Optical properties of metal-dielectric composites. The role of electric and magnetic dipole absorption

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Idea: to study the frequency dependence of the absorption coefficient of infrared radiation by a composite with spherical metallic nanoparticles-inclusions, taking into account both electric and magnetic dipole absorption.

Metal-dielectric nanocomposites with unique optical properties are widely used, in particular, for obtaining structures with a negative, high, or low refractive index, which are characterized by selective absorption or transmission of electromagnetic radiation. When creating such composites, a dielectric medium with embedded spherical metal nanoparticles is used.

Due to the fact that with an increase in the size of nanoparticles in the infrared region of the spectrum, eddy currents, which are induced by the magnetic field of an electromagnetic wave, play a significant role, it seems necessary to go beyond the quasi-static approximation and, in addition to the electric one, take into account magnetic dipole absorption. Also in this case, it is necessary to take into account both volume and surface scattering.

The results of calculations of the absorption coefficient of the composite "Teflon-aluminum particles" are shown in fig. 1. Note that in the infrared range of the spectrum, the absorption coefficient increases with increasing frequency. In addition, at the same frequencies, the absorption coefficient is higher for composites with a high volume content of Al nanoparticles.

Summary: For composites with a low content of metal nanoparticles, a model was constructed that takes into account both electric and magnetic dipole absorption in the infrared region of the spectrum. The calculation results indicate an increase in the absorption coefficient with increasing frequency and an increase in the volume content of the metal fraction in the nanocomposite.

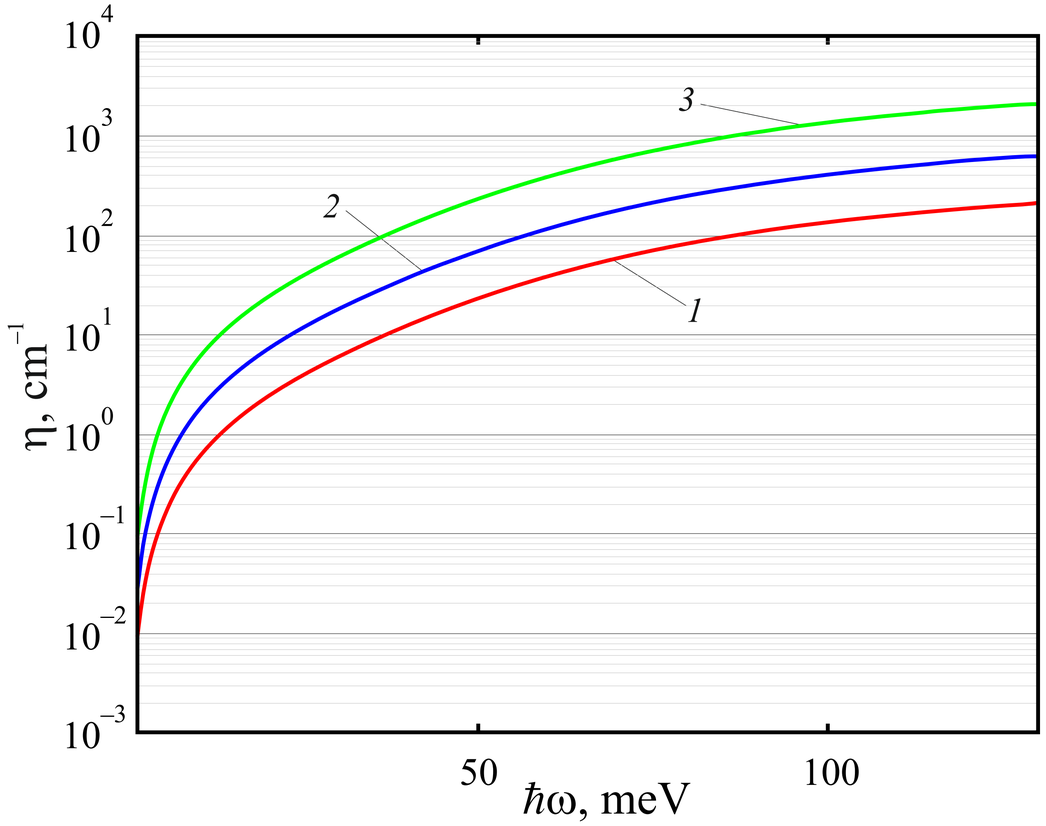

Fig. 1. Frequency dependences of the absorption coefficient of Al nanoparticles in Teflon. Designations:
1 – β= 0.005 ;
2 – β= 0.015;
3 – β= 0.025.