O 66: Metallic Nanostructures I (on Metals)

Time: Thursday 12:45–15:15 Location: MA 041

O 66.1 Thu 12:45 MA 041

Photochemical tuning of plasmon resonances in gold nanostructures — •Thomas Härtling[1], Yury Alaverdyan[2], Marc Tobias Wenzel[1], René Kullock[1], Mikael Käll[2], and Lukas M. Eng[1] — [1]Insitut für Angewandte Photophysik, TU Dresden, 01062 Dresden, Germany — [2]Department of Applied Physics, Chalmers University of Technology, SE-41296 Göteborg, Sweden

A photochemical method for the in-situ controlled tuning of size and shape of individual gold nanostructures is presented. This novel nano-optical fabrication technique combines the top-down approach of electron beam lithography with the genuine bottom-up strategy of autocatalytic nanoparticle growth to reach highest precision in nanoscale structure manufacturing on the sub-10-nm length scale. The technique is preeminently suitable for the fabrication of spectrally optimized nano-optical antennas used for instance as SERS substrates or surface-plasmon-based biosensors. The fabrication method is demonstrated by syntonizing the localized surface plasmon resonances of sub-wavelength nanoparticles, i.e., single spheres, single and paired nanodiscs, as well as ellipsoids. We show how a distinct red- or blueshifted surface plasmon resonance can be achieved due to photochemical tuning of size and shape of the particles.

O 66.2 Thu 13:00 MA 041

Tunable Quantum Wires: New Horizons in Plasmonics — •Dominic Zerulla[1], Michael Berndt[2], Stephanie Rehwald[3], Stephan Schwieger[4], and Erich Runge[4] — [1]UCD Dublin, School of Physics, Dublin 4, Ireland — [2]MPI of Molecular Cell Biology and Genetics, Dresden, Germany — [3]Heinrich-Heine-University Duesseldorf, Germany — [4]TU Ilmenau, Theor. Physik I, Germany

Here we report on the excitation of surface plasmon polaritons (SPP's) on a periodical arrangement of quantum wires with tunable periodicity. The ability to vary its two-dimensional lattice constant results in an additional degree of freedom, permitting excitation of SPP's for any combination of wavelength and angle of incidence within the tuning range of the system. Moreover it allows crucial questions on a fundamental level to be answered by shedding light on the characteristic localization properties of SPP's. Planar waveguides and photonic crystal structures are being intensively investigated as primary solutions for integrated photonic devices. However, there may be an alternative approach to the manufacturing of highly integrated optical devices with structural elements smaller than the wavelength, which nevertheless enables strong guidance and manipulation of light - the use of metallic and metallodielectric nanostructures in conjunction with Surface Plasmon Polaritons (SPP's). Our novel design opens new vistas regarding the tuneability of SPP localisation, propagation and coupling efficiencies.

[1] S. Rehwald, M. Berndt, F. Katzenberg, S. Schwieger, E. Runge, K. Schierbaum, D. Zerulla, Phys. Rev. B 76, 085420 (2007)

O 66.3 Thu 13:15 MA 041

Tailoring Surface Plasmon Polariton Propagation via Specific Symmetry Properties of Nanostructures — •Brian Ashall[1], Michael Berndt[2], and Dominic Zerulla[1] — [1]UCD Dublin, School of Physics, Dublin 4, Ireland — [2]MPI of Molecular Cell Biology and Genetics, Dresden, Germany

SPs are electromagnetic surface waves propagating along the interface of two materials with dielectric functions of opposite sign. They are essentially light waves that are trapped on the surface as a result of interactions between the illuminating wave and the free electrons of the conductor, and are called Surface Plasmon Polaritons (SPPs) to reflect this hybrid nature. Recent advances in fabrication technologies have created new opportunities to control SPP properties to reveal new aspects of their underlying science, and to tailor them for specific applications. We report on an experimental investigation on SPP propagation and interaction on 2D arrays of differing symmetry properties. Providing the required symmetry variations, and forming the basis of the arrays, are tailor designed nanostructures. The symmetry properties of the nanostructures have a definite impact on the SPP propagation direction on the surface. In particular, it is demonstrated how in certain orientations our rotor nanostructures have interesting wave-guiding interactions with propagating SPPs, and polarization twisting effect on the SPP re-radiated light.

[2] B. Ashall, M. Berndt, D. Zerulla; Appl. Phys. Lett. 91, 203109 (2007)

O 66.4 Thu 13:30 MA 041

Influence of arrays of nanodiscs on surface plasmon propagation — •Stefan Griesing, Andreas Englisch, and Uwe Hartmann — Saarland University, Experimental Physics Department, P.O.Box 151150, D-66041 Saarbruecken

Arrays of discs were produced by means of electron-beam lithography (EBL) on top of a 40nm thick silver layer. The discs with a diameter of 250nm were realized in two different ways: On the one hand as 30nm thick gold structures produced by a lift-off process, on the other hand as polymer structures with a thickness of 130nm by using a direct-writing process. The distance between the discs varies between 1.5 microns and 300nm. A plasmon beam was excited by a focused laser beam of 673nm wavelength passing through the Kretschmann configuration. The plasmon beam with a half-width of 5 microns propagates from the excitation spot to the nanostructures. The influence on the propagation behavior in dependence on the period is studied by scanning near-field microscopy for normal and oblique incidence. The results are compared with finite elements calculations.

O 66.5 Thu 13:45 MA 041

Optical Properties of Metal Nanorod Arrays — •René Kullock[1], Paul R. Evans[2], Robert J. Pollard[2], and Lukas M. Eng[1] — [1]Institut für Angewandte Photophysik, TU Dresden, 01062 Dresden, Germany — [2]Centre for Nanostructured Media, IRCEP, The Queens University of Belfast, Belfast BT7 1NN, UK

Single gold or silver nanorods strongly interact with visible light due to surface plasmon resonances (SPRs) [1]. By periodically arranging multiple nanorods, these SPRs can be easily tuned [2], hence allowing such structures to be used either for manipulating optical light transmission or generating high optical near-field strengths.

Here, we report on the optical near- and far-field properties of such gold and silver nanorod arrays with individual rods of 300 nm length and 20 nm width beeing arranged with a 60 nm periodicity. Using the semi-analytical method of multiple-multipoles, we study the electromagnetic near-field distribution of the SPRs, which are completely changed compared to the single nanorod case, and strongly depend on the geometry of our structures. Hence, we are able to identify various modes having different energies and shapes [3]. Furthermore, we are also interested on the far-field properties of the structure, and therefore investigate the influence of the structure on light transmission both theoretically and expmerimentally. Finally, applications of these near- and far-field effects in such structures are discussed.

[1] S. Link et al., J. Phys. Chem. B 103, 3073 (1999).
[2] R. Atkinson et al., Phys. Rev. B 73, 235402 (2006).
[3] P. Evans et al., *submitted.*

O 66.6 Thu 14:00 MA 041

fabrication of ordered cluster arrays on pre-structured surfaces — •Jian Zhang[1], Violetta Sessi[1], Jan Honolka[1], Axel Enders[1,2], and Klaus Kern[1] — [1]Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, 70569 Stuttgart, Germany — [2]Dept. of Physics and Astronomy, University of Nebraska, Lincoln NE 68588, USA

We will present results on the fabrication of ordered cluster arrays on structured surfaces. Fe and Co clusters of less than 3 nanometer diameter were prepared by buffer layer assisted growth1 (BLAG). The advantage of this method is that the clusters are formed before they make contact with the substrate. Thus, their initial structure is not affected by the substrate. While the resulting clusters are randomly distributed on flat crystalline surfaces, we find that cluster ordering can be promoted with pre-structured surfaces. Two examples will be discussed. On stepped a Pt(997) surface the clusters are arranged along the steps after landing, resulting in linear chains of clusters. Hexagonally arrays of isolated clusters can be achieved on a periodically corrugated boron-nitride nanomesh template. Here, the clusters preferentially occupy the pores in the BN layer. High nanomesh filling is achieved by repeated cluster deposition cycles. However, the maximum nanomesh filling is still limited by the cluster diffusion on the nanomesh, as will be discussed.

O 66.7 Thu 14:15 MA 041

Role of surface roughness in superhydrophobicity — •Chunyan Yang, Ugo Tartaglino, and Bo Persson — IFF, FZ-Juelich, 52425, Germany

Superhydrophobic surfaces, with liquid contact angle theta greater than 150 degree, have important practical applications ranging from self-cleaning window glasses, paints, and fabrics to low-friction surfaces. Many biological surfaces, such as the lotus leaf, have hierarchically structured surface roughness which is optimized for superhydrophobicity through natural selection. Here we present a molecular dynamics study of liquid nanodroplets in contact with self-affine fractal surfaces. Our results indicate that the contact angle for nanodroplets depends strongly on the root-mean-square surface roughness amplitude but is nearly independent of the fractal dimension of the surface[1,2].

References: [1] C. Yang, U. Tartaglino and B.N.J. Persson, Phys. Rev. Lett. 97, 116103 (2006) [2] C. Yang, U. Tartaglino and B.N.J. Persson, arXiv:0710.3264

O 66.8 Thu 14:30 MA 041

Strain induced micro-island formation on Ni/Ru(0001) monolayers — Kai Anhut and •Peter Jakob — Fachbereich Physik und Wissenschaftliches Zentrum für Materialwissenschaften, Philipps-Universität Marburg, D-35032 Marburg, Germany

Morphological changes of Ni monolayers on Ru(0001) induced by oxygen adsorption have been investigated using scanning tunneling microscopy. Specifically, the creation of well defined and uniform Ni micro-islands consisting of 3, 6 or 9 Ni atoms is reported and their geometrical structure, as well as their coordination with respect to the substrate lattice determined. The island formation is directly linked to a phase transition of the pseudomorphic Ni layer (lattice constant $\Delta d = d_{Ru-Ru} = 2.706$ Å) into a densified, moiré-distorted phase (lattice constant $\Delta d = d_{Ni-Ni}= 2.492$ Å) as Ni areas grow to lateral sizes beyond about 200 Å. An increasing lateral stress within such densified Ni monolayers induced by the adsorption of oxygen is held responsible for the expulsion of Ni clusters from the monolayer film. The micro-islands represent unusually stable units (with respect to recombination of neighboring islands) which is tentatively attributed to oxygen atoms attached to the trimers and hexagons.

O 66.9 Thu 14:45 MA 041

Adsorbate-Induced Faceting of Ir and Re Surfaces — •Payam Kaghazchi, Timo Jacob, and Matthias Scheffler — Fritz-Haber-Institut der MPG, Faradayweg 4-6, D-14195 Berlin

Since high-index clean metal surfaces typically have lower surface atom densities and higher surface free energies compared to the close-packed surfaces of the same metal they can be used as the basis for surface reconstruction and facet formation experiments. In this context the group of T.E. Madey at Rutgers University found recently that on Ir(210) and Re($11\bar{2}1$) surfaces strongly interacting adsorbates are able to induce the formation of well defined nanostructures after annealing the system at elevated temperatures.

Using density functional theory calculations with the PBE functional and *ab initio* atomistic thermodynamics we studied the adsorption of oxygen and nitrogen on the different surface orientations, which are involved in the nanostructures on Ir(210) and Re($11\bar{2}1$). Constructing the corresponding (p, T)-surface phase diagrams, we find that at experimental pressure conditions ($p_{O_2} = 5 \cdot 10^{-10}$ atm) above 1100 K for Ir and above 1200 K for Re the planar surfaces are stable, while lowering the temperature stabilizes the nanofacets found experimentally. While on Ir(210) most nanoscale pyramids consist of smooth and unreconstructed planes, some (110) faces show a stepped double-missing row superstructure, which is only stable at higher temperatures (1000 K< T <1100 K). Interestingly, we find that this superstructure only appears at the faceted surface, but turns out to be unstable on a Ir(110) substrate.

O 66.10 Thu 15:00 MA 041

Fabrication and metallic filling of sub30nm-nanoholes by PLD — Marc Saitner, •Christian Pfahler, Achim Manzke, Alfred Plettl, and Paul Ziemann — Solid State Physics, University of Ulm, D-89069 Ulm, Germany

Gold or platinum nanoparticles with diameters between 6 and 14nm were produced using a micellar technique and H_2 plasma ashing. Preparing such particles on e.g. silicon substrates, they act as a mask in subsequent anisotropic reactive ion etching with a CF_4/CHF_3 gas mixture. Direct processing results in nanopillars, whereas nanoholes can be created by inversion of this mask. Diameter and height of the holes are typically in the range of 10-40nm and 10-250nm, respectively. Aside from crystalline silicon it is possible to transfer the whole process directly to amorphous silicon, silicon oxide or nitride and thus to corresponding multilayer systems.

By using Pulsed Laser Deposition (PLD) these nanoholes can be filled with different metals. The influence of the substrate, the shape of the holes and the energy density of the laser will be discussed, and applications will be presented.