Giant tunnel magnetoresistance using a cation-disorder $MgAl_2O_4$(001) epitaxial barrier deposited by a direct sputtering technique

NIMS, °Mohamed Belmoubarik, Hiroaki Sukegawa, Tadakatsu Ohkubo,

Seiji Mitani, and Kazuhiro Hono

E-mail: belmoubarik.mohamed@nims.go.jp

Recently, the capability of $MgAl_2O_4$ tunnel barrier in magnetic tunnel junctions (MTJs) has been investigated for future non-volatile magnetoresistive memory applications. To date, a large tunnel magnetoresistance (TMR) ratio exceeding 300% at room temperature (RT) was achieved in $MgAl_2O_4$ based MTJs using a post-oxidation of an Mg-Al alloy layer [1]. However, the potential issues of chemical non-uniformity and rough interfaces of the post-oxidized $MgAl_2O_4$ barriers make it difficult to achieve a large TMR ratio when the tunnel barrier thickness is reduced. In this study, we report a large TMR ratio and very flat $MgAl_2O_4$ barrier interfaces using direct sputtering from a sintered $MgAl_2O_4$ target.

The MTJs with the following structure was prepared using an ultra-high vacuum magnetron sputtering system: MgO(001) substrate/Cr (40)/Fe (100)/MgAl/$MgAl_2O_4$/Fe (7)/IrMn (12)/Ru (10), units in nm. The $MgAl_2O_4$ barrier was deposited using RF sputtering and subsequently post-annealed at 500°C to improve the crystalline quality. The ultra-thin MgAl layer was also inserted to tune the interface state. DC 4 probe method was used for the transport measurements of micro-fabricated MTJ pillars. An annular dark-field scanning transmission electron microscopy (ADF-STEM) image showed the excellent quality of the barrier and perfect lattice-matched interfaces with the Fe electrodes as shown in Fig. 1 (a). In addition, the formation of the cation-disorder $MgAl_2O_4$ structure was confirmed by the nano-electron beam diffraction (NBD) (see inset of Fig. 1 (a)). Figure 1 (b) shows the TMR curve of the MTJ with a 1.5 nm thick $MgAl_2O_4$ barrier. A large TMR ratio of 245% at RT was observed, which exceeded those of epitaxial Fe/MgO/Fe (~180%) [2] and Fe/post-oxidized $MgAl_2O_4$/Fe (~212%) MTJs [3]. These results indicate that the direct sputtering is an alternative way for the achievement of high performance spinel barrier-based MTJs, and meanwhile will be favorable for realizing uniform and thin $MgAl_2O_4$ tunnel barriers with an extended applicability. This work was partly funded by ImPACT Program of Council for Science, Technology and Innovation.

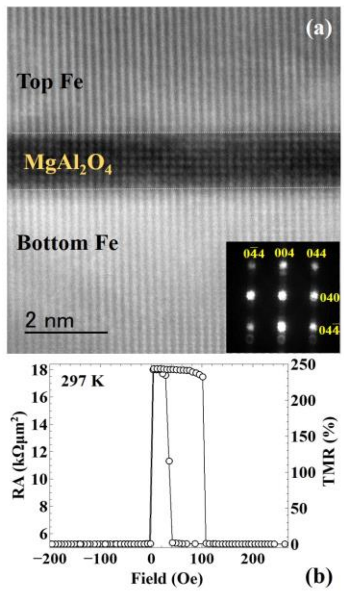

Fig. 1. (a) ADF-STEM image of a Fe/sputtered $MgAl_2O_4$/Fe MTJ. (b) TMR ratio and resistance as a function of magnetic field at RT. Inset of (a) is the NBD pattern of the barrier.

References:

[1] H. Sukegawa *et al.*, Phys. Rev. B **86**, 184401 (2012).

[2] S. Yuasa *et al.*, Nat. Mater. **3**, 868 (2004).

[3] H. Sukegawa *et al.*, Appl. Phys. Lett. **105**, 092403 (2014).