BA03

Transport Properties of Magnetic Tunnel Junctions Comprising NiFeSiB/CoFeB Hybrid Free Layers

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We reported MgO magnetic tunnel junctions (MTJs) with hybrid free layer composed of NiFeSiB/CoFeB to substitute conventionally used CoFeB layers with an aim to reduce saturation magnetization (M_s) while maintaining high TMR ratio in case of same magnetization of free layer structure [1]. In particular, we investigate the magneto transport properties depending on the thickness of amorphous NiFeSiB layer with fixed CoFeB layer thickness as a 3 nm. The MTJs consisting of Ta(5) / Ru(40) / Ta(5) / hybrid free layer / MgO(1.9) / CoFeB(4) / Ru(0.85) / CoFe(3) / IrMn(7.5) / Ta(5) / Ru(50) (in nm) were prepared by magnetron sputtering. When the hybrid free layer consisted of CoFeB(4), NiFeSiB(0.67) / CoFeB(3), NiFeSiB(1.33) / CoFeB(3) and NiFeSiB(2.66) / CoFeB(3), the TMR ratio are 204%, 230%, 210% and 214% respectively. These results are summarized in table 1. When the thickness of NiFeSiB layer became 0.67 nm, the TMR ratio increased to 230%. The microstructure of the underlying amorphous CoFeB layer appears important to obtain (001) oriented MgO layer. Also the microstructure of CoFeB layer is affected by a crystallinity of seed layer. The thin amorphous NiFeSiB layer is effective to form amorphous CoFeB structure. The relation between the microstructure of the free layer and magneto-transport is to be discussed.

Table 1. TMR ratios and RA value of the MTJs with different free layer structure. And the thickness of MgO layer was fixed to 1.9 nm. The layer thickness scale is given in nm.

Pinning type	Free layer	TMR (%)	RA ($\Omega\mu m^2$)
Top type	CoFeB (4)	204.0	87,000
	CoFeB (3)/NiFeSiB(0.67)	230.4	1,883
	CoFeB (3)/NiFeSiB(1.33)	209.8	2,381
	CoFeB (3)/NiFeSiB(2)	214.9	2,753

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Consistent Relationship between the Tunnel Magnetoresistance of CoFeB/ MgO/ CoFeB Junctions and X-Ray Diffraction Properties

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We present a simple and effective way to optimize deposition conditions for a high tunnel magnetoresistance (TMR) and suitable resistance area (RA) product of CoFeB/ MgO/ CoFeB magnetic tunnel junctions (MTJs). Recent studies revealed that the coherent tunneling in MgO-based MTJs presents a very high TMR, and the quality of the MgO barrier plays an important role for obtaining a high TMR[1, 2]. It takes much effort to find the deposition conditions providing a high-quality MgO barrier[3], which are dependent on the details of a deposition system.

We have investigated the effect of Ar pressure during the MgO sputtering on the TMR and RA product of CoFeB/ MgO/ CoFeB junctions. The TMR of MTJs with a thin MgO barrier deposited at Ar pressure of 1.3 to 25 mTorr shows a consistent relationship with x-ray diffraction (XRD) properties such as the intensity of MgO (002) peak in $\theta/2\theta$ scan and the full width at half maximum of MgO (002) peak in rocking curve measurement of thick MgO films deposited with the same conditions. The XRD data are obtained using thick MgO films (26 nm) grown on thermally oxidized Si/ SiO2 (300nm) wafers, and the TMR and RA product of MTJs are measured using MTJs with a cross-geometry structure.

It is shown that there exists an optimum range of Ar pressure for a high TMR and reasonable RA product. Deposition of the MgO-barrier at a low Ar pressure of 1.3mTorr results in a low TMR and high RA product due to a disordered MgO barrier, while the deposition at a high Ar pressure of 25mTorr results in a rough MgO barrier, and thereby gives rise to a low RA product as well as a shift of the TMR versus magnetic field curve due to a large orange-peel coupling.

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