HL 23: Plasmonics and Nanophotonics I (Joint Session with DS/O)

Time: Tuesday 10:30–13:00
Location: H2

HL 23.1 Tue 10:30 H2

Electrochemically tunable photonic metamaterial — †LIMUCA SHAO, STEFAN LINDEN, MATTHIAS RUTHE, JÖRG WEISSMULLER, and MARTIN WEGENER — Institut für Nanotechnologie and DFG-Center for Functional Nanostructures (CFN), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

We report experiments to combine two approaches for designing functional nanomaterials. Photonic metamaterials provide a strategy for obtaining unconventional optical response - in the extreme, negative refractive indices - by lithographically structured elements like arrays of split-ring resonators (SRR). Nanomaterials with tunable electronic structure exploit large specific surface area of metal nanostructures to tune the surface properties through the controlled space-charge regions for tuning macroscopic properties. The combination is a photonic metamaterial in which the space-charge at the surface of SRR is controlled via an applied potential, leading to a tunable optical resonance. We report first results support this concept. SRR structures with resonance frequencies in the near infrared are immersed into aqueous electrolytes as working electrode in an electrochemical experiment. Varying the electrode potential, E, induces a space-charge layer at the metal surface as part of the electrochemical double-layer. We find the resonance frequencies vary linearly, reversibly, and reproducibly with E, with a blue shift for negative potential. A tentative explanation is based on the effective thickening of the SRR by the excess electrons, which changes the SRR aspect ratio. The observation of larger frequency shift for thinner SRR’s is compatible with this scenario.

HL 23.2 Tue 10:45 H2

Mixing colours like nature — †MATHIAS KOLLE, MAIK SCHEIER, PEDRO CUNHA, FUMIN HUANG, JEREMY BAUMBERG, and ULLRICH STRINER — Cavendish Laboratories, University of Cambridge, UK

Biomimetic attempts to produce novel photonic structures have attracted increasing research interest in recent years. Nature offers us an enormous amount of multifunctional micro- and nanostructures, that provide outstanding, distinctive, dynamic and tailored colouration. A “brilliant” example is the Indonesian butterfly papilio blumei, whose wing scales are covered with 5-10μm wide concavities, that are cladded with a perforated cuticle multilayer. The regularly shaped multilayer structure gives rise to very impressive colour mixing effects, accompanied by controlled change in light polarisation.

We have successfully replicated the intricate photonic structure of papilio blumei on the cm²-scale in four simple steps involving colloidal templating, electrochemical growth and atomic layer deposition. A small conceptual modification of the original photonic structure leads to a completely different optical effect. Any freely chosen colour and its complementary hue can be separated and reflected into different directions, partially due to transmission effects.

Since the procedures are easily up-scaleable, these biomimetic photonic structures have a huge potential for industrial applications in security printing, encoding of information, non-emissive display technology and other fields where distinct colours play an important role.

HL 23.3 Tue 11:00 H2

Optical properties of carpets of randomly grown silicon nanowires on glass — †GERALD BRÖNSTRUP and SILKE CHRISTIANSEN — Institut für Photoniche Technologien e.V., Abt. Halbleiter-Nanostrukturen, 07745 Jena

Silicon Nanowires [SiNWs] have attracted much attention in the recent years as possible future building blocks for field effect transistors, sensors, photo detectors and solar cells. For the latter SiNWs grown on a copper substrate have large area of special interest. To build solar cells with high efficiencies a high absorption is mandatory. We present a study of the influence of the diameter of the reflection, transmission and absorption spectra of carpet like assembly of SiNWs grown on glass.

We grew SiNWs on glass using gold colloids of different fixed diameters to achieve a control over the diameter of the SiNWs. Then we measured the reflection R and transmission T using an integrating sphere. The absorption A was calculated using the simple formula A=1−RT.

For a better understanding of the underlying physics of the absorption happening in SiNWs with diameters much smaller than the wavelength of the visible light we present a statistical model based on scattering cross sections calculated for single SiNWs using Mie-theory.

HL 23.4 Tue 11:15 H2

Suppressed transmission through ultrathin metal films by subwavelength hole arrays — †JULIA BRAUN, BRUNO GOMPf, UWE HUENNER, and MARTIN DRESSL — Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart — 2IPIT Jena, Albert-Einstein-Straße 9, 07745 Jena

If an opaque metallic film is periodically perforated by tiny subwavelength holes the light transmission cannot follow the classical electromagnetic transmission laws [1]. We investigate the transmission through subwavelength hole arrays (SWHA) in ultrathin semitransparent Au films with various periodicities and hole diameters and observe the opposite behavior: less light is transmitted through the pierced metal compared to the closed film. The samples were fabricated by optical interference and electron beam lithography in 12 nm and 20 nm thick Au films with periodicities between 250 nm and 400 nm, and than characterized in the frequency range 4400 cm⁻¹ to 37000 cm⁻¹ (0.6 eV to 4.6 eV). The optical properties of SWHA cannot be explained by a pure dielectric function, but show a strong k-dependent behavior. In ultrathin Au films it is marked by the excitation of strongly damped antisymmetric short range surface plasmons.

The obtained dispersion curves perfectly agree with this explanation when the altered dielectric function of the ultrathin Au films is taken into account [2].


HL 23.5 Tue 11:30 H2

Manipulation of fluorescence resonance energy transfer in single plasmonic nanoresonators — †VALERIE FÄSSLER, CALIN HRELESCU, SERGIY HAVLIO, FRANK JÜDEL, and JOCHEN FLEMMANN — Photonics and Optoelectronics Group, Department of Physics and Center for Nano Science (CeNS), Ludwig-Maximilians-Universität München, Amalienstrasse 54, 80799 München, Germany

We show that fluorescence resonance energy transfer (FRET) between two organic chromophores can be manipulated in plasmonic nanoresonators consisting of two spherical gold nanoparticles. The nanoresonators can be tuned by varying the inter-particle distance or the nanoparticle size. This allows us to selectively modify the decay channels of the chromophores. FRET can be suppressed if the molecules are placed in the nanoresonator at a certain distance from the nanoparticle surface. Furthermore we observe spectral shaping and intensity modulation of the fluorophore emission in the nanoresonators [1]. Correlated whitelight Rayleigh scattering and fluorescence microscopy data of the hybrid system is discussed in the framework of generalized Mie theory.


HL 23.6 Tue 11:45 H2

Optical antenna thermal emitters — †JON SCHULLER, THOMAS TAUBER, and MARK BRONGERSTMANN — Stanford University, Stanford, CA, USA — 2Physikalisches Institut, RWTH Aachen, Germany

Optical antennas are a critical component in nanophotonics research[1] and have been used to enhance nonlinear and Raman cross-sections and to make nanoscale optical probes [2]. In addition to their receiving properties, optical antennas can operate in broadcasting mode, and have been used to modify the emission rate[3] and direction [4] of individual molecules.

In these applications the antenna must operate at frequencies given by the altered dielectric function of the ultrathin Au films is taken into account [2].


Spatial Resolved Near Field Interference on Nanooptical Bowtie Antennas — PASCAL MELCHIOR, DANIELA BAYER, CHRISTIAN SCHNEIDER, MARTIN ROHNER, ALEXANDER FISCHER, and MARTIN AESCHLIMANN — Fachbereich Physik and Research Center OPTIMAS, Technische Universität Kaiserslautern, Erwin-Schrödinger-Str. 46, 67663 Kaiserslautern, Germany

The response of metallic nanostructures is responsible for interference effects of the electric near field in the vicinity of the structure surface. While the incoming electric field vectors are independent in the far field, spectral interference in the near field can occur since the resulting field vectors are not necessarily perpendicular. On the nanostructure configuration of a Bowtie antenna, we show how the superposition of different plasmonic excitation modes leads to a local enhancement of the incoming electric field vectors. Via an interferometric superposition of the effective near field depending on the phase relation between the different plasmonic excitation modes, we demonstrate how the superposition of field vectors are not necessarily perpendicular. On the nanostructure field, spectral interference in the near field can occur since the resulting field vectors are not necessarily perpendicular. On the nanostructure, spatial switching of the photoemission yield depending on the phase relation between the incoming electric field vectors. Two laser pulses with cross polarized electric fields the near field influence of the preparation steps to the final structure. For optical investigation UV-VIS-NIR spectrometry and scanning near field optical microscopy have been used showing extraordinary light transmission.

Surface Plasmon Resonance Coupling on Magnetically Capped Gold Nanorods — GILLIAN DOYLE and DOMINIC ZERULLA — Plasmonic and Ultrafast Optics Group, School of Physics, University College Dublin, Belfield, Dublin 4, Ireland

Nanorods compared to their spherical counterparts exhibit enhanced sensitivity and are used for a wide variety of applications from biosensing to solar cells. The presence of two resonance peaks in their scattering spectra allows their two geometrical axes, the longitudinal and transverse axes to be separately distinguished. In this research we use iron capped gold nanorods with geometrical dimensions in the range of 60 x 700 nm. Coupling of the surface plasmons between the two axes is investigated both in multiple particle and single particle experiments and the effect of the proximity of particles to each other and their associated coupling is considered. In the single particle experiments a 532 nm laser beam is used to optically trap and manipulate a nanorod, while coupling white light to the setup allows for optical resonance experiments and the effect of the proximity of particles to each other and their associated coupling is considered. In the single particle experiments a 532 nm laser beam is used to optically trap and manipulate a nanorod, while coupling white light to the setup allows for optical resonance experiments and the effect of the proximity of particles to each other and their associated coupling is considered.