

Tunnel Magnetoresistance Effect in Magnetic Tunnel Junctions with $L1_0$ -ordered MnAl electrode

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Magnetic tunnel junctions using perpendicularly magnetized ferromagnetic electrodes (p -MTJs) have great useful for the spintronics devices. According to the theoretical expectation [1], a switching current density (J_{co}) is directly related to saturation magnetization (M_s) and Gilbert damping constant (α) of the ferromagnetic free layer of MTJs. In order to achieve high thermal stability and low switching current density in p -MTJs, ferromagnetic materials with large perpendicular magnetic anisotropy energy (K_u), small M_s and low α are required. We focus on a $L1_0$ -MnAl alloy as a promising ferromagnetic material with small M_s , high K_u and low α . In our previous work, we have succeeded to fabricate $L1_0$ -ordred MnAl films with high K_u over 10^7 erg/cc and low α of 0.006 [2]. In this work, we have investigated tunnel magnetoresistance (TMR) effect in MTJs using a $L1_0$ -ordred MnAl electrode.

All the films were prepared by a magnetron sputtering system. The structure of prepared films was MgO(001)-sub./Cr(40)/MnAl(50)/CoFeB(1.3)/MgO(3)/CoFe(5)/Ta(5) (in nm). The substrate temperature (T_s) during deposition of MnAl films was 250°C. All the MTJs were patterned into 4-terminal structure by photo-lithography and Ar ion milling. After the micro-fabrication of MTJs, annealing process was carried out at $T_a = 200 - 400^\circ\text{C}$. TMR effect was measured by DC 4-probe method at RT.

We confirmed by XRD measurements that the prepared MnAl electrode had (001)-orientation and $L1_0$ -ordered structure. In addition, the M - H curves measured by VSM shows that the MnAl electrode possess perpendicular magnetic anisotropy. The MnAl electrode showed a relatively small saturation magnetization of 530 emu/cm³, large magnetic anisotropy energy of ca. 1×10^7 erg/cm³ and small surface roughness of 0.4 nm. Fig. 1 shows TMR curves in MTJs with the MnAl electrode annealed at 250°C. TMR ratio at RT was 12.5%. This is the first observation of TMR effect in MTJs using $L1_0$ -ordred MnAl electrode. This work was supported by the FIRST program.

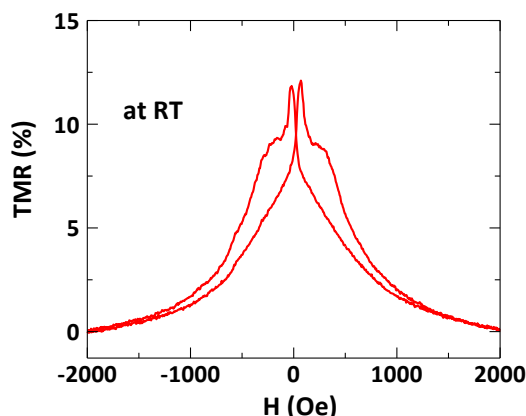


Fig. 1 TMR curve in a MnAl/MgO/CoFe magnetic tunnel junction

[1] J. C. Slonczewski, J. Magn. Magn. Mater., 159, L1 (1996)

[2] M. Hosoda, M. Oogane, M. Kubota, T. Kubota, H. Saruyama, S. Iihama, H. Naganuma, and Y. Ando, J. Appl. Phys. 111, 07A324 (2012)