二軸引っ張り歪み印加によるフレキシブル基板上 Co 薄膜の垂直磁気異方性制御

Control of perpendicular magnetic anisotropy of Co thin films formed on a flexible substrate by using a biaxial stretching technique

東大物工 [1], 阪大産研 [2], 阪大 CSRN[3]

○松本 啓岐 [1,2], 太田 進也 [1,2], 小山 知弘 [2,3], 千葉 大地 [2,3]

The Univ. of Tokyo[1], ISIR, Osaka Univ. [2], CSRN-Osaka[3]

°Hiroki Matsumoto[1,2], Shinya Ota[1,2], Tomohiro Koyama[2,3], and Daichi chiba[2,3]

E-mail: hmatsumoto@g.ecc.u-tokyo.ac.jp

Magnetization direction of ferromagnetic metal thin films deposited on a flexible substrate can be controlled by uniaxially stretching the substrate [1,2]. If a tensile strain is induced by stretching it along the *x* axis, compressive strain is induced both in the *y* and *z* axes owing to the Poisson's effect. In an fcc(111)-oriented Co film, the stretch-induced shrinkage in the out-of-plane direction is expected to induce a perpendicular magnetic anisotropy (PMA) [3]. Although a PMA modulation by uniaxial stretching has been reported for Pt/Co/Pt tri-layer structure, the induced PMA is much smaller than the in-plane magnetic anisotropy induced along the stretched direction [1,4]. To apply a much larger perpendicular compressive strain without inducing the in-plane anisotropy, we utilize a *biaxial* stretching technique. As a result, we successfully demonstrate the stretch-induced magnetization easy axis switching from in-plane to out-of-plane in Pt/Co/Pt.

Ta/Pt(2.0nm)/Co(1.5nm)/Pt(2.0nm) layers from the substrate side were deposited on a flexible polyethylene naphthalate substrate by rf sputtering. Anomalous Hall resistance R_{AHE} loops were measured under several in-plane uniaxial tensile strain ε_u and biaxial ε_b conditions. As shown in Figure, the sample initially shows in-plane easy axis and remains in-plane-easy even at $\varepsilon_u = 2.0$ %. On the other hand, a PMA-induced square hysteresis is clearly observed at $\varepsilon_b = 2.0$ %. The effective PMA field by the shrinkage effect is in the order of 0.1 T. This easy-axis-switching is confirmed also in the similar samples with Pt layers instead of the Pd top and bottom layers.

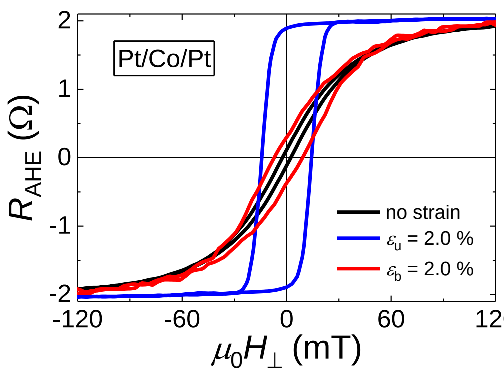

Figure: The result of anomalous Hall measurements under no strain, 2.0 % uniaxial tensile strain, 2.0 % biaxial tensile strain.

The authors thank A. Ando for useful discussion and technical help. This work was partly supported by JSPS KAKENHI (Grant Nos. 19H00860 and 17J03125) from JSPS, and Spintronics Research Network of Japan.

[1] S. Ota *et al.*, *Appl. Phys. Express.* **9**, 043004 (2016). [2] R. Asai *et al.*, *J. Appl. Phys.* **120**, 083906 (2016). [3] H. Takahashi *et al.*, *J. Magn. Magn. Mater.* **126**, 282 (1993). [4] S. Ota *et al.*, *Nat. Electron*. **1**, 124 (2018).