Abstract submitted to the
NATO ADVANCED RESEARCH WORKSHOP
New materials for thermoelectric applications: theory and experiment
September 19 - 25, 2011 Hvar, Croatia

Theoretical study of thermoelectric and thermomagnetic characteristics of Bismuth nanowires under a quantizing magnetic field

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Submitted : 10-09-2011
Keywords : Bismuth nanowire, Nernst effect, Phonon drag

The phonon-drag contribution to the Nernst thermoelectric power S_{yx} in bismuth nanowires is numerically investigated. Hasegawa *et al.* [1] have fabricated the single Bismuth nanowires with diameter 150 nm $\sim$ 500 nm and length over 1 mm, as illustrated in Fig. 1. The wire diameters are short enough to quantize the acoustic phonons but larger than the Fermi wave lengths of electrons. In the systems, therefore, the phonons travel one-dimensionally, while the electrons are found to be still three-dimensional. In the present study, we calculate the phonon-drag thermopower S_{yx} of the nanowires under a quantizing magnetic field and discuss the effect of the dimensionality on the transport properties of the systems.

We utilize a theory of a single Bismuth crystal that includes the contribution of both holes and electrons [2]. The theory revealed that the phonon drag is dominant in the prominent magneto-oscillations in the S_{yx} of a bulk bismuth [3]. Thus, the phonon-drag effect is expected to play a dominant role also in nanowires.

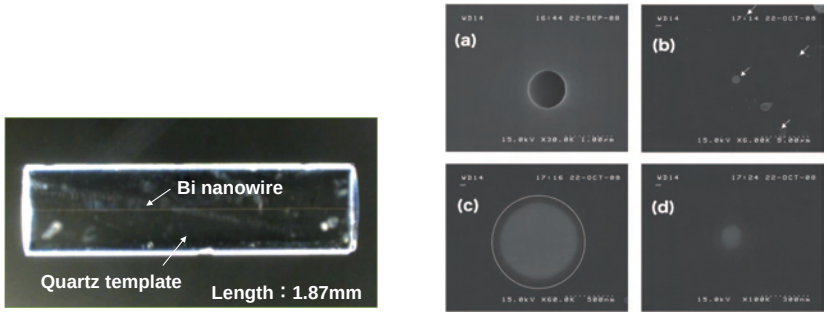

Figure 1: (Left) An optical microscope image of a Bismuth nanowire encased in a quartz template, which is fabricated by Hasegawa *et al.* [1]. (Right) SEM images at the edges of the nanowires show that they have diameters of 150 $\sim$ 850 nm.

[1] Y. Hasegawa, D. Nakamura, M. Murata, H. Yamamoto, T. Komine, T. Taguchi, and S. Nakamura, J. Elec. Mat. **40**, 1005 (2011)
[2] M. Matsuo, A. Endo, N. Hatano, H. Nakamura, R. Shirasaki, and K. Sugihara, Phys. Rev. B **80**, 075313 (2009)
[3] K. Behnia, M.-A. Méasson, and Y. Kopelevich, Phys. Rev. Lett. **98**, 166602 (2007)