Anomalous Nernst effect of epitaxial Fe_4N films grown on $SrTiO_3(001)$ substrates

IMR, Tohoku Univ.[1], CSRN, Tohoku Univ.[2], Dept. Mater. Process Eng., Nagoya Univ.[3], JST-CREST[4], CSIS, Tohoku Univ.[5]

○Keita Ito[1,2], Jian Wang[2,1], Himanshu Sharma[1,3,4], Masaki Mizuguchi[1,2,3,4], Koki Takanashi[1,2,5]

E-mail: keita.ito.e3@tohoku.ac.jp

Recently, the development of thermoelectric power generation (TEG) devices utilizing the anomalous Nernst effect (ANE) is attracting increasing interest. However, a current critical technical issue for practical application to ANE-based TEG is a much small value of the thermoelectric power of ANE (S_{ANE}) compared with that of the conventional Seebeck effect (SE)-based TEG. We focus on Fe_4N as a new material with a large S_{ANE}. Fe_4N is composed of earth abundant elements and relatively large S_{ANE} of 2.2 μV/K has been experimentally reported in a Fe_4N film on a MgO(001) substrate [1]. In addition, large transverse Peltier coefficient (α_{xy}) of 2.4 A/(m·K) is theoretically predicted [2]. In this study, ANE of epitaxial Fe_4N films grown on $SrTiO_3$(STO)(001) substrates were measured in order to experimentally evaluate its α_{xy}.

The epitaxial Fe_4N film with a thickness of 27 nm was grown at 400 ºC on STO(001) substrates by molecular beam epitaxy (MBE). Subsequently, a 2-nm-thick Al capping layer was formed on the Fe_4N layer in a sputtering chamber connected to the MBE chamber. The sample was microfabricated into a Hall bar shape using photolithography and ion milling for the measurements of ANE, SE, and the anomalous Hall effect (AHE). External magnetic fields were applied in the direction perpendicular to the film surface and temperature gradient (∇T) was applied to the in-plane Fe_4N[110] direction.

The S_{ANE} of 2.5 μV/K was obtained and this value is larger than that of the Fe_4N film on the MgO(001) substrate [1]. The lattice mismatches of MgO(001)/Fe_4N and STO(001)/Fe_4N are −9.9 and −2.8%, respectively, and the Fe_4N films on the STO(001) substrates have better crystal orientation [3]. That is considered to be the reason why a larger S_{ANE} was obtained in STO(001)/Fe_4N sample. By using the results of ANE, SE, and AHE measurements, α_{xy} of the sample was estimated to be 1.5 A/(m·K). This value is smaller than the theoretically predicted 2.4 A/(m·K) [2]. The difference between the experimental and the theoretically predicted values might be due to the imperfect chemical ordering of N atoms in the Fe_4N film. The anisotropy of S_{ANE} in Fe_4N films depending on the crystallographic ∇T direction will be presented.

We thank T. Seki, W. Zhou, and Y. Sakuraba for technical support to measure ANE. This work was supported by the Grants-in-Aid for Scientific Research (S) (JP18H05246) and (C) (JP21K04859) from JSPS KAKENHI, JST-CREST (JPMJCR1524), the Murata Science Foundation, CASIO Science Promotion Foundation (37-01), Collaborative Research Center on Energy Materials, IMR, Tohoku University, and the Cooperative Research Project of the Research Institute of Electric Communication, Tohoku University.

[1] S. Isogami *et al.*, Appl. Phys. Express **10**, 073005 (2017). [2] A. Sakai *et al.*, Nature **581**, 53 (2020).
[3] K. Ito *et al.*, J. Cryst. Growth **455**, 66 (2016).