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Magnetic properties of NiFe/Cu/NiFe/IrMn spin valve structure dependence on pinning layer

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1. Introduction

The discovery of the spin-valve (SV) effect in soft ferromagnetic (FM) multilayer films has attracted much interests from the point of view of fundamental science and applications, particularly in high-density recording systems, MRAM and sensors devices. A simple SV consists of a biasing antiferromagnetic (AFM) layer, a pinned ferromagnetic (FM) layer, a nonmagnetic spacer layer, and a ferromagnetic layer whose magnetization is free to rotate in an applied field. Exchange biasing is currently under investigation as its origins are not well understood.

NiFe/IrMn may be the most extensively studied exchange coupling system in recent years, however we found that a higher exchange coupling field H_{ex} can be obtained for the NiFe/IrMn multilayers than for spin valve multilayers NiFe/Cu/NiFe/IrMn on an average.

Therefore in this study we have carried out an investigation of exchange bias variation at NiFe/Cu/NiFe/IrMn as a function of the thickness of the pinning layer in the 2.5 7 nm thickness range in multilayers prepared by DC magnetron sputtering.

2. Experiment

The NiFe/Cu/NiFe/IrMn spin valve structures were fabricated by DC magnetron sputtering on Si/SiO_2 wafers with a seed layer of Ta(5 nm) at room temperature. Ta(5 nm) was deposited on top of all the samples, to prevent oxidation. The base pressure of the chamber was below 2×10^{-7} torr and the Ar working pressure was 3 mTorr. During deposition, a magnetic field of 150 Oe was applied to form the uniaxial anisotropy in the NiFe layer. The thickness of the NiFe pinning layer varied from 2.5 to 7 nm. The hysteresis loop and the coercivity were obtained by vibrating sample magnetometer (VSM). The microstructure of the films was examined by X-ray diffraction (XRD) method.

3. Results and discussion

The exchange bias and coercivity are plotted as a function of the seed layer thickness as shown in Fig. 1. The bias for the pinning layer attains its maximum value of 325 Oe at the thickness of 2 nm. The bias for the pinning layer decreases steadily with increasing thickness, in line with 1/ t behavior. The XRD pattern in Fig. 2. shows the (111) texture for the NiFe and IrMn layers.

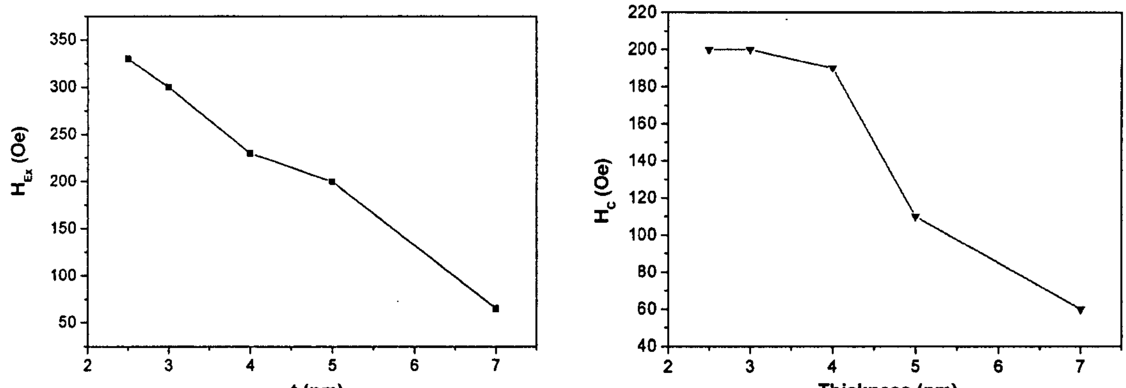

Fig 1. Dependence of exchange bias field H_{ex} and coercivity H_c with the NiFe pinning layer thickness for Ta (5nm)/NiFe (6nm)/Cu (3nm)/NiFe (t nm)/IrMn (15nm)/Ta (5nm).

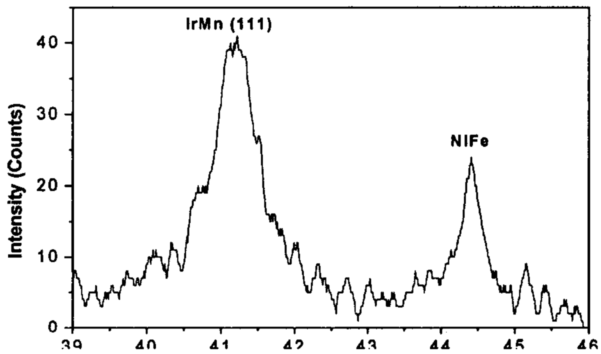

Fig. 2. The XRD of Ta (5nm)/NiFe (6nm)/Cu (3nm)/NiFe (5 nm)/IrMn (20 nm)/Ta (5nm) structure

4. Conclusions

The spin-valve structure of Ta /NiFe/Cu/NiFe/IrMn/Ta was investigated as function of pinning layer thickness. The exchange bias field of spin valve structure inversely proportional to pinning thickness. The XRD pattern shows the (111) texture for the NiFe and IrMn layers.

5. References

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