RB10

An Investigation for Existence of Iron Oxide Layer at the MgO/Fe Interface on MgO-Based TMR System

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For several decades, reserches of tunnel magnetoresistance (TMR) for enhancement of MR value have been fascinatingly attracted due to their scientific interests and possibility of industrial applications. Recently, there are so many researches on the magnetic tunnel junction (MTJ) systems using MgO as an insulating layer because of their large TMR values in contrast to Al_2O_3-based MTJ systems. Moreover, many theoretical calculations have reported that TMR value for MgO-based MTJ system has several thousands percent. However, the reported experimental TMR value at room temperature is at most below 300%. At present, this discrepancy is mainly explained due to the existence of iron oxide layer at the MgO/Ferromanget interface.

Hence, we intensively invetigate the interface between MgO and Fe layers to clarify the existence of oxide layer using x-ray absorption spectroscopy (XAS), magnetic circular dichroism (MCD), hysteresis, and spin resolved photoemission spectroscopy (SRPES) for epitaxially grown Fe/MgO/Fe samples on W(100) substrate.
As a result, we found three remarkble experimental results.

First, we found that no sizable iron oxide layer formation exists at this interface, and that the electron transfer occurs very easily from iron oxide to magnesium with XAS study of Fe/MgO systems.
Second, there are some changes in the magnetic behavior in the case of without iron oxide layer at the interface from MCD and hysteresis experiments.
Finally, we also found that the changes in the density of states at the Fermi energy and(or) in the electronic structures occurs using SRPES. Hence, we suggest that this electronic modifications at the interfaces can be another reason to reduce the TMR value.

RB11

Magnetotransport Characteristics of Magnetic Tunnel Junctions with Amorphous Synthetic Antiferromagnetic Free Layers

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A synthetic antiferromagnet (SAF) structure comprising of ferromagnetic amorphous $Co_{70.5}Fe_{4.5}Si_{15}B_{10}$ layers has been devised and employed as a free layer of magnetic tunnel junctions (MTJs) to enhance magnetoresistance ratio (TMR) and magnetization switching (Hsw) performance [1]. In $Si/SiO_2/Ta$ 45/Ru 9.5/IrMn 10/CoFe 7/AlO_x 1.5/CoFeSiB 7-*t* (F1)/Ru 1.0/CoFeSiB *t* (F2)/Ru 60 (nm) MTJ structures, we found the thickness dependence of the resistance and Hsw originating from the tunnel barrier/CoFeSiB free layer interface characteristics. When the thickness of F1 layer is thicker than F2 layer, it offerssmooth tunnel barrier/free layer interface (less electrical weak point) and hence, it shows a higher tunneling resistance. Moreover the SAF effect, such as reduction of magnetostatic energy in the free layer, is restricted due to the asymmetry of the free layer thickness separated by nonmagnetic space layer. Bcause of this, more asymmetry structure has higher Hsw. However, in terms of the TMR ratio, more asymmetric structure has the higher value. This improvement is due to thehigher effective magnetic moment in the more asymmetric sample. It is thought that the TMR ratio, tunnel resistance, and Hsw characteristics were dominated by the thickness difference in the SAF free layered MTJs.

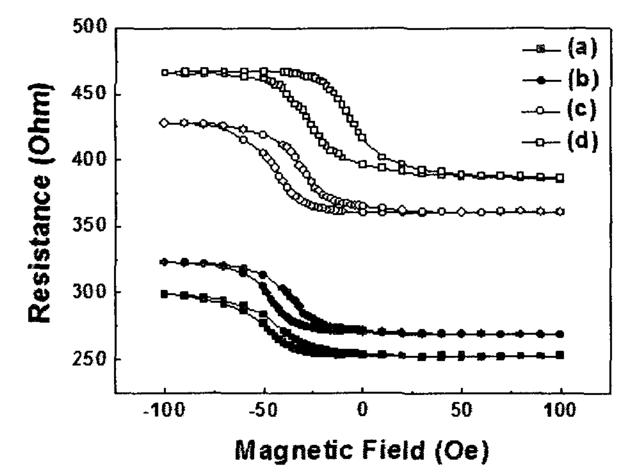

Fig. 1. *Magnetoresistance curve and switching filed for a various SAF free layered MTJs.* (a) CoFeSiB 3.5/Ru 1.0/CoFeSiB 3.5, (b) CoFeSiB 4.0/Ru 1.0/CoFeSiB 3.0, (c) CoFeSiB 4.5/Ru 1.0/CoFeSiB 2.5, and (d) CoFeSiB 5.0/Ru 1.0/CoFeSiB 2.0 (nm). When the thicker CoFeSiB layer was placed just above the tunnel barrier, higher TMR ratio, resistance, and Hsw were observed.

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