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Microstructural investigation of magnetic CoCrPt:SiO_2 films

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Magnetic recording is today the dominant storage technology and CoCrPt:SiO_2-based systems with perpendicular magnetic anisotropy represent a very important resource for hard disk drives (HDDs) realisation [1,2]. In the present work, the correlation between the structural properties of granular CoCrPt:SiO_2 films with variable thickness and the magnetization reversal mechanisms are investigated.

$[(Co_{90}Cr_{10})_{80}Pt_{20}]_{92}:(SiO_2)_8$ thin films with a nominal thickness of 7.5, 10 and 17.5 nm (hereafter referred to as ML7.5, ML10 and ML17.5) were deposited by magnetron sputtering on 2.5-inch hard disk HOYA substrates, with a complex underlayer structure – Cr(2.5nm)/Ru(8nm)/Ru(12nm) – aimed to promote a perpendicular anisotropy and good microstructural properties; films were covered by a 4 nm protective overcoat of diamond-like carbon. Structural characterization were carried out by X-ray diffraction (XRD) and transmission electron microscopy (TEM) techniques. Magnetic measurements were carried out by using a vector vibrating sample magnetometer (vVSM, ADE-Technologies Model 10).

X-ray diffraction patterns of the samples show the presence of only two peaks. One peak labelled as Ru (002), is due to the underlying dual Ru layer, while the second peak is attributed to the (002) reflection of the hexagonal CoCrPt recording layer. The absence of any other Ru or CoCrPt peak suggests a preferential growth of both layers with the *c*-axis perpendicular to the substrate. The degree of preferential growth along the *c*-axis of CoCrPt and Ru layers was estimated by measuring the full width at half maximum (FWHM) of the corresponding rocking curves. TEM plan view observations reveal the granular nature of the CoCrPt films. Fine grains with an average size of 7 nm, well separated by amorphous-like material (Si-oxide), are clearly visible in all the samples, Figure 1. The analysis of angular and time-dependent magnetic measurements indicates that the magnetization reversal mechanism is determined by the coexistence of coherent and incoherent processes, with a tendency toward more coherent reversal processes (i.e. Stoner-Wohlfarth character) as the thickness of the magnetic layer increases. It is important to stress that the switch between coherent and incoherent process is connected to a lower or higher ferromagnetic exchange coupling among neighbouring grains. Looking at the plan view images of the samples the CoCrPt grains have the same lateral average size and degree of separation regardless of the film thickness. Therefore, to understand the nature of magnetic results, TEM cross section observations of the samples were performed, Figure 2.. Results show that all the samples can be considered as formed by an initial thin layer at the interface with the Ru underlayer, consisting of nanograins physically in contact among them; on top of such layer, well separated columnar islands grow, whose height increases with increasing thickness, with an intergrain distance remaining roughly constant through the entire film thickness. Such peculiar microstructural features are consistent with magnetic results.

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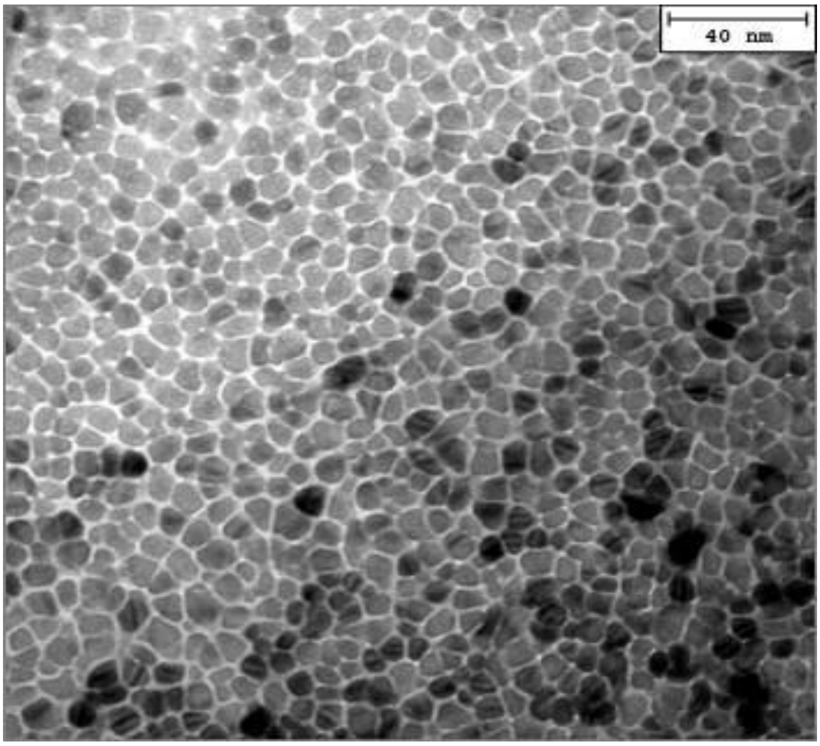

Figure 1. Typical TEM plan view image of a granular $CoCrPt:SiO_2$ film.

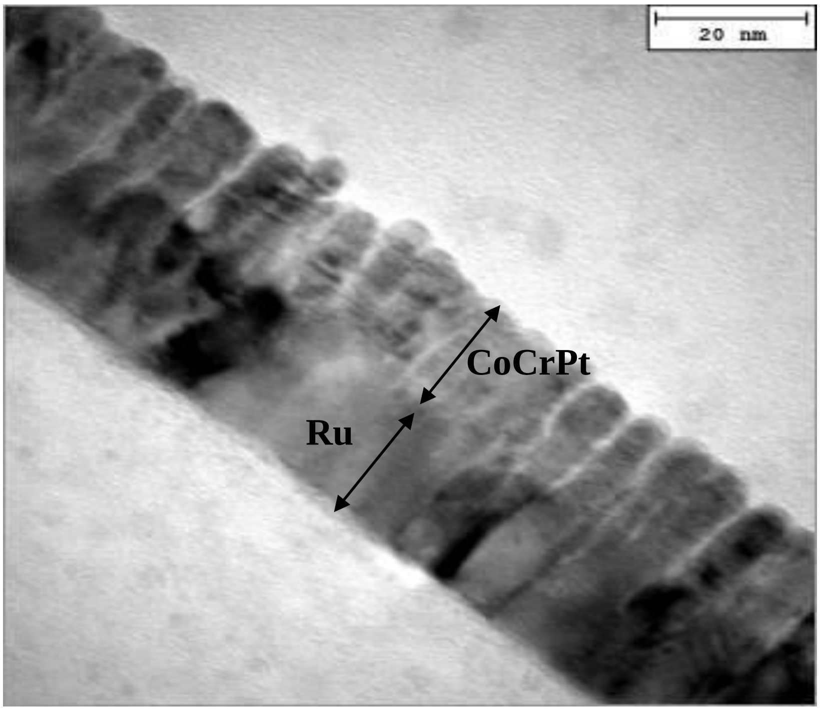

Figure 2. TEM cross section image of the ML17.5 sample. The dual Ru layer and recording layer are indicated.