O 33: Poster Session - Plasmonics and Nanooptics: Applications and other Aspects

Time: Monday 18:15–20:00 Location: P1C

O 33.1 Mon 18:15 P1C

Shape optimization of magneto-optic metasurfaces for enhanced Faraday rotation — •Thomas Kiel[1], Paris Varytis[1,2], Bettina Beverungen[1], Philip Kristensen[1], and Kurt Busch[1,2] — [1]Humboldt-Universität zu Berlin, Institut für Physik, Newtonstr. 15, 12489 Berlin — [2]Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin

Magneto-optic nanostructures and the associated effects such as Faraday rotation enable nonreciprocal devices, i.e. miniaturized photonic isolators etc. Although a large Faraday rotation is reported for various nanophotonic geometries, a simultaneous high transmittance is hard to achieve due to material losses. To overcome this limitation, it has been suggested to use a Huygens' metasurface composed of periodically arranged Ce:BIG nanodiscs embedded in SiO_2 [1].

Building on this original idea, we present here how to further increase the Faraday rotation with shape-optimized nanodiscs. The optimization is based on numerical solutions of the Maxwell equations using the discontinuous Galerkin time-domain method [2] with an extension to anisotropic materials [3] in order to model the Ce:BIG. We show that even with a simple optimization strategy, a doubling of the possible Faraday rotation is achievable for nearly the same effective optical thickness of the metasurface.

[1] A. Christofi et al., Opt. letters **43**, 1838 (2018)
[2] K. Busch et al., Laser & Photonics Rev. **5**, 773 (2011)
[3] J. Alvarez et al., IEEE Ant. Wirel. Propag. Lett. **11**, 1182 (2012)

O 33.2 Mon 18:15 P1C

Formation of conducting polymer by plasmon-induced photopolymerization — •Marisa Hoffmann[1,2], Anja Maria Steiner[1], Charlene Ng[1], and Andreas Fery[1,2] — [1]Leibniz-Institut für Polymerforschung Dresden e.V., Germany — [2]Department of Physical Chemistry of Polymeric Materials, TU Dresden, Germany

Metal nanoparticles (NPs) exhibit localized surface plasmon resonances (LSPRs). LSPRs of NPs can be utilized to induce various kinds of reactions in the vicinity of the NP surface, e.g. plasmon-induced polymerizations. By this, metal-polymer nanostructures can be created which can combine conducting polymers like polypyrrole with plasmonic gold NPs. Despite the potential of those hybrid materials, the mechanisms behind the plasmon-induced polymerizations are not fully understood. How LSPRs contribute to these reactions is still at debate and requires further investigations.

In this work, we investigate the mechanism of the formation of polypyrrole at the interface between a single plasmonic gold NP and a planar TiO2 surface upon visible light illumination. The parameters for the plasmon-induced oxidative polymerization process are evaluated by UV-Vis-NIR-spectroscopy, Scanning Electron Microscopy (SEM), conductivity measurements and Kelvin Probe Force Microscopy (KPFM). The results thereof are subsequently used to transfer the plasmon-induced photopolymerization from single particle level to NP lines, leading to a scalable bottom-up method for the fabrication of functional electronic devices.

O 33.3 Mon 18:15 P1C

A tuneable photochromic lens for the visible — •Till Leuteritz and Stefan Linden — Universität Bonn, Deutschland

Tuneable metasurfaces have attracted considerable attention in recent time. In order to modify their optical properties, different approaches like dynamic carrier doping, phase change materials, mechanical deformation and electrical tuning by capacitances have been used and different tunable devices like microwave metalenses and light controllable reflections have been demonstrated [1]. In our work, we employ the photochromic material XDTE for optical switching. Under incident of uv or red light it undertakes a ring-closing or opening transition of a carbon ring, respectively. This leads to a change of refractive index, which is used to shift the plasmonic resonance of V-shaped nanoslot antennas. Thus the phase of the emitted light of each antenna can be tuned and hence the focal length of the lens.

XDTE has the advantages, that it can be easily spin coated on a sample during fabrication and that it can undergo a large number of cycling transitions without degradation.

[1] He, Qiong, et al., AAAS Research Volume 2019, Article ID 1849272

O 33.4 Mon 18:15 P1C

Surface roughness in finite element meshes — •Fabian Loth[1,2], Thomas Kiel[1], Kurt Busch[1,2], and Philip Kristensen[1] — [1]Humboldt-Universität zu Berlin, Institut für Physik, Newtonstr. 15, 12489 Berlin — [2]Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin

Surface roughness at the nanoscale is of great importance in nanooptics since it can have a significant effect on the optical properties of photonic and plasmonic nanostructures. We present a practical approach for constructing meshes of general rough surfaces with given autocorrelation functions based on the unstructured meshes of the nominal smooth surfaces. The approach builds on a well-known method to construct correlated random numbers from white noise using a decomposition of the autocorrelation matrix [1]. The resulting mesh can be used in numerical methods, such as the discontinuous Galerkin time domain method [2], to compute the electromagnetic fields and derived physical observables such as scattering and absorption cross sections. Apart from nanooptics, the approach can be used in a broad range of numerical methods in various fields of science and engineering.

[1] H. Kaiser, K. Dickman, Psychometrika **27**(2), 179–182 (1962)
[2] K. Busch et al., Laser & Photonics Rev. **5**, 773 (2011)

O 33.5 Mon 18:15 P1C

THG imaging with nonlinear dielectric metalenses — •Christian Schlickriede[1], Sergey Kruk[2], Basudeb Sain[1], Yuri Kivshar[2], and Thomas Zentgraf[1] — [1]Universität Paderborn, Paderborn, Deutschland — [2]Australian National University, Canberra, Australien

In our approach we fabricate a new kind of nonlinear all-dielectric metalenses of sub-micrometre thickness, which are working in the nonlinear regime by third-harmonic frequency conversion for the incident near-infrared light. Therefore, we use wavefront control via the nonlinear Huygens principle emerging from the different nanopillar geometries. In the experiments, we determine the formation of the real and virtual focal planes for illumination with Gaussian beams and we demonstrate nonlinear imaging abilities that giving rise to real and virtual images of real objects at visible wavelengths. Most importantly, we found that the nonlinear image evolution is not governed by the conventional lens equation but by a modified version of it.

O 33.6 Mon 18:15 P1C

Investigating the coupling of plasmonic metasurfaces and WS_2 — •Florian Spreyer and Thomas Zentgraf — Paderborn University, Paderborn, Germany

Recent studies show great potential for transition metal dicholgenides (TMD) and their optical application. By downscaling TMD*s to a monolayer flake of atomical thickness, TMD*s become semiconductors with a direct band gap. These monolayer flakes can be used to fabricate hybrid metasurfaces combining plasmonic nanoantennas and a monolayer of TMD. Hybrid metasurfaces with TMD*s with a band gap in the visible regime show great potential for an enhanced light matter interaction for nonlinear applications. Here we, investigate the coupling between a metasurface made of plasmonic gold nanoantennas and a monolayer of tungsten disulfide (WS_2). By using photoluminescence and nonlinear measurements, we present recent results of the characterization of WS_2 flakes with plasmonic nanoantennas fabricated on top of monolayer WS_2 flakes.

O 33.7 Mon 18:15 P1C

Optical trapping by silicon based high numerical aperture metalenses — •Rene Geromel, Basudeb Sain, Christian Schlickriede, Michael Tiemann, and Thomas Zentgraf — Universität Paderborn, Paderborn, Deutschland

In this work, we present a high numerical aperture metalens that focuses near-infrared laser light to optically trap dissolved polystyrene microbeads with different diameters. To increase the numerical aperture of our metalenses, the silicon antennas are embedded in porous silicon dioxide. The porous coating also acts as a protective layer and allows us to place the metalens directly inside the particle solution. In order to achieve an appropriate numerical aperture, we use the concept of a geometric phase emerging from the configuration of rotated silicon meta-atoms. Depending on the incident circular polarization of light, the phase profile can be switched between convex and concave which makes this lens a suitable candidate for polarization dependent particle drag and drop. In the experiments, we investigate the trap stiffness and potential of the metalenses.

O 33.8 Mon 18:15 P1C

Large-scale optical programming of phase-change material metasurfaces — •Laric Bobzien, Andreas Hessler, Julian Hanss, Thomas Kalix, Matthias Wuttig, and Thomas Taubner — Institute of Physics (IA), RWTH Aachen

Metasurfaces have the ability to arbitrarily manipulate light with the help of subwavelength, periodically arranged, scatterers. Functionalities like beam steering, lensing and holography have been realized. However, once fabricated, metasurfaces remain passive, i.e. they have one fixed functionality. They can be rendered active and programmable by including active materials like phase-change materials (PCMs) [1] which have large optical contrast between their metastable crystalline and amorphous phases.

A home-built setup for optical switching of PCMs was prevously applied to great success for reversible switching of ultra-confined surface phonon polariton resonators [2], advanced optical programming of individual antennas in metallic metasurfaces [3] and all-dielectric Huygens' metasurfaces [4]. So far, this setup has however been limited to small-scale programming of 20x20 μm^2. Here, we present our work on re-designing the switching setup for larger-scale optical programming. In the future, we hope to apply the improved setup to realize advanced functionalities like switching between holographic images.

[1] M. Wuttig et al., *Nature Photonics* **11**, 465-476 (2017)
[2] P. Li et al., *Nature Materials* **15**, 870-875 (2016)
[3] A.-K. U. Michel et al., *Advanced Materials* **31**, 1901033 (2019)
[4] A. Leitis et al. *submitted to Advanced Functional Materials*

O 33.9 Mon 18:15 P1C

Revealing time resolved electron-electron interactions on the nanoscale with ultrafast electron microscopy — •Andreas Wöste[1], Germann Hergert[1], Jan Vogelsang[2], Dong Wang[3], Petra Gross[1], and Christoph Lienau[1] — [1]Universität Oldenburg — [2]Lund University — [3]TU Ilmenau

New spectroscopic methods providing high spatial and temporal resolution are needed to improve our understanding of the dynamics of electrons, nuclei and their spin excitations on the nanoscale. Recently ultrafast point-projection electron microscopy (UPEM) emerged as a promising approach. Here ultrashort electron wavepackets are photoemitted from a metal nanotaper by fs laser pulses. The time resolution of the laser pulses is preserved by an arbitrarily small emitter-sample distance that makes electron pulse broadening negligible. Measuring the complete electron momentum by spatially resolved time of flight detection allows mapping of the electron beam-sample interactions. Here we have employed UPEM for probing the photoemission of electrons from a gold nanoresonator with 30fs temporal and 25nm spatial resolution. We compare our experimental results with numerical simulations to reconstruct the trajectories and the contributing forces. We show how the Coulomb interactions between a single probe electron and photemitted electrons from the sample governs the time-dependent image contrast in UPEM. Our results suggest that UPEM can provide a direct measurement of the time-dependent local charge density, opening up highly interesting new perspectives for probing various types of light-induced charge-transfer processes in nanoystems.

O 33.10 Mon 18:15 P1C

Nonreciprical Polarization Encryption of Holographic Images by Plasmonic Metasurfaces — •Daniel Frese[1], Qunshuo Wei[2], Yongtian Wang[2], Lingling Huang[2], and Thomas Zentgraf[1] — [1]Paderborn University, Warburger Str. 100, 33098 Paderborn, Germany — [2]Beijing Institute of Technology, 100081, Beijing, China

Metasurfaces provide high flexibility in tailoring optical wavefronts within subwavelength dimensions. However, two-dimensional metasurfaces consisting of nanostructures exhibit only weak spatial asymmetry perpendicular to the surface. Hence, the transmission properties are the same if one illuminates the metasurface from the front or the backside. To realize asymmetric transmission properties, we designed and fabricated a metasurface hologram consisting of two stacked layers of plasmonic meta-atom arrays, which allows full spatial phase and amplitude control of the transmitted light. The pixel-by-pixel encoded Fourier-hologram appears in a particular linear cross-polarization channel and disappears if one flips the sample around, illuminating the metasurface from the backside. This concept opens up new possibilities in information processing, designing security features, as well as nonreciprocal polarization optics.

O 33.11 Mon 18:15 P1C

Switchable plasmonic metasurfaces using the polymer PEDOT — •Juliane Ratzsch, Tobias Pohl, Andy Steinmann, Florian Sterl, Jinglin Fu, Mario Hentschel, and Harald Giessen — 4th Physics Institute, University of Stuttgart, Germany

Metasurfaces offer a wide range of interesting applications, such as metalenses, beam steering, and holograms. We have realized an electrochemically switchable metasurface, using plasmonic gold nanoantennas covered with the polymer PEDOT.

PEDOT changes its refractive index upon oxidation and reduction, and thus shifts the resonance of the nanoantenna array. This is achieved by applying small voltages in the range of -1V to 1V, and is reversible over many cycles. This enables us to switch on and off the desired functionality of the metasurface, which is designed to perform at a specific wavelength.

We have achieved a resonance shift of 130 nm, at switching times in the order of 10 seconds. This will enable us to apply this concept to a beam-steering metasurface, designed with the geometric phase approach, and thus realize an electrically switchable microscale beam-steering device.