Constriction induced thermo-electric voltage in a mesoscopic single metal wire

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When the dimensions of metal structures become comparable to the length of the mean free path of conducting electrons in bulk, electron scattering at the surface and interface can alter the electronic characteristics of devices, e.g., reduction of the absolute Seebeck coefficient [1,2]. Therefore, as shown in Fig. 1, a metal with constricted shape potentially can be used as a thermocouple similar to the conventional bimetallic one. The absolute Seebeck coefficient of the metal wire can be varied at the wide position (S_{A_wide}) and the narrow position (S_{A_narrow}) due to the size effect. As a result of the difference in the Seebeck coefficient, open-circuit voltage (V_{oc}) can be generated when heat gradient (ΔT) is applied to the constricted wire [3].

In this study, thermo-electric voltages generated at the abrupt constriction were measured. The thin film metal nanostructure and nanoscale heaters were fabricated using electron-beam lithography, as shown in Fig. 2. We measured V_{oc} at the end of the single metal structure using lock-in technique in a high-vacuum cryostat.

Figure 3 shows the open-circuit voltage when either one of the heaters nearby the constricted sections was turned on. Here we confirmed that single metal with constricted segment could be used as a thermocouple, with simpler fabrication compared to the typical bimetallic one. This single metal thermocouple can be potentially useful to measure the heat flow direction in sub-micron scale. In the future work we will measure the material, temperature, and constriction shape dependence of the generated thermo-electric voltage.

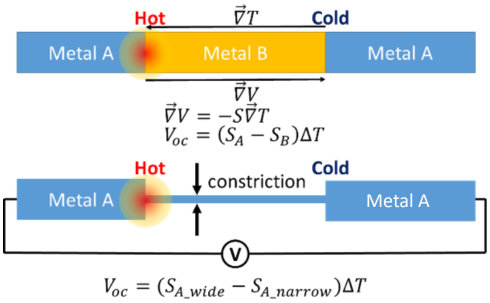

Figure 1. Schematic comparison of thermo-electric voltage generation in bimetallic (top) and single metal thermocouple (bottom).

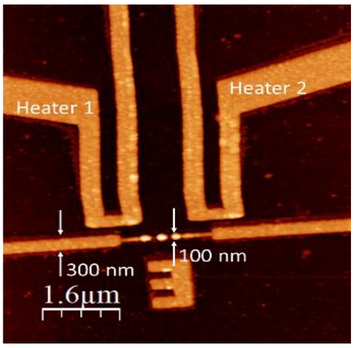

Figure 2. AFM image of the device used in this study.

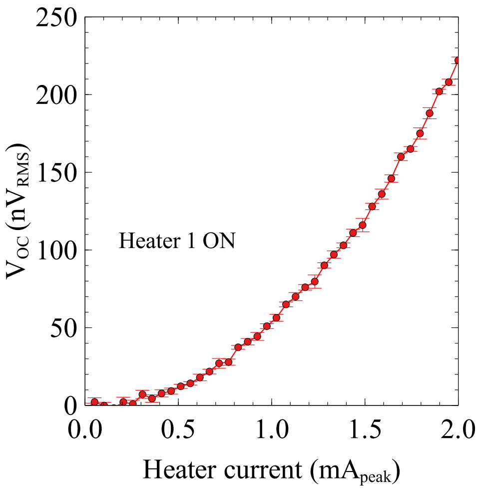

Figure 3. Open-circuit voltages plotted as a function of the heater 1 current at 300K.

References
1. C. R. Tellier, *Thin Solid Films*, vol. 51, no. 3, pp. 311-317, Jun. 1978.
2. C. R. Pichard, C. R. Tellier, A. J. Tosser, *J. Phys. F: Met. Phys.*, vol. 10, no. 9, pp. 2009-2014, Sep. 1980.
3. D. M. Rowe, CRC Handbook of Thermoelectrics, Boca Raton, FL, USA:CRC Press, 1995.