Week interlayer exchange coupling in Fe-Zr and Fe-Ti layered structures

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20nm-Fe/d_{Zr}-Zr/20nm-Fe and 20nm-Fe/d_{Ti}-Ti/20nm-Fe trilayers with wedged Zr and Ti sublayers were prepared at room temperature using UHV (5×10^{-10} mbar) RF/DC magnetron sputtering. As a substrate we have used Si(111) wafers with an oxidised surface. The chemical composition and the cleanness of all layers was checked *in-situ*, immediately after deposition, transferring the samples to an UHV (4×10^{-11} mbar) analysis chamber equipped with X-ray photoelectron spectroscopy (XPS). From the exponential variation of the XPS Fe-2p and Ti-2p and Zr-3d integral intensities with increasing layer thickness we conclude that the Fe, Ti, and Zr sublayers grow homogeneously during the deposition processes of the trilayers.

In the case of the wedged trilayers, the bottom Fe layer was deposited on rather rough Zr or Ti buffer layer. Such a layer showed greater coercivity compared to the top Fe layer deposited on quasi-amorphous Zr-Fe (Ti-Fe) interlayer. For a sufficiently small Zr-Fe (Ti-Fe) thickness the exchange coupling energy of the Fe layers across paramagnetic spacer is large enough for simultaneous magnetisation reversal process of the bottom and top sublayers. For a week exchange coupling ($d_{Zr} > \sim 1.5$, $d_{Ti} > \sim 2$) nm we have observed a step-like hysteresis [1-2]. The observed two significantly different coercive fields, H_{c1} and H_{c2}, are originated from the soft and hard magnetic Fe layers, respectively. Results on the systematic coercivity studies as a function of the Zr (Ti) interlayer thickness for the wedged trilayers allow us to characterise the week interlayer exchange coupling of the Fe sublayers [1-2]. For $d_{Zr} \sim 2$ nm we have observed weak minimum and maximum of H_{c1} and H_{c2} values, respectively. The above behaviour could indicate weak antiferromagnetic (AFM) coupling between Fe layers with maximum near $d_{Zr} \sim 2$ nm. In the intermediate case between fully coupled and independent (*i.e.* fully decoupled) Fe layers, the exchange field felt by each layer due to presence of the second layer decreases (increases) the observed switching field of the soft (hard) magnetic layer in the case of AFM coupling, and vice versa for ferromagnetic coupling. The hysteresis measurements showed that the Fe layers are very weakly exchange coupled or decoupled for $d_{Zr} > 3$ nm ($d_{Ti} > 3.5$ nm). The small decoupling Ti and Zr thickness could be explained by spontaneous formation of a quasi-amorphous structure of the paramagnetic spacer during the deposition process.

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