Surface Plasmon Resonance Dependence on Size in Metallic Nano-Spheres

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Abstract

Metalic nanostructures are of high interest due to their ability to capture, concentrate and manipulate light in sub-wavelength scale. Such remarkable properties are attributed to the excitation of free electron oscillations on metallic surface, called surface plasmons and has variety possible applications to photovoltaic, photonic, sensing and surface-enhanced Raman scattering. According to experimental observations plasmon resonance is high sensitive to nanoparticle size, shape and refractive index of surrounding media. Particularly we see redshift of resonance wavelength with growing size and changes in resonance intensity. Proper understanding of this effect will allow to optimize nanoparticle dimension in design of future plasmonic devices.

Plasmon oscillations could be described by dipole type excitations , where dissipation is caused by scattering and Lorentz friction due to electromagnetic field irradiation. Dependence on nano-sphere radius for both those processes is investigated in aim to optimize nanoparticle size for largest attenuation rate.

In research we use semiclassical random phase approximation, which take into consideration electron density oscillations in metal and classical electrodynamics approach by Finite element method (FEM) provided by COMSOL Multiphysics® package. COMSOL Multiphysics® RF module has been used in order to accurately simulate extinction spectra from gold and silver nanoparticles as a function of particle radius and surrounding dielectric media.

The theoretical and numerical predictions have been verified by a measurement of extinction of light due to plasmon excitations in nanosphere colloidal water solutions, for gold and silver metallic components with radius from 10 to 75 nm (figure 1).

Reference

W.Jacak et al., Radius dependent shift of surface plasmon frequency in large metallic nanospheres: theory and experiment, J. Appl. Phys. 107, 124317 (2010).

Figures used in the abstract

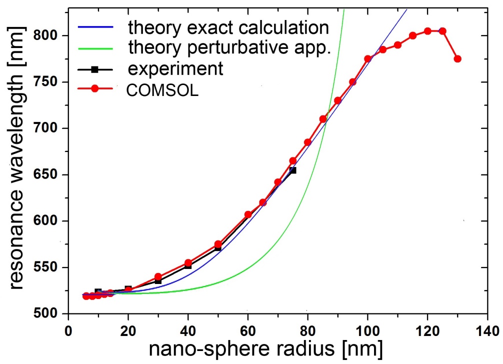

Figure 1: Comparison of theoretical and numerical calculations with experimental data. We obtained good agreement of plasmon resonance redshift with experimental results.