Localized Surface Plasmon Resonance in the IR Regime

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Abstract- Different sizes of disk shaped gold nanoantenna arrays which support extinction spectra in IR are prepared by e-beam lithography, which show localized surface plasmon resonance and Rayleigh anomalies in the range from 1000-1400nm. Embedded quantum dots surrounding the nanoantennas show up to 4-fold photoluminescence enhancement due to the coupling to the surface plasmon lattice resonances for larger disk diameters.

In the field of quantum optics, the possibility to enhance absorption or emission in a very small volume has been greatly influenced by high optical confinement and local field enhancement of the localized surface plasmons resonances (LSPR) occurring at metal nanoparticles, nanostructures or nanoantennas [1-3]. To investigate this important LSPR property of metallic nanoantennas further, a systematic investigation for the effect of multiple scattering among regularly arranged metal nanoantennas was carried out. In addition the resulting enhancement of light emission from quantum dots placed in their vicinity has been analyzed.

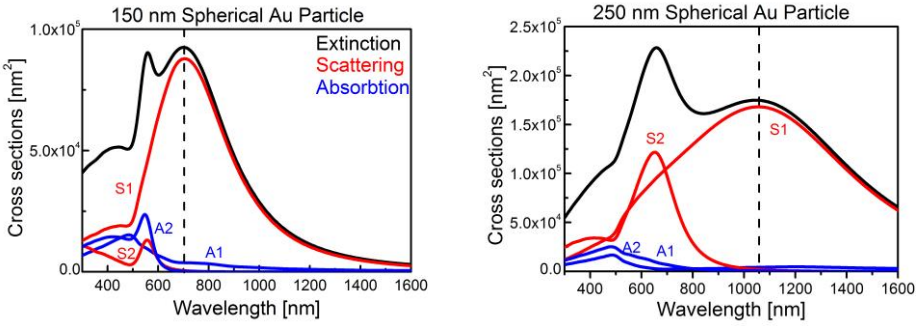

Figure 1: Mie Extinction calculation for a) 150 nm Spherical Au Particle b) 250 nm Spherical Au Particle.

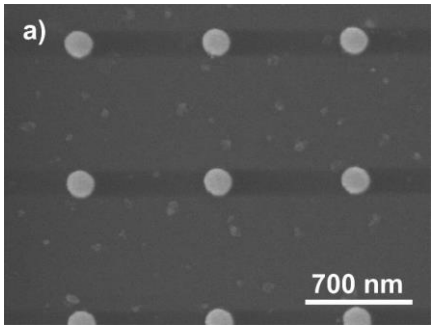

Figure 2: SEM Images of disk shaped nanoantennas diameter ø 175nm.

Nanoantennas with different structure sizes have been analyzed in literature before, but most of them were resonant in the visible regime [4]. In this work we show the shift of the resonances into IR regime. In addition a systematic variation of particle size, shape and period was carried out confirming the suspected far field coupling between neighbouring antennas including the impact of polarization.

It is shown that for disk shaped nanoantennas the scattering resonances can still be well predicted using Mie theory (as defined in [5]) shown in Figure1. Increasing the diameter shifts the particle resonances (especially the interesting dipole resonance A1,S1) towards the infrared. Experimentally such disk shaped nanoantennas have been produced by E-Beam Lithography in 2D periodic arrays (SEM of one of them is shown in Figure 2). In all the measured transmission spectral of these samples, a broad single particle resonance and a sharper fano line shape at longer wavelengths are clearly visible. The sharper fano style resonances are formed due to mutual coupling of localized surface plasmon resonance (LSPR) resulting in the surface lattice resonance (SLR) to the red side of the Raleigh anomaly (RA). This can actually be observed twice - very clearly for the (1,0) Raleigh anomaly and once in a much weaker form for the (1,1) RA. All single particle resonances show good theoretical fitting with a Loretzian curves. On reducing the size of the disks (same periodicity), a blue shift of single particle resonance also leads to a reduced lattice coupling of the LSPRs.

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