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Optical response features of Si-nanoparticle arrays

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Abstract

Periodic structures of spherical silicon particles are analyzed using the coupled-dipole equations for studying optical response features and local electromagnetic fields. The model takes into account the electric and magnetic dipole moments of the particles embedded in a homogeneous dielectric medium. Particles with radius of 65 nm and larger are considered. It is shown that, due to the large permittivity of silicon, the first two Mie resonances are located in the region of visible light, where the absorption is small and the extinction is basically determined by scattering. The main contribution is given by the induced magnetic and electric dipoles of the particles. Thus, in contrast to metal particle arrays, here is a possibility to combine separately either the electric or magnetic dipole resonances of individual particles with the structural features. As a result, extinction spectra can have additional narrow resonant peaks connected with multiple light scattering by the magnetic dipoles and displaying a Fano-type resonant profile. Reflection and transmission properties of the Si particle arrays are investigated and the conditions of low light reflection and transmission by the particle arrays are discussed, as well as the applicability of the dipole approach. It is shown that the light transmission of finite-size arrays of Si particles can be significantly suppressed at the conditions of the particle magnetic dipole resonance. It is demonstrated that, using resonant conditions, one can separately control the enhancements of local electric and magnetic fields in the structures.

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