Light absorption by a composite with randomly arranged metal nanocylinders

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Idea: to study the frequency dependence of the absorption coefficient of a composite with randomly arranged metal nanosized cylinders, when the concentration of inclusions is not low.

It is known that the absorption coefficient of metal-dielectric nanocomposites is determined by its effective dielectric function, which in the case under consideration is determined by the Bruggeman formula. We assume that cylindrical inclusion particles have a finite length. Therefore, the calculation of size-dependent parameters for cylindrical nanoparticles (depolarization factors and effective relaxation rate) was carried out within the framework of the effective prolate spheroid model [1].

The frequency dependence of the absorption coefficient was calculated for the case of Ag nanocylinders embedded in Teflon. Note that the curves in Fig. 1 have two maxima, regardless of the ratio between the diameter and length of the cylindrical nanoparticle. However, the location of these maxima depends significantly on the specified ratio. Thus, when the diameter is significantly less than the length of the cylinder, one maximum is located in the infrared region of frequencies, and the second is in the ultraviolet region (curves *1*,*2*,*4*,*5*), and in the case when the diameter value approaches the length of a cylindrical nanoparticle, both maxima are located in the ultraviolet region (curve *3*). It should also be noted that the smaller the ratio of the diameter to the length of the cylinder, the greater will be the maximum values of the absorption coefficient.

Summary: The frequency dependences of the absorption coefficient of the composite medium "silver nanocylinders - Teflon matrix" are calculated. It is established that the absorption coefficient has maxima in the infrared and ultraviolet regions of the spectrum, except for the case when the ratio of diameter to length tends to unity. It is shown that as the ratio of diameter to length decreases, the magnitude of the maxima increases.

[1] Korotun A.V., Karandas Ya.V., Reva V.I. Analytical theory of plasmon effects in rod-like metal nanoparticles. The equivalent-spheroid model // Ukr. J. of Phys.-2022.-67, N 12.-P. 849-858.

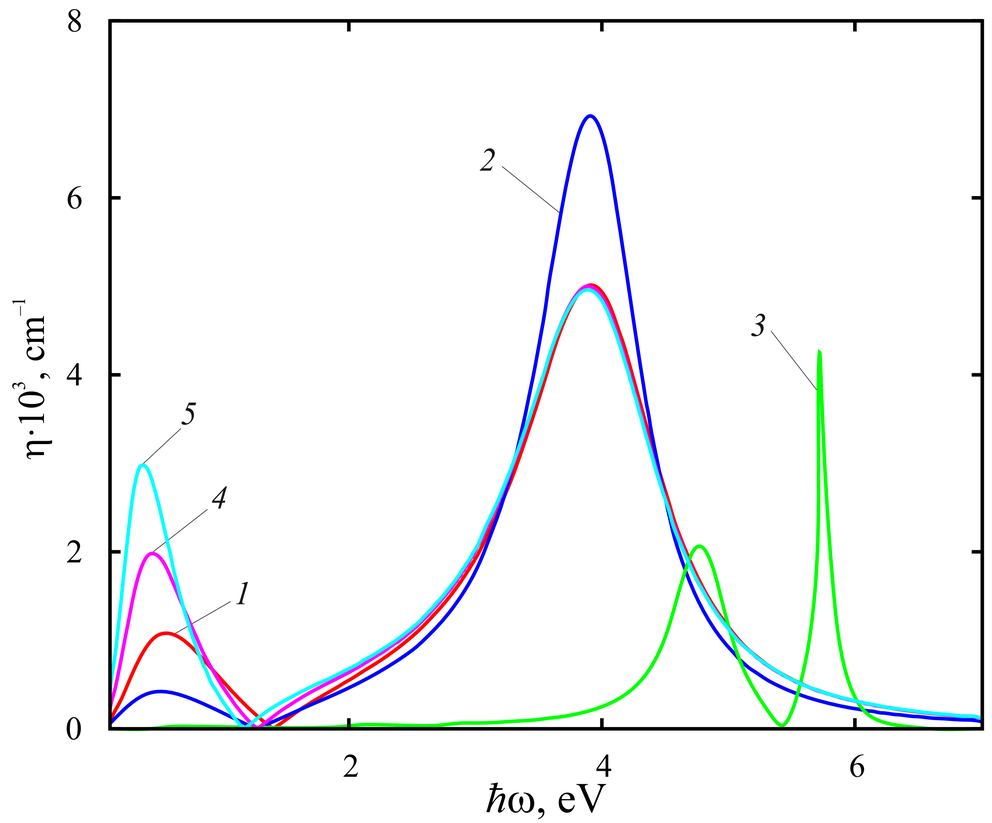

Fig. 1. Frequency dependences of the absorption coefficient of Ag nanocylinders in Teflon. Designations:
1 – r = 10 nm, l = 100 nm;
2 – r = 15 nm, l = 100 nm;
3 – r = 40 nm, l = 100 nm;
4 – r = 10 nm, l = 150 nm;
5 – r = 10 nm, l = 200 nm.