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Annealing Effect on Exchange Coupling in NiFe/FeMn/CoFe Trilayers

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Annealing effect on exchange coupling was investigated by using a sandwich NiFe/FeMn/CoFesample which prepared by sputtering. Annealing was performed at 210 to 390 °C under 720 Oe for 60 minutes (Type I) and 90 minutes (Type II). Magnetic properties were measured by alternating gradient magnetometer (AGM) at room temperature. The exchange bias field (Hex) in Type I and Type II does not change observably with increasing the annealing temperature. The Hex of both types decreases sharply after annealing at 330 °C. The stronger Hex of Type II is observed in this article.

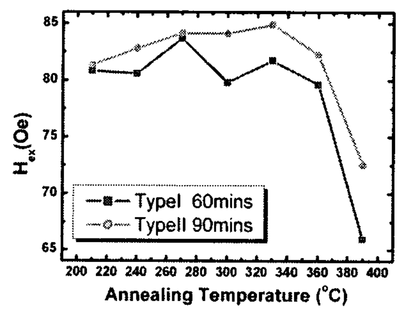

Fig. 1. Hex of Type I and Type II as a function of the annealing temperature.

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RE03

Effect of Interface Intermixing on the Magnetoresistive and the Exchange Couplingin Bottom- and Top-Spin Valves

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Exchange coupling is fundamentally an interfacial phenomenon and any modification of the interface structure can exercise a significant influence on it. Important factors include interfacial roughness [1], interfacial interdiffusion of atoms [2,3], and the texture and grain size of AFM thin films [4]. Previously, we investigated the magneto-transport properties and interlayer diffusion behavior of synthetic bottom (B)-spin valves (SVs) and top (T)-SVs [3]. The degree of interfacial mixing during deposition of IrMn/CoFe or CoFe/IrMn depended on the deposition sequence and was a major factor in causing degradation in magnetoresistance (MR) during annealing. In this study, we examined the exchange coupling behavior that occurred during interfacial mixing at two different interfaces, CoFe/IrMn in a T-SV and IrMn/CoFe in a B-SV, using angle-resolved XPS to both analyze and identify the degree of interfacial mixing at both interfaces. Angle resolved Mn-2p high resolution XPS spectra were obtained for T- and B-SV at α = 15°, 30°, 45°, and 60°. The relative signal intensity of Mn-2p spectra increases with increasing detectable sampling depth. In the T-SV, the binding energies of the Mn-2p were not changed as a function of depth (higher the angle, deeper information we could get). However, in the B-SV, the binding energies of the Mn-$2p_{3/2}$ were increased in the vicinity of the IrMn/CoFe interface (α = 15° or 30°). But the binding energy was recovered in the high angle information (α = 45° or 60°). It means that the IrMn/CoFe interface of B-SV was not as abrupt as the CoFe/IrMn interface of T-SV. When the samples were annealed, the resistivity of the B- and T- SVs increased by 4.9% (from 14.4 to 15.1 μΩcm) and 6.4% (from 12.6 to 13.4 μΩcm), respectively. The H_{ex} of the T-SV decreased from 270 to 225Oe but for the B-SV increased from 249 to 617Oe, about 2.5 times enhancement. The CoFe/IrMn interface in the T-SV appears more abrupt at as-deposited state but is energetically unstable. Thus a compositionally inhomogeneous interfacial structure is evolved during annealing due to high driving force for interdiffusion. This interfacial mixing is the major reason for the degradation of the exchange coupling field. In contrast to that, little change in interfacial structure in the B-SV due to limited driving force because the B-SV which has already a little intermixed interface in the as-deposited state as explained before [3]. In addition to that, we have reported that we were able to reduce the interfacial mixing in IrMn/CoFe using hydrogen surfactant, especially for the B-SV result from modification of the sputter atom energy, ad-atom surface mobility, and surface contamination [4].

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