Electrodeposition of p-type Bi-Sb-Te alloys and fabrication of Π-structured micro-thermoelectric device

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Thermoelectric devices, which can directly convert heat into electricity, have numbers of advantages and attract attention in the field of energy harvesting. In particular, micro-thermoelectric device is expected to generate electricity from various heat sources. Here, we report investigation of electrodeposition of p-type Bi-Sb-Te films, and fabrication of Π-structured micro-thermoelectric device via electrodeposition process.

For fabrication of devices, n-type Bi_2Te_3 and p-type Bi-Sb-Te films were electrodeposited. N-type films were obtained using reported condition[2)], and p-type films were electrodeposited from HNO_3 based aqueous solution containing $Bi(NO_3)_3$ $5H_2O$, TeO_2, Sb_2O_3, and tartaric acid. Three electrodes including Au/Cr/Glass as working electrode, Pt mesh as counter electrode, and Ag/AgCl as reference electrode were employed. The electrodeposition condition was optimized by controlling bath temperature, bath composition, and deposition potential. Π-structured thermoelectric device consists of 55 p-n units, which were electrodeposited to the patterned substrate formed by lithography. Each pattern has array of 200 μm in diameter. The properties of thermoelectric device were measured by giving temperature difference using halogen lamp as a heat source.

At first, the deposition condition of p-type Bi-Sb-Te films was optimized using Au flat substrate. Using this condition, electrodeposition into the patterns was carried out. However, surfaces of patterned deposits were not sufficiently flat to fabricate the devices. Hence, the effect of deposition condition such as the deposition potential was studied and fixed at -80 mV and +530 mV, which could form smooth surface as is shown in Figure 1. The Seebeck coefficient of this film was 29.1 μVK^{-1}. Based on this condition, thermoelectric devices were fabricated. Figure 2 shows the performance of the device. The obtained maximum power of the device was 2.35 μW around 200°C, which was improved compared to previous study[2)] (0.96 μW).

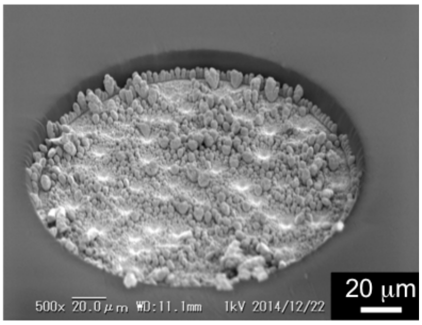

Fig.1 SEM image of p-type pattern

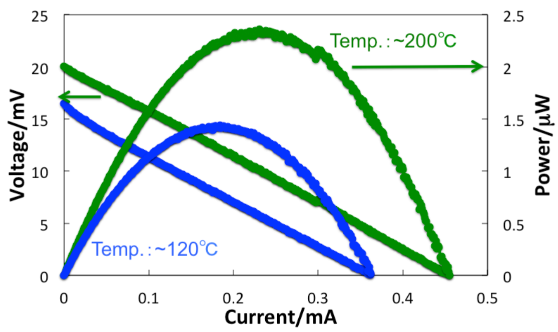

Fig.2 I-V curves of thermoelectric device

Reference:

1) G.J. Snyder, J.R. Lim, C.K. Huang, J.P. Fleurial ; Nature 2, 528–531 (2003)
2) K. Uda, Y. Seki, M. Saito, Y. Sonobe, Y-C. Hsieh, H. Takahashi, I. Terasaki, T. Homma ; Electrochimica Acta, 153, 515-522 (2015)