MM 35: Topical session (Symposium MM): Correlative and in-situ Microscopy in Materials Research

Sessions: Surfaces and Interfaces; Thin Films and Nanostructures

Time: Thursday 10:15–13:00 Location: H45

Topical Talk MM 35.1 Thu 10:15 H45

Friction mechanisms revealed by scanning force and electron microscopy — •Roland Bennewitz[1], Christiane Petzold[1], Marcus Koch[1], Nicholas Chan[3], SG Balakrishna[1], Philip Egberts[3], Andreas Klemenz[2], and Michael Moseler[2] — [1]INM Leibniz Institute for New Materials, Saarbrücken, Germany — [2]Fraunhofer Institute for Mechanics of Materials IWM, Freiburg, Germany — [3]Department of Mechanical and Manufacturing Engineering, University of Calgary, Canada

Atomic force microscopy (AFM) is a well-established imaging tool in nanoscience, in some applications with atomic resolution. Beyond imaging structure on nanometer scale, force measurements by AFM also reveal molecular-scale mechanisms of friction. As an example, we will present data for the structure and friction response of graphene layers grown epitaxially on Pt(111) surfaces. In friction and wear studies, the AFM tip is not only an imaging probe but equally important part of the sliding contact. While surface wear is revealed by AFM imaging, tip wear requires electron microscopy of the tip. We will discuss results for the tribochemical wear of tips when sliding silicon against gold.

MM 35.2 Thu 10:45 H45

Characterization of surface reactions by non-contact atomic force microscopy with functionalized tips — •Andreas Dörr[1], Maximilian Ammon[1], Van-Dong Pham[1], Milan Kivala[2], and Sabine Maier[1] — [1]Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen — [2]Centre for Advanced Materials, Ruprecht-Karls-Universität Heidelberg, Heidelberg

Atomically resolved images of surface-supported molecular structures have been achieved using non-contact atomic force microscopy (nc-AFM) with functionalized tips.[1] The key step involves the attachment of suitable small molecules, e.g. CO, to achieve high spatial resolution. Submolecular resolution imaging is a versatile tool to unravel novel reaction pathways of surface-supported molecules in on-surface synthesis. Here, we present a low-temperature scanning tunneling microscopy and nc-AFM study with functionalized tips to understand the on-surface reaction of amine-functionalized carbonyl-bridged triphenylamine derivatives. On Au(111), we observe linear structures upon reaction, while on Ag(111), covalently-linked dimers are formed that connect to 2D structures at higher temperatures. However, the molecular structure of the polymerized reaction products is found to be similar on both surfaces. The nc-AFM measurements with CO functionalized tips indicate that mainly the amine-groups are involved in the polymerization reaction. We will discuss the geometric structure of the reaction products and the reaction kinetics on both surfaces.

[1] L. Gross, et al. Science 325, 1110 (2009)

MM 35.3 Thu 11:00 H45

Mesoscopic THz imaging of quantum materials - The instrument perspective — •Marc Westig, Holger Thierschmann, Allard Katan, Matvey Finkel, and Teun M. Klapwijk — Department of Quantum Nanoscience, Kavli Institute of Nanoscience, TU Delft, The Netherlands

One of the challenges in modern condensed-matter physics is the fundamental understanding and technological use of quantum materials. In these materials, strong interactions between electrons and other quasi-particles lead to emerging properties. Examples are high-temperature superconductivity, magnetism and hydrodynamic electron flow in graphene. Another effect of strong electron interactions is that different ground states compete. In the detector-relevant disordered superconductors, this leads to electronic inhomogeneity over a range of few tens of nanometers. The consequences for their local electrodynamics are still unknown and, hence, how the detector sensitivity is influenced.

Motivated by these challenges, we have started to develop high-frequency local probe instruments ranging from a few up to several hundred GHz. My talk will focus on the instrument side, but always keep an eye on the physical systems we envision to probe. A natural question which arises is about the image formation on the nanometer scale in such an instrument. Our approach focuses on two different probe technologies, a microstrip coupled metallic tip and a waveguide coupled dielectric tip. We will show preliminary imaging results in a disordered model system around 3 GHz.

30 min. break

Topical Talk MM 35.4 Thu 11:45 H45

In-situ Microscopy Testing of Metallic Thin Films — •Velimir Radmilović — University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, 11120 Belgrade, Serbia — Serbian Academy of Sciences and Arts, Knez Mihailova 35, 11000 Belgrade, Serbia

Despite low ductility and wear resistance as well as poor fracture toughness, silicon and silicon-nitride (Si3N4) have been widely used in fabrication of micro-electromechanical (MEMS) and nano-electromechanical (NEMS) systems. Although metallic resonators tend to demonstrate considerably higher energy dissipation in the medium frequencies band, they have been proposed as a potential substitute for Si and Si3N4 devices since metallic films offer higher electrical conductivity and superior ductility. Resonant properties of nanocrystalline MEMS and NEMS metallic devices have been investigated by means of in-situ electron microscopy mechanical testing, using near-infrared laser interferometry. Mechanical testing is performed in tandem with shape modification and microstructural characterization by focused ion beam, scanning and transmission electron microscopy. Depending on alloy chemical composition and processing parameters, metallic films transform from pure crystalline to a unique microstructure with a dense distribution of nm-scale crystallites dispersed in an amorphous matrix. These films exhibit high nanoindentation hardness, metallic conductivity and tunable residual stresses, while surfaces display smooth morphology, characteristic for sputtered amorphous films.

MM 35.5 Thu 12:15 H45

Correlative in situ microscopy studies of highly directional nanowires — •Lilian Vogl, Peter Schweizer, Mingjian Wu, and Erdmann Spiecker — FAU Erlangen-Nürnberg, IMN

Here we present a novel approach to synthesize Molybdenum oxide nanowires from Molybdenum Disulfide (MoS2) in situ, using microscopy as a direct feedback-mechanism enabling parameter optimization as well as the analysis of growth kinetics. The Nanowire Synthesis is carried out in an in situ Light Microscopy heating chamber under controlled oxygen atmosphere. This allows us to directly measure the growth rate using digital image correlation and determine the influence of temperature and pressure on the synthesis. Correlative Electron Microscopy and spectroscopy is used to characterize the crystal structure and growth direction as well as to analyze the chemical composition of the wires. The diameter of the synthesized nanowires is typically between 15 to 250 nm with a length of up to several tens of micrometers. The growth of the wires is highly directional and follows the [11-20] directions of MoS2. In Addition to the analysis of the growth behavior of the nanowires, the functional properties are elucidated. To determine the electrical properties of the wires in situ four probe measurement in an SEM are performed on the micro-scale. The U-I sweep shows a linear behavior of the nanowires corresponding to an ohmic conductor. Currently in situ bending tests and Resonance measurements are done to evaluate the mechanical properties of the nanowires.

MM 35.6 Thu 12:30 H45

Correlative TEM and XRD study of the role of Au on the solid state dewetting behavior of Au/Ni bilayers on α-Al2O3 — •Johannes Will[1], Patrick Herre[1], Tobias Zech[1], Johanna Schubert[1], Mingjian Wu[1], Tadahiro Yokosawa[1], Jan Schwenger[1], Stefan Romeis[1], Dong Wang[2], Tobias Unruh[1], Wolfgang Peukert[1], and Erdmann Spiecker[1] — [1]FAU Erlangen-Nürnberg — [2]TU Ilmenau

In this study, we investigated the influence of Au on the structure and properties of binary Au-Ni nanoparticles (NPs) equilibrated by solid-state dewetting and subsequent quenching on (0001) oriented sapphire single crystals. We contribute to the research field by investigating the role of Au on the mechanical as well as structural properties of Au-Ni NPs by a systematic variation of the Au content. Here, our methodological approach is to combine TEM and EDXS with XRD in order to obtain complementary information about the morphology, orientation and in-plane as well as out-of-plane strain of the NPs with respect to the sapphire substrate. Furthermore, the impact of alloying and interface structure on the mechanical properties of the NPs was tested by in situ SEM compression experiments. As shown by XRD and TEM, it is possible to fabricate alloyed NPs for all investigated Au concentrations. Moreover, a pronounced in- and out-of-plane orientational relationship is demonstrated. In addition, no misfit dislocations at the NP substrate interface are present. This kind of interface is in-line with previous findings for pure Ni NPs, where it was denoted as delocalized coherent interface.

MM 35.7 Thu 12:45 H45

In situ TEM observation of phase decomposition in NiAu nanoparticles derived from solid-state dewetting of bilayer metal thin films — •Johanna Schubert[1], Christian Wiktor[1], Simon Kraschewski[1], Patrick Herre[2], Mingjian Wu[1], Wolfgang Peukert[2], and Erdmann Spiecker[1] — [1]Institute of Micro- and Nanostructure Research, FAU, Erlangen, Germany — [2]Institute for Particle Technology, FAU, Erlangen, Germany

Solid-state dewetting of multilayer metal thin films is a novel method to tailor alloy nanoparticles in composition, size, shape and orientation by varying layer thicknesses and dewetting parameters. Alloy nanoparticles produced in this way are ideal model systems for studying fundamental aspects of phase transformation in confined volumes. By dewetting of Ni-Au bilayers AuxNi1-x alloy nanoparticles with various compositions were produced. Despite a large miscibility gap in the Ni-Au system solid solution particles were obtained by fast quenching. Subsequent annealing at lower temperature allowed us to study the phase decomposition under controlled conditions. Two decomposition pathways were observed resulting in particles with Au-rich phases on the outer facets and particles with lamellar structure of alternating Ni- and Au-rich phases. In situ TEM was applied to gain deeper insight into the role of nanoparticle morphology on the mechanisms and kinetics of phase decomposition. High resolution analysis of particle cross sections revealed closely spaced 1/2[110]-typed edge dislocations at the phase boundaries. The dislocations compensate the large lattice misfit of > 10 % between the Ni- and Au-rich phases.