Magnetic tunnel junctions with a Li-substituted $MgAl_2O_4$ barrier

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Magnetic tunnel junctions (MTJs) with an $MgAl_2O_4$ spinel barrier and bcc-based ferromagnetic electrodes, e.g., Fe and Co_2FeAl, have been demonstrated to show large tunnel magnetoresistance (TMR) ratios owing to the good lattice matching of $MgAl_2O_4$ with the bcc electrodes [1,2]. For future applications of spinel-based MTJs, it will be effective to tune various barrier properties through substituting the constituent elements in a spinel oxide barrier. In this study, we choose Li as a substitution element in $MgAl_2O_4$ because it is the lightest alkali metal in the periodic table and it is able to form stable spinel oxides due to its small ionic radius (i.e. $Li_{0.5}Al_{2.5}O_5$). A Li-substituted $MgAl_2O_4$ ($Li_xMg_{1-2x}Al_{2+x}O_4$) insulator was first investigated as a material for the use in Li-ion batteries [3]. In this study, we fabricated a Li-substituted $MgAl_2O_4$ barrier by oxidation of Mg/Li-Al alloy bilayers for a new coherent-tunneling MTJs [4].

MTJ multilayers were fabricated by magnetron sputtering on an MgO(001) substrate. The stacking structure is: MgO substrate//Cr (40)/Fe (30)/Mg (0.45)/$Li_{11}Al_{89}$ (1.05)/plasma oxidation and annealing at $T_{Barrier}$/Fe (6)/IrMn (12)/Ru (20), (thickness in nm). The barrier composition was estimated to be $Li_{0.25}Mg_{0.72}Al_{2.03}O_4$. Crystalline structures of the whole multilayers were investigated using X-ray diffraction (XRD). Magneto-transport properties were characterized using current-in-plane tunneling (CIPT) and dc four probe method.

The XRD analysis confirmed an epitaxial growth with (001) orientation for both the bottom- and top- Fe electrodes, revealing an epitaxial growth of the Li-substituted $MgAl_2O_4$ barrier. The TMR ratio up to 120% at room temperature (RT) was observed for $T_{Barrier}$ = 250°C. The typical TMR curve for a microfabricated MTJ is shown in Fig. 1. We also found a weak temperature dependence of the resistance for the parallel magnetization state and local minima in the differential conductance spectrum, suggesting the occurrence of coherent tunneling through the barrier. Therefore, Li-based spinel oxides are promising materials for MTJ applications.

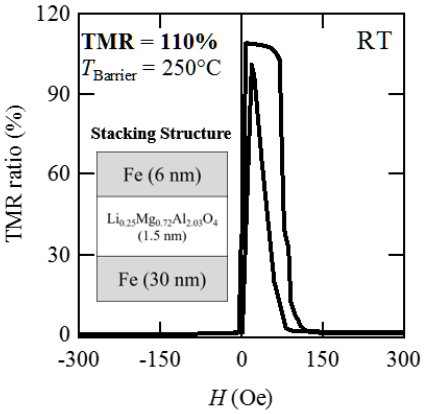

Fig. 1. TMR curve at RT for a microfabricated MTJ. Inset shows the stack structure.

This study was partly supported by JSPS KAKENHI 16H06332&16H03852, and the ImPACT Program of Council for Science, Technology and Innovation, Japan.

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