O 12: Nanostructures at Surfaces II: Designer Structures and Surfaces

Time: Monday 15:00–17:45 Location: H15

Invited Talk O 12.1 Mon 15:00 H15

Nanoscale engineering at surfaces — •F Stefan Tautz — Peter Grünberg Institut (PGI-3), Forschungszentrum Jülich, 52425 Jülich, Germany — Jülich Aachen Research Alliance (JARA), Fundamental of Future Information Technology, 52425 Jülich, Germany — Experimental Physics IV A, RWTH Aachen University, 52074 Aachen, Germany

The increasing interest in quantum technologies puts tailor-made materials into the focus. In this context the term material is more and more understood in a wider sense to also include designer structures beyond a single crystalline phase. For example, such designer structures can be customized stacks of 2D materials as well as surface-supported nanostructures made by assembling individual atoms or molecules. A further challenge, apart from crafting the structures, is studying their properties. Often, this requires the refinement of existing experimental methodologies. In my talk, I will report on our recent work regarding tailor-made materials based on graphene and designer structures based on individual atoms and molecules. With increasing complexity, new properties and phenomena emerge, and the design of functional (quantum) devices becomes possible. As it turns out, even relatively simple designer structures show intriguing functionalities, including quantum dot behaviour, electrostatic potential sensing, and coherent single-electron field emission. On the analytic side, I will illustrate the power of several advanced experimental methodologies.

O 12.2 Mon 15:30 H15

The electrostatic potential of atomic chains and clusters imaged quantitatively with scanning quantum dot microscopy — Philipp Leinen[1,2], •Rustem Bolat[1,2], Ruslan Temirov[1,2], F. Stefan Tautz[1,2], and Christian Wagner[1,2] — [1]Peter Grünberg Institut (PGI-3), Jülich, Germany. — [2]JARA-Fundamentals of Future Information Technology

Fabrication of artificial atomic clusters and chains facilitates the observation and investigation of various quantum effects. The size and geometry of such assemblies influence electrostatic potentials, catalytic efficiency as well as a magnetic response. Here, we investigate the electrostatic properties of differently sized and shaped Ag clusters which have been created on a Ag(111) substrate by atomic manipulation with a scanning probe microscope (SPM). We use scanning quantum dot microscopy (SQDM) [1,2] with a single molecule quantum dot attached to the SPM tip [3] to image the surface potential over atomic chains and compact clusters. These potentials originate from the Smoluchowski effect and influence, e.g., the local reactivity. We find that the surface dipole moment per adatom drops rapidly for compact assemblies while it converges to a value of about 0.26 Debye for atoms in a chain.

[1] C. Wagner, et al. Phys. Rev. Lett. 115, 026101 (2015)
[2] M. Green, et al. Japan. J. Appl. Phys. 55, 08NA04-7 (2016)
[3] R. Temirov, et al. Phys. Rev. Lett. 120, 206801 (2018)

O 12.3 Mon 15:45 H15

Low temperature chemical vapor deposition of ZnO nanowire arrays for field emission applications — •Carina Hedrich, Stefanie Haugg, Robert H. Blick, and Robert Zierold — Center for Hybrid Nanostructures (CHyN), Universität Hamburg, Luruper Chaussee 149, 22607 Hamburg, Germany

In the last years, ZnO nanostructures of many different morphologies have been fabricated by various physical and chemical methods and several applications have been realized. Arrays of one-dimensional ZnO nanostructures are promising candidates for electron field emission devices due to their high aspect ratio and low work function of the material. To tailor the synthesis of ZnO nanowires, the influence of the growth parameters on the properties of the nanostructures have to be known. Here, we report about a comprehensive morphology study of ZnO nanowire arrays grown by low temperature (500 -650 °C) chemical vapor deposition as a function of the process parameters. The vapor transport growth was conducted by utilizing zinc acetylacetonate hydrate and oxygen as precursors. The electron field emission characteristics of optimized ZnO nanowire array devices are investigated, by measuring the electron tunnel current as a function of the applied voltage, using a home-made electron field emission setup. Analysis of the field emission data reveal the potential of our nanostructures for tailor-made electron field emission devices. In the future, such ZnO nanowire arrays on silicon nitride membranes might pave the way for advanced detector technologies used in time-of-flight mass spectrometry of proteins with much higher mass resolution than nowadays accessible.

O 12.4 Mon 16:00 H15

X-ray Photoelectron Diffraction and Spectroscopic Investigation of Near-Surface Alloying of Cu/Au(111) — •David Batchelor[1], Federico Grillo[2], Rory Megginson[2], Matthias Muntwiler[3], and Christopher J. Baddeley[2] — [1]KIT, Karlsruhe, Germany — [2]University of St Andrews, St. Andrews, United Kingdom — [3]PSI, Villigen, Switzerland

Binary metal alloys have been, and are, the subject of much investigation. The Copper/Gold System is one such well studied bulk system. The solid alloy is completely miscible over the whole concentration range and a large temperature region, only becoming ordered at low temperature (≈650K). In comparison there are relatively few Surface studies. Recently, it has been demonstrated using STM [1,2] that ordered Surface structures can be grown for this system. To investigate the structures further a Synchrotron Radiation and STM study on the PEARL beamline [3] at the SLS was undertaken. X-ray Photoelectron diffraction was chosen as method as it is not only sensitive to the Surface but also buried layers. In addition to the geometric structure data electronic state information from both valence and core levels was obtained. The data will be discussed together with the results of calculations and modelling.

[1] F. Grillo et al., New J. Phys., 13, 013044 (2011)
[2] F. Grillo et al., e-JSSNT, 16, 163 (2018)
[3] M. Muntwiler et al. J. Synchrotron Rad. 24, 354 (2017)

O 12.5 Mon 16:15 H15

Femtosecond laser generation of microbumps and nanojets on single and bilayer Cu/Ag thin films — •Aida Naghiou[1], Miao He[2], Jasmin S. Schubert[1], Leonid V. Zhigilei[1,2], and Wolfgang Kautek[1] — [1]University of Vienna, Department of Physical Chemistry, Vienna, Austria — [2]University of Virginia, Department of Materials Science and Engineering, Charlottesville, Virginia, USA

Femtosecond laser ablation of metal thin films has been of vivid interest since decades. The generation of microbumps and nanojets have been observed in many studies. It is generally accepted that frozen nanojets are produced through rapid melting. However, the mechanism for the formation of microbumps, is still under discussion. Subsurface boiling and pressure of the vapor released at the substrate-film interface, melting and redistribution of molten material, and plastic deformation of the irradiated film have been suggested as the processes responsible for the generation of the microbumps. In this study, the mechanisms of the formation of microbumps and nanojets on Ag/Cu thin films and double layers irradiated by a single 60 fs laser pulse are investigated experimentally and with atomistic simulations. The composition of the laser-modified bilayers is probed with the energy dispersive X-ray spectroscopy. The simulations reveal the important role of the difference in the electron-phonon coupling factor of the two metals in the mechanism of bump formation and breaching. The computational predictions of the threshold fluences for the formation of microbumps exposing different component of the bilayer targets, and the conditions for the bump breaching, agree well with experimental observations.

O 12.6 Mon 16:30 H15

Structural and electronic characterization of Eu-doped Bi_2Te_3 epitaxial films — •Celso I. Fornari[1], Hendrik Bentmann[1], Thiago R. F. Peixoto[1], Paulo Rappl[2], Eduardo Abramof[2], Sérgio Morelhão[3], Martin Kamp[4], and Celso Fornari[1] — [1]Experimentelle Physik VII, Würzburg — [2]Instituto Nacional de Pesquisas Espaciais, Brazil — [3]Universidade de São Paulo, Brazil — [4]Physikalisches Institut, Würzburg

Bismuth telluride is a simple model for three-dimensional topological insulators (TIs) with a single Dirac cone at the surface. The topological surface states are protected against backscattering due to small imperfections in the lattice or from scattering due to non-magnetic impurities by time reversal symmetry (TRS). However, to unlock novel physical phenomena, it is a prerequisite to break TRS. In this sense, TIs have been investigated by doping with transition metals or rare earth elements and by proximity effect to magnetic layers or substrates.

In this work, we report on a systematic study of the MBE growth of europium doped bismuth telluride films on (111) BaF_2. The small lattice mismatch (0.04 %) to bismuth telluride makes this material a suitable substrate to grow high-quality thin films. Films with nominal Eu concentration ranging from 0 (reference) up to 9 % were produced. Using high-resolution X-ray diffraction (HR-XRD), transmission electron microscopy (TEM) and angle-resolved photoemission spectroscopy (ARPES), evidences of Eu entering Bi sites up to concentrations around 4 % were obtained with a preserved Dirac cone at the surface.

O 12.7 Mon 16:45 H15

Characterization of the optical Kerr-Effect in $CsPbBr_3$-perovskite films — •Daniel Frese[1], Linghai Meng[2], Haizheng Zhong[2], and Thomas Zentgraf[1] — [1]Universität Paderborn, Warburger Str. 100, 33098 Paderborn — [2]Beijing Institute of Technology, Beijing, China

Halide perovskites, like $CsPbBr_3$, have received a lot of attention lately, because of their optical and electronic properties. For example, perovskites have a tunable bandgap and excitons can exist at room temperature, which makes them promising candidates for applications in photovoltaic and electro optical devices. Here, we investigate the optical Kerr-Effect by studying the nonlinear refractive index and nonlinear absorption of $CsPbBr_3$, using the z-scan technique with femtosecond pulsed excitation. The high third-order nonlinearity of thin film perovskites opens up new possibilities in nonlinear optical applications, like nanoscale frequency conversion, wave-mixing, nonlinear holography, and all-optical switching.

O 12.8 Mon 17:00 H15

Revealing the influence of structural disorder in plasmonic systems — •Ediz Herkert, Florian Sterl, Steffen Both, Thomas Weiss, and Harald Giessen — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Pfaffenwaldring 57, 70569, Stuttgart, Germany

In the vast majority of studies, ensembles of plasmonic nanostructures are modeled as identical particles arranged in a perfectly periodic fashion. Several algorithms can efficiently calculate the optical response of these ideal systems. However, in all experiments structural disorder is present due to imperfections in the manufacturing process. This disorder is in fact expected to influence the optical properties. We investigate how disorder affects the optical response and how by the same token disorder can be utilized to tune the optical properties of the plasmonic ensemble. To this end, we define parameters that allow us to control the correlation and randomness of the structures and implement a coupled dipole model to compute the far-field response of any configuration of nanostructures. We validate these simulations with a microscopy setup that provides spectrally resolved real- and Fourier-space images of the plasmonic systems. Based on this data we explore the correlations between the disorder parameters and the optical spectra as well as the optical color appearance. Eventually, we aim to deduce the microscopic structural disorder solely from the measured far-field optical response of the plasmonic structures and tailor ab initio the bidirectional reflection distribution function.

O 12.9 Mon 17:15 H15

Nanostructuring new optical materials using BCML and RIE methods — •Louise Kaeswurm, Zhaolu Diao, Klaus Weishaupt, and Joachim Spatz — Max-Planck-Institute for Medical Research, Department of Cellular Biophysics, Jahnstr. 29, 69120 Heidelberg

To improve the optical properties of silica glass, moth-eye inspired nanostructures etched into the surface of silica glass have shown promising results in reducing the reflectance and increasing the transmittance over 99.5 %. To create these moth-eye structures, an etching mask is applied to the sample via micellar block copolymer lithography (BCML) and pillars are etched into the substrate in a reactive ion etching process.

With this method the performance for a rather large spectral range is increased and the effect is not restricted to a small angular range. Since many other glasses and materials would also profit from such a treatment, current research is focused on the transfer of these techniques to other materials, for example, etching these nanostructures into sapphire, diamond or borosilicate glass. One challenge of these new materials is finding a way to etch very hard or chemically inert structures or irregular structures such as found in borosilicate glass. For this, new etching procedures had to be developed. Another challenge is the cleaning of the substrates without destroying the fragile nanostructure. Here, common ultrasonic cleaning methods did not give convenient results and therefore, megasonic cleaning was tested and optimized.

O 12.10 Mon 17:30 H15

Development of Nanoporous & Mesoporous materials for Environmental Applications — •Chamila Gunathilake — Department of Chemical & Process Engineering, University of Peradeniya, Sri Lanka

Mesoporous silica & carbon materials with various organic pendant groups were developed for interesting applications including high temperature carbon dioxide (CO2) sequestration from power plant, treatment of wastewater streams, uranium extraction from seawater. Research is mainly focused on the incorporation of metal (aluminum, zirconium, calcium, and magnesium) species into mesoporous silica materials with organic pendant (amidoxime) and bridging groups (isocyanurate, benzene) for CO2 capture at elevated temperatures (60, 120 oC). All these hybrid materials synthesized by co-condensation followed by EISA showed high CO2 uptake at elevated temperature (60, 120 oC) reaching the CO2 sorption capacities in the range of 2.15-4.71 mmol/g. Mesoporous silica materials with diethylphosphatoethyl groups (DP-MS) and hydroxyphosphatoethyl pendant groups (POH-MS) were prepared for lead ions adsorption. High affinity of hydroxyphosphatoethyl groups toward lead ions (Pb2+) makes the POH-MS materials attractive sorbents for lead ions, which is reflected by high lead uptake reaching 272 mg of Pb2+ per gram of POH-MS. Amidoxime-modified ordered mesoporous silica (AO-OMS) materials are also attractive sorbents for uranium recovery as evidenced by very high uranium uptake reaching 57 mg of uranium per gram of AO-OMS under seawater conditions.