HL 54: Focus Session: Nanophotonic concepts and materials for energy harvesting - Plasmonics, transformation optics, upconversion, and beyond II

Continuation of the morning session 'Nanophotonic concepts and materials for energy harvesting - Plasmonics, transformation optics, upconversion, and beyond I'

Organization: Carsten Rockstuhl (KIT, Karlsruhe), Jan Christoph Goldschmidt (FhG ISE, Freiburg), Ralf Wehrspohn (MLU Halle), Uli Lemmer (KIT, Karlsruhe)

Time: Wednesday 15:00–16:30 Location: EW 201

Invited Talk HL 54.1 Wed 15:00 EW 201
Nanophotonic light harvesting concepts from the visible to the mid-infrared — •Stefan A Maier — Imperial College London, London, UK

Surface polariton modes facilitate the controlled focusing of electromagnetic energy from the far to the near field, overcoming the diffraction limit of optics. This talk will discuss new developments in this field, focusing firstly on surface plasmon polaritons based on metallic nanostructures. Here, transformation optics serves as a useful design tool and also as a powerful formalism to reveal the underlying physics of the light harvesting process. At mid-infrared frequencies, surface phonon polariton modes in polar dielectrics are preferable due to longer phonon lifetimes and hence less absorption-induced damping. Examples of light harvesting with silicon carbide and hexagonal boron nitride nanostructures will be presented in the second part of the talk, including the characterization of hyperbolicity in polar van der Waals crystals.

Invited Talk HL 54.2 Wed 15:30 EW 201
Material Design of Luminescent Glasses and Glass Ceramics for White-LED Applications — •Stefan Schweizer[1,2], Franziska Steudel[2], Sebastian Loos[1], Bernd Ahrens[1,2], Peter Nolte[2], and Florian Wagner[1] — [1]South Westphalia University of Applied Sciences, Lübecker Ring 2, 59494 Soest — [2]Fraunhofer Application Center for Inorganic Phosphors, Branch Lab of Fraunhofer Institute for Mechanics of Materials IWM, Lübecker Ring 2, 59494 Soest

The majority of white light emitting diodes (LED) is based on a blue light emitting diode with a yellow phosphor on top. The phosphor powder, which converts a part of the blue light from the LED into yellow light, is usually embedded in an organic polymer and directly coated onto the LED chip. Heat-induced degradation of the encapsulate, however, results in an efficiency decrease and colour temperature change. Luminescent glasses or glass ceramics might represent an interesting alternative due to their higher thermal and chemical stability. Here, rare-earth single- and double-doped glasses and glass ceramics are investigated for their potential as photon converters. Interestingly, the colour coordinate of the double-doped glass can be varied over a broad spectral range by changing the rare-earth doping ratio accordingly. In addition, double-doping allows for a change in the colour coordinate by using different excitation wavelengths.

HL 54.3 Wed 16:00 EW 201
Enhancing Upconversion with a Bragg Structure — •Clarissa Hofmann, Barbara Herter, Stefan Fischer, and Jan Christoph Goldschmidt — Fraunhofer Institute for Solar Energy Systems, Heidenhofstraße 2, 79110 Freiburg, Germany, Phone: +49 (0) 761 4588-5922 Fax: + 49 (0) 761 4588-9250

Abstract intented for focused session on Nanophotonic Concepts and Materials for Energy Harvesting - Plasmonics, Transformation Optics, Upconversion, and Beyond

Upconversion describes the generation of one higher energy photon out of at least two lower energy photons. This upconversion process can be influenced by the environment of a photonic crystal, by a modulated local density of photon states (LDOS) and an enhanced local irradiance. We present the theoretical analysis of the photonic effects of a Bragg structure on the upconversion process of the embedded upconverter β-NaYF_4:25%Er^{3+}. Considering the modulated LDOS in a rate equation model of the upconversion dynamics, we show that this effect increases the maximum possible upconversion quantum yield (UCQY) from 14% to 16% for an optimised Bragg stack design. Furthermore, due to a high irradiance enhancement, it is possible to find a Bragg stack design for each investigated incident irradiance (100 W/m^2 - 5000 W/m^2) that yields the maximum possible UCQY of 16%. At 200 W/m^2 this corresponds to a UCQY enhancement factor of 6, making the Bragg stack a very effective photonic structure for increasing the UCQY, especially in the low irradiance range.

HL 54.4 Wed 16:15 EW 201
Metamaterial concepts for energy harvesting applications — •Carsten Rockstuhl[1,2], Aimi Abass[2], Stephan Fahr[3] und Samuel Wiesendanger[3] — [1]Institute of Theoretical Solid State Physics, Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany — [2]Institute of Nanotechnology, Karlsruhe Institute of Technology (KIT), 76021 Karlsruhe, Germany — [3]Institute of Condensed Matter Theory and Solid State Optics, Abbe Center of Photonics, Friedrich-Schiller-Universität Jena, 07743 Jena, Germany

Metamaterials provide us unprecedented means to control the propagation of light and to tailor its interaction with matter. The latter aspect is specifically rewarding in the context of energy harvesting applications such as solar cells. There, a referential example that would particularly benefit from a better optical performance is a thin-film solar cell, where the light absorption in a thin layer across an extended spectral domain is poor and enhancing it is a well defined problem. In such situation, metamaterials may provide opportunities for new concepts that can contribute to the solution of this problem. Here, we present our latest results along these lines and show how metamaterial concepts can be used to enhance absorption in solar cells. This concerns the absorption enhancement in solar cells employing Fabry-Perot resonances that are made to be spectrally broad using complementary materials and the use of metamaterial devices perceived in the context of transformation optics for a similar purpose.