

## Abstract

The thesis concerns the topic of optical properties of metallic nanoparticle systems related to collective electron oscillations emerging in them, called plasmons. The dissertation consists of two main parts following a short introduction. In the first part, I describe the properties of isolated metallic nanoparticles (see Chapter (3)). The second part considers the effect of light absorption efficiency enhancement due to metallic nanoparticle covering of the cell surface (see Chapter (4)).

The main tools used in the thesis are numerical models built using the finite element method. The detailed description of their structure can be found in subsection (3.3) for isolated nanoparticles and in subsection (4.3.2) for a solar cell covered with metallic nanoparticles. The presented approach is innovative because it includes effects like the Lorentz friction, spatial dispersion of dielectric function of metal and near field interaction between plasmon excitations and electron states in semiconductor.

In Chapter (3), I present the influence of size, shape and surroundings refractive index on localization of plasmon resonance wavelength. Apart from spherical and ellipsoidal nanoparticles the nanoshells and bimetallic nanoparticles are analysed. In the case of spherical particles, I show the influence of different plasmon oscillations damping models on localization and intensity of extinction spectra.

The next chapter (4) presents the results of simulations of maximal photocurrent gain possible to achieve after deposition of metallic nanoparticle layer on the top of the Si solar cell. Detailed analysis is made regarding the nanoparticle size and concentration effect on the light absorption in Si. I consider rare aperiodical nanoparticle coverings as well as periodic dense arrays of nanoparticles with different periods. In particular, the size and period of Au nanoparticle array on Si optimizing the light absorption enhancement related to near field interaction were found.

All the calculations were performed in the classical model describing the effects of light scattering only, and in the quantum model which includes also near field interaction of plasmon excitations with the electron states in semiconductor. The comparison of the obtained results with experimental data suggests that the near field interaction is especially important for cells with shallow pn junction for which the measured enhancement of photocurrent cannot be explained within the classical model, i.e. by increased light scattering in the active layer.

In the last part of the chapter (4), I show the influence of the spacial dispersion of dielectric function of metal on the light absorption in Si. The predicted enhancement of photocurrent is higher up to 5 % in comparison to the local model. But the sizes and concentrations of nanoparticles for which these effects are significant are different from the sizes and concentrations which are optimal for light absorption.

The final chapter (5) summarizes the results presented in the thesis.