Local field effects and interference quenching of light in planar plasmonic nanostructures

S. Kachan[1], A. Ponyavina[2]
[1] Belarusian National Technical University, Belarus;
[2]Institute of Physics NASB, Belarus

Unique optical properties of metal nanoparticles originated from localized surface plasmon resonance (LSPR) excitations have already found practical applications in various fields of science and technology. Spectral manifestations of the LSPR can be affected by particle sizes, shapes, materials and even more dramatically by collective interactions in particle arrays. Already in two-dimensional (2D) arrays of small nanoparticles (with sizes of some nm) lateral electrodynamic coupling leads to a strong change in local field characteristics and results in the red concentration shift of the LSPR absorption band. On the other hand, for 2D arrays of silver nanoparticles with sizes of about one hundred nanometers the strong suppression of dipole plasmon band and the appearance of an intense and sharp extinction peak at the frequency near a quadrupole plasmon mode were experimentally revealed [1] for intermediate concentrations of nanoparticles. We analyze these phenomena on the base of universal mechanisms of scattered waves interference and especially the local field effects. As soon as submicron particles have an essentially radiative type of the plasmon excitations decay, short-range ordering of these strong scatterers in densely packed monolayers leads to the partial coherence of scattered light waves. It amplifies the role of local field effects, which have a strong influence on amplitudes and phases of radiation scattered by particles. Employing the statistical theory of multiple scattering of waves, we examine the role of interference quenching in the formation of a strong and narrow extinction band in a monolayer of metal nanoparticles and determine the conditions of the quenching enhancement.

[1] Malynych S, Chumanov G. J.Am.Chem.Soc V. 125, 2003, p.2696–2698

NOTES

Microwave absorption by magnetic nanocomposite of disordered carbon nanotubes arrays

V. Labunov, A. Danilyuk, A. Prudnikova, I. Komissarov, B. Shulitski, F. Normand, S. Prischepa
Belarusian State University of Informatics and Radioelectronics, Belarus

The interaction of electromagnetic radiation in the X and Ka bands with magnetic nanocomposite of disordered carbon nanotubes arrays has been investigated both experimentally and theoretically. Samples were synthesized on the quartz reactor walls by decomposition of ferrocene and xylene which provided random intercalation of iron phase nanoparticles in carbon nanotube array. We found that the absorption of the electromagnetic wave monotonically increases with the frequency. To describe these experimental data, we extended the Bruggeman effective medium theory to a more complex case of magnetic nanocomposite with randomly distributed spherical ferromagnetic nanoparticles in conducting medium. The essential feature of the developed model is the consideration of the complex nature of the studied material. In particular, such important parameters as magnetic and dielectric properties of both the carbon nanotube medium and the nanoparticles, the volume concentration and the dimensions of the nanoparticles, the wave impedance of the resistive-capacitive shells of the conductive nanoparticles, are explicitly taken into account in our model. Moreover, analysing the experimental results, we were able to obtain the frequency dependencies of permittivity and permeability of the studied nanocomposite.

NOTES