THE SCATTERING OF NON-EQUILIBRIUM PHONONS IN AL_2O_3 NANOCERAMICS

Y.N. Barabanenkov[1], V.V.Ivanov[2], S.N.Ivanov[1], A.V.Taranov[1] and E.N.Khazanov[1]

[1] Institute of Radioengineering and Electronics RAS Moscow.
[2] Institute of Electrophysics RAS Ekaterinburg.

The interest to nanoceramic materials determines by expecting of good mechanical properties, but the thermal physical properties of these materials are also very interesting matter,since the decrease of ceramic grain size leads to the increase the role of intergrain boundaries and layers. The goal of present work is the investigation of scattering slightly non-equilibrium thermal phonons with frequency up to 200GHz on intergrain structures by "heat pulse" method. The Al_2O_3 ceramics studied was made by magnetic pulse pressure method [1], their density was about 98%.

In our ceramics the phonon mean free path l>>R (R is the grain size) and the phonon scattering determines by only intergrain structures [2]. In our experiments the time of the maximum of diffusive phonon signal t_m was measured. The temperature dependencies of t_m allowed us to get information about phonon scattering mechanisms and, hence, to propose the intergrain structure and its properties.

We have measured a set of ceramics with grain size R in the range of $0.1 \div 20\mu m$. Our experiments shows that the phonon scattering or the effective diffusion coefficient D_{eff} of phonons in ceramic samples with grain size $R \geq 0.2\mu m$ depends on grain size as $D_{eff} \sim R$ and the derivative $\partial t_m/\partial T$ has the positive sign. In ceramics with grain size $R < 0{,}2\mu m$ D_{eff} decreases up to $2 \div 3$ orders of value with respect to samples with $R \geq 0.2\mu m$. The derivative $\partial t_m/\partial T$ also changes sign, i.e. $\partial t_m/\partial T < 0$ for $R > 0.2\mu m$ samples. It should be noted that the mean grain size R in our case remains up to $3 \div 4$ times larger than the phonon wavelength, so there is no dimension effect. These results denotes on the change of the scattering mechanism, i.e. the change in the intergrain structure properties.

The authors advance the model for intergrain structure which explains the experimental results.

The work was supported by grants: ISTC No 1030, RFBR No.00-02-17426.

1. V.V.Ivanov, Ju.A.Kotov, A.N.Vikhrev. N.I.Noskova, Acad. Of Sci. Reports, 1997, v.352, No.6, p.759 (in Russian).
2. S.N.Ivanov, A.G.Kozorezov, E.N.Khazanov, A.V.Taranov, Sol.St.Comm., 1992, v.83, p.365.