Molecular Plasmonics 2011

19.-21. May 2011, IPHT Jena (Germany)

Summary

Plasmonic effects based on localized (or particle) surface plasmon resonance (LSPR) and directed towards molecules and molecular conjugates represent an emerging field between nanooptics and life sciences with a great potential for applications especially in diagnostics and therapy. This years meeting – in a series of similar symposia aiming at recent developments in molecular plasmonics bi-annually since 2005 (cf. www.ipht-jena.de/dna.html) - was focused on recent developments in this field. This includes e.g. phenomenon occurring at molecular components due to local field enhancement effects, interactions with fluorescent dyes, sub-wavelength apertures, synthesis pathways to controlled spectroscopic properties based on size/geometry/composition as well as comparisons of simulations with experimental results.

Description of the scientific content and discussion

The meeting started with a session about a key technology used today by various groups in order visualize individual particles, and – beyond this plain visualization - to access and study the LSPR at the level of single particle. This technology was invented as Ultramikroskop about hundred years ago in Jena at the Zeiss company, and the same principle is still used today in commercial setups in order to visualize sub-wavelength metal nanoparticles. In the first session, the Ultramikroskop in its historical setup was discussed by T. Mappes (KIT) including the demonstration of a historical microscope more than 80 years old. Other talks described structured illumination and its application in modern high-resolution microscope development (Heintzmann group, Jena), the evolution of the plethora of recent high-resolution approaches (E. Stelzer, Frankfurt), and the application of ultramicroscopic technology in neuroimaging (U. Dodt, Wien). In the break, the historical instrument could be inspected, as well as the Optical Museum.

The next session dealt with visualization of plasmons as well as the application of plasmonic excitation for sensorics. In order to visualize the plasmons, a kind of imprinting approach was chosen (C. Deeb, Troyes). A

polymer which polymerizes under light exposure is used with a laser light exposure which is below the polymerization threshold. At nanostructures, field enhancement is observed, which overcomes locally the threshold resulting in polymerization just in these regions. After washing away the liquid polymer, the regions of enhanced electromagnetic field are clearly visible. The other talks in this session were directed towards bioanalytical applications: J. Homola (Prague) gave an introduction and overview about methods using plasmon resonance. P. Englebienne (Pharmadiagnostics) reflected the development in the field and defined future tasks. I. Willner (Jerusalem) devised again novel approaches in order to detect analytes based on spectroscopic readout with even higher sensitivity. The session was closed by a talk by Y.F. Chau (Taipeh) describing hot spots for photocatalysts based on plasmonic principles.

The next session extended the sensoric applications of plasmonic effects in the talk of O. Stranik (Jena). Both single particle spectroscopy approaches as well as sub-wavelength holes in chromium metal layers were utilized in order to yield bioanalytical signals. J. Lakowicz (Baltimore) described the technique of plasmon controlled fluorescence and its implications for bioanalytics. D. Gerard (Troyes) talked about the application of hybrid plasmonic nanoantennas for biochemical detection. The combination with propagating surface plasmons was presented in the talk by K. Lesson (Reykjavik), R. Grange (Jena) demonstrated how nonlinear optical effects can be utilized for novel cell labels.

Metal particles are expected to play an important role for surface enhanced spectroscopy, such as for Raman (SERS). A central question in using plasmonic nanoparticles is the distribution in optical properties. In order to minimize variations, a tailoring is possible, e.g. by laser light as reported by F. Hubenthal (Kassel). Another option are lithographic particles as presented by L. de la Chapelle (Paris). V. Joseph (Berlin) reported the development and characterization of novel planar SERS sensors. P.-M. Adam (Troyes) presented results in surface enhanced spectroscopy, and explained the ties between SERS and metal enhanced fluorescence.

Although molecular linkers for plasmonic particles are known, A. Kotlyar (Tel Aviv) presented results using a novel DNA superstructure (G4-DNA) which exhibits a much higher stability, and which was used to realize highly defined particle-dimers.

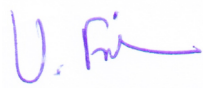
Photothermal effects induced by plasmonic excitation of particles by laser light represent a hot topic in the field. D. Hahn (Marburg) demonstrated the light-triggered heating of polyelectrolyte films using embedded metal nanoparticles in order to realized a remote release of molecules. V. Pustovalov (Minsk) showed a comparative analysis of the optical properties of plasmonic particles and the implications for applications. M. Dinah (Toulouse) presented a theoretical study of SPR in small clusters.

The interaction between fluorescence and nanoparticles was the subject of the concluding session. J. Wenger (Marseille) described the enhanced and directional emission from molecules in a nanoaperture. S. Tanaka (Osaka)

introduced platinum nanoclusters which are fluorescent. Finally, A. Chipouline (Jena) explained metamaterials and their connection to plasmonics.

Assessment of the results and impact of the event on the future direction of the field

Molecular Plasmonics, the field combining the effect of localized surface plasmon resonance with the molecular world, represents a hot field which is still growing fast. As the symposium showed, SERS and fluorescence are the two emerging fields in this area. Bioanalytical applications are certainly the most probable (and fastest) possibility to commercialize the studied effects. Therefore, detection and highly defined but also cost-efficient fabrication techniques are required. This will lead to developments of more reliable and also more homogeneous synthesis routes, as well as to post-synthesis tailoring processes.



Jena, 15. July 2011 Dr. Wolfgang Fritzsche