Zeitschrift: Helvetica Physica Acta

Band: 65 (1992)

Heft: 2-3

Artikel: Resonance (surface) phonon transport through point contacts

Autor: Feher, A. / Stefányi, P. / Záboj, R.

DOI: https://doi.org/10.5169/seals-116481

RESONANCE (SURFACE) PHONON TRANSPORT THROUGH POINT CONTACTS

A. Feher, P. Stefányi, R. Záboj
Šafárik University, Dept. of Experimental Physics, 04154 Košice, nám. Febr. vít. 9, Czech and Slovak Federal Republic
Shkorbatov A. G.
Inst. for Low Temp. Phys. & Engin, UkrSSR Acad. Scien., 310164 Kharkov, Lenin Avenue 47, USSR

ABSTRACT. The heat flux $\dot{Q}(T)$ through point contacts NaCl-NaCl, KBr-KBr and KBr-Cu (with diameter ~ 10^2 nm) have been investigated from 2 K to 30 K. The increase in the heat flux above that for ballistic regime is explained on the basis of the resonance transport of phonons.

The thermal boundary resistance at interfaces between two crystals is very sensitive to the condition of the interface [1]. We studied the phonon transport through the interface between two solids (NaCl-NaCl, KBr-KBr and KBr-Cu) using point-contact method (PC). The characteristic dimension of contacts (10^2nm) was small compared with phonon scattering length in the investigated temperature range 2 K to 30 K. For measurements of the heat flux $\dot{Q}\ (T_2, T_1)$ through the PC an experimental setup described in [2] was used, in which the temperature of one bank (NaCl or KBr) was changed in given temperature range whereas the temperature of the second bank (NaCl, KBr or metallic Cu) was typically kept between 2 and 5 K. This experimental arrangement leads to a negligible contribution to $\dot{Q}\ (T_2, T_1)$ from phonon scattering in the bulk near PC and moreover, in dielectric-metal PC, the phonon-electron scattering becomes ineffective near the contact. Thus, the process of the heat conductivity is determined only by transport of phonons crossing the interface and by their "ballistic dissolving" in the near-PC region. As is indicated by the experimental results, the physical contact between the two lattices was not complete, an expected phenomenon for the used pressure-type PC. We assume that on the contact surface in addition to regions with strong coupling (perfect lattice) there are regions with weak coupling (contact through impurity interlayers). The heat flux $\dot{Q}_s$ through the regions with strong coupling may be fairly well described by the acoustic mismatch theory [3] as $\dot{Q}_s \sim C\ (T_2^4-T_1^4)$ where T_1 and T_2 are bank temperatures. For the parallel heat flux through the regions with weak coupling the

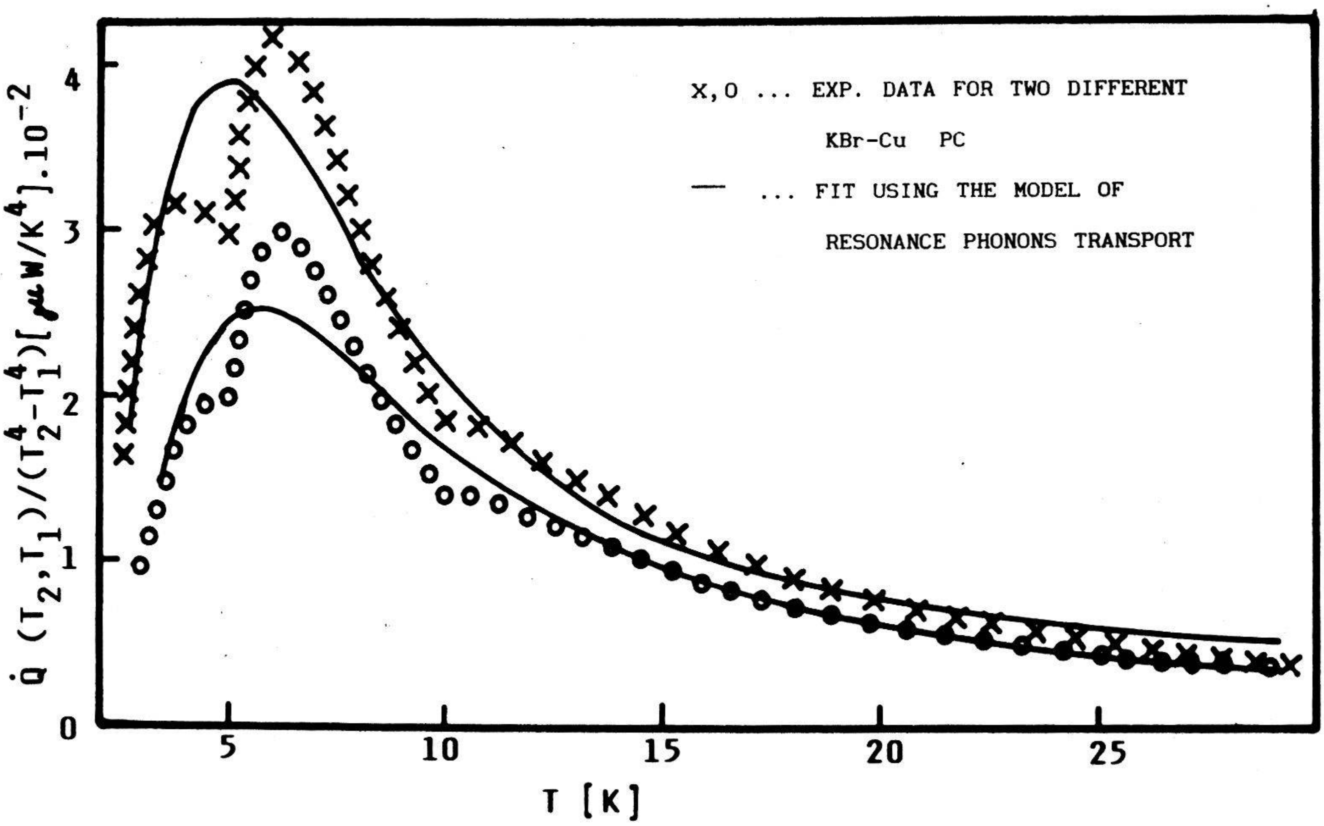

Fig.1.: $\dot{Q}$ $(T_2, T_1)/(T_2^4-T_1^4)$ versus T for two KBr-Cu PC.

resonance transport of phonons with characteristic frequency ω_o may be responsible. This frequency may be approximately determined according to [4] as $\omega_o \sim (E/\rho)^{1/2}.h^{-1}$, where E is Young's modulus, ρ is density and h is the thickness of the surface layer. Because the value of E in the weak-coupled surface layers is much less than the value for the bulk, it may be expected that $\hbar\omega_o << k_B\theta_D$, where θ_D is Debye temperature.

Fig. 1 shows a typical temperature dependence of the heat flux through the KBr-Cu PC. The resonance frequency ω_o is connected with T_{max} by the relation $\hbar\omega_o = 3.8\ k_B T_{max}$ [1]. Results obtained on the NaCl-NaCl PC indicate that the ballistic transport of phonons begins to prevail already at temperatures above 10 K (θ_D of NaCl is higher than that of KBr).

REFERENCES

[1] E.T. Swartz , R.O. Pohl , Rev. Mod. Phys. 605, **61** (1989).

[2] P. Stefányi , A. Feher , A. Orendáčová , Phys. Lett. 259, **A1433** (1990).

[3] W.A. Little , Can. J. Phys. 334, **37** (1959).

[4] Ju.A. Kosevich , E.S. Syrkin , Kristallografija 1339, **33** (1988).