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Large magnetoresistance effect in magnetic tunnel junctions with a $Cu(In_{0.8}Ga_{0.2})Se_2$ barrier with a low resistance-area product

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The magneto resistance (MR) effect is indispensable phenomenon for future device applications such as read head sensors of HDDs over 2 Tbit/in^2. In order to realize highly sensitive read head sensors, a large MR ratio at a low resistance-area product (*RA*) of ~ 0.1 Ω·μm^2 is required [1]. Although there are a few promising reports [2, 3], this requirement is a great challenge for both magnetic tunnel junctions (MTJs) with an MgO barrier and current perpendicular to plane giant magnetoresistance devices with Heusler-alloy ferromagnetic electrodes. Another approach is to utilize semiconducting barriers, because their smaller band gaps may lead to an adequate *RA* without degrading MR ratios. In this study, we demonstrate a large MR ratio and a high output voltage by using the MTJs with a $Cu(In_{0.8}Ga_{0.2})Se_2$ (hereafter, CIGS) compound semiconductor barrier, having a good lattice matching with the Heusler alloys such as $Co_2Fe(Ga_{0.5}Ge_{0.5})$ (hereafter, CFGG).

The film consisting of Ru (8 nm)/Ag (5 nm)/CFGG (10 nm)/CIGS (2 nm)/CFGG (10 nm)/Ag (100 nm)/ Cr (10 nm) was deposited on an MgO (001) substrate by magnetron sputtering. After annealing at 300°C, the film was patterned into 200 × 150 nm^2-size ellipsoidal pillars by electron beam lithography and Ar ion milling. Transport properties were measured by the dc-4-probe method.

From the HAADF-STEM image, the epitaxial relationship of (001)[110]CFGG//(001)[110]CIGS and well defined layered structure with sharp interfaces were observed. The bottom and top CFGG layers were $L2_1$ and $B2$ structures, respectively. Figure 1 shows the bias voltage (V_{bias}) dependence of the (a) MR ratio and (b) output voltage ΔV (= MR ratio × V_{bias}) at 300 K. As shown in the inset of figure 1 (a), a large MR ratio of 47 % was observed at V_{bias} ~ 0 mV with a desired *RA* value of 0.14 Ωμm^2. First-principles calculation results have shown this is due to the Δ_1 electrons' coherent tunneling [4]. The MR ratio does not decrease significantly with increasing V_{bias}, resulting in the large ΔV of 24 mV at V_{bias} = 60 mV. These results suggest that CIGS is a promising barrier for the read head sensors of HDDs over 2 Tbit/in^2.

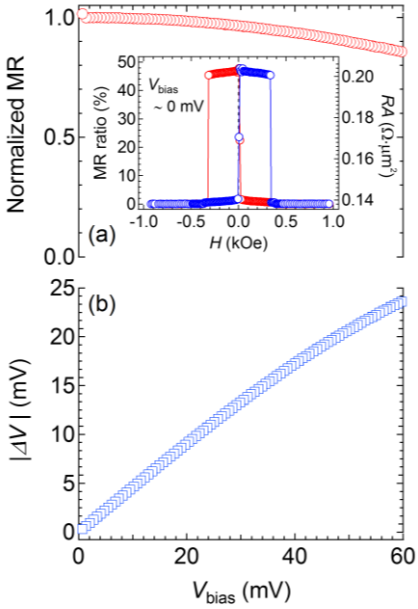

Fig. 1 Bias voltage dependence of (a) normalized MR and (b) output voltage at 300 K.

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[1] M. Takagishi *et al.*, IEEE Trans. Magn. **46**, 2086 (2010). [2] H. Maehara *et al.*, Appl. Phys. Express **4**, 033002 (2011). [3] T. Nakatani *et al.*, Appl. Phys. Express **8**, 093003 (2015). [4] K. Masuda *et al.*, arXiv: 1609.07713 [5] K. Mukaiyama *et al.*, Appl. Phys. Express **10**, 013008 (2017)

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