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Spin-torque-induced magnetic resonance in Fe nanoparticles

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The electrical manipulation and detection of submicron-scale magnets have been successfully conducted by using the spin-torque and magnetoresistance (MR) effects. Nanoscale magnets are currently attracting a great deal of attention and magnetic nanoparticles are one of the most promising technologies for fundamental physics and device applications. Hence, it is important to understand and control the magnetization dynamics in such systems; furthermore, the electrical manipulation of nanomagnets, and thus the physics of spin-torque acting on these small-spin systems, is indispensable. Spin-torque magnetic resonance in magnetic tunnel junctions (MTJs) [1] is known as a highly sensitive magnetic resonance detection tool. [2] In the present study, we have tried to employ the spin-torque magnetic resonance to detect the magnetization dynamics in Fe nanoparticles embedded in MgO insulating matrix. [3]

Figure 1(a) shows the schematic structure of the device, and all of the layers are grown by molecular beam epitaxy methods. The Fe film (50 nm) and Fe nanoparticles (0-3 nm) act as a magnetic reference layer and free layer, respectively. The resistance of the MgO barrier is much greater than that of the MgO cap layer, thus this structure enables us to study magnetization dynamics in Fe nanoparticles. The designed junction size was 1.2 x 0.3 μm^2. From magnetoresistance curves, the diameters of the Fe nanoparticles are estimated to be several nanometers. (from 7 nm to 2 nm) Then we applied the RF current into the tunnel junctions and detect the magnetic resonance spectra as a DC homodyne detection voltage (Fig. 1(b)).

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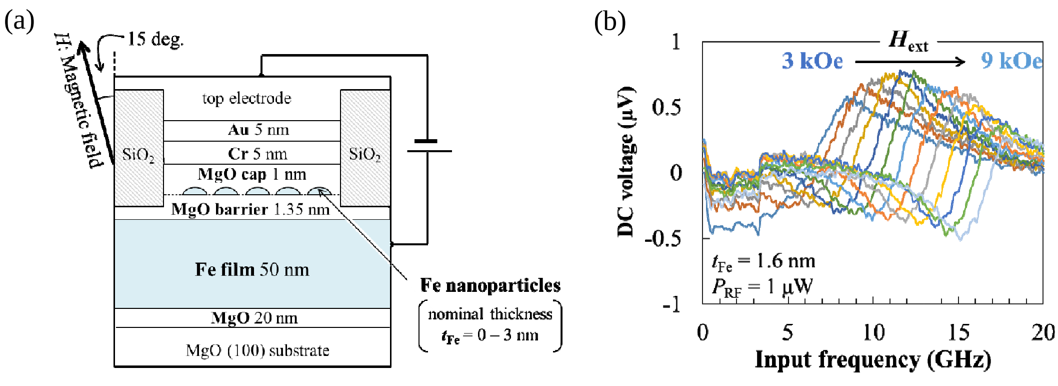

Figure 1　(a) Device structure　(b) Typical magnetic resonance spectra in the Fe nanoparticles

[1] A. A. Tulapurkar *et al.*, Nature **438**, 339 (2005).
[2] S. Miwa *et al.*, Nature Mater. **13**, 50 (2014).
[3] S. Miwa *et al.*, Appl. Phys. Express **5**, 123001 (2012).