ENHANCEMENT OF SECOND-HARMONIC GENERATION FROM METAL NANOPARTICLES BY PASSIVE ELEMENTS

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Optical antennas enable the coupling of electromagnetic radiation at optical-frequency from a source into the far field or vice versa [1,2]. Passive elements play an important role in the design of antennas, usually to improve the directionality of radiation from the antennas. We show that the presence of passive elements can also be used to enhance the efficiency of second-harmonic generation (SHG) from metal nanoparticles.

The SHG measurements were performed with a Nd:glass laser (1060 nm, 200 fs, 80 mW, 82 MHz) at normal incidence for the arrays of gold nanoparticles consisting of: a) SHG-active Ls [3] (linewidth 100 nm, length 175 nm or 275 nm, 1000 nm period, Fig. 1), b) passive bars (50 × 300 nm, 500 nm period) acting as antennas and c) combination of Ls and bars oriented along the x or y direction (Fig. 1b).

For the combined Ls and bars, the SHG signals are enhanced by about a factor of two compared to the respective reference (Ls) sample although the plasmon resonances of the active and passive particles occurred at very different wavelengths. This suggests that the enhancement is related to the modification of the plasmon resonances at the fundamental wavelength and associated local-field distributions affected by the passive bars. This result is further supported by the fact that the effect of bars oriented in the orthogonal direction had very little effect on the SHG signals. Moreover the size of unit cell (1×1 µm) facilitates coupling between particles in the array and supports lattice-surface modes. The enhancement can be understood qualitatively by using a coupled-dipole model where the field acting on the individual particle includes the incident field and the sum of the retarded fields due to the other particles. The effective polarizability of the Ls is thus modified by their coupling to the bars.