90 度磁気結合膜の X 線反射率による構造解析

The X-Ray Reflectivity analysis of the film with 90 degrees magnetic coupling

鍾永師 [1]，永島玄 [1]，堀池周 [1]，花島隆泰 [2]，黒川雄一郎 [1]，湯浅裕美 [1]
[1] 九州大シス情，Faculty of Information Science and Electrical Engineering, Kyushu University
[2] Neutron Science and Technology Center, CROSS

It has been theoretically reported that spin transfer torques (STT) in antiferromagnetic (AFM) materials can be obtained [1], and the supporting experimental evidences have been reported [2, 3]. However, STT in AFM is difficult to be observed because of the strong exchange coupling between adjacent atoms. Comparing to this, we supposed that it is easy to obtain STT evidence in the quasi AFM layer which has stripe domains with alternately antiparallel magnetization to others using 90 degrees magnetic coupling between two ferromagnetic (FM) layers through Fe-O layer. The film has too complicated magnetic structure to be determined by the macroscopic measurement like M-H curves. The Polarized neutron reflectivity analysis (PNR) is useful but there are too many parameters for fitting the reflection curves. This is why we reduced the number of variable parameters by determining the crystalline structure. In this report, we fabricated the film with the quasi AFM layer and analyzed the crystalline structure of this film by using the X-ray reflectivity analysis (XRR) before Polarized neutron reflectivity analysis (PNR).

Ta 5/Ru 2/$Ir_{22}Mn_{78}$ 5/$Co_{90}Fe_{10}$ 2(A)/Fe-O 1/O_2 50KL/$Co_{90}Fe_{10}$ 2 (B)/Cu 6/ $Co_{90}Fe_{10}$ 2.5(C)/Cu 1/Ta 5 (unit: nm) films were sputtered on thermal oxidized Si wafer. The details for sample fabrication and magnetic properties measured by VSM were shown in ref. [4]. To analyze the crystalline structure, we measured the X-ray reflectivity of this film and used the software named GenX to fit the data of this X-ray experiment, from which we can find out the thickness, atomic density and roughness of the film.

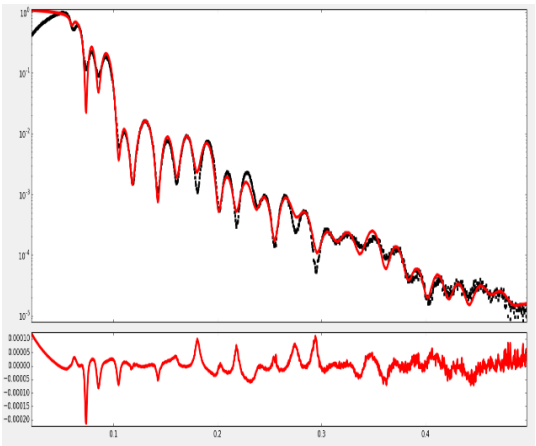

Fig. 1 Fitting curve of the X-ray reflectivity

Fig.1 shows the fitting curve of the X-ray reflectivity, which the black line in means the experiment data of X-ray reflectivity and the red line means the simulation result. The detail data of the fitting result is showed in Table.1. As what can be seen from Fig.1, we successfully completed the fitting of the experiment data and simulation result, which means the data showed in Table.1 is trustable. We found that the CoFe layer is oxidized and the Ta layer upon the SiO2 layer, Fe-O layers' roughness is comparatively large against the other layers. In the presentation, we will show the process how we fitted the experiment data and the simulation result.

	膜厚 d[nm]	原子数密度 N_i[atomsÅ^{-3}]	Roughness σ [nm]
Ta_2O_5	2.96	0.0118	0.50
Ta	2.69	0.0576	0.28
Cu	1.34	0.0993	0.33
CoFe(C)	3.05	0.0997	0.80
Cu	5.71	0.1005	0.01
CoFe(B)	1.08	0.0826	0.15
CoO	1.20	0.0052	0.20
Fe_2O_3	0.46	0.0399	0.51
Fe_3O_4	0.66	0.0204	1.85
CoO	0.50	0.0124	0.24
CoFe(A)	1.97	0.0897	0.43
IrMn	5.28	0.0812	0.25
Ru	2.51	0.0730	0.02
Ta	3.72	0.0705	2.40
SiO_2		0.0228	0.37

Table.1 Detail data of the film

This work was supported by The Canon Foundation.

[1] A. S. Núñez *et al.*, Phys. Rev. B **73**, 214426 (2006).
[2] Z. Wei *et al.*, Phys. Rev. Lett. **98**, 116603 (2007).
[3] T. Moriyama *et al.*, J. Appl. Phys. **106**, 162406 (2015).
[4] G. Nagashima *et al.*, JSAP Spring.**65**, 17P-p10-17 (2018).

© 2019年 応用物理学会