RE12

Annealing Temperature Dependence of Microwave Permeability in CoFe/MnIr Bilayers

Dong Young Kim*[1], C.O. Kim[1], M. Tsunoda[2], and M. Takahashi[2]
[1]ReCAMM, Chungnam National University, 220 Gung-Dong, Yu-Seong Gu, Daejeon, 305-764, Korea
[2]Department of Electronic Engineering, Tohoku University, Aoba-ku, Sendai, 980-8579, Japan
*Corresponding author: dykim30@hanmail.net, Phone: +81 22 795 7044, Fax: +81 22 263 7398

Many studies for exchange coupling phenomenon between ferromagnetic (F) and antiferromagnetic (AF) bilayers have been focused on enhancement of exchange bias field. Recently, the microwave permeability of F/AF bilayers has been studied for antiferromagnetic thickness dependence on exchange bias field [1, 2], and for high frequency device applications [3]. In this study, we prepared CoFe/MnIr bilayers on silicon substrates in order to investigate the annealing temperature dependence of microwave permeability. The exchange bias field was obtained from hysteresis loop measured by vibrating magnetometer. And the microwave permeability was measured in the frequency range of 100 MHz to 9 GHz using a permeameter. The measured microwave permeability in CoFe/MnIr bilayers was analyzed using the Landau-Lifshitz-Gilbert theory in terms ofthe exchange bias field. The initial permeability and ferromagnetic resonance frequency can be tuned by controlling the exchange bias field, which is depend on the CoFe thickness and unidirectional anisotropy. The tuneablerange of ferromagnetic resonance frequency is up to 20 GHz in CoFe/MnIr bilayers. Therefore, the exchange coupled CoFe/MnIr films, which shows the high permeability and low loss properties in the microwave frequency range, canbe applied to the microwave devices.

REFERENCES
[1] S. Queste, S. Dubourg, O. Acher, J.C Soret, K.U. Barholz, and R. Mattheis, J. Magn. Magn. Mater. 288, 60 (2005)
[2] H. Xi, J. Rantschler, S. Mao, M.T Kief and R. M White, J. Phys. D: Appl. Phys. 36, 1464 (2003)
[3] B. Viala, G. Visentin and P. Gaud, IEEE Trans. Magn. 40, 1996 (2004)

RE13

Antiferromagnetic Interlayer Coupling Through a Thin MgO Layer in (Iron Oxides)/MgO/Fe(001) Multilayers

H. Yanagihara, Yuta Toyoda, and Eiji Kita*
Institute of Applied Physics, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, 305-8573, Japan.
*Corresponding author: kita@bk.tsukuba.ac.jp, Phone: +81 29 853 5303, Fax: +81 29 853 5205

We have found strong antiferromagnetic coupling between ferromagnetic metal (Fe) and ferromagnetic Fe oxides ($Fe_{3-\delta}O_4$) via insulator MgO. The maximum amplitude is slightly smaller than that of the strongest metallic system, Co/Ru. We have succeeded in growing spinel type Fe oxides $Fe_{3-\delta}O_4$ / MgO / Fe multilayers epitaxially on MgO(001) substrates[1]. A conventional MBE technique was utilized to grow the MgO(001) and Fe(001) layers, and the Fe oxides ($Fe_{3-\delta}O_4$) layers were grown by reactive MBE with ozone and/or oxygen gases. During the Fe oxidesgrowth, an oscillating intensity of the specular spot of reflection high energy electron diffraction (RHEED) pattern was observed, indicating atomically flat surfaces. γ-Fe_2O_3(maghemite) was obtained by using ozone gas and Fe_3O_4(magnetite) for pure oxygen. A wedge structure of MgO layer was formed by using a moving shutter and the thickness was varied from 0 to 30 Å.The sample with thicker MgO layer (200 Å) was also fabricated to confirm the characteristic of non-coupled ferromagnetic layers. The thicknesses of $Fe_{3-\delta}O_4$ and Fe layers were 130 Å and 300 Å, respectively.

Magnetization curve of MgO(001)/γ-Fe_2O_3(maghemite)/MgO(5 Å)/Fe(001) multilayers was shown in Fig.1 The remanent magnetization and saturation magnetization (about 3 kOe) correspond to the balance and sum of those for two ferromagnetic layers. Such a curve has been also found in the Fe_3O_4(magnetite) case and itstrongly suggests the presence of antiferromagnetic coupling between Fe and $Fe_{3-\delta}O_4$ (maghemite and magnetite) layers. When the thickness of MgO was sufficiently large as 20 nm, however, magnetization switching of each layer of Fe and $Fe_{3-\delta}O_4$ occurs independently. In these cases, two magnetic layers have no magnetic coupling through the MgO layers. The absolute value of the magnetic coupling was monotonically increased with decreasing the MgO thickness and was about 2 erg /cm^2 for both 5 Å of γ-Fe_2O_3 and Fe_3O_4 cases. It is noted that the magnitude decreased for γ-Fe_2O_3(maghemite) while keeps constant for Fe_3O_4, with further decreasing of MgO layer thickness. Antiferromagnetic coupling via insulating MgO layer has been reported for Fe/MgO/Fe case, however, the magnitude for the present case is 10 times larger[2,3].

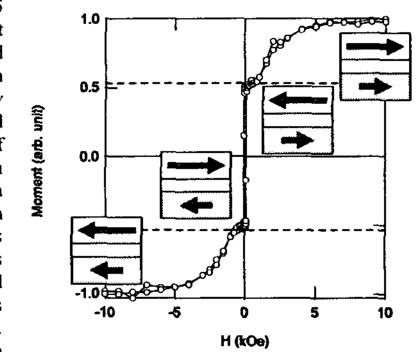

Fig. 1. Magnetization cuve of γ-Fe_2O_3/MgO(0.5 nm)/ Fe(001) multilayer

REFERENCES
[1] H. Yanagihara *et al.* J. Phys. Soc. Jpn. **75**, 054708(2006).
[2] J. Faure-Vincent *et al.*, Phys. Rev. Lett. **89**, 107206 (2002).
[3] T. Katayama *et al.* Appl. Phys. Lett., **89**, 112503 (2006).