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Effect of Interfacial Roughness Configuration on Exchange Bias in NiO-based Spin Valves

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Two batches of NiO-Co-Cu based spin valves with different deposition conditions were fabricated. The nominal structure for the two batches is the same. Each batch of samples includes a TSV, with a NiO layer at the top of the Co/Cu/Co, and a BSV, with a NiO layer at the bottom of Co /Cu/Co. For batch 1 (SV1), the base pressure was 1.95×10^{-5} Pa and the sputtering Ar pressure remained 0.1Pa during the sample growing. The deposition rate for NiO was 0.034nm/s. For batch 2 (SV2), the base pressure was 3×10^{-5} Pa, the sputtering Ar pressure raised to be 0.3Pa, and the deposition rate for NiO was 0.020nm/s. Phases and textures for each film were identified by X-ray diffraction (XRD). The thickness, surface & interface microstructures were characterized by the grazing incident X-ray reflectivity (XRR) and transverse X-ray scattering measurement (TXS). For TSV2, the Co, Cu and NiO sub-layers are all in the texture of (111), but for others, there are no textures observed. Exchange bias is only observed in batch 2. We believe that textured structure is not a prerequisite factor for exchange bias in NiO/Co/Cu/Co spin valves. For all samples, the averaged roughness of NiO/Co interface are almost the same (0.3nm for BSV, 1.2nm for TSV), which indicates that there is no obvious relationship between the exchange bias and interface average roughness. However, TXS fitting clearly showed that the correlation length of the interface roughness for SV2 is about 100nm, which is much larger than that for SV1. The dimension of the roughness for SV2 is also a little different from that for SV1 (about 10nm). We, therefore, conclude that the correlation length and dimension of the interface roughness may be the key effects on the exchange bias in NiO based Co/Cu/Co spin valves.

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Experimental Observation of the Electric Coupling Effect in Split ring Resonators and the Prevention

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We studied experimentally the transmission properties of arrays of split ring resonators (SRRs) for different electromagnetic field (EM) polarizations in the microwave frequency regime. It is known that, besides the electric response through the cut-wire like, another electric coupling to the magnetic resonance appears when the incident electric field is parallel to the gap-bearing sides of the SRR [1]. The frequency resonance of this effect is very close to the magnetic frequency resonance. This might degrade or even destroy the left-handed materials when the SRRs are combined with the wires. To avoid this effect we have changed the structure of SRRs from asymmetry with one gap to symmetry with two or four gaps. Finally, the results are compared with the previous theoretical studies [2].

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