Large Reduction of Fabrication Temperature for Fully Epitaxial Fe/GaO_x/Fe Magnetic Tunnel Junctions

N. Sai Krishna[1], N. Matsuo[1,2], N. Doko[1,2], °H. Saito[1] and S. Yuasa[1]

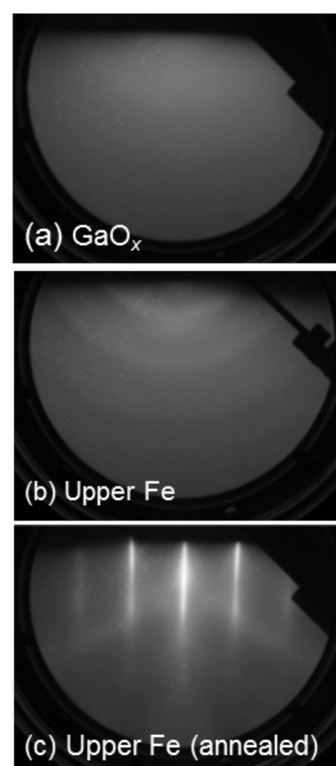
Spintronics Research Center AIST [1], Chiba Institute of Technology [2]

E-mail: h-saitoh@aist.go.jp

Semiconducting materials have recently attracted considerable attention to the tunnel barrier of magnetic tunnel junctions (MTJs) [1,2]. We have recently reported a high MR ratio up to 92% in fully epitaxial Fe(001)/GaO_x(001)/Fe(001) MTJs [3], where the GaO_x is one of the emerging semiconductors for practical applications. However, the formation temperature of the single-crystalline GaO_x is too high (~500ºC) to apply to practical applications. In this study, we developed a novel fabrication process that can largely reduce the formation temperature of the fully epitaxial MTJ from 500°C to 250°C.

MTJ films were prepared by molecular beam epitaxy. The structure of the MTJ was Au (10 nm) / Co (10 nm) / Fe (5 nm) / GaO_x (2 nm) / MgO (1 nm) / Fe (30 nm) / MgO (10 nm) on MgO(001) substrates. The GaO_x barrier layer was deposited at 80°C under an O_2 pressure of 1×10^{-6} Torr.

Figures 1 show reflection high-energy electron diffraction (RHEED) images of the (a) GaO_x barrier layer, (b) Fe upper electrode, and (c) same layer after an *in situ* annealing at 250°C, respectively. The RHEED image of the Fe upper electrode changed from broad rings to streak patterns after the *in situ* annealing. For this MTJ, we observed a high MR ratio up to 102% at RT, which is close to the reported value in the fully epitaxial MTJ [3]. These indicate that fabrication of fully epitaxial structure is possible at low temperature of 250°C.



Figs. 1 RHEED images of the (a) GaO_x barrier layer, (b) Fe upper electrode, and (c) same layer after an *in situ* annealing at 250°C, respectively.

Acknowledgments

This work was supported by the ImPACT Program and KAKENHI "Nano Spin Conversion Science" (Grant No. 26103003)

Reference

[1] T. Kanaki, H. Asahara, S. Ohya, and M. Tanaka, Appl. Phys. Lett. **107**, 242401 (2015).

[2] S. Kasai, Y. K. Takahashi, P. -H. Cheng, Ikhtiar, T. Ohkubo, K. Kondou, Y. Otani, S. Mitani, and K. Hono, Appl. Phys. Lett. **109**, 032409 (2016).

[3] N. Matsuo, N. Doko, T. Takada, H. Saito, and S. Yuasa, Phys. Rev. Applied **6**, 034011 (2016).