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垂直磁気異方性を有する Fe/Ni 超格子のダンピング定数

Magnetization Damping of Fe / Ni Superlattices with Perpendicular Magnetic Anisotropy

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[Introduction] Rapid development of spintronic and magnetic storage devices has required us to achieve ultrafast device operation with low power consumption. Magnetization damping is a key physical parameter because it affects the magnetization switching speed and the current density required for spin-transfer switching. Recently, the damping parameters have intensively been studied for ferromagnetic thin films with perpendicular magnetization. An $L1_0$-FeNi thin film also has a possibility as a new material with perpendicular magnetization [1]. Although there are many reports on the damping parameter for FeNi alloys, *e.g.*, Permalloy (~ $Fe_{20}Ni_{80}$), the systematic investigation has not been carried out for Fe/Ni superlattices including $L1_0$-FeNi. In this study, we systematically investigated the magnetization dynamics of the Fe/Ni superlattices such as the Ni composition dependence of the magnetization damping.

[Experimental Procedure] Thin films were prepared employing a molecular beam epitaxy system. A 50 nm-thick $Au_{0.06}Cu_{0.51}Ni_{0.43}$ ternary buffer layer was grown on an MgO (001) single crystal substrate with a 70 nm-thick Cu_3Au layer and a 1 nm-thick Fe seed layer. Then, Fe and Ni layers were alternatively deposited using the monolayer-controlled technique. Magnetic properties for thin films were measured using a superconducting quantum interference device magnetometer. Magnetization dynamics was characterized using a coplanar waveguide (CPW) and a vector network analyzer (VNA). A transverse rf magnetic field of ~ 6 Oe was applied to the thin films, and the change in the reflected signal was detected with VNA. The static magnetic field (H) was applied in the film plane.

[Results and Discussion] The $L1_0$-FeNi film ($Fe_{50}Ni_{50}$ (at.%)) showed relatively high perpendicular magnetic anisotropy of $K_u = 7 \times 10^6$ erg/cm^3 although the film was magnetized in the film plane due to its demagnetizing field. Clear resonant peaks were observed in the ferromagnetic resonance spectra for the Fe / Ni superlattices with various Ni concentrations. The damping parameter (α) was estimated from the resonant linewidth as a function of H, which was obtained to be 0.091 for $L1_0$-FeNi. This value of α was much larger than the value reported in the sputtered FeNi film ($\alpha = 0.0027$) [2]. We also measured α for the disordered FeNi film prepared by co-deposition of Fe and Ni using the MBE system. α for the disordered FeNi was obtained to be 0.013, which was almost one order of magnitude smaller than that for $L1_0$-FeNi. The Ni composition dependence of α suggests that there exists the linear relationship between α and K_u in the Fe / Ni superlattices.

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