Magnetic resonance of Fe thin-films investigated by the anomalous Hall effect

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Understanding of the spin dynamics in nano-scale ferromagnetic materials is interesting since the ferromagnetic materials shows different physical properties in the nano-scale regime. To investigate this, employing the spin-torque induced ferromagnetic resonance (FMR) is one candidate. [1,2] However, there are some problems in the analysis employing the spin-torque induced FMR especially in a demand of reference layers and limitation in the magnetic field angle. The anomalous Hall effect has been employed to characterize static magnetization dynamics as well as FMR dynamics. [3] In the present study, we tried to detect the magnetic resonance of Fe thin-films using the anomalous Hall effect.

Figure 1(a) shows an optical microscope image of the device. First, Fe (0-5 nm)/V(12 nm)/Au(3 nm) multilayer was prepared on single crystal MgO (001) substrate using molecular beam epitaxy methods. Substrate temperature during the Fe deposition was 200℃. V and Au layer were deposited at room temperature. Then the multilayer was patterned into the Hall bars using electron beam lithography and Ar ion milling. FMR in the Fe is excited by the current–induced magnetic field from the RF oscillators. Since the magnetization precession should produce RF anomalous Hall voltage under DC current, the FMR spectra should be measured as the DC homodyne detection voltage under RF current. Figure 1(b) shows typical FMR spectra, where the thickness of the Fe is 5 nm. Clear peak which depends on the input current frequency was observed. Fe thickness, input current frequency, magnetic field angle dependences will be discussed in the presentation. This work was supported by a Grant-in-Aid for Scientific Research (S) (No. 23226001).

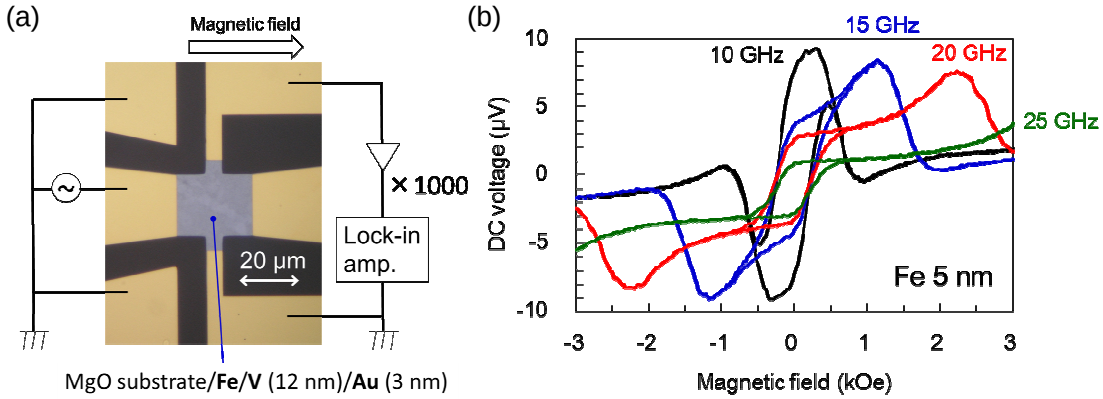

Figure 1　(a) Optical microscope image of the device.
(b) DC voltage measured using Lock-in amp, which shows the FMR spectra of the Fe-5-nm-film.

[1] A. A. Tulapurkar *et al.*, Nature **438**, 339 (2005).　[2] S. Miwa *et al.*, APEX **5**, 123001 (2012).
[3] N. Kikuchi *et al.*, APL **105**, 242405 (2014).