SECOND-HARMONIC GENERATION MICROSCOPY OF INDIVIDUAL METAL NANOPARTICLES USING CYLINDRICAL VECTOR BEAMS

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In recent years, there has been an increased interest in the use of cylindrical vector beams which exhibit rotationally symmetric polarization states [1]. Moreover, tightly focusing these beams gives rise to inhomogeneous local fields that can be utilized in microscopy of metal nanostructures [2]. Orientation imaging of metal nanostructures however, has been mainly restricted to the use of linear optical techniques. Furthermore, the linear response may not have sufficient sensitivity to detect low levels of anisotropy and structural deformations.

In this work, we use focused cylindrical vector beams to image the far-field second-harmonic generation (SHG) response that arises from the excitation of plasmon oscillations in individual metal nanoparticles with varied structural details. SHG is a coherent optical process where an optical field at frequency ω is converted to the second-harmonic field at frequency 2ω. Due to the extreme sensitivity of SHG to structural symmetry and subwavelength-sized defects, it has been used to characterize a variety of metal nanostructures [3]. Our technique allows us to directly determine the orientation of individual gold nanobumps (Figs. 1a and 1b) and nanocones (Figs. 1d and 1e) that were fabricated using ultraviolet-nanoimprint lithography [4]. In essence, any deviation of the image pattern from circularly symmetric can be correlated with subtle structural features of the particles.

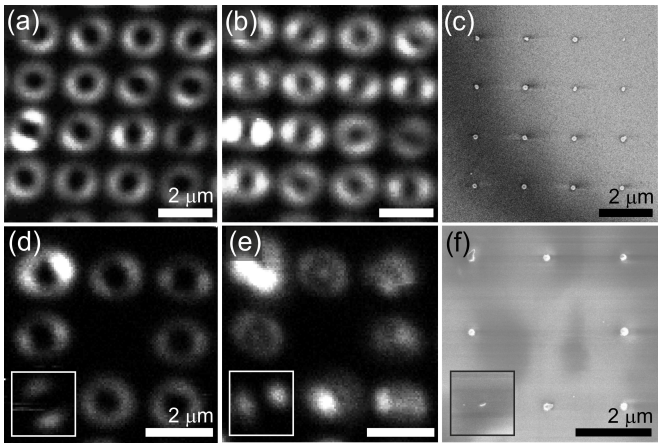

Figure 1: SHG images of an array of (a,b) gold nanobumps and (d,e) gold nanocones using focused azimuthal (a,d) and radial polarizations (b,e). Representative top-view scanning electron microscopy (SEM) images of (c) gold nanobumps from the same array and (f) corresponding gold nanocones. Insets (d-f) correspond to SHG and SEM images of a gold nanorod on the same substrate.

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