TD01

Inverse tunnel magnetoresistance in MgO-based magnetic tunnel junctions with Fe_4N electrode

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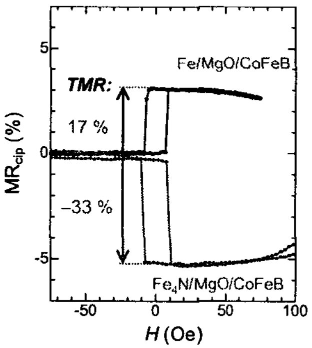
Recent development of giant tunnel magnetoresistance (TMR) ratio at room temperature in CoFeB/MgO/CoFeB magnetic tunnel junctions (MTJs) [1-2] has opened a door to the wide application fields for MTJs. While the theory has predicted and well explains the giant TMR ratio in fully epitaxial MTJs, such as Fe(001)/MgO(001)/Fe(001) [3], the role of light element B on the spin-polarized transport have not been clarified yet, excepting its metallurgical role as an amorphous former. Nitrogen is also a familiar light element, which forms various intermetallic compounds with 3d-transition metals. Fe-N system shows a specific feature in its crystalline structure and resultant magnetic properties, as N content is modified. For instance, interstitially induced N atoms up to 12 at.% expand the lattice constant *c* of α-Fe and forms α'(b.c.t.) phase. Further doping of N up to 20 at.% in a octahedron site of Fe lattice transforms the b.c.t. structure to f.c.c. structure and forms the stable Y'-Fe4N phase. In the present study, we investigated tunnel magnetoresistance of MgO-based MTJs with Fe4N, comparing to those with Fe, in order to clarify the role of N on the spin-polarized transport phenomena.

Specimens in a stacking sequence of substrate / MgO / U.L. / Fe or Fe_4N / MgO / CoFeB / Ru / Fe / MnIr / C.L. were deposited on thermally oxidized Si wafers with magnetron sputtering method. For the deposition of the MgO layer, RF magnetron sputtering from a MgO target was employed. The Fe_4N layer was fabricated by DC reactive sputtering method from an Fe target. The specimens were thermally annealed in vacuum at 320°C for 1 hr under applied field of 3 kOe. The magnetotransport properties were measured at room temperature with current-in-plane tunnelling (CIPT) methodfor wafers and with DC 4-probe method for micro-fabricated MTJs.

Figure shows CIP-magnetoresistance (MR) curves of the MTJs with Fe and Fe_4N electrodes. In the figure, calculated TMR ratios are also shown. In the case of Fe-MTJ, the MR curve shows usual TMR effect, where the parallel configuration of the Fe and CoFeB magnetizations results in lower resistance state and the antiparallel in higher resistance state. On the other hand, Fe_4N-MTJ shows an inverse MR curve with 33% of the TMR ratio. Similar inverse TMR effect was also observed in the Fe/MgO/Fe_4N-MTJs. These experimental facts clearly mean that the spin-polarization of Fe_4N electrode has opposite sign to that of Fe and CoFeB. The bias dependence of the inverse TMR effect will be presented in the conference.



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TD02

STM observation of MgO barrier layers grown on CoFeB ferromagnetic layers

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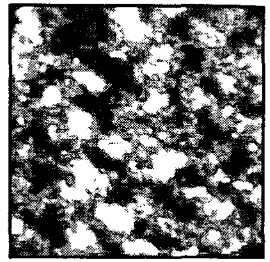

Fig. 1. A STM image (100 nm×100 nm) of a MgO layer (1.5 nm) grown on an amorphous CoFeB layer (10 nm).

Several studies relating to high tunnelling magnetoresistance (TMR) ratio in magnetic tunnel junctions (MTJs) using epitaxial MgO barrier layers have been reported[1-3]. Particularly, it is well known that annealing of MTJs using CoFeB ferromagnetic layers yields an increase of TMR ratio[4]. Local crystallizaton of CoFeB layers near interfaces by annealing is thought to be a possible mechanism accounting for the increase of TMR ratio, however detailed mechanism is unknown. In this study, we observed surface structures of MgO barrier layers grown on CoFeB ferromagnetic layers by *in situ* scanning tunnelling microscopy (STM) and investigated relation between structures and transport properties.

CoFeB layers (10 nm) and MgO layers (1.0-1.5 nm) were deposited by sputtering and molecular beam epitaxy, respectively. Topographic images were taken in a STM chamber linked to all the growth chambers under an ultra high vacuum. Figure 1 shows a STM image of a MgO barrier layer (before annealing) with a thickness of 1.5 nm grown on a CoFeB layer. Island structures with diametersof 10-20 nm were observed. These islands might reflect morphology of the amorphous CoFeB underlayer, and it was clarified that surface structures of MgO layers grown on CoFeB layers are completely different those of MgO layers grown on epitaxial Fe layers[5]. Annealing effect and thickness dependence of MgO layers will be discussed.

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