Hybrid Inorganic/Organic Systems for Opto-Electronics

Collaborative Research Centre 951

Colloquium Announcement

of the Collaborative Research Centre 951
"Hybrid Inorganic/Organic Systems for Opto-Electronics"

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Ultrafast electron spectroscopy and microscopy using sharply etched gold nanotips

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Hybrid colloidal materials based on plasmonic nanoparticles

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Place: Erwin-Schrödinger-Zentrum, Rudower Chaussee 26, Room 0'119.

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Ultrafast electron spectroscopy and microscopy using sharply etched gold nanotips

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Directly observing the electron dynamics, e.g., in artificial solar cell materials or metal or hybrid nanostructures, is an open challenge of ultrafast science. Optical technologies provide femtosecond time resolution, and electron microscopes enable microscopy with atomic resolution. Ultrahigh combined spatio-temporal resolution, however, is currently still limited. Here we bridge the gap by merging ultrafast nanoplasmonics and electron point-projection microscopy.

We employ sharply etched metal nanotips, which have recently come into focus as potential sources of highly confined electron wavepackets of short temporal duration and high spatial directivity. Specifically the strong-field regime, where electron emission by tunneling becomes dominant over multi-photon and above-threshold ionization, enables the generation of (sub)-femtosecond electron wavepackets. A key aspect for their use as electron emitter in an ultrafast electron microscope is their ability to support surface plasmon polaritons and to transform propagating, far-field light into a non-propagating, strongly localized plasmon mode. In this talk I will illustrate the unique properties of gold nanotapers as plasmonic electron emitters, and I will show how they can be applied in a point-projection setup to perform ultrafast electron microscopy. I will present a first demonstration, where we have directly observed the motion of electrons that are photo-released from a nanoantenna on a few-tens-of-femtosecond time scale and with a few-tens-of-nanometers spatial resolution.

Hybrid colloidal materials based on plasmonic nanoparticles

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Plasmonics has become one of the most active fields in nanophotonics. In the last several years, there has been a rapid increasing activity within this field as its wide application field ranging from sensing and biomedicine to imaging and information technology.

During our research work, Au and Ag nanocrystals with defined size and shape have been fabricated by the simple wet-chemical method. Hybrid structures based on metal nanoparticles with tuneable surface plasmon absorption band can be fabricated by this approach. For example, deposition of Ag on the Au nanorod (NR) surface leads to a blue shift in the longitudinal surface plasmon absorption band of Au. After covering these metal nanoparticles with a homogeneous SiO_2 layer, organic dye molecules will be immobilized inside to form the metal core/conjugated organic shell hybrid structure. On the single particle level, dark field microscopy was finally employed by collaboration with the group of Prof. Benson. This introduces a route towards revealing the relation between structure, shape, and optical (plasmonic) properties of complex composite metal particles. In addition, various approaches have been designed to spatially and spectrally correlate a high amount of dye molecules to a single gold nanoparticle. These hybrid structures have been optically pumped to achieve spasing. However, no spasing could be observed despite various approaches. Comparison with a theory showed that such metal nanostructures need unrealistic high gain to overcome the inherent losses and achieve spasing.

Based on these results, we are now focusing on the analysis and demarcation of collective coherent effects in active organic/plasmonic hybrid nano-structures. For this purpose, silver nanowires with controllable length (1 - 4 μm) and diameter (30-100 nm) have been successfully synthesized. The silver nanowires obtained can be further coated with a silica shell embedded with certain amount of dye molecules. The optical properties of the silica-coated silver nanowires with incorporated dye molecules have been investigated by dark field spectroscopy which is combined with atomic force microscopy and fluorescence studies with a confocal microscope on the same individual particles.