Anomalous Nernst effect in compensated ferrimagnetic Mn_2Ru_xGa

IMR, Tohoku University[1], CSRN, Tohoku University [2], CSIS, Tohoku University [3]

○Yong-Chang Lau[1,2], Jian Wang[1,2], Takahide Kubota[1,2], Koki Takanashi[1,2,3]

E-mail: yongchang.lau@imr.tohoku.ac.jp

Compensated ferrimagnets are interesting for spintronics as they exhibit the advantages of an antiferromagnet (e.g. fast switching, high storage density and immunity to external field) while simultaneously are compatible with the well-understood reading and writing schemes for a ferromagnet. Mn_2Ru_xGa (MRG) is a prototypal compensated ferrimagnet crystallizing in the XA inverse Heusler structure, where Mn atoms occupy two inequivalent 4*a* and 4*c* sublattices and couple antiferromagnetically. Magnetic compensation may be realized at a temperature T_{comp} due to the distinct temperature dependence of two Mn sites. T_{comp} can be tuned by varying the Ru composition *x*. Previous works have demonstrated high spin polarization [1], large anomalous Hall effect [2], finite tunnel magnetoresistance [3], efficient spin-orbit torque switching [4], and single-pulse optical switching [5] in nearly compensated MRG.

Here, we explore the potential of using epitaxial MRG films with strong perpendicular magnetic anisotropy (PMA) and tiny net saturation magnetization M_s for the generation of thermoelectric power via anomalous Nernst effect (ANE), without creating stray field to the surrounding. Epitaxial (001)-oriented MRG films with thicknesses ~27 nm and *x* ranging from 0.26 to 0.73 were grown on MgO (001) substrates by magnetron co-sputtering Mn_2Ga and Ru targets. The growth temperature was ~350°C. The PMA of MRG is attributed to the substrate induced in-plane biaxial compressive strain which gives rise to a weak tetragonal distortion of the lattice. MRG films were fabricated into millimeter-scale Hall bar devices. The longitudinal Seebeck coefficient S_{xx} and the transverse anomalous Nernst coefficient S_{xy} were measured by applying an in-plane thermal gradient along MRG [110], while sweeping an out-of-plane magnetic field.

We systematically measured the *x*-dependence of the transport/thermoelectric properties at 300 K. We first identified T_{comp} ~ 300 K for x ~ 0.6. Then, we found that ρ_{xy}, S_{xx}, S_{xy}, and the transverse thermoelectric conductivity α_{xy} all switch sign across compensation. For x = 0.51 and x = 0.73, i.e. MRG with T_{comp} just below and above 300 K, with their tiny M_s < 20kA/m, we obtain $|S_{xy}|$ ~ 0.2 μV/K and $|\alpha_{xy}|$ ~ 0.07 A/(K·m). These values are comparable with those of the chiral antiferromagnet Mn_3Sn [6]. We have established that the thermoelectric properties of MRG is governed by the magnetization direction of Mn sublattices rather than that of the net moment. This work was partly supported by JSPS KAKENHI (Grant No. JP20K15156, JP20K05296).

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