Fabrication of quasi antiferromagnetic layer by 90°magnetic coupling through magnetic oxide layer

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Introduction

It has been theoretically reported that Spin transfer torques (STT) in antiferromagnetic (AFM) materials should be obtained[1] and the supporting experimental evidences have been reported[2,3]. STT in AFM can realize a spin torque oscillation (STO) without a stray field, which is expected to expand the STO applications. However, STT in AFM has never observed directly because it needs a higher critical energy than a typical STT in ferromagnetic (FM) materials. Therefore, we try to fabricate "quasi" AFM layer, which takes a middle state between FM and AFM, by using 90° magnetic coupling[4,5] through Fe-O layer.

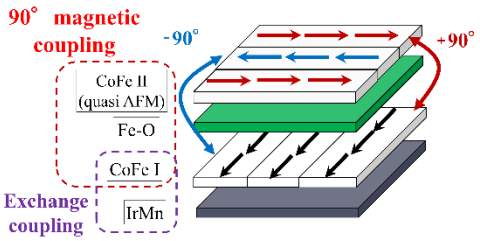

Fig.1 Quasi antiferromagnetic layer by 90° magnetic coupling

Experimental method

On the thermally oxidized Si wafers, The samples with structure Ta(5nm)/Ru(2nm)/IrMn(*t* nm)/CoFe I(2nm)/Fe-O(1nm)/CoFe II(2nm)/Cu(3nm)/CoFe III(2.5nm)/Cu(1nm)/Ta(5nm) are deposited by dc magnetron sputtering, and annealed at 270 ℃ in a field of 4.1 kOe for 1 hour. We measured *M-H* and *R-H* properties in parallel and perpendicular magnetic fields to the pinning filed by IrMn, by using VSM and 4 point probes, respectively.

Results

In the case of 10 nm of IrMn the magnetic coupling between CoFe I and CoFe II was not the 90°magnetic coupling but the ferromagnetic coupling whole of oxygen exposure range. One considerable reason of the ferromagnetic coupling was roughness of deposited layers [6]. Since 90°magnetic coupling realizes when the components of the ferromagnetic coupling and the antiferromanetic coupling compete against each other. In case of the sputtered film, the films have the roughness generally. Because the roughness leads the orange peel coupling, that is one of the ferromagnetic coupling, the balance of ferromagnetic and antiferromagnetic coupling components is lost. In order to restrain the roughness, we decreased the IrMn thickness to 5 nm and confirmed the small roughness by the cross sectional TEM images. As a result, 90 ° magnetic coupling realized when the film roughness is small as expected.

References

[1] A.S.Nunez *et al.*,Phys.Rev.B **73** 214426 (2006).[2] S.Urazhdin *et al.*,Phys.Rev.Lett. **98** 116603 (2007). [3] T. Moriyama *et al.*,, J. Appl. Phys. **106**, 162406 (2015). [4] H.Fukusawa *et al.*, J.Appl.Phys. **91**,6684 (2002). [5] C-H.Lai *et al.*,J.Appl.Phys. **93**,8412 (2003). [6] S.Maat *et al.*, J.Appl.Phys. **93**,7229 (2003)

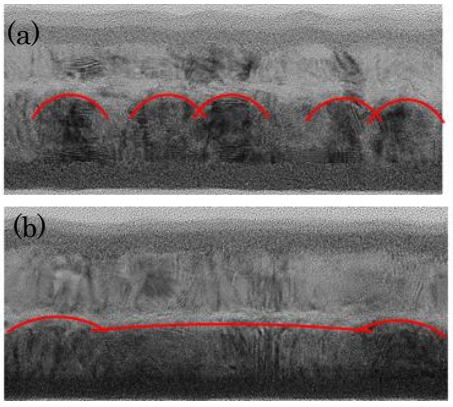

Fig.2 Cross-section TEM images
(a) IrMn 10nm (b) IrMn 5nm