Fabrication of plasmonic nanostructures by etch mask transfer

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Plasmonic nanostructures act as optical antennas when excited with light, which makes them interesting systems for basic research on light-matter interactions. Highly enhanced and localized near-field spots are harnessed for applications in near-field microscopy, high sensitivity spectroscopy, and biosensor technology. The aim is to develop a pool of smooth metallic nanostructures whose optical properties can be tuned over a wide wavelength range by varying their material and geometric parameters.

A flexible method based on thin film metallization, local creation of etch masks, and argon ion milling was developed to obtain a variety of metal structures (see Figure 1), including nanocones with tip radii down to less than 10 nm.[1,2] The process allows for the systematic variation of individual parameters to monitor their influence on the optical properties. This way the properties of different identically treated structures can be directly compared. For the critical step of nanomask fabrication, several processes have been explored. In a serial approach, electron beam lithography of negative resist or lift-off using positive resist are applied on planar substrates, while electron beam induced deposition of etch masks is applied to non-planar surfaces.[3] For parallel fabrication of large arrays, nanoimprint lithography and nanosphere lithography are established.

By means of this method, plasmonic nanocones, nanorings, nanocups, corrals, and triangles are made from gold, silver, and copper layers on silicon, glass and ITO. Their optical properties are investigated using confocal and near-field imaging. Radially and azimuthally polarized laser modes are employed for excitation with electric field vectors that are oriented out-of-plane and in-plane, respectively, with high selectivity.[4,5] The plasmon resonance frequency is monitored via dark field scattering. Single cones are integrated for near field microscopy and tip-enhanced Raman spectroscopy, while arrays of nano-structures are employed as surface enhanced Raman spectroscopy platforms.

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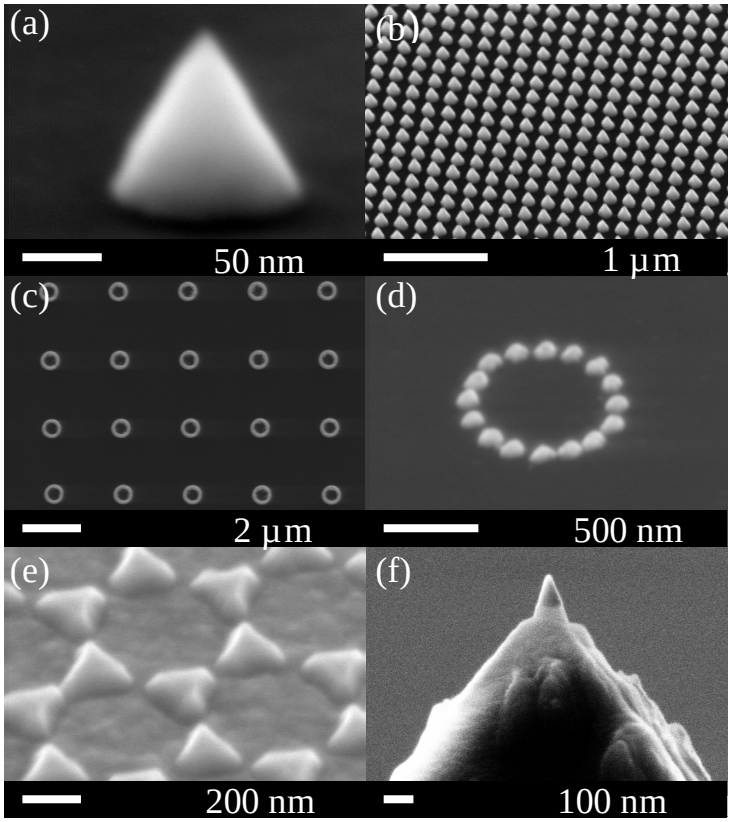

Figure 1: Examples of nanostructures fabricated by transferring etch masks into a metal layer: (a) gold nanocone, (b) array of nanocones, (c) gold rings, (d) nanocorral, (e) triangles, (f) nanocone on a cantilever tip.