HL 35: Focussed Session: Metasurfaces II

Organizers: Isabelle Staude and Carsten Ronning (U Jena)

Time: Thursday 9:30–10:45 Location: EW 201

HL 35.1 Thu 9:30 EW 201

Mie-resonant all-dielectric metasurfaces with tailored positional disorder — •Dennis Arslan[1], Aso Rahimzadegan[2], Stefan Fasold[1], Matthias Falkner[1], Carsten Rockstuhl[2], Thomas Pertsch[1], and Isabelle Staude[1] — [1]Friedrich Schiller University Jena, 07745 Jena, Germany — [2]Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany

Optical metasurfaces typically consist of subwavelength-sized scattering particles placed deterministically on top of a flat surface. The tuning of the metasurface's structural parameters allows for a fine control over the modulation of the wavefront, polarization, and spectrum of a given incident light field.

So far, most of the realized metasurfaces were based on a periodic arrangement of the scattering particles, as the introduction of disorder in the particle position, shape, or orientation inevitably leads to an increase of incoherent scattering and thus to a deterioration of the metasurface's optical properties. More recently, however, it was recognized that the controlled introduction of disorder can, for example, decrease unwanted anisotropy in the optical response and enhance the channel capacity of wavefront-shaping metasurfaces.

In this study, we investigate disordered silicon metasurfaces exhibiting electric and magnetic dipolar Mie-type resonances. We systematically investigate how the introduction of different types of positional disorder influences the phase and intensity transmitted by these metasurfaces, showing that disorder can serve as a new degree of freedom in the design of wavefront-shaping devices.

HL 35.2 Thu 9:45 EW 201

Multiphysics Simulation of Phase Change Material based Metasurfaces — •Sebastian Meyer and Dmitry N. Chigrin — Institute of Physics (IA) RWTH Aachen

Meta-surfaces, despite their small length scale, provide immense control over the phase, amplitude and direction of electromagnetic waves. Adding phase-change materials as an active medium promises high flexibility in designing meta-surfaces, which can be reversibly reconfigured in the post-production. Being able to accurately describe the phase change process at the individual meta-atom level is fundamental for understanding and improving functional meta-surface designs.

This presentation deals with the implementation of a self-consistent model combining electromagnetic, thermal and phase transition kinetics simulations. The model is applied to study an all-optically induced resonance shift in a perfect absorber meta-surface. The multiphysics simulations enable design optimisation leading to a significant improvement in the tunability range of the perfect absorber.

HL 35.3 Thu 10:00 EW 201

Control of the Ge(Si) quantum dot emission by Mie resonances in silicon nanostructures — •Viktoriia Rutckaia[1], Mihail Petrov[2], Alexey Novikov[3], Mikhail Shaleev[3], Frank Heyroth[4], and Joerg Schilling[1] — [1]Centre for Innovation Competence SiLi-nano, Martin-Luther-University Halle-Wittenberg, Halle (Saale), Germany — [2]Department of Nanophotonics and Metamaterials, ITMO University, St. Petersburg, Russia — [3]Institute for Physics of Microstructures of the Russian Academy of Sciences (IPM RAS), 603950 Nizhniy Novgorod, Russia — [4]Interdisciplinary center of material science, Martin-Luther-University Halle-Wittenberg, Halle (Saale), Germany

Light manipulation at the nanoscale can be achieved using all-dielectric resonant nanostructures. We show an active photonic system based on Ge(Si) quantum dots coupled to silicon nanodisks. We show that Mie resonances govern the enhancement of the photoluminescent signal from embedded quantum dots due to a good spatial overlap of the emitter position with the electric field of Mie modes. We identify the coupling mechanism, which allows for engineering the resonant Mie modes through the interaction of several nanodisks. In particular, the mode hybridization in a nanodisk trimer results in an up to 10-fold enhancement of the luminescent signal due to the excitation of resonant anti-symmetric magnetic and electric dipole modes. Results of the time-resolved measurements show the modification of the QD spontaneous emission rate governed by the Purcell effect in the Mie resonators.

HL 35.4 Thu 10:15 EW 201

Fundamental mode decomposition in a patch-wire metasurface stack — •Jan Sperrhake, Matthias Falkner, Stefan Fasold, and Thomas Pertsch — Friedrich-Schiller Universität Jena, Institute of Applied Physics, Abbe Center of Photonics, Albert-Einstein-Str. 6, 07745 Jena

A widely studied class of optical materials in modern photonics are artificially structured dielectric or metallic surfaces with geometric parameters in the subwavelength regime of impinging electromagnetic waves. If the optical far-field response of these so called metasurfaces is solely determined by their fundamental mode, they can be considered to be homogeneous in the sense of an effective medium. Then, it is furthermore possible to stack different kinds of metasurfaces and achieve a wide range of artificial optical properties.

In our contribution we demonstrate the decomposition of both amplitude and phase of a transmitted fundamental mode into leading transmissive and contributing interferometric parts. We will apply our approach to a fabricated metasurface stack comprised of a lower layer of gold nano-wires and an upper layer of gold nano-patches. Both are differently periodic such that the stacked layers form a super-cell structure. Usually, these have to be handled employing rigorous numerics albeit covering up some of the finer details of the underlying physics. Instead, we employ a faster semi-analytic algorithm that allows for a deeper analysis.

HL 35.5 Thu 10:30 EW 201

Towards macroscopic non-reciprocal light propagation by colloidal self-assembly of gain and loss nanoparticles — Max Schnepf[1,3], Fabian Gossler[1,3], Vaibhav Gupta[1,3], and •Tobias König[1,2,3] — [1]Leibniz-Institut für Polymerforschung Dresden e.V., Institute of Physical Chemistry and Polymer Physics — [2]Technische Universität Dresden, Physical Chemistry, Technische Universität Dresden — [3]Cluster of Excellence Centre for Advancing Electronics Dresden (cfaed), Technische Universität Dresden

For the next generation of optical computing, a novel and cost efficient approach is needed. This future development requires both tailored control over nanometer-sized building blocks on large area and a fundamental understanding of the strong as well as coherent coupling mechanisms. Currently, practical demonstrations are scarce, and are limited in terms of how many devices may be fabricated in parallel. To realize fabrication on a larger scale, a synergy between optical metamaterials and colloidal self-assembly will be leveraged. This requires, on the one hand, applying concepts from parity-time symmetry metamaterials and, on the other hand, using pre-existing gain and loss building blocks, which form an organized structure on large area by reducing their free energy [Nano Lett. 2014, 14, 6863.; Faraday Discuss. 2016, 191, 159.]. We discuss our recent achievements in finite-difference time-domain modelling, large area self-assembly of tailored building blocks as well as time and space resolved optical characterization to fabricate cost-efficient, programmable and up-scalable photonic diodes.