O 33: Nanostructures at Surfaces: Metals, Oxides and Semiconductors I

Time: Tuesday 10:30–13:00 Location: REC/PHY C213

O 33.1 Tue 10:30 REC/PHY C213

Two-color excitation of image potential states and above threshold ionization at gold nanotips — •Thomas Quenzel, Jörg Robin, Jan Vogelsang, Andreas Wöste, Petra Gross, and Christoph Lienau — Institut für Physik, Carl von Ossietzky Universität, 26129 Oldenburg

Metallic nanotapers give access to strong field phenomena at a single solid-state nanostructure [1-3]. Experiments on bulk solid-state systems have established the existence of surface states by two photon photoemission experiments [4]. Here we use femtosecond two-color photoemission from a home-built NOPA to study the excitation and the dynamics of image potential states on a metallic nanotip.

We measure kinetic energy spectra of the photoemitted electrons as a function of delay between the (visible) pump pulse and the (near-infrared) probe pule. Atomic-like above-threshold ionization spectra are observed, which indicate the excitation of long-lived, weakly bound states at the surface of the nanostructure. With the presented work we take a step towards the emission of cold electron pulses as a promising source for ultrafast electron microscopy.

[1]Herink, Nature 483, 190-193 (2012),[2]Krüger, Nature 475, 78 (2011),[3]Piglosiewicz, Nat. Photon. 9, 37 (2014),[4]Höfer, Science 277, 1480 (1997)

O 33.2 Tue 10:45 REC/PHY C213

Effect of Substrate on Plasmonic Signatures of Silver Nanoparticles studied by Photoemission Electron Microscopy — •Kevin Oldenburg, Hannes Hartmann, Karl-Heinz Meiwes-Broer, Sylvia Speller, and Ingo Barke — University of Rostock, Institute of Physics, 18059 Rostock, Germany

The plasmonic response of metal nanostructures not only depends on material, shape and size but also on coupling phenomena to the environment. By optical excitation close to the resonance wavelength, efficient electron emission can be triggered which is accessible using photoemission electron microscopy (PEEM) with spatial, energetic, and angular resolution [1]. Here the electron emission of individual silver nanoparticles in the size range between 5 and 30 nm is measured using fs laser excitation between 355 nm and 460 nm. The data are correlated to geometric properties obtained by atomic force microscopy (AFM). The clusters were produced in the gas phase and soft-landed onto natively oxidized Si(111) and Si(111)-(7x7) to access the role of cluster-surface interaction.

[1] M. Rohmer et al., Phys. Stat. Sol. B 247, 1132 (2010).

O 33.3 Tue 11:00 REC/PHY C213

Multi-photon luminescence of single gold nanoparticles: Exploring the dynamics of plasmons and electron hole pairs — •Frank Wackenhut, Xiao Wang, and Alfred J. Meixner — Eberhard Karls University, Institute of Physical and Theoretical Chemistry, Tübingen, Germany

We utilize non linear excitation to investigate the optical properties of single gold nanoparticles and report on efficient two and three photon luminescence emission based on the excitation of electron hole pairs. Furthermore, we show that the emission of the same gold nanoparticle strongly depends on the excitation conditions and can be controlled by changing the excitation pulse duration from 500 fs to 100 fs. Additionally we are using single gold nanorods with different aspect ratios to investigate the interplay between the particle plasmon and electron hole pairs, which enables us to develop a quantitative model to fully describe the two and three photon luminescence emission of single gold nanoparticles. These findings greatly increase the understanding of the physical processes underlying the luminescence of gold and hence help to increase the usefulness of gold nanoparticles in various application fields, e.g. in material science, bio imaging, microscopy and spectroscopy.

O 33.4 Tue 11:15 REC/PHY C213

Examining small iron clusters by AFM with CO terminated tips — •Sonia Matencio, Ferdinand Huber, Julian Berwanger, Matthias Emmrich, Alfred J. Weymouth, and Franz J. Giessibl — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany

Physical properties of metal clusters depend on size and structure. With scanning tunneling microscopy (STM), it is difficult to resolve the adsorption site and number of atoms of a cluster. We use atomic force microscopy (AFM) at low temperature and with a CO terminated tip to study clusters of iron on Cu(111). This technique previously revealed single iron atoms as torii with subatomic features and small clusters (<5 atoms) as connected structures [1]. In this work, we study larger single-layer clusters (10 atoms) and two-layer clusters. Between some atoms of the cluster a repulsive feature is observed. This feature can be laterally manipulated by the tip and provides information about the vertical relaxation of iron atoms [2].

[1] M. Emmrich et al., Science 348, 308 (2015).
[2] S. Polesya, S. Mankovsky and H. Ebert. Unpublished.

O 33.5 Tue 11:30 REC/PHY C213

Ultranarrow Nonlinear Resonances in Hybrid Fiber-Plasmon Cavities — •Qi Ai[1], Domenico Paone[1], Martin Mayer[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCOPE, University of Stuttgart, Germany — [2]Leibniz Institute of Polymer Research Dresden, Department of Physical Chemistry and Polymer Physics, Germany

We demonstrate substantial reduction in the LSPR linewidth of an Au nanorod by depositing it onto the surface of a tapered fiber. When the tapered diameter is reduced to about 1-3 **m, we observe signatures of strong coupling between the LSPR modes and the whispering gallery modes of the tapered fiber. This results in a very narrow hybrid plasmon-fiber resonance of the single Au nanorod, with a much higher quality factor Q (up to 300) when compared with that of an Au nanorod or an uncoated fiber with the same diameter. Meanwhile, the strong coupling leads to a significant enhancement of the peak scattering intensity at plasmon resonance when compared to an uncoupled Au nanorod. Nonlinear optical processes such as second-harmonic generation can therefore be produced from such a simple system with extremely high conversion efficiency, as it should theoretically scale with Q4. Moreover, we observed ultranarrow (linewidth < 10nm) nonlinear resonances in the second harmonic spectrum of this coupled hybrid system.

O 33.6 Tue 11:45 REC/PHY C213

Capability of oxygen related defects in controlling the water wetting properties of metal oxide nanostructure — •Kavita Yadav and J. P. Singh — Department of physics, IIT Delhi, New Delhi-110016, India

The water wetting of metal oxide surfaces is generally governed by the surface topography, surface crystallography and the surface defects. A detailed study suggests that the surface defects are most powerful tool for controlling the water wetting properties on metal oxide nanostructures rapidly and economically. The effect of surface crystallography on water wetting properties of metal oxides was studied using first-principles-based DFT calculations for metal oxide crystallographic planes. On the basis of DFT analysis, we conclude that the water dissociation does not depends on the crystallographic surface planes but depends strongly on the surface stoichiometry. Also, the defects related study further support the DFT results and reveals a truth that the highly oxygen deficient metal oxide nanowires show highly water repellent nature similar to a lotus leaf. By utilizing this idea, we have demonstrated a facile approach for the preparation of metal oxide nanowires with tunable surface wettability. The surface wetting properties can be manipulated reversibly in a controlled manner from a superhydrophilic state to a superhydrophobic state by using hydrogen and oxygen gas annealing treatments. The water resistant properties of the metal oxide nanowires coating is found to be durable and can be applied to a variety of substrates.

O 33.7 Tue 12:00 REC/PHY C213

Ultra small iron nanoparticle superlattice on graphene/iridium(111) — •Konstantin Krausert[1,2], Elin Grånäs[1], Arti Dangwal Pandey[1], Heshmat Noei[1], Dirk Franz[1,2], and Andreas Stierle[1,2] — [1]DESY NanoLab, Notkestraße 85, D-22607 Hamburg — [2]University of Hamburg, D-20355 Hamburg

The physical properties, such as magnetism of ultra small clusters can differ fundamentally from the bulk material and are dominated by their confinement and atomic structure [1, 2]. The arrangement of

such nanoparticles in a superlattice not only allows to reach high density and possibly trigger intercluster effects, but it also enables new characterization approaches [2].

Iridium seeded ultra small Fe nanoparticle superlattices were grown on graphene on Ir(111) support [1]. These are studied with various measurement techniques to gain and correlate structural, electronic and magnetic information. The bottom up fabrication is reproducible and gives the oportunity to link different structural characterisation from scanning probe techniques to electron and x-ray diffraction (XRD) measurements. The regular arrangements of the clusters also enables an atomical scale XRD characterisation [2]. Growth on thin film Ir substrates [3] and well defined coverage widens the charaterisation possibilties for ex situ and magnetic measurements. The present findings in the project and an outlook will be given in the talk.

[1] A. T. N'Diaye, et al, New Journal of Physics 11, 103045 (2009) [2] D. Franz, et al, Phys. Rev. B 93, 045426 (2016) [3] A. Dangwal Pandey, et al, J. Appl. Phys. 120, 075304 (2016)

O 33.8 Tue 12:15 REC/PHY C213

Simulation of metal cluster growth on a thin polymer film during sputter deposition — •Jan Willem Abraham[1], Thomas Strunskus[2], Franz Faupel[2], and Michael Bonitz[1] — [1]Institut für Theoretische Physik und Astrophysik, CAU Kiel — [2]Institut für Materialwissenschaft, CAU Kiel

The fabrication of metal-polymer nanocomposites with tailored optoelectronic properties has been a challenge since the early days of nanotechnology. Under typical conditions in plasma-based physical vapor deposition experiments, crucial properties such as composition, size and shape of the nanoparticles evolve in a self-organized process and are hence difficult to obtain in a controlled way. Computer simulations can be helpful to improve the understanding of the relevant processes, but the required length and time scales impose big challenges on all currently available methods. In this work, we present an approach based on Langevin dynamics that allows us to investigate the growth of Au and bi-metallic Ag-Cu clusters on polymer surfaces on experimentally relevant time scales [1]. We show that our results are in good agreement with recent GISAXS experiments that were carried out to study the morphology and optical properties of sputtered gold on a thin polystyrene film in real time [2]. Finally, we demonstrate some approaches to calculate the intensity of scattered X-rays as well as the UV-Vis absorption spectrum for our simulated structures. [1] J. W. Abraham et al., J. Appl. Phys. 119, 185301 (2016). [2] M. Schwartzkopf et al., ACS Appl. Mater. Interfaces 7, 13547 (2015).

O 33.9 Tue 12:30 REC/PHY C213

A DFT-based investigation of 3d adatoms and small clusters on Cu(111): magnetism and AFM images — •Svitlana Polesya[1], Sergiy Mankovsky[1], Hubert Ebert[1], and Franz J. Giessibl[2] — [1]LMU München, Dept. Chemie, München, Germany — [2]Inst. Experimentelle Physik, Univ. Regensburg, Germany

Density Functional Theory (DFT) based calculations have been performed in order to investigate the forces on a CO tip in the vicinity of 3d atoms deposited on Cu(111) surface. For this, a full structure relaxation of adatoms and surrounding surface atoms has been taken into account. In the case of an Mn adatom the crucial role of relaxation to stabilize its magnetic state is shown. The effects of local electronic correlations have been investigated via GGA+U calculations. The forces on a CO tip obtained within DFT calculations are discussed in comparison with experimental AFM images. It is found that all magnetic adatoms reveal a three fold symmetry of the lateral AFM-image as observed experimentally for a Fe adatom [1]. The relaxed geometry and magnetic moments distribution have been also calculated for larger Fe clusters (up to 10 atoms). For 10-atom Fe cluster the hexagonal rim shape of the experimental AFM image is obtained. Surprisingly, the force maxima do not fully coincide with the positions of 'hexagon' atoms but are located between these atoms, in full agreement with experiment [2].

[1] M. Emmrich, F. Huber et al., Science **348**, 308 (2015)

[2] S. Matencio, F. Huber, J. Berwanger, M. Emmrich, A. J. Weymouth, F. J. Giessibl. Unpublished.

O 33.10 Tue 12:45 REC/PHY C213

Semiconductor thin films with functionalized crystalline silicon nanoparticles — •Domenikos Chryssikos[1], Francesco Casablanca[1], Willi Aigner[1], Martin Stutzmann[1], Rui N. Pereira[1,2], and Anna Cattani-Scholz[1] — [1]Walter Schottky Institut and Physik-Department, Technische Universität München, Am Coulombwall 4, 85748 Garching bei München, Germany — [2]Department of Physics and Institute for Nanostructures, Nanomodelling and Nanofabrication, University of Aveiro, 3810-193 Aveiro, Portugal

Electronic devices incorporating solution-processable crystalline nanoparticles, in particular thin films of II-VI or IV-VI materials, have been the subject of many studies in recent years. However, up to now, only few works employ elemental semiconductors like silicon nanoparticles (Si-NPs), which are advantageous regarding their abundance and non-toxicity. In this work, we exploit the assembling of thin films of Si-NPs covalently bound to silicon oxide surfaces via alkyldiphosphonic acid molecules. The aim of this investigation is to create a stable immobilization and homogenous distribution of Si-NPs on solid substrates that can also allow for controlling the positioning of the semiconductor nanostructures. The structural and morphological properties of the Si-NP layers have been studied by X-ray photoelectron spectroscopy, contact angle measurements, atomic force microscopy and Raman spectroscopy. Moreover, these novel nanostructures have also been characterized with respect to their electronic properties using electrical conductivity measurements.