DIMENSIONAL BOUNDARY BETWEEN THE NANO- AND VOLUME STATUS

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Absteract – There is measured border between nano- and macrostate of substance. This fact is explained with the Debye model for the distribution of the frequencies of phonons in crystals. If the size of crystal such that a phonon with a wave-length bigger than the Debye's wave-length can not propagate, it acquires the properties of a substance different from the macroscopic properties of the crystal.

I. INTRODUCTION

When considering the atomic processes in solids often use the classical notions of condensed matter physics. An example is the description of the elementary act of diffusion, the calculation of the specific heat at temperatures close to normal, the calculation of the coefficient of elasticity, etc. The physical properties of the particles when their reduced dimensions remain unchanged until a certain value L_0. For particle sizes smaller than L_0, acquires the properties of a substance different from those of macroscopic size. The curves of the "property-size" for different properties have looks similar to the dependence of the ratio of Young's modulus of iron with grains sizes in the nano- range size to Young's modulus of iron with an ordinary grain size depending on the grain size [1].

II. THE TEMPERATURE EQUIVALENT OF THE PARTICLE SIZE.

To determine the boundary between the nano- and volume status we use a model of continuous Debye phonon spectrum [2]. The Debye frequency related to the energy, momentum, wavelength, and Debye temperature:

$$E_D = \hbar\omega_D; P_D = \hbar\omega_D / u; \lambda_D = 2\pi u / \omega_D; \theta = \hbar\omega_D$$

u- speed of propagation of phonons.

The Debye's temperature (θ) is the temperature bound between classical and quantum approximations. If $T > \theta$ then physical phenomena are described by classic physics otherwise it must take quantum methods. Side by side with Debye's energy $(E_D = k\theta)$ it is proposed to use Debye's momentum $\left(P_D = (2E_D m_e)^{1/2}\right)$ for electrons in the particles. Mechanical displacement of the nucleus leads to excitation of an electron and transfers it to the level exceeding on the main level with the value of the phonon energy. The mass in determining the Debye's momentum is taken equal to the mass of the electron.

Let L_0 is a size bound when mechanism of physical processes changes. If $L > L_0$ the size of particle does not exert an influence to mechanism of physical processes. When $L < L_0$ then the properties of particle different from ones in the bulk objects and the sizes of particles influence to their properties. For calculation of L_0 it must take the uncertainty relation $P_D L_0 = h$. Hence it follows

$$L_0 = h(2m_e k\theta)^{-1/2};$$

h – Plank constant, *k* –Boltzmann constant, *m* – mass of electron.

The L_n are maximum value for nan sizes and are different for matters. F. e. for diamond $L_n = 5nm\ (\theta = 1850K)$ but for lead $L_n = 24nm\ (\theta = 95K)$.

III. CONCLUSION

Currently, despite the intensive development of a number of industries who consider themselves to nanotechnology, the theory cannot explain the phenomenon of nanoparticles. There are serious objections against the very expressions that have the prefix "nano". If the experimental results obtained when the dispersion and heating (cooling) give the same result in the determination of physical properties, we can introduce the temperature equivalent particle size. Therefore the determination of the true place of nanoscale objects and systems in real industrial production is a multifaceted problem whose solution can be obtained only on the basis of a systematic approach and coordination of intellectual potential of the various participants in the life cycle of innovative products.

REFERENCES

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