

Cadmium iodide nanostructures and their dielectric properties

Tovstyuk N.K.¹, Karkulovska M.S.¹, Kravchuk I.M.¹, Rudka N.N.¹, Seredyuk B.O.²

¹Institute of Mathematics and Applied Physics, Lviv Polytechnic National University, Bandera str.,12, Lviv-790012, Ukraine. E-mail:ntovstyuk@gmail.com.

²Dept. of Rocket Troops and Artillery, National Army Academy named after Hetman Petro Sahaidachnyi, Herojiv Majdany str.32.Lviv-79032, Ukraine.

Cadmium iodide crystals have C6 structural type which is based on a tight hexagonal packing of J-Cd-J layers, within which the interactions are strong ion-covalent, and between the layers - weak van der Waals one. This causes a strong anisotropy of many physical properties of CdJ₂ and allows in some cases to use them as models of two-dimensional crystals.

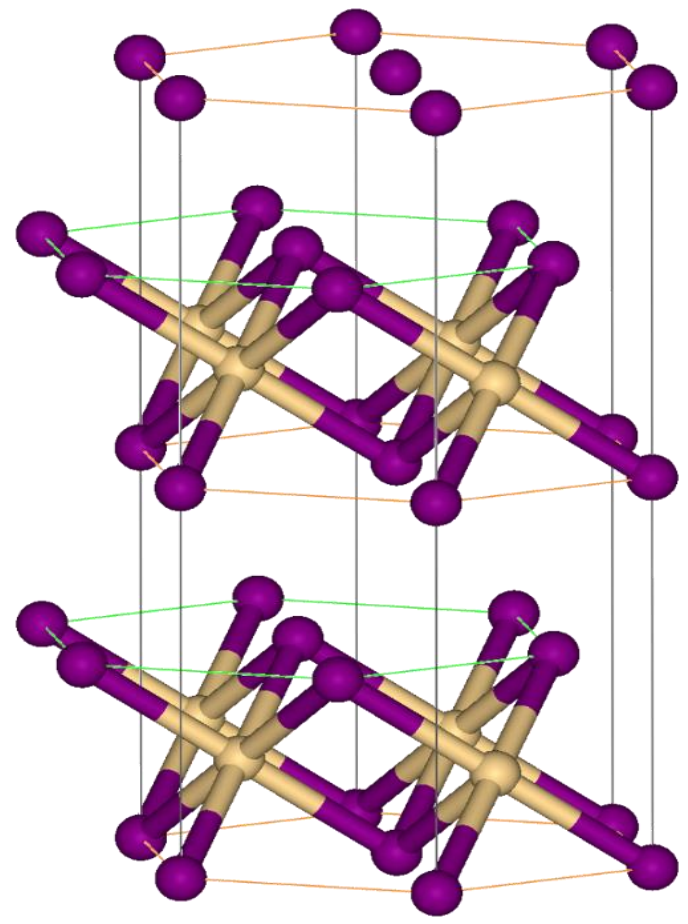


Fig.1. Crystal structure of CdJ₂;

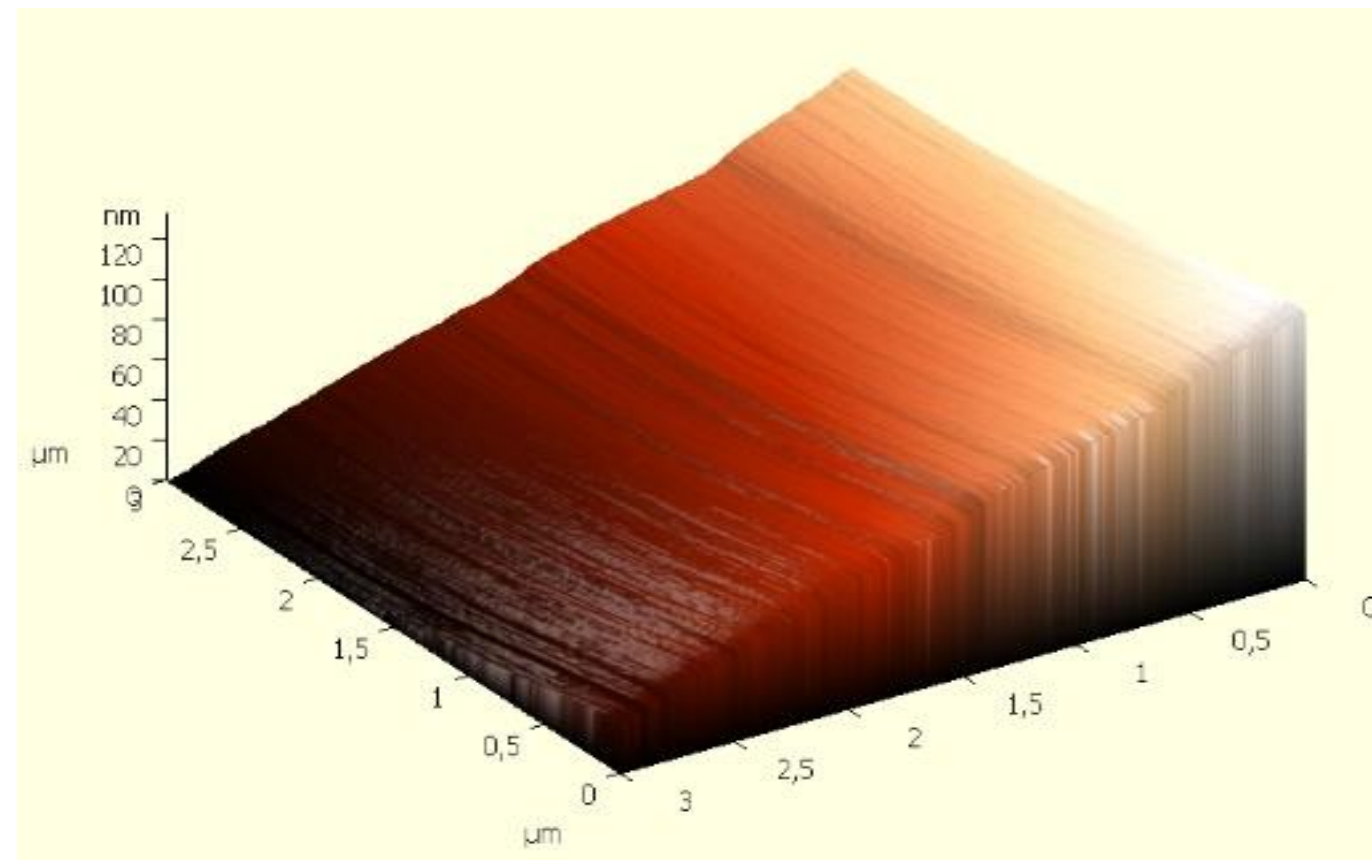


Photo 1. The surface of CdJ₂ crystal in atomic forced microscope;

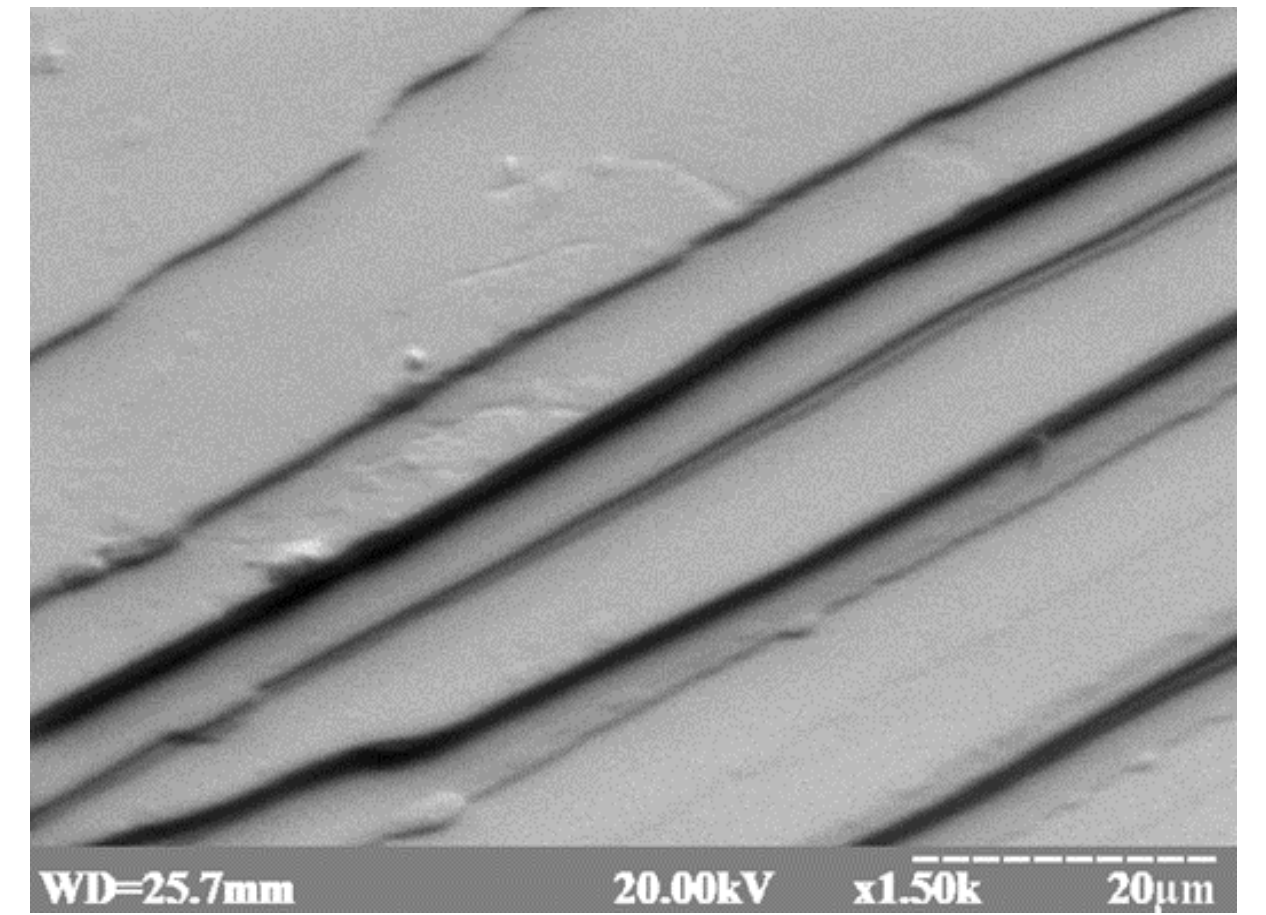


Photo 2. Cleavage planes

The paper examines the influence of the dimensionality of the crystal structure on the calculations of the frequency and dispersion dependence of the components of the dielectric function (or absorption coefficient and refractive index) for crystals of different dimensions in the random phase approximation.

Non-parabolic law of electron dispersion $E(\vec{k}) = \alpha(k_x^2 + k_y^2) + t(1 - \cos k_z)$, at $\epsilon_F \rightarrow 2t$ here $\alpha=1$ eV (it is inversely proportional to effective mass of electron moving within the sandwich of layers) $t=0,1$ eV is electron mixing along the anisotropy axis. In one-dimensional systems ($\alpha=0$) in the static case ($\Omega=0$), the behavior of $\epsilon_1(q)$, $\epsilon_2(q)$ dependence and extrema on the corresponding curves are related to singularities in the real component of the polarization loop at $q=2k_F$ and $q=2(\pi - k_F)$.

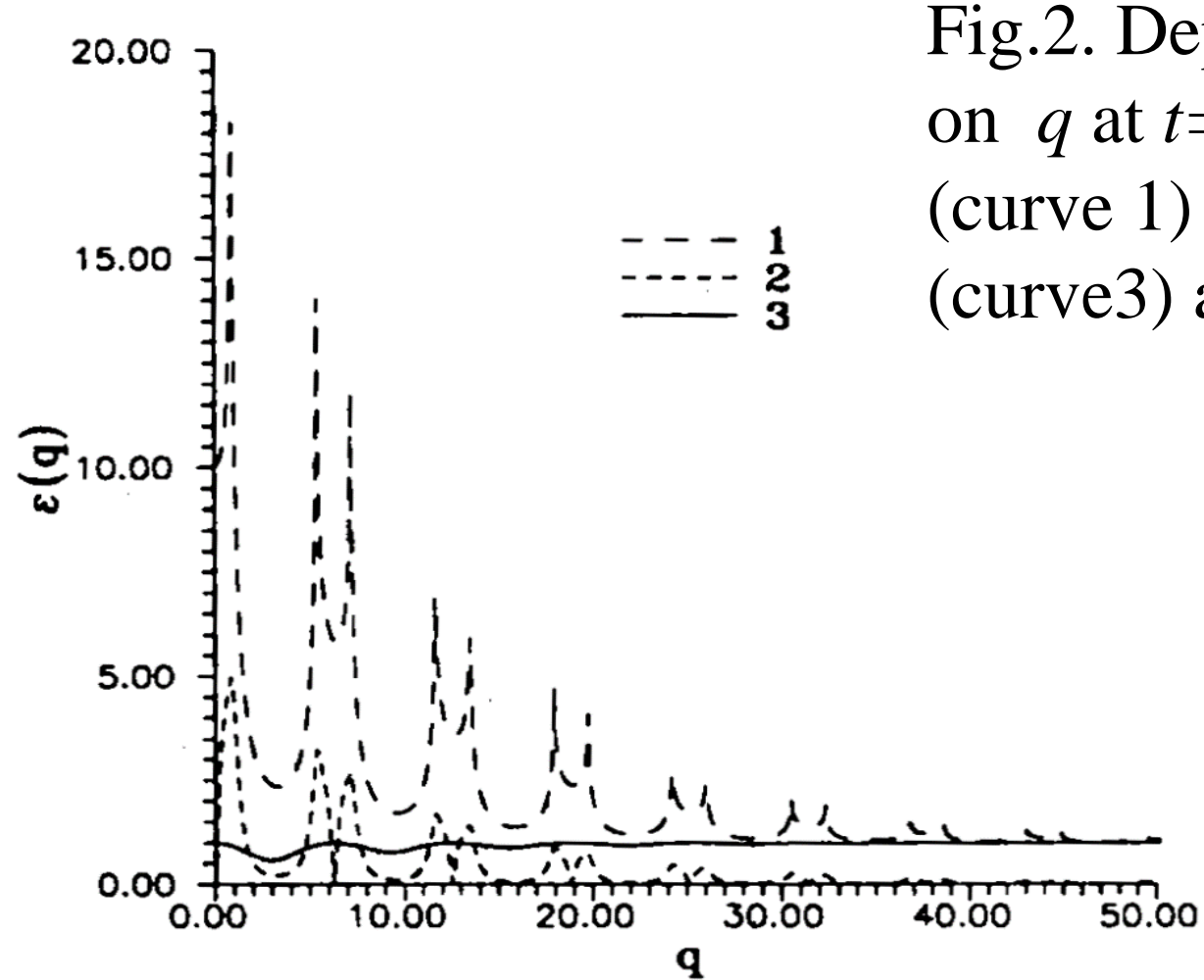


Fig.2. Dependence of dielectric functions $\epsilon_1(q)$, $\epsilon_2(q)$ on q at $t=0.1$, $Q=0.9$ в статичному випадку $\epsilon_1(q)$ (curve 1) and $\epsilon_2(q)$ (curve 2); in dynamic case $\epsilon_1(q)$ (curve3) at $\Omega=0.4$.

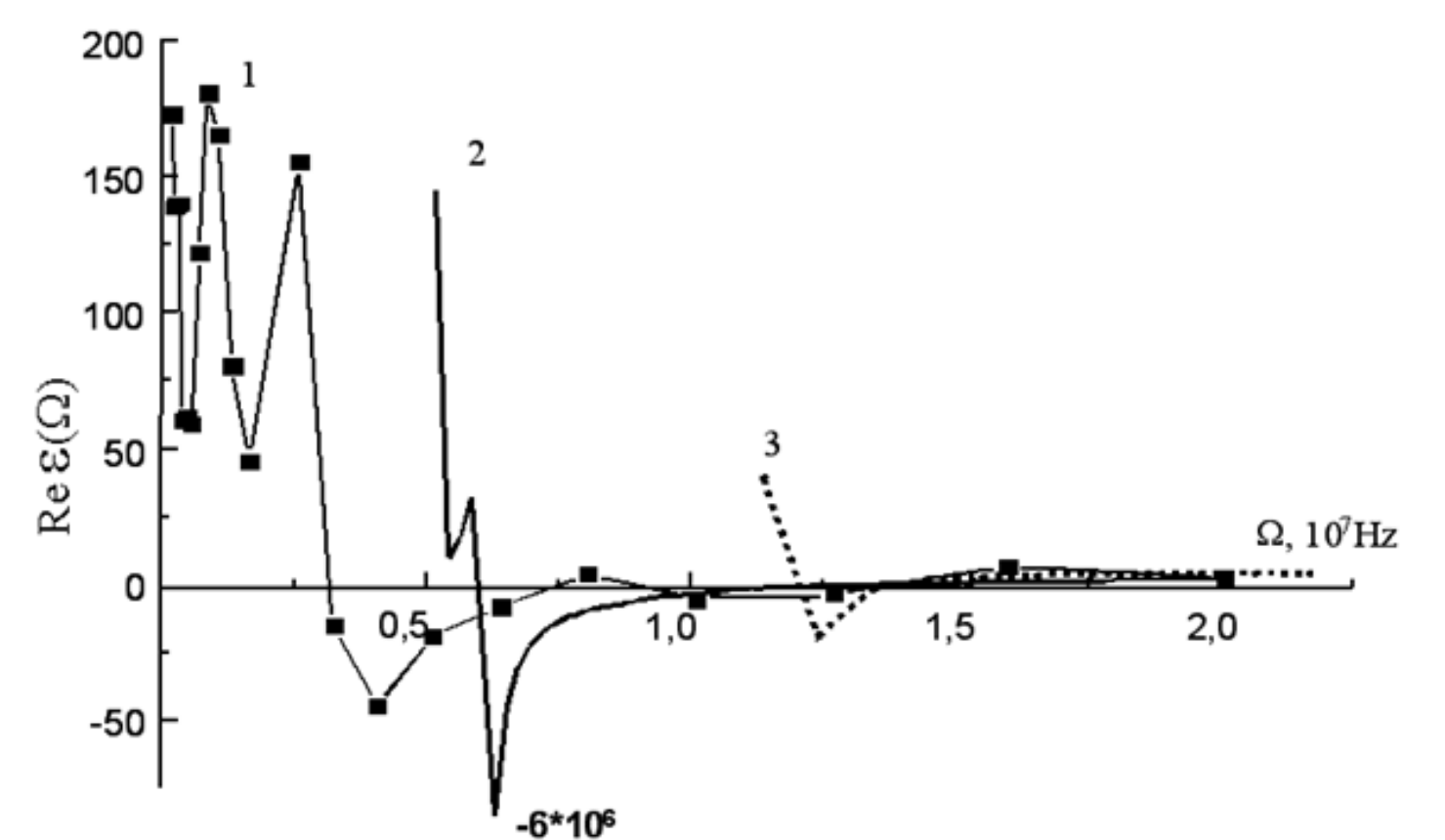


Fig.3. Frequency dependence of real component ϵ_1 : 1 - experiment, 2 - calculations for 1D model, 3 - for 3D anisotropic model

$$\chi = \sqrt{\frac{1}{2}(-\epsilon_1 + \sqrt{\epsilon_1^2 + \epsilon_2^2})}, n = \sqrt{\frac{1}{2}(\epsilon_1 + \sqrt{\epsilon_1^2 + \epsilon_2^2})}$$

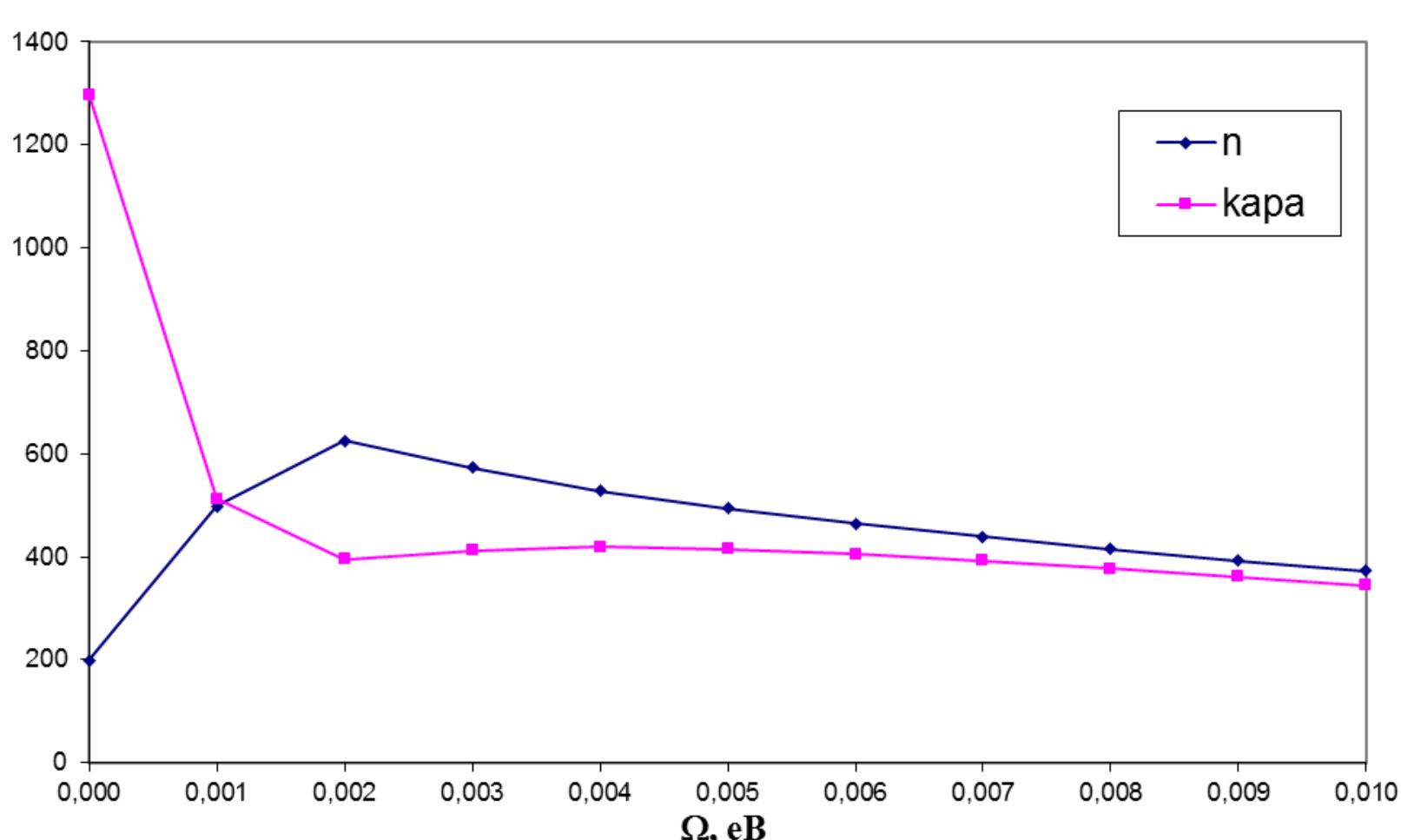
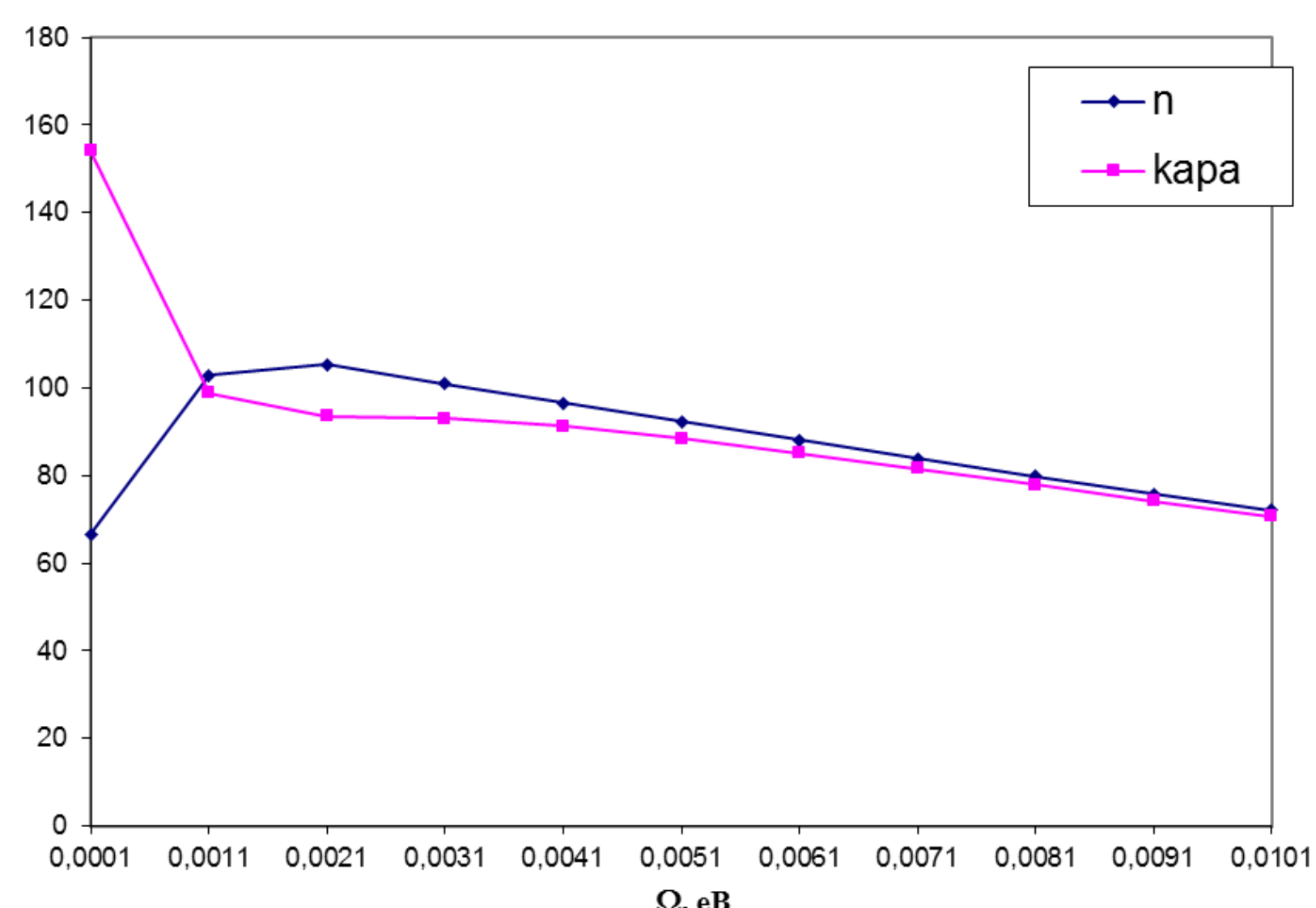


Fig. 4. Frequency dependence of the absorption coefficient (χ) and refractive index (n): a) Fermi energy equals $2t$; b) Fermi energy $\ll 2t$



CONCLUSIONS: MOVING FROM 1D SYSTEM TO 3D SYSTEM SIGNIFICANTLY CHANGES OPTICAL CONSTANT IN VALUE, IN FREQUENCY DEPENDENCE, AND ESSENTIALLY NARROWS THE FREQUENCY REGION OF THEIR DIFFERENCE.