DS 20: Focussed Session: Frontiers in Exploring and Applying Plasmonic Systems II (Joint Session of CPP, DS, HL, MM, and O, organized by DS)

With the increasing importance of plasmonics and the variety of its number of applications it becomes obvious that experimental characterization beyond the far-field optical standard methods and also theoretical tools that access the plasmonic behaviour on the atomic scale are indispensable for further development and improvement of the basic knowledge and thus, for new kinds of applications. The "Focused Session" gathers experts for unusual experimental methods (near-field studies with SNOM and EEL-TEM) and for the theoretical exploration of quantum effects in plasmonic excitations. Furthermore, new kinds of plasmonic applications (devices exploiting phase changes, alternative displays and holograms) will be introduced.

Organizers: Laura NaLiu (U Heidelberg) and Annemarie Pucci (U Heidelberg)

Time: Tuesday 9:30–12:45 Location: CHE 89

Topical Talk DS 20.1 Tue 9:30 CHE 89

Driving nanophotonics to the atomic scale — •Javier Aizpurua — Center for Materials Physics (CSIC-UPV/EHU) and DIPC, San Sebastian, Spain

Plasmonic nanogaps are formed at the junction of two metallic interfaces and provide a great opportunity to explore atomic-scale morphologies and complex photochemical processes by optically monitoring the excitation of their intense surface plasmonic modes. In recent years, optical spectroscopy of these cavities has proven to be extremely sensitive to atomic-scale features that determine the chemistry and the optoelectronics in the gaps. In this regime, classical theories often fail to address the fine details of the optical response, and more sophisticated quantum models based on condensed matter theory techniques are needed. Additionally, theoretical approaches based on quantum electrodynamics (QED) can be properly developed to address the complex coupling of subnanometric optical cavities with electronic and vibrational states of molecules nearby. A few experimental situations in optoelectronics, molecular spectroscopy and optomechanics, where optics is proven to address the atomic scale and thus quantum effects are shown to be of paramount importance, will be described.

Topical Talk DS 20.2 Tue 10:00 CHE 89

Transverse and Longitudinal Resonances in Plasmonic Gold Tapers — Surong Guo[1], Nahid Talebi[1], Wilfried Sigle[1], Ralf Vogelgesang[2], Gunther Richter[3], Martin Esmann[2], Simon F. Becker[2], Christoph Lienau[2], and •Peter A. van Aken[1] — [1]Max Planck Institute for Solid State Research, Stuttgart, Germany — [2]Carl von Ossietzky University of Oldenburg, Oldenburg, Germany — [3]Max Planck Institute for Intelligent Systems, Stuttgart, Germany

Conically-shaped metallic tapers are one of the most common structures with concomitant capabilities of nanofocusing and field enhancement. We distinguish two different dynamic mechanisms, reflection and phase matching, of surface plasmons excited by relativistic electrons in three-dimensional gold tapers with various opening angles from 5° to 47° which are studied both experimentally and theoretically, by means of electron energy-loss spectroscopy and finite-difference time-domain numerical calculations, respectively. We observe distinct resonances along the taper shaft independent of opening angles. We show that the origin of these resonances is different at different opening angles and results from a competition between two coexisting mechanisms. For large opening angles ($> 20°$), phase matching between the electron field and that of higher-order angular momentum modes is the dominant contribution because of the increasing interaction length between electron and the taper near-field. In contrast, reflection from the taper apex dominates at small opening angles ($< 10°$). A gradual transition of these two mechanisms is observed for intermediate opening angles.

Topical Talk DS 20.3 Tue 10:30 CHE 89

Nanoimaging and control of polaritons in 2D materials — •Rainer Hillenbrand — CIC nanoGUNE, San Sebastian, Spain

A promising solution for active control of light on the nanometer scale are plasmons in graphene, which offer ultra-short wavelengths, long lifetimes, strong field confinement, and tuning possibilities by electrical gating. Here, we discuss scattering-type scanning near-field optical microscopy (s-SNOM) for real-space imaging of graphene plasmons [1-3] in nanoresonators [4] and hBN-graphene heterostructures [5]. We also introduce THz near-field photocurrent nanoscopy and discuss its application for imaging acoustic graphene plasmons in a graphene-based THz detector [6]. Further, we discuss ultraslow hyperbolic volume and surface phonon polaritons in boron nitride flakes [7,8].

[1] J. Chen et al., Nature, 487, 77 (2012) [2] Z. Fei et al., Nature 487, 82 (2012) [3] P. Alonso-González et al., Science 344, 1369 (2014) [4] A. Y. Nikitin et al., Nat. Photon. 10, 239 (2016) [4] A. Woessner et al., Nat. Mater. 14, 421 (2015) [6] P. Alonso-González et al., Nat. Nanotechnol. DOI: 10.1038/nnano.2016.185 [7] E. Yoxall et al., Nat. Photon. 9, 674 (2015) [8] P. Li et al, Nano Lett. DOI: 10.1021/acs.nanolett.6b03920

15 min. break.

Topical Talk DS 20.4 Tue 11:15 CHE 89

Switchable infrared nanophotonic elements enabled by phase-change materials — •Thomas Taubner — Institute of Physics (IA), RWTH Aachen University

The strong confinement and enhancement of light when coupled to surface waves or nanoparticles is key for various applications in nanophotonics such as sensing, imaging or the manipulation of light fields. In the mid-infrared spectral range, metallic nanoantennas and materials supporting surface phonon polaritons (SPhPs) can be used as building blocks of such devices. Often, their optical functionality is only obtained at a fixed wavelength, determined by the geometric design and the material properties.

By using phase-change materials (PCMs) as tunable environment for nanophotonic resonators, their resonance frequency can be altered in a non-volatile, reversible way. PCMs offer a huge change in refractive index due to a phase transition from their amorphous to crystalline state, which can be thermally, optically or electrically triggered. We present results on thermal and optical switching, as well as addressing of individual IR resonances of both systems, metallic nanoantennas and resonators for SPhPs. SPhPs on polar dielectrics exhibit lower losses and larger Q-values compared to metallic nanoantennas, and their confinement can be even increased by adding ultrathin, switchable PCM layers. We show the all-optical, non-volatile, and reversible switching of the SPhPs by controlling the structural phase of the PCM [1], opening the door for re-configurable metasurfaces.

[1] P. Li et al., Nat. Mat. 15, 870 (2016).

Topical Talk DS 20.5 Tue 11:45 CHE 89

Nonlocal response in plasmonic nanoparticles: How much quantum? — •N. Asger Mortensen — Technical University of Denmark

Plasmonics is commonly explored and interpreted within the framework of classical electrodynamics. On the other hand, with the increasing ability to explore plasmonics in nanostructures with yet smaller characteristic dimensions, intrinsic length scales of the electron gas are anticipated to manifest in a nonlocal plasmonic response and other quantum corrections to the light-matter interactions. In nanoparticles, nonlocal response promotes frequency blueshifts and nonlocal damping of high-order modes, as has been observed in single-particle EELS. As to the quantum mechanical origin of these effects, one can quantify the degree of nonclassical effects from an energy perspective. This provides a direct link between the experimentally observed resonance blueshift and the fraction of electromagnetic energy attributed to quantum degrees of freedom.

Topical Talk DS 20.6 Tue 12:15 CHE 89

Short-range plasmonics — •Harald Giessen — University of Stuttgart, Stuttgart, Germany

Short-range plasmons with extreme light compression down to 60 nm with light wavelength of 800 nm are demonstrated. Also, the formation of orbital angular momentum of plasmons with subfemtosecond resolution is studied.