Q-10

MAGNETORESISTANCE AND PINNING BEHAVIOR IN SYNTHETIC FERRIMAGNET BASED SPIN–VALVES

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1. Introduction

Conventional spin-valves(SV) have certain disadvantages such as low pinning field strength and low thermal stability. Due to the presence of a strong magnetostatic field from the pinned layer, in particular, when the device size becomes submicrometers, it is unable to completely pin the magnetization of the pinned layer [1]. Recently, SV structures with synthetic ferrimagnets (SF) comprising CoFe/Ru/CoFe layers have been suggested [2,3]. The synthetic SVs with SF pinned layers not only exhibit large pinning fields even at high temperature, but assure stable pinning resulting from reduced magnetostatic energy.

Magnetoresistive properties in the SF SV structures as a function of Δt ($=t_{P\text{-}2}-t_{P\text{-}1}$) in Free/Cu/CoFe(P-2)/Ru/CoFe(P-1)/Antiferromagnet structure were characterized in this sturdy. In particular, we analyzed coupling, spin flop, and canting angle of the pinned layer(P-1) with different Δt.

2. Experimental Procedure

Synthetic SF SV films consisting of Si/Al_2O_3/Ta (5)/NiFe (3.2)/ CoFe (1.7)/Cu (2.8)/ CoFe ($t_{P\text{-}2}$)/Ru (1)/ CoFe ($t_{P\text{-}1}$)/IrMn (11)/Ta (5) (in nm) were prepared by dc-magnetron sputtering with a base pressure below 5×10^{-8} Torr. CoFe layer thickness($t_{P\text{-}1}$) was fixed at 2 nm whereas CoFe ($t_{P\text{-}2}$) layer thickness was varied from 1 to 3 nm. During the deposition of the ferromagnetic layers, the growth field of 150 Oe was applied to the film plane. The direction of the growth field for free and pinned layers during deposition was orthogonal. The magnetoresistive properties were measured by dc-four point probe method at room temperature. The magnetization and field angle effect of the samples were measured using a vibration sample magnetometer (VSM).

3. Results and Discussion

Fig. 1 shows MR curves of the synthetic SVs with different Δt. When $\Delta t < 0$ and $\Delta t \geq 0$, inverse MR and normal MR curves were observed, respectively. In accordance with different Δt, each magnetic layer has a different coupling and the flip behavior. When $\Delta t \geq 0$, MR ratio increased, meanwhile the effective pinning field decreased as Δt increased. Fig. 2 shows MR curves for $\Delta t = 0$ as a function of Θ (Θ = 0, 25, 60, 90, 115, 120°), when Θ is an angle between the external field and the growth field direction. In SV structures, the pinning direction is unidirectional due to IrMn, and therefore, when the external field is applied parallel to the pinning axis, the MR curve does not appear symmetric. In addition, if the external field is applied orthogonal to the pinning axis, a symmetric MR curve might appear. We could obtain a symmetric MR curve at $\Theta = 115°$ ($90° + 25°$) for $\Delta t = 0$. which means that the pinning direction was set up 25° off to the growth field axis. Therefore, we could obtain a maximum MR ratio at $\Theta = 25°$. As Δt increases, the pinning direction (P-1) get closer to growth field axis.

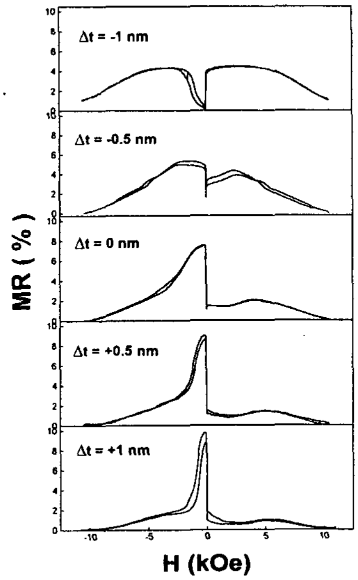

Fig. 1. MR curves with different Δt (= $t_{P\text{-}2}$-$t_{P\text{-}1}$) in SF SVs

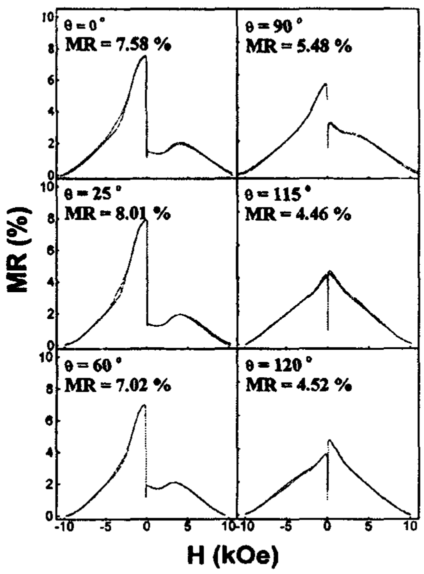

Fig. 2 Angular dependence of MR in SF SV for $\Delta t = 0$. Θ is an angle between the external field and growth field direction.

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