FERROMAGNETIC RESONANCE STUDIES OF DILUTED IRON NANOGRANULAR FILMS

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Diluted ferromagnetic-metal nanogranular films, in which a volume fraction of the granules (x_v) is much lower than the percolation threshold, have been of great interest because they are proposed as a possible candidate for materials with both electrical permittivity (ε) and magnetic permeability (μ) negative, called left-handed materials (LHMs) [1]. The effective permittivity (ε_{eff}) of such films is negative at frequency less than the plasma frequency of ferromagnetic-metal particles. On the other hand, the effective permeability (μ_{eff}) can be negative at frequency in the vicinity of the ferromagnetic resonance (FMR) frequency (ω_0). ω_0 is usually in the region of microwaves. It may thus be possible to prepare a material with ε_{eff} and μ_{eff} both negative for microwaves. In order to realize LHMs by using this system, detailed knowledge of FMR of the diluted ferromagnetic-metal nanogranular films is crucial.

In this contribution, we have studied FMR of diluted iron nanogranular films, in which Fe nanoparticles are embedded in amorphous SiO_2 matrices. Films with different Fe volume fraction (x_v=0.05 and 0.15) were prepared by co-sputtering method. In FMR studies, we observed a clear resonance signal assigned to a uniform mode from both samples. Neither of temperature nor angular between the sample plane and applied magnetic field affects on the resonance signal of a sample with x_v=0.05. On the contrary, the resonance signal of x_v=0.15 strongly depends on the both parameters. The dependence can be explained by Kittel's equations for a ferromagnetic disk [2]. These results suggest that Fe nanoparticles in x_v = 0.15 are magnetically coupled. Furthermore, in FMR spectra of x_v=0.15 at low temperature, we found that an additional resonance emerges at a magnetic field below the uniform mode. A possible origin of the additional resonance will be discussed.

[1] S. T. Chui and L. Hu, Phys. Rev. B **65**, 144407 (2002).

[2] C. Kittel, *Introduction to Solid State Physics*, 7th ed. (Wiley, New York, 1996).

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