the high brilliance of beamline P22 at PETRA III [1]. We present an XPD study for electrons from the C 1s core level in graphite in a wide energy range from 2840 to 7283 eV. Fine details in the diffractograms reflect the large number of scatterers (10^5-10^6) due to the large inelastic mean free path. A calculation based on the Bloch wave approach to electron diffraction by lattice planes [2] shows excellent agreement. The short photoelectron wavelength (10% of the interatomic distance) "amplifies" phase differences and turns hard X-ray XPD into a very sensitive structural tool. The results are important for valence band XPD [3].

[1] C. Schlueter et al., Synchr. Radiation News 31, 29 (2018); [2] A. Winkelmann et al., New J. of Phys. 10, 113002 (2008); [3] G. Schönhense et al., arXiv 1806.05871 (2018).

KFM 5.4 Mon 16:10 PHY 5.0.21

High-Resolution High-Sensitivity Characterization using SIMS based Correlative Microscopy — •Santhana Eswara, Alisa Pshenova, Jean-Nicolas Audinot, and Tom Wirtz — Advanced Instrumentation for Ion Nano-Analytics, MRT, Luxembourg Institute of Science and Technology, L-4422 Belvaux, Luxembourg

Technological materials are being increasingly engineered by optimizing the structure at the nanometer-level and the chemical composition at the dopant-level. Therefore, analytical techniques capable of both high-resolution and high-sensitivity are indispensable. Transmission Electron Microscopy (TEM) offers excellent lateral resolution down to atomic scale, but the analytical techniques typically available in a TEM such as EDX or EELS do not have the sensitivity to analyze trace elements (e.g. dopants). In comparison, Secondary Ion Mass Spectrometry (SIMS) is well-known for high-sensitivity analysis of materials down to the ppm level. However, the lateral resolution of SIMS is fundamentally limited by the ion-solid interaction volume to ~ 10 nm. Recently we developed SIMS in a Helium Ion Microscope (HIM) and demonstrated a SIMS lateral resolution of ~ 15 nm[1]. While this is a remarkable breakthrough, it is still 2 to 3 orders-of-magnitude poorer in comparison to high-resolution techniques such as TEM imaging. To overcome this limitation, we developed correlative microscopy methods combining SIMS imaging with high-resolution techniques such as TEM and HIM (SE mode). We will discuss the HIM-SIMS and in-situ TEM-SIMS correlative techniques[2]. [1] D. Dowsett et al, Anal. Chem., 89, 8957-8965, 2017 [2] L. Yedra et al, Sci. Rep. 6, 28705, 2016