ES01

Positive Perpendicular Exchange Bias in Ion-Beam Deposited [Pt/Co]$_4$/Cr_2O_3 Multilayers

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Exchange bias [1] has been studied extensively during the last decade due to its applications in spin valves for ultra high density magnetic recording. More recently, perpendicular exchange bias [2], that refers to the exchange bias field shift when an applied field is normal to the film plane, has been reported. In this work, different thicknesses of [Pt/Co] layers were prepared on top of a Cr_2O_3 (20 nm) bottom layer to study the exchange bias behavior and to identify the Co thickness required for perpendicular exchange bias. The plane-view TEM micrographs show that the grain sizes of these polycrystalline [Pt/Co]$_4$/Cr_2O_3 multilayers range from 5 nm to 15 nm. Electron diffraction patterns establish that the film components consist of f.c.c. Pt (3.93 Å), h.c.p. Co (a= 2.46 Å, c= 4.10 Å), and h.c.p. Cr_2O_3 (a= 5.23 Å, c= 10.97 Å). Magnetometry results have shown that a [Pt(3nm)/Co(2.5nm)]4/Cr_2O_3 multilayer exhibits an in-plane easy axis with the $H_{ex//}$~ +30 Oe and the $H_{c//}$~ 200 Oe at 5 K. However, decreasing the Co thickness to 1.25 nm (i.e. [Pt(3nm)/Co(1.25nm)]$_4$/Cr_2O_3) resulted in an out-of-plane easy axis. In addition, this sample exhibited a positive perpendicular exchange bias with $H_{ex\perp}$ ~ +50 Oe (exchange energy, σex ~0.023 erg/cm2) and an enhanced $H_{c\perp}$ ~ 1400 Oe. The observed positive $H_{ex\perp}$ indicates the spin orientations between the FM Co and the AF Cr_2O_3 align perpendicularly when the applied field is normal to the film plane. Further, a strong temperature dependence of $H_{c\perp}$ that exhibits single domain like behavior was observed in the [Pt(3nm)/Co(1.25nm)]4/Cr_2O_3 multilayer, whereas the $H_{ex\perp}$ increased monotonically with decreasing temperature, having a blocking temperature, TB~225 K.

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ES02

Positive Exchange Bias in CoFe/IrMn Multilayers Comprising Nano Oxide Layer

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Exchange anisotropy is caused by the magnetic interaction between a ferromagnetic and an antiferromagnetic interface and results, normally, the magnetic hysteresis loops are shifted along the field axis in the opposite direction to the applied cooling field (negative exchange bias). Positive exchange bias (shifted along the same cooling field direction), however under certain conditions, can also be observed [1]. In the present work, we examine the dependence of exchange bias on the location of nano oxide layer (NOL) in Ru 70/CoFe 7/IrMn 10/Ta 10 nm multilayers. The NOLs were formed by oxygen plasma oxidation of CoFe layer. We prepared and compared: (a) a reference structure mentioned above without NOL, (b) an NOL on the top of CoFe, (c) an NOL in the middle of CoFe, and (d) an NOL on the bottom of CoFe layer, respectively. As shown in figure 1, we found (a) negative, (b) less negative, and positive exchange bias ((c), (d)) depending on the location of NOL. Positive exchange bias is believed to be due to the fact that the interfacial interaction is antiferromagnetic. The presence of NOL offered reduction in interfacial roughness, because amorphous NOL helped to retard the columnar growth of subsequent layers. The multilayer with smooth interfaces shows positive exchange bias while with rough interfaces shows negative exchange bias. This behavior was found to be due to a crossover from antiferromagnetic to ferromagnetic exchange coupling with increasing roughness. Even though the sample (b) has NOL layer, it shows negative exchange bias. The exchange anisotropy usually enhances the Hc. The formation of magnetic dead layer during the NOL process, however, it reduces the exchange anisotropy results in lower Hc.

depends on the location of nano oxide layer (NOL) in Ru 70/CoFe 7/IrMn 10/Ta 10 nm multilayers, where the sample (c) and (d) shows positive exchange bias.

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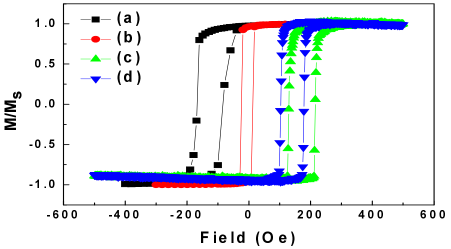

Fig. 1. Hysteresis loops.

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