IMPROVED PROPERTIES OF Co-Cr MADE BY CO-EVAPORATION

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Abstract. – CoCr was made by a co-evaporation process. Good properties could be obtained by applying a Ti seedlayer. Further we confirmed that “process-induced” segregation, resulting in increased perpendicular coercivity, can be controlled by angle of incidence.

1. Introduction

Previously we reported on deposition of Co-Cr by co-evaporation under intermediate oblique incidence and opposing vapour stream [1]. The present paper is on the improvement of the material and magnetic properties by applying a Ti seedlayer. We also show results which confirm our assumptions on the influence of the angle of incidence in the formation of a process-induced segregated state, which causes moderate perpendicular coercivity \(H_{c\perp}\) at low process temperatures \(T_p\). The experiments have been carried out using the basic configuration in our Leybold L560 vacuum system [1]. The applied geometries are shown in figure 1.

![Diagram showing process geometries](image)

**Table I.** – Comparison between a single layer Co-Cr and a Co-Cr layer deposited on 35 nm Ti.

<table>
<thead>
<tr>
<th>Orientation of the hcp c-axis (\Delta\theta_{50})</th>
<th>Co – Cr</th>
<th>Co – Cr/Ti</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perpendicular coerc. (H_{c\perp})</td>
<td></td>
<td>similar</td>
</tr>
<tr>
<td>In – plane coerc. (H_{c\parallel})</td>
<td>24 – 35 kA/m</td>
<td>8 – 30 kA/m</td>
</tr>
<tr>
<td>Anisotropy constants of the direction (K_{1}, K_{2}, K_{3})</td>
<td>similar</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1. – Process geometries applied in our experiments.

2. Co-deposition of Co-Cr on a Ti seedlayer

It has been shown that the structural properties and texture of the Co-Cr layers is influenced by the surface condition of the substrate [2]. In our experiments we applied Ti as a seedlayer for the Co-Cr. We used Si-wafers as a substrate. Deposition was done without etching of the surface, only rinsing by alcohol was applied. The Ti layers were deposited at \(T_p = 30^\circ\text{C}\) and a standard thickness \(\delta_{Ti} = 35\) nm was applied. Geo I was used and Ti was deposited from the same position as the Cr. Also in our process we obtained an improvement of the orientation of the Co-Cr \(\Delta\theta_{50}\). A comparison between the main properties of Co-Cr and Co-Cr/Ti layers is given in table I. Investigations on the influence of \(\Delta\theta_{Ti}\) (7-70 nm) showed that \(\delta_{Ti} > 10\) nm, the magnetic properties were independent. In figure 2, the characteristic relation \(H_{c\perp}\) vs. \(M_s\) is given. At low \(T_p\) it shows a tendency to lower \(H_{c\perp}\) when applying the Ti. This can be understood by assuming changing substrate conditions, resulting in changes in the morphology of the layers. Related to this is the fact that we find lower \(H_c\) values in the region where domain-wall motion is the supposed magnetisation reversal mechanism (at high \(M_s\) values and in the in-plane direction).

3. Angle of incidence effects

Our most remarkable result was the appearance of higher \(H_{c\perp}\) at low \(T_p\) [1]. This was explained to be attributed to the process-induced segregated state caused by shadowing effects. In order to investigate this phenomenon, we performed deposition under several process geometries (see Fig. 1). Deposition was done at \(T_p = 50^\circ\text{C}\) and \(\delta_{CoCr} \sim 0.3\) \(\mu\text{m}\). A Ti seedlayer was applied for Geo II and III. In figure 3 the \(H_{c\perp}\) vs. \(M_s\) characteristic is given. Clearly the influence of the angle of incidence is shown. For decreasing angle between Co and Cr incidence direction, the \(H_{c\perp}\)
(0.5 tan α₁) is plotted. This line gives an approximation for tilting of columns in single source deposition [4]. The observed values of γₓ are all smaller than this calculated value, which could also be expected for our deposition process. Remarkable is the fact that for Geo II in which α₁Co ≈ 0° (almost 70-80 at % of the material is Co) we find a significant tilting towards the Cr source.

4. Conclusions

Application of the seedlayer material Ti showed excellent structural properties for the Co-Cr layer (Δθ₅₀ ≈ 4°). Furthermore, our experiments on angle of incidence effects gives understanding of the fundamental growth mechanism of Co-Cr. Increased $H_{c\perp}$ at higher α₁ shows the relation between the shadowing effects, the "process-induced" segregated state and magnetisation reversal mechanisms [1]. The intermediate oblique incidence did not significantly influence the value of the magnetic anisotropy energy but only the direction of the anisotropy axis. Good balancing of the rates and angle of incidence of the sources will result in good material and magnetic properties for perpendicular magnetic recording.