Ultrafast Adaptive Optical Near-Field Control in Multi Photon Photoemission Electron Microscopy

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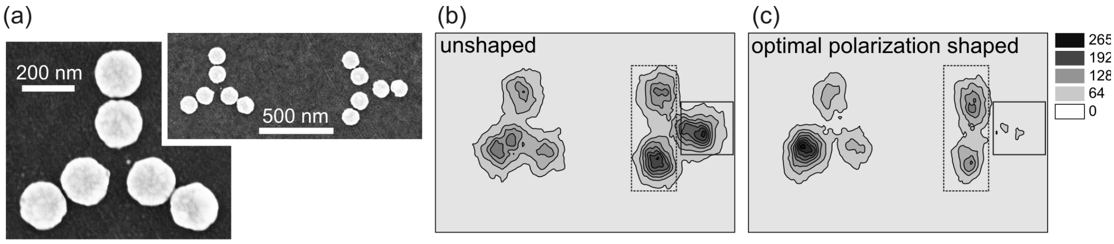
The optical response of nanostructures exhibits fascinating properties, such as subwavelength variation of the field, local field enhancement, and local fields with vector components perpendicular to those of the incident field. Moreover, the combination of ultrafast laser spectroscopy, *i.e.* illumination with broadband coherent light sources, and near-field optics opens a new realm for nonlinear optics on the nanoscale.

Recently, it has been demonstrated theoretically that the interaction of polarization-shaped femtosecond laser pulses with a nanostructure allows the simultaneous control of the spatial and temporal evolution of the optical near-field distribution [1]. Here we report first experiments demonstrating this scheme using a planar nanostructure (Fig. 1a shows a scanning electron microscope image) and two-photon photoemission electron microscopy. The silver nanoparticles manufactured by e-beam lithography are illuminated with ultrashort polarization shaped laser pulses (80 MHz repetition rate, center wavelength 800 nm, 30 nm FWHM spectral width, 8 nJ pulse energy). The spatially resolved two-photon photoemission pattern is recorded using PEEM. It is shown that the emission pattern critically depends on the polarization state of the incident laser pulse. Furthermore, it is demonstrated that adaptive polarization pulse shaping allows optimizing a particular emission pattern as exemplified in Fig. 1b and 1c. Here the ratio between the emission yields integrated over the dashed rectangle and the solid rectangle of the right-hand nanostructure was optimized using an evolutionary algorithm. The experiments show that the local interference of the optical near-fields generated by the two orthogonal incident polarization components can be utilized to manipulate the local field distribution.



[1] T. Brixner, F. J. García de Abajo, J. Schneider, and W. Pfeiffer, *Phys. Rev. Lett.* **95**, 093901 (2005).