Magnetic anisotropy of Fe thin films on vicinal Si(111) substrate

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The magnetic anisotropy of magnetic system is one of the key parameters in spin-electronic devices because the magnetic anisotropy strongly affects magnetic properties such as coercivity and remanence. Recently, epitaxially grown two-dimensional (2D) single-crystalline magnetic layers on semiconductor substrates have been widely introduced due to its efficient spin injection property [1]. It is necessary to investigate the magnetocrystalline anisotropy (MCA) because MCA plays a primary role in determining magnetic properties of the single-crystalline materials. Especially, (111) oriented 2D magnetic layer is very sensitive to substrate misorientation owing to enhanced interplay between MCA and magnetostatic field [2]. In this study, the magnetic properties of 3 nm and 7 nm thick Fe layers on Si (111±0.5°) along [110] direction are measured by vibrating-sample magnetometer and analyzed using a total energy equation. Although it is not easy to describe the total energy of magnetic system, reflection high-energy electron diffraction patterns and X-ray diffraction patterns show that the Fe layer is nearly single-crystalline structure and the total energy equation can be expressed in a simple form. Figure 1 shows the remanence ratios of in-plane hysteresis loops of 3 nm and 7 nm Fe layer. In Fig. 1, 3-nm-thick Fe layer shows two-fold anisotropy owing to not MCA but induced uniaxial anisotropy resulted from the interface between the Fe layer and Si substrate. On the contrary, 7-nm-thick Fe layer shows asymmetric four-fold anisotropy due to the effects of vicinal substrate on MCA, and the effects of vicinal substrate are estimated by calculated hysteresis loops using the total energy equation.

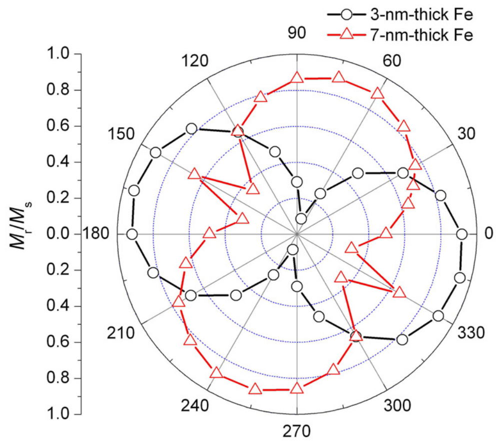

Figure 1. Polar plot of remanence ratios (M_r/M_s) measured from 3-nm-thick Fe hysteresis loops (circles) and 7-nm-thick Fe hysteresis loops (triangles).

Reference

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