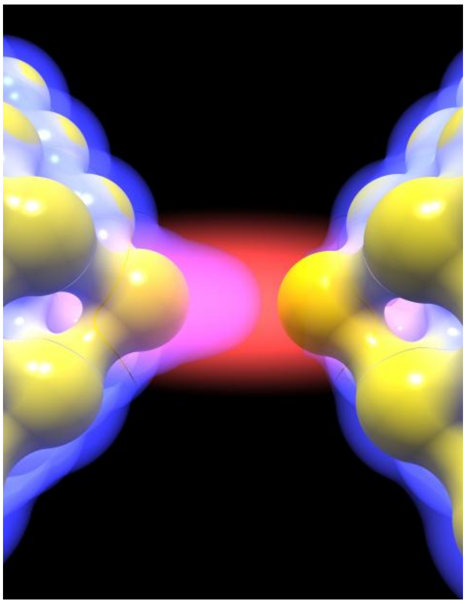
When Light Hits Minute Metal Structures

Scientists Detect Enormous Electric Fields of a New Optical Nanoantenna



Electromagnetic field enhanced by a factor of 1000 in the gap between two gold nano-structures. The schematic representation shows gold atoms and their chemical bonds (yellow), electron density (blue), and the enhanced electromagnetic field (red) (by Daniel R. Ward).

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Scientists from KIT and Rice University, Houston/Texas, have developed an antenna on the nanometer scale that promises to open up new applications in optics and molecular detection in biology and chemistry. The scientists for the first time succeeded in directly measuring the enhanced field of the optical antenna. The results of their research work have now been published in the renowned journal "Nature Nanotechnology".

When light hits a metal nanostructure, it may excite waves in the density of the electrons. These density waves make the nano-structure act like an antenna for light, similar to conventional antennas for longer-wave radiation in radios or mobile phones. Density variations and associated electric fields in everyday life's antennas are mostly small. This does not apply to the nanoantenna that has now been developed by researchers from Karlsruhe and Houston. Two metal tips are separated on the nanometer scale, which means that their distance from each other is less than a hundred thousandth of the thickness of a human hair. “In this way, the energy in the light wave is focused on a very small volume, which causes enormous electric fields and opens up entirely novel applications,” reports the physicist Professor Gerd Schön from the KIT Center for Functional Nanostructures (CFN). So far, however, it has been difficult to directly measure this enhanced field in the experiment.

This has now been achieved by an international group of researchers. The physicist Dr. Fabian Pauly, head of a young investigator group at the KIT Institute of Theoretical Solid-state Physics, his coworker Falco Hüser, and the former KIT scientist Juan Carlos Cuevas, now professor at the Autonomous University of Madrid, performed theoretical studies in parallel to the experiments of Professor Douglas Natelson and Daniel R. Ward from the Rice University, Houston. The scientists measured the field of a sample where two metal tips are separated from each other by a gap of less than one nanometer and found field enhancements by more than a factor of 1000. For these state-of-the art measurements, they ~~intelligently~~ combined optical rectification and highly sensitive conductance measurements.

The measurements and results demonstrate the potential and limits of metal nanoantennas, so-called plasmonic antennas, for spectroscopic studies of surfaces, chemical, biological, and medical sensors, as well as for fundamental research into the interaction of light and matter on the nanoscale. Advanced theoretical and experimental studies of similar topics in the field of nanooptics are presently being performed by various KIT research groups.

Literature

Daniel R. Ward, Falco Hüser, Fabian Pauly, Juan Carlos Cuevas, and Douglas Natelson: Optical rectification and field enhancement in a plasmonic nanogap. Nature Nanotechnology, published online 19 September 2010 | doi: 10.1038/nnano.2010.176

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