Phonon Dispersions in the Thermo-electric Material of Bi0.88Sb0.12

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Bi0.88Sb0.12 is known as a thermoelectric material with a high cooling power under magnetic fields due to high mobility of electrons and holes [1] and from that it is also inferred that the heat conduction by phonons may be affected by the application of strong magnetic fields [2]. So in the present experiments we try to investigate this problem by measuring phonon dispersions without magnetic fields first.

Single crystals of Bi0.88Sb0.12 were obtained with the brigeman method and the mosaic width of the crystal used in the present experiments was good enough (about 0.1 deg.) for phonon measure- ments and the crystal was confirmed to be consisted mostly with a single grain. A triple axis neutron spectrometer of 4G was used with collimators of 40′-40′-40′-40′ and the single crystal sample was cooled to 77K by using a refrigerator. Bi0.88Sb0.12 is a disordered alloy with the trigonal symmetry (R m) containing two atoms in a unit cell which usually indexed as a hexagonal cell.

Figure 1(a) shows acoustic branch of phonon dispersions measured along the trigonal axis (the c-direction in the hex. cell). Along with our data Smith's data of pure Bi measured at 75K were inserted to compare to our Sb added Bi data. Acoustic branches of Bi0.88Sb0.12 almost agree with that of Bi for longitudinal and transversal modes, however, for longitudinal scans a branch which appears below TA mode was observed, which is not identified at present. The branches along the c-direction suggest that the force constants along the c-planes are not much altered by the addition of Sb atoms .

Figure 1(b) shows acoustic branches measured along the a-axis, which appear above that of pure Bi. This suggests that the addition of Sb makes the bonding between atoms fasted in the c-plane. This is consistent with the improvements of the thermoelectric properties for directions in the c-plane by the addition of Sb in Bi.

References

[1]R. Wolfe and G. E. Smith, Appl. Phys. Lett. 1,5(1962).
[2] O. Yamashita, private communication.
[3] D. B. Smith, Unpublished Thesis, Los Alamos Scientific Report No. LA- 3773 (1967).

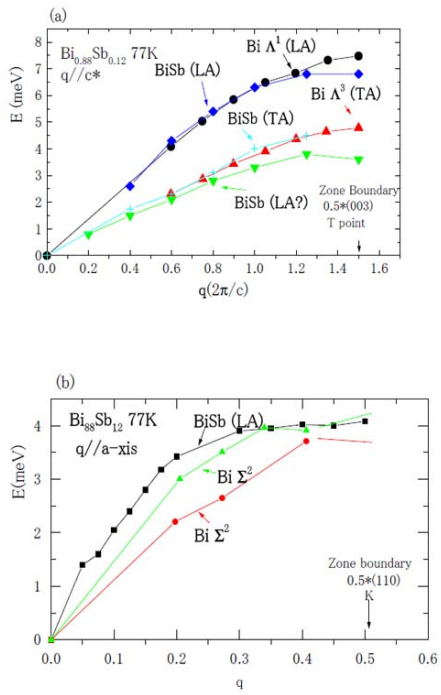

Fig. 1. 1 (a) Phonon dispersions of Bi0.88Sb0.12 along the c-direction as a function of the wave vector q. The data of pure Bi [1] are shown. (b) Phonon dispersions of Bi0.88Sb0.12 along the a-axis.