O 98: Plasmonics and Nanooptics V

Time: Friday 10:30–13:00 Location: TRE Ma

O 98.1 Fri 10:30 TRE Ma

Evidence for graphene plasmons in the visible spectral range probed by molecules — •Philipp Lange, Günter Kewes, Nikolai Severin, Oliver Benson, and Jürgen P. Rabe — Humboldt-Universität zu Berlin, Department of Physics, 12489 Berlin, Germany

Graphene is considered to be plasmon active only up to the infrared based on combined tight binding model and random phase approximation calculations. Here we show that the optical properties of graphene as measured by ellipsometry and simulated by density functional theory imply the existence of strongly localized graphene plasmons in the visible with a line width of 0.1 eV. Using small emitters that provide the high wave vectors necessary to excite graphene plasmons at optical frequencies we demonstrate graphene plasmon induced excitation enhancement by nearly 3 orders of magnitude.

O 98.2 Fri 10:45 TRE Ma

Electroluminescence of single oligothiophene wire suspended in a STM junction. — •Gaël Reecht[1], Fabrice Scheurer[1], Virginie Speiser[1], Fabrice Mathevet[2], Yannick Dappe[3], and Guillaume Schull[1] — [1]IPCMS , Strasbourg, France — [2]Laboratoire de Chimie des Polymères, Paris, France — [3]IRAMIS CEA, Saclay, France

In a pioneering experiment [1], it has been demonstrated that the fluorescence of a single molecule could be excited using a scanning tunnelling microscope (STM). In this case the molecule was separated from the electrodes by thin insulating layers. For direct molecule-electrode contacts experiments [2], luminescence mechanisms intrinsic to the molecule are quenched because of the strong hybridization with the electrode states. Combining direct molecule-electrode coupling and fluorescence in a same junction is therefore a challenging key issue towards molecular optoelectronic devices.

Here we used the tip of a low temperature STM to lift a unique π-conjugated polymer chain from a Au(111) surface. For positive sample voltage, passing current through the suspended molecular wire induced an emission of light whose spectral and voltage dependencies are consistent with the fluorescence of the wire junction mediated by localized plasmons. For the opposite polarity the emission is strongly attenuated. Our molecular contact junction can therefore be viewed as a single molecular wire light emitting diode.

[1]. X. H. Qiu, and al. Science 299, 542 (2003).
[2]. N. L. Schneider, and al. Phys. Rev. Lett.109, 186601 (2012).

O 98.3 Fri 11:00 TRE Ma

Bloch Oscillations in Plasmonic Waveguide Arrays — •Alexander Block[1], Christopf Etrich[2], Felix Bleckmann[1], Thorsten Limböck[1], Carsten Rockstuhl[2], and Stefan Linden[1] — [1]Physikalisches Institut, Bonn, Germany — [2]Institut für Festkörpertheorie und -optik, Jena, Germany

We present the experimental observation of spatial Bloch oscillations in arrays of dielectric-loaded surface plasmon polariton waveguides. By fabricating strips of PMMA on a gold film via gray-scale electron beam lithography, it is possible to guide surface plasmon polaritons. We study the evanescent coupling of light propagating through arrays of such plasmonic waveguides which is described by coupled mode theory. The equation of motion for the evolution of the light field along the waveguides takes the same form as the crystal electron wavefunction's time evolution in the tight binding model of solid state physics. Therefore, we can visualize quantum mechanical condensed matter phenomena in a coherent, yet classical wave environment by mapping the probability distribution to the surface plasmon intensity distribution in real space which is directly imaged via leakage radiation microscopy. We observed plasmonic Bloch oscillations by fabricating waveguide arrays with linearly increasing effective refractive indices. This gradient mimics the linear potential gradient of a DC electric field as required for Bloch oscillations of crystal electrons. The results clearly show the expected spatial Bloch oscillation of a shape retaining Gaussian beam wave package. These results excellently agree with finite-difference time-domain simulations, which are also presented.

O 98.4 Fri 11:15 TRE Ma

Fabrication of hybrid nanostructures composed of quantum dots and plasmonic nanoparticles — •Manuel Peter, Cody Friesen, and Stefan Linden — Physikalisches Institut, Universität Bonn, Nußallee 12, 53115 Bonn, Germany

In this contribution, we present a two-step electron lithography process for the reliable positioning of colloidal quantum dots in the vicinity of plasmonic nanoparticles with sub-50-nm spatial accuracy. In the first lithography step, gold nanoparticles are fabricated with spectral features at the emission wavelength of the used quantum dots (λ=780 nm). Following this, a second layer of PMMA is deposited on the sample. Then a mask is written with the electron beam to define the positions for the colloidal quantum dots. After development, the surface of the substrate as well as that of the quantum dots are chemically modified such that a linker molecule can bind the quantum dots to the predefined spots. After removing the PMMA mask, we obtain hybrid nanostructures composed of gold nanoparticles and quantum dots. With our fabrication method, we will be able to precisely control all geometrical parameters of the hybrid nanostructures. This opens interesting opportunities to study the interaction of quantum dot with particle plasmon resonances via fluorescence microscopy and life-time measurements.

O 98.5 Fri 11:30 TRE Ma

Linear colloidal assemblies with adjustable dimensions and plasmonics — •Christoph Hanske, Moritz Tebbe, Vera Bieber, Mareen Müller, Munish Chanana, Nicolas Pazos-Perez, and Andreas Fery — Physical Chemistry II, University of Bayreuth, 95440 Bayreuth, Germany

Topographical templating is a powerful technique to assemble simple colloids into complex structures with advanced optical functionality. We present the fabrication of linear colloidal arrangements by convective assembly of spherical particles on wrinkled substrates. The method does not rely on conventional lithographic processes and yields highly regular structures over macroscopic areas.[1] In a subsequent transfer step additional features with micron- or even submicron-sized dimensions can be introduced through the use of patterned target substrates.[2] We discuss the role of the underlying surface chemistry and demonstrate how this assembly strategy can be employed to manipulate the plasmonic properties of metallic nanoparticles. In UV-Vis/NIR investigations linear arrangements of close-packing spherical gold particles display a pronounced polarization dependent spectral response. The observed anisotropy is caused by strong plasmonic coupling between adjacent particles and can be described in analogy to the transversal and longitudinal modes common for gold nanorods.

O 98.6 Fri 11:45 TRE Ma

Fano resonances in T-like configured nanospheroids — •Manuel Gonçalves[1], Taron Makaryan[2], Hayk Minassian[3], Armen Melikyan[4], and Othmar Marti[1] — [1]Ulm University - Inst. of Experimental Physics, Ulm, Germany — [2]Yerevan State University - Radiophysics Department, Yerevan Armenia — [3]Yerevan Physics Institute, Yerevan, Armenia — [4]Russian-Armenian (Slavonic) University, Yerevan, Armenia

Nowadays the growing interest towards systems of metallic nanoparticles is often conditioned by the possibility of revealing Fano resonancies in surface plasmon (SP) oscillations. In this communication we consider plasmonic coupling effects in metallic spheroidal nanoparticles when they form T-like configuration. While identical spheroids do not present Fano resonances, proper choice of aspect ratios of non identical spheroids makes possible strong dipole-quadrupole coupling. When the length of the horizontal spheroid is approximately twice of the length of vertical one Fano resonance takes place if the incident light is polarized along the vertical spheroid and leads of pronounced atenuation in the scattering. Calculations were carried out using COMSOL Multiphysics software for Au spheroids of several aspect ratios and interparticle separations. At the Fano resonance, calculations of near field distribution show that the energy of surface plasmon (SP) oscillations is mainly concentrated in the horizontal spheroid. It is important to note that due to the symmetry of the system the dipole moment of horizontal spheroid vanishes, and the radiation losses are conditioned only by the SP oscillations in the vertical one.

O 98.7 Fri 12:00 TRE Ma

Electrochemical route to large-area mono-crystalline gold platelets for plasmonic applications — •Bettina Frank[1],

Adrian Ruff[2], Sabine Ludwigs[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany — [2]Institute of Polymer Chemistry, University of Stuttgart, Germany

We fabricate high-quality gold platelets for plasmonic applications using an electrochemical approach. This process consists of dissolution of a sacrificial gold electrode by cyclic voltammetry in HCl-water-based electrolytes with a 3-electrode setup. Within a specific negative voltage range the Au ions are reduced back to gold atoms and can rearrange in micrometer-sized monocrystalline hexagons, triangles and truncated triangles. Placed underneath the sacrificial electrode, any kind of substrate collects the high-quality microstructures. The particles can be tailored in size, thickness, and number per area, depending on the electrochemical parameters. Sizes of several tens of micrometers can be reached, and thicknesses are in the 10-100 nm range. To demonstrate single-crystallinity, we perform AFM surface analysis which demonstrates that our structures are extremely flat, down to monoatomic flatness. TEM studies confirm the single-crystallinity via electron diffraction by showing the exact hexagonal arrangement of the gold atoms. Our single-crystalline gold platelets will serve as bulk material for high quality plasmonic structures and long-range propagation.

O 98.8 Fri 12:15 TRE Ma

CMOS-compatible switchable plasmonic perfect absorber — •Andreas Tittl[1], Behrad Gholipour[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCOPE, University of Stuttgart, Germany — [2]Centre for Disruptive Photonic Technologies, Nanyang Technological University, Singapore

We demonstrate experimentally, for the first time, a CMOS-compatible switchable plasmonic perfect absorber based on the phase-change material germanium antimony telluride (GST). Our design incorporates an array of square aluminum nanopatches stacked above a GST spacer layer and an aluminum mirror. We target the atmospheric window in the 3 to 5 μm spectral range, which is of great importance for infrared detection and metrology. Furthermore, the Al/GST material system ensures full compatibility with industrial CMOS fabrication techniques. Our structures exhibit tunable absorbance >90% starting at a wavelength of 2.5 μm, which can be switched off by thermal heating of the sample above the transition temperature of 160°C. This pronounced switching behavior enables a multitude of applications ranging from infrared imaging to localized reaction control.

O 98.9 Fri 12:30 TRE Ma

Matrix induced growth: a versatile tool for preparing crystalline Au nanoparticles for photonic applications — •Christian Katzer[1], Philipp Naujok[1], Hendrik Bernhardt[1], Gabriele Schmidl[2], Robert Müller[2], Wolfgang Fritzsche[2], and Frank Schmidl[2] — [1]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Helmholzweg 5, D-07743 Jena — [2]Institute of Photonic Technology (IPHT), Albert-Einstein-Str. 9, D-07745 Jena

In the past years different methods such as wet chemical synthesis were used to fabricate metal nanoparticles for photonic applications. In order to overcome typical solution based problems like aggregation of particles, new in-situ methods of preparing them directly on the substrate surface are highly favoured. The authors present a novel in-situ method of fabricating crystalline gold nanoparticles by a thin film controlled self-organization technique using two different thin film matrices ($YBa_2Cu_3O_{7-\delta}$ and $SrTiO_3$). We will show that it is possible to individually control the size and the distribution of the nanoparticles as well as their shape. Thus, it is also possible to fabricate highly anisotropic particles which are of great interest due to the local field enhancement. All can be achieved by adjusting process parameters that are easily accessible. As one might have to extract the nanoparticles from the surrounding matrix material to realise photonic applications we will present our findings concerning the matrix dissolution.

[1] C. Katzer et al., J. Nanopart. Res. 14, 1285 (2012)
[2] C. Katzer et al., Proc. SPIE 8807, Nanophotonic Materials X, doi:10.1117/12.2024058

O 98.10 Fri 12:45 TRE Ma

Manipulating and probing the growth of plasmonic nanoparticle arrays using light — Oral Ualibek[1], Ruggero Verre[2], Brendan Bulfin[1], •Karsten Fleischer[1], John F. McGilp[1], and Igor V. Shvets[1] — [1]School of Physics, Trinity College Dublin, Ireland — [2]Department of Applied Physics, Chalmers University of Technology, 412 96 Göteborg, Sweden

Highly ordered self-assembled silver nanoparticle (NP) arrays have been produced by glancing angle deposition on faceted c-plane Al_2O_3 templates. The NP shape can be tuned by changing the substrate temperature during deposition. Reflectance anisotropy spectroscopy has been used to monitor the plasmonic evolution of the sample during the growth. The structures showed a strong dichroic response related to NP anisotropy and dipolar coupling. Furthermore, multipolar resonances due to sharp edge effects between NP and substrate were observed. Analytical and numerical methods have been used to explain the results and extract semi-quantitative information on the morphology of the NPs. The results provide insights on the growth mechanisms by the glancing angle deposition. Finally, it has been shown that the NP morphology can be manipulated by a simple illumination of the surface with an intense light source, inducing changes in the optical response. This opens up new possibilities for engineering plasmonic structure over large active areas.