MAGNETIC AND STRUCTURAL PROPERTIES OF CoPt ALLOYS

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Introduction

Some microelectromechanical systems (MEMS) like microswitches require integrated permanent magnets in order to reduce sizes and power consumption.
Usual hard magnetic layer deposition process consists in sputtering and the layers must be annealed to ensure the best magnetic properties. Electrodeposition is another way to process such materials because it is low cost and an easy process. Moreover, high thickness can be achieved in microstructures and annealing is not necessary.
CoPt electrodeposition have already been studied and alloys have shown suitable magnetic properties for specific applications. These alloys were deposited from alkaline bath between 40 and 65°C [2]. These electroplating conditions can be harmful for photoresists used in microelectronic processes. Therefore, we have studied CoPt alloys deposited from an acidic bath at ambient temperature.

Experimental

Deposits were carried out onto silicon substrate with an Au seed-layer. The bath contains boric acid as buffer, 10^{-2}M of cobalt salt and phosphorous compound and 1M of ammonium chloride. The solution is unstirred and its pH is around 4,5. A platinum sheet is used as a counter electrode. The platinum salt concentration is varied in range $10^{-3} – 5.10^{-2}$M and the current density is between 0.5 and 5 mA/cm^2. The alloy composition is measured by EDS and magnetic properties by VSM. The alloy structure is investigated by X-ray diffraction and TEM.

Results

The platinum content in the films is increased when platinum salt concentration [Pt] or current density is increased. The Pt content is then varied from 5 to 30at%. P content is about 0.5at.% in our deposits.
SEM cross-section observations show a columnar structure (fig. 1). TEM patterns and XRD diagrams show that CoPt alloys crystallize in the hexagonal system and so have an anisotropic structure (fig. 2) [3]. That appears like a cobalt matrix containing inclusions of Pt atoms.
The easy magnetization axis fits with the (001) hexagonal direction. Depending on the platinum concentration, the orientation of the (001) direction is then varied with respect to the film plane. These variations cause changes in hysteresis loop shapes (fig. 3) : the material appears either anisotropic or isotropic and shows M_r/M_s ratios from 0.01 to 0.5. In most cases, (001) direction is preferentially perpendicular to the film plane but coercive fields (H_c) as high as 3000 Oe are reached thanks to low size crystallites. It is possible that crystallites are single domain grains what improves H_c.

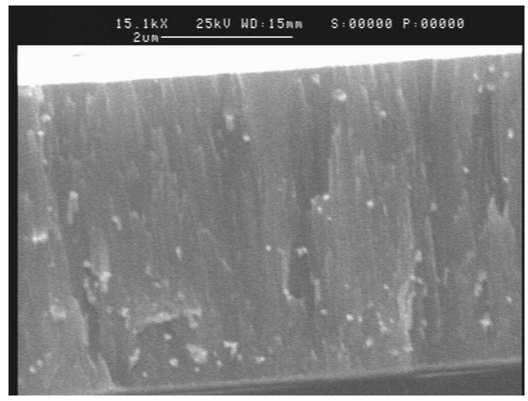

Figure 1 : SEM cross-section picture showing the columnar structure.

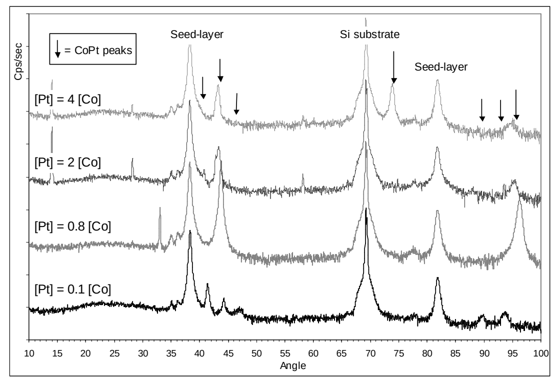

Figure 2 : XRD diagrams depending on [Pt] concentration at 5mA/cm^2.

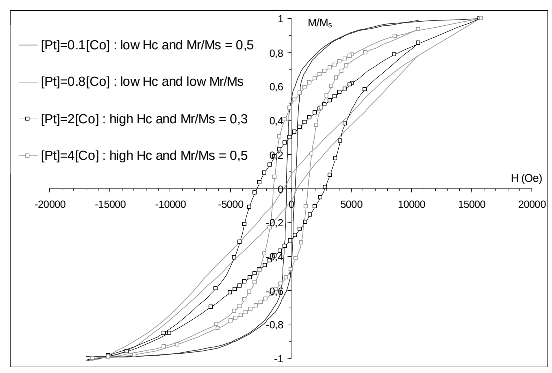

Figure 3 : Hysteresis loops depending on [Pt] concentration at 5mA/cm^2.

References

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[3] – J. Du, et al., J. Magn. Magn. Mat., 231, (2001), 231.