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Cross-Type Domain in Exchange-coupled NiO/NiFe bilayers

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Exchange biasing is intrinsically a microscopic phenomena. However, research efforts on NiFe/NiO have exclusively focused on macroscopic studies of unidirectional aligned ferromagnetic layer. In this work, we studied the thickness effect of nickel oxide on the microscopic domain structure and magnetization reversal in a unidirectional and isotropic exchange-coupled NiO(thickness:0-60 nm)/NiFe(10 nm) films using magnetic force microscopy. The NiFe film was deposited over the NiO film without breaking vacuum, by dc sputtering with and without the external magnetic field (H_d) of 300 Oe to get in-plane unidirectional and isotropic coupling, respectively. As the NiO thickness increases, the microscopic domain structure of the unidirectional biased film changed from a mesh type ***ripple*** pattern with no NiO to a more complicated and coarse-grained ***ripple*** structure at 60 nm as shown in the figure. The mesh type ripples are easily removed with an applied field of 3 Oe, but the complicated ripple pattern of the 60nm NiO bilayer persists even up to 100 Oe, with the pattern preserved until magnetization direction was reversed. On the other hand, for the isotropic exchange coupled bilayer deposited without H_d, we observed a new ***cross type domain*** with out-of plane magnetization. The density of the cross-type domain was found to be proportional to H_{ex}, and the fact that the domain mainly originated from the strongest exchange coupled region was confirmed by MFM in an applied external field during a magnetization cycle. We believe that the microscopic domain structure of the isotropic coupled NiFe layer represent a more realistic picture for exchange coupling at the interface than the unidirectional biased case. In this paper, we will present these results as well as explain the origin and structure of the cross-type domain.

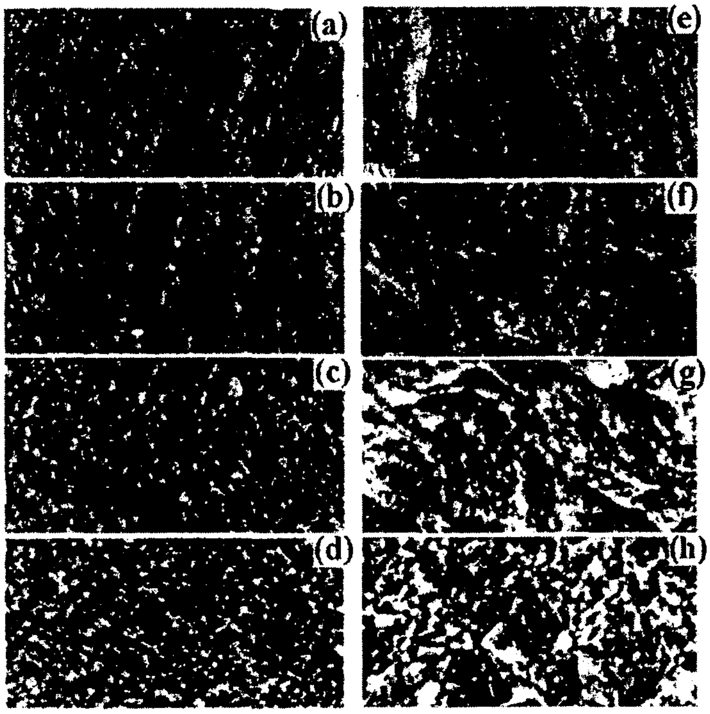

Figure 1 *The dependences of microscopic MFM images on NiO thickness in the NiO(t nm)/NiFe(10 nm) bilayer deposited with and without* ***Hd*** *, where t is (a, e) 0, (b, f) 10 nm, (c, g) 30 nm, and (d, h) 60 nm. The (a) (d) images were measured from the bilayers with* ***Hd*** *and the (e) (h) ones without* ***Hd.*** *The scan size of width is 20 m. The deposition rate of NiO is 3 A/min.*