O 72: Poster Plasmonics and Nanooptics: Light-Matter Interaction, Spectroscopy

Time: Wednesday 18:00–20:00 Location: P2

O 72.1 Wed 18:00 P2

Implementation of a fiber-based cathodoluminescence detector system for a scanning electron microscope — •Filip Majstorovic[1], Paul H. Bittorf[1], and Nahid Talebi[1,2] — [1]Institute for Experimental and Applied Physics, Kiel University, Leibnizstraße 19, D-24118 Kiel, Germany — [2]Kiel Nano, Surface and Interface Science KiNSIS, Kiel University, Christian-Albrechts-Platz 4, D-24118 Kiel, Germany

Cathodoluminescence (CL) is the light emitted from materials irradiated with the electron beam, within the infrared to ultraviolet spectral range. CL recently has gained a major interest in analyzing quantum materials and emitters, thanks to its high spatial and temporal resolutions. In our study, inside a scanning electron microscope (SEM) high energy and broad bandwidth electron beams are generated. The CL emission is then collected with a detector, consisting of a multimode fiber attached to piezo stages, which allows for nanometer precision movement of the fiber near the sample. We present the variety of possible measurements such a system allows. One component of this is obtaining the spectrum of the emitted light, that for example enables the investigation of plasmonic resonances. Further this detector system provides a way to measure the emission profile by scanning the fiber three-dimensionally along the sample. Such emission profiles give information about the processes responsible for this radiation and show if coherent or incoherent CL are more dominant. Moreover, higher-order correlations unravel a superbunching effect in CL generated from semiconducting samples.

O 72.2 Wed 18:00 P2

Comprehensive Probing of Electron and Phonon Systems by Raman Scattering — •Jan Kutschera[1], Marc Herzog[1], Wouter Koopman[1], Felix Stete[1], and Matias Bargheer[1,2] — [1]Institut für Physik & Astronomie, Universität Potsdam, Potsdam, Deutschland — [2]Helmholtz Zentrum Berlin, Berlin, Deutschland

Inelastic processes in light-matter interactions are crucial for understanding energy transport within solid-state materials, where energy is distributed between electron and phonon systems. Investigating these interactions provides deeper insights into fundamental processes relevant to plasmonics, optoelectronics, and optoacoustics. However, knowledge about the energy transfer dynamics within each system is also essential for a complete picture. By extending Raman spectroscopy to ultrashort timescales, we aim at analyzing the transient population dynamics of phonon modes and the interplay of different electronic bands to ultimately establish ultrafast Raman Spectroscopy which directly probes electron-electron, electron-phonon, and phonon-phonon interactions. Here, we present an intraband emission of the conduction band electrons in gold nanoparticles, which is excited by interband absorption and appears as a continuous background in static Raman experiments. Pump-probe experiments can help further examine the origin of this emission and the interaction of different electronic subsystems. Moreover, we investigate the phonon modes of HfN and other materials as potential candidates for the catalysis of light-driven reactions.

O 72.3 Wed 18:00 P2

Adiabatic focusing of propagating Surface plasmon polaritons at gold nanotriangles — •Gregor Stockmann, Felix Stete, and Matias Bargheer — Institut für Physik und Astronomie, Universität Potsdam, Deutschland

Surface plasmon polaritons (SPPs) are the collective oscillations of surface-near charges at a dielectric-metallic interface. Due to the Coulomb force, these oscillations can propagate along the surface. This effect can be utilized to spatially separate the laser excitation and a chemical reaction site. In this work, we use gold nano-triangles, to focus SPPs from a μm-sized excitation spot to the tip at the nanometer scale. We investigate the influence of different parameters on the propagation behavior of SPPs. Key parameters are the particle dimensions, excitation wavelength and the light polarisation.

O 72.4 Wed 18:00 P2

Plasmon assisted catalysis of Ferricyanide by Gold-Nanoparticles with different sizes and light intensities. — •Kyra Peikert, Wouter Koopman, and Matias Bargheer — Institut für Astronomie und Physik Universität Potsdam, Potsdam, Deutschland

In recent years plasmonic catalysis emerged as promising new field in photocatalysis. However, to improve its efficiency, a better understanding of its governing principles is required. In this study we investigate the reaction kinetics of the light driven reduction of ferricyanide catalyzed by gold nanoparticles of different sizes. To refill the holes generated by electron transfer to ferricyanide the hole scavenger Ethanol (EtOH) is added to the solution. We compare this situation to reactions in a purely aqueous solution. The kinetics under different light intensities including dark conditions help to understand the mechanisms. The results show indications of a charging effect of the particles due to the presence of the hole scavenger, which speeds up the reaction rate.

O 72.5 Wed 18:00 P2

Single particle sample with gold nanorods for micro-spectroscopy — •Alexandra Faber — Institut für Physik und Astronomie, Universität Potsdam, Deutschland

Nobel metal nanostructures show great potential for photocatalytical applications due to their broadband plasmonic absorption across the visible spectrum. Chemical reactions taking place at surfaces can be accelerated by several effects, including charge transfer and local heating. As one important factor, the accumulation of charges on the particle during a reaction process, is expected to have a large influence on the charge transfer process. In order to better understand the effects of photocharging of gold nanorods (GNR), possible electron transfer between individual GNRs and the substrate, single nanoparticles are studied by optical micro-spectroscopy. The samples are investigated by dark-field as well as scanning electron microscopy and must therefore fulfill different requirements. This includes that the sample must provide the necessary criteria such as conductivity and light transmission in order to be observed with both microscopy methods. At the same time, it should be possible to rediscover individual GNRs and the distance between the particles has to be large enough to allow spectroscopy of individual GNRs. We show the development and improvement of the sample preparation procedure as well as first recorded dark-field scattering spectra and fluorescence spectra of single GNRs.

O 72.6 Wed 18:00 P2

Size effects on the plasmon resonance in silver cluster anions studied by energy-resolved photoemission — •Norman Iwe[1], Klara Raspe[1], Franklin Martinez[1], Lutz Schweikhard[2], Karl-Heinz Meiwes-Broer[1,3], and Josef Tiggesbäumker[1,3] — [1]Institute of Physics, University of Rostock, Germany — [2]Institute of Physics, University of Greifswald, Germany — [3]Department of Life, Light and Matter, University of Rostock, Germany

Numerous applications ranging from efficient solar cells to cancer treatment profit from the interaction between nanoparticles and light. In the case of metal clusters, one often takes advantage of collective resonances of the valence electrons, which lead to a strong increase of the cross section at a certain wavelength. Previous studies already showed, that the resonance energy can be tuned via size and charge state of the nanoparticles. However, systematic measurements to explore the development of the plasmonic resonance in free metal clusters so far concentrate on small sizes.

We conduct photoelectron spectroscopy on anionic silver clusters Ag_N^- in a size range $N = 7 - 300$. By extracting photodetachment cross sections, we gain insights into the collective resonances. At $N = 55$, we observe a transition from a blueshift to a general redshift of the plasmon energies with decreasing cluster size. However, the resonance energies for sizes below N = 55 are oscillating whereby the maxima are found at known electronic shell closures. On top, a splitting of the resonance is observed at a few smaller cluster sizes, hinting on a deformation of the particle.

O 72.7 Wed 18:00 P2

Anisotropic photoelectron emission from individual Ag nanoparticles on silicon — •Waqas Pervez[1,2], Kevin Oldenburg[1,2], Sylvia Speller[1,2], and Ingo Barke[1,2] — [1]Institute of Physics, University of Rostock, Germany — [2]Department of Life, Light & Matter, University of Rostock, Germany

Laser excitation of localised plasmons in nanoparticles can give rise to a vastly enhanced photoemission yield [1, 2]. Here we study detailed characteristics of the photoelectron emission process of size-selected nanoparticles with diameters around 10 nm, deposited from the gas phase onto silicon. To this end we employ femtosecond laser excitation with wavelengths around 800 nm and 400 nm, respectively, in a photoemission electron microscope (PEEM). The spatially resolved electron yield is investigated as a function of laser wavelength and polarisation. Furthermore, we report on photoelectron emission from individual, supported nanoparticles in reciprocal space. Upon resonant plasmon excitation we observe anisotropic electron yield that depends on the laser polarisation. The observed photon order, ranging from 2PPE to 5PPE, and the underlying excitation and emission mechanisms are discussed in view of the local near field distribution and the effect of the substrate.

[1] M. Rohmer et al., Phys. Stat. Solidi B 247, 1132 (2010)
[2] K. Oldenburg et al., J. Phys. Chem. C 123, 1379 (2019)

O 72.8 Wed 18:00 P2

Near-field Fano spectroscopy of MaPbI3 nanoparticles — Jinxin Zhan[1], Tom Jehle[1], Sven Stephan[1], •Sam Nochowitz[1], Ekaterina Tiguntseva[2], Sergey Makarov[2], Juanmei Duan[1], Petra Gross[1], and Christoph Lienau[1] — [1]Universität Oldenburg, D-26129, Germany — [2]St. Petersburg, Russia

Semiconducting halide perovskite nanoparticles support Mie-type resonances that confine light on the nanoscale in localized modes with well-defined spatial field profiles yet unknown near-field dynamics. We introduce an interferometric scattering-type near-field microscopy technique [1] to probe the local electric field dynamics at the surface of a single MAPbI3 nanoparticle [2]. The amplitude and phase of the coherent light scattering from such modes are probed in a broad spectral range and with high spatial resolution. In the spectral domain, we uncover a Fano resonance with a 2π phase jump. In the near-field dynamics, this Fano resonance gives rise to a destructive interference dip after a few femtoseconds. Mie theory suggests that the interference between electric quadrupole and magnetic dipole modes of the particle, with spectra affected by resonant interband absorption of MAPbI3, lies at the origin of this effect [3]. Our results open up a new approach for probing local near-field dynamics of single nanoparticles. [1] Zhan, J., et al. Advanced Photonics 2020, 2 (04) [2] J. Zhan et al., Nano Lett. 2024 [3] Tiguntseva, E. Y., et al. Nano Lett. 2018, 18 (2), 1185-1190.

O 72.9 Wed 18:00 P2

Energy and momentum distribution of surface plasmon-induced hot carriers — •Ellen Brennfleck[1], Christopher Weiss[1], Jannis Lessmeister[1], Tobias Eul[2], Benjamin Stadtmüller[3], and Martin Aeschlimann[1] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern-Landau, Germany — [2]Institute of Experimental and Applied Physics, University of Kiel, Germany — [3]Institute of Physics, University of Augsburg, Germany

Are the spectroscopic properties of plasmon- and photon-induced carriers fundamentally different? This question is crucial for advancing plasmonic energy conversion. Initial studies have suggested characteristic energy and momentum distributions for the photoemission of both bulk plasmon resonances and surface plasmons. For surface plasmons, however, the separation of plasmon and photon-induced emission patterns by their inherent spatial and dynamics remains challenging [1].

To further characterize the electron emission pattern of surface plasmons, we combine a femtosecond laser system with a spatial light modulator to generate a vector vortex beam to excite surface plasmon polaritons at an annular structure. Our photoemission electron microscope enables us to compare the spectroscopic properties of photoemitted electrons and those generated by plasmonic emission at the center of the structure, providing valuable insights into the distinct emission mechanisms.

[1] Hartelt et al., ACS Nano 15, 12 (2021), 19559–19569

O 72.10 Wed 18:00 P2

Self-organized plasmonic particles configurations in front of mirror — •Aleksei Overchenko and Frank Cichos — Leipzig University, Peter Debye Institute for Soft Matter Physics, Linnéstr. 5, 04103 Leipzig

Plasmonic particles and their field enhancement properties found wide applications in various fields. For example, they are used in Surface-Enhanced Raman Spectroscopy (SERS), plasmon-enhanced fluorescence, Photothermal Therapy and energy conversion. Field enhancement can be achieved by bringing two spheres into close proximity, placing a sphere on a mirror, fabricating bowtie antennas, or designing hybrid structures like particle-dielectric-mirror systems. In most cases, surface functionalization often requires complicated modification methods such as lithography and chemical binding, e.g., of DNA origami which leads to complicated and non-reconfigurable systems. Here, we deliberately manipulate induvial as well as multiple gold particles in front of a gold mirror by local laser-induced temperature fields generating thermo-osmotic flow. Multiple particle trapping is performed by focused laser that can divide in multiple independent beams via AOD. We characterize the resulting single, dimeric and higher order clusters, their plasmonic coupling and the coupling of the particles to a thin gold film by scattering spectroscopy. The distance between the film and particles is around 10 nm due to the second minimum of the DLVO-theory. Enhancement is described by sensing of biomolecules. The system is reconfigurable as no binding is required and analytes may be bound to the film to enable spatially resolved SERS.

O 72.11 Wed 18:00 P2

Optical resonance tuning of micro- and nanoparticles with phase change materials in the near-infrared and visible range — •Rebecca Rahmel, Hristiyana Kyoseva, Jonathan Müller, Lukas Conrads, Thomas Taubner, and Gero von Plessen — I. Institute of Physics (IA), RWTH Aachen University

Micro- and nanoparticles with scattering and absorption resonances promise interesting optical behaviour. These resonances are highly sensitive to the particle size, shape, and configuration, as well as the dielectric properties of both particle and surrounding medium [1]. Phase-change materials (PCMs) show high optical contrast when switched between their amorphous and crystalline phases [2], facilitating antenna resonance tuning based on a change in refractive index [3]. The novel plasmonic PCM In_3SbTe_2 (IST) can be locally optically switched between the dielectric amorphous and the metallic (in the infrared) crystalline phase, enabling a sign change in permittivity [4]. While antenna resonance tuning with PCMs has been studied extensively, locally addressing PCMs below single particles has not been demonstrated yet. Here, we investigate the optical response of single polysterene micro- and gold nanoparticles placed on thin films of IST and other PCMs and locally switch the PCMs to tune the particle resonances. Our work paves the way towards mode selection of nanoparticles beneficial for tuning of emitters and sensing applications.

[1] Dahmen et al. *Aust. J. Chem.* **60**, 447-456 (2007) [2] Wuttig et al. *Nature Photon* **11**, 465-476 (2017) [3] Michel et al. *Adv. Mater.* **31**, 1901033 (2019) [4] Heßler et al. *Nat. Com.* **12**, 924 (2021)

O 72.12 Wed 18:00 P2

Analytical Theory of the Optical Inter- and Intraband Response in Noble Metals — •Robert Lemke, Andreas Knorr, and Jonas Grumm — Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Berlin, Germany

The optical response of plasmonic noble metal nanostructures can be attributed to the interplay of electronic intra- and interband processes described by coupled Boltzmann-Bloch equations. In this set of coupled equations, the specific properties of the noble metal are addressed by an anisotropic electronic dispersion relation expanded in the vicinities of the X and L high symmetry points.

In order to address the dephasing of the inter- and intraband polarizations we consider near equilibrium electron-phonon scattering rates in random phase approximation to estimate relaxation timescales. Our approach allows to connect spectroscopic signatures directly to microscopic processes, not possible with simple Drude-Lorentz models.

O 72.13 Wed 18:00 P2

Kinetics of hydrogen molecules on Ag(111) by tip-enhanced Raman spectroscopy — Shuyi Liu[1,2], Jun Yoshinobu[3], Martin Wolf[1], Takashi Kumagai[4], and •Akitoshi Shiotari[1] — [1]Fritz-Haber Institute of the Max-Planck Society, Berlin, Germany — [2]Huazhong University of Science and Technology, Wuhan, China — [3]University of Tokyo, Kashiwa, Japan — [4]Institute for Molecular Science, Okazaki, Japan

Surface diffusion is the first step for adsorbates to undergo characteristic chemical and physical phenomena such as self-assembly, catalytic reactions, and low-dimensional molecular transport. However, the characterization of highly diffusive molecules, such as physisorbed molecules, has been challenging even with scanning tunneling microscopy and its related techniques. In this study, we use tip-enhanced

Raman spectroscopy (TERS) to sensitively detect hydrogen molecules physisorbed on Ag(111) at low temperatures around 10 K. Strong Raman peaks were observed only when the diffusive molecule entered the plasmonic tip-sample junction, while the peaks decayed by thermal desorption at higher temperatures. By monitoring the peak intensities and investigating its temperature dependence, we successfully analyzed the kinetics of hydrogen molecules on the surface. This demonstrates that TERS is useful for evaluating the dynamics of diffusive molecules.