## RE04

# Interdiffusion Effect on Exchange Coupling in Annealing NiFe/FeMn and FeMn/NiFe Systems

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The effect of interdiffusion on the exchange coupling field (Hex) andcoercivity (Hc) in annealing NiFe/FeMn and FeMn/NiFe systems was investigatedin the study. Type I: substrate/Ta/NiFe/FeMn/Ta and Type II: substrate/Ta/FeMn/NiFe/Ta were prepared. Annealingwas carried out at 150 to 450℃ for 2 hours under 720 Oe, respectively. Magnetic measurements were made by alternating-gradient magnetometer (AGM) at room temperature. The crystallographic structure was examined by x-ray scattering technologies. The results show that the Hex and Hc in two types were dependent on the annealing temperature. For both types the magnetization loss ratio (△M/M) is negative, which reflects a loss of magnetization associated with interfacial mixing caused by annealing. The magnetization loss ratio becomes larger when the annealing temperature increases. The exchange coupling of two types is associated with interfacial diffusion between the NiFe and FeMn interface. The annealing treatment also affected the Hc. In two types, the exchange coupling was improved by annealing from modification of the interface between layers. The extended annealing (above 375°C) changes the exchange coupling in two types due to interdiffusion of the interface between NiFe and FeMn layers. It results in unwanted interdiffusion at the interface and a concomitant reduction in the exchange bias field.

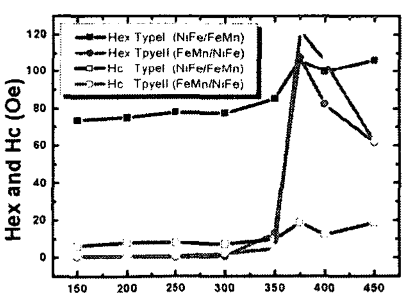


Fig. 1. Hex and Hc in Type I and Type II as a function of annealing temperature.

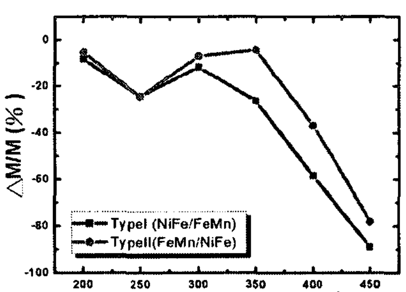


Fig. 2. Variation of the magnetization in two type films before and after annealing as a function of annealing temperature.

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## RE05

# Exchange Bias in FeMn/NiFe/Cu(t)/NiFe Structures

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Exchange coupling has been one of the highly pursued research areas due to its technological importance for applications of magnetic memory devices and giant magnetoresistance based read head sensors. Ever since the first observation of long range interlaying exchange coupling between two ferromagnetic layers across a nonmagnetic spacer [1], many efforts have been made by several workers to understand the origin, natureand strength of this coupling [2,3]. The results of these studies were soon interpreted as due to oscillatory nature of magnetoresistance and the origin of such oscillatory behavior comes from the periodical switching from parallel to antiparallel alignment and vice versa of the adjacent ferromagnetic layers when the thickness of the nonmagnetic spacer varies [4]. Attempts were also made to explain the oscillatory behavior of exchange coupling theoretically by various models [5]. However, in order to make these structures feasible for read sensors, one of the ferromagnetic layers needs to be pinned by an antiferromagnetic layer to facilitate magnetization reversal of the free layer for a small field and the pinned layer will change its state only when it is subjected to a large enough field. As a result of this pinning, there exists a different exchange coupling at the interface of antiferromagnetic and pinned ferromagnetic layers and *this extends to the free ferromagnetic layer too through the nonmagnetic spacer. The aim of this work deals with the study of* exchange bias field and coercivity in FeMn/NiFe/Cu (t)/NiFe structures as a function ofnonmagnetic spacer layer thickness using two different experiments based on vibrating sample magnetometry (VSM) and surface magneto optic Kerr effect spectrometry (SMOKE).Exchange biased magnetic structures based on the configuration Cu(5)/NiFe(7)/CoFe(0.3)/Cu(t)/CoFe(0.3)/NiFe(6)/FeMn(20)/Cu(2) were deposited by rf magnetron sputtering on Si (100) substrates for different values of t in between 2.0 and 3.0 nm with a base pressure of less than $10^{-7}$ Torr and working Ar pressure of $3\times10^{-3}$ Torr. A magnetic field of 60 Oe was applied in the film plane during the deposition of the magnetic layersto set the ferromagnetic uniaxial anisotropy axis and the initial exchange bias direction. Hysteresis curves on all the samples were obtained using VSM and SMOKE. The observations of SMOKE (estimated MOKE reflections from approximately 0.4 nm away from the interface in unpinned ferromagnetic permalloylayer) reveal that the exchange bias field is larger for Cu spacer thickness of 2.2 nm in the investigated range and is in good agreement with the bulk exchange bias field obtained by VSM. Also, for the whole range of Cu spacer layer thicknesses, the exchange bias field obtained by both the techniques matches well. However, the coercivity is observed to be more surface sensitive than volume, and larger values of coercivity are resulted for the SMOKE experiment compared to the VSM, particularly at larger spacer thicknesses. Since the SMOKE gives only the localized magnetic information related to the atomic layer at which the incident light gets reflected, the discrepancies in coercivity estimations for different Cu spacer thicknesses are understood to have resulted due to changes in local anisotropies at different depths in the ferromagnetic layer. The results are discussed keeping in view the oscillatory nature of the exchange coupling due to the variations in nonmagnetic space layer thickness.

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