DOI: 10.1017/S143192760344258X
Microsc Microanal 9(Suppl 2), 2003

Effects of Alloying and Processing on the Microstructure and Magnetic Properties of CoCr(PtTa) Longitudinal Recording Media

J.F. Al-Sharab, J.E. Wittig, J. Bentley,* G.A. Bertero,** P.C. Dorsey,** and N.D. Evans*

Dept. of Electrical Engineering, Vanderbilt University, Nashville, TN 37232, USA
*Metals & Ceramics Div., Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA
**Komag, Incorporated, 1710 Automation Parkway, San Jose, CA 95131, USA

The performance of thin-film Co-Cr based longitudinal recording media is strongly dependent on their nano-scale structure and chemistry [1]. Detailed structural and compositional characterization is required to make structure-property correlations. A critical microstructural feature in sputtered thin films of CoCr(PtTa) is the Cr grain boundary segregation that produces magnetic isolation between grains. The Cr depletion within the grain interiors also influences recording properties such as thermal stability, since saturation magnetization M_s and magnetocrystalline anisotropy K_u are sensitive to local Cr content [2]. This current investigation is a basic study of the influence of alloy composition and processing parameters on the microstructure and resulting magnetic properties of CoCr(PtTa) sputtered longitudinal recording media.

Magnetic thin films, 25 nm thick, of $Co_{84}Cr_{16}$, $Co_{80}Cr_{16}Ta_4$, $Co_{80}Cr_{16}Pt_4$, and $Co_{76}Cr_{16}Pt_4Ta_4$ were D.C magnetron sputtered onto identical substrates with a CrMo seed-layer. Disks were sputtered at 9 different substrate conditions for each alloy by varying the substrate temperature (150, 200, and 250°C) and bias voltage (no bias, -200 V, and –300 V). The magnetic properties were measured with a vibrating sample magnetometer (VSM). Energy-filtered transmission electron microscopy (EFTEM) was performed at 300 kV with a Philips CM30 (LaB_6 cathode) and Gatan imaging filter (GIF). Quantitative Cr compositions with a spatial resolution of ~1 nm were obtained from Cr/Co intensity ratio images (Cr elemental map divided by Co elemental map) in order to analyze the grain boundary Cr enrichment and grain interior depletion [3]. High-resolution imaging (HRTEM) was performed with a Philips CM200FEG. Quantitative data on grain-interior Cr levels (from EFTEM) were used to determine the local values of K_u and, together with grain size distributions, to calculate the product of K_u and the grain volume (K_uV), a quantity used as a measure of thermal stability.

Figure 1 (a-d) compares Cr/Co intensity ratio images for the four alloys sputtered with a 250°C substrate temperature. Qualitatively, it can be seen that the alloys with Pt and Ta have greater Cr segregation than the binary alloy, with the Ta containing materials having the largest amounts of Cr at the grain boundaries. However, the CoCr and CoCrPt alloys have greater intragranular segregation than the CoCrTa and CoCrTaPt samples. In order to make quantitative comparisons of the Cr segregation in the different alloys, the integrated Cr profile at a grain boundary (at.%Cr*nm) was measured for a statistically significant number of boundaries in each material. The quantitative results fully support the qualitative trends and allow detailed structure-property correlations to be developed. Comparisons of high-resolution images and EFTEM maps for identical areas were used to reveal the origin of the intragranular segregation. Grain boundary misorientations, defined by the angle between the respective c-axes, were measured and the densities of special grain boundaries, such as 90° boundaries, were estimated. The difference in intragranular segregation behavior between Ta-free and Ta-containing alloys can be related to differences in nucleation and growth mode during the sputtering process, with lattice mismatch between substrate and magnetic film playing an important role. The effects of substrate temperature and bias voltage on microstructure and magnetic properties have also been extensively investigated. Generally, with some interesting exceptions - most notably the binary alloy, increasing substrate temperature from 150 to 250°C leads to coercivity increases and more extensive Cr segregation, whereas increasing the bias voltage from 0 to -300 V leads to much smaller changes in Cr segregation and coercivity [4].

References

[1] Y. Hosoe et al., IEEE Transactions on Magnetics, 31(6) (1995) 2824.
[2] M. Futamoto et al., Journal of Magnetism and Magnetic Materials, 193 (1999) 36.
[3] J.E. Wittig, J.F. Al-Sharab, J. Bentley, and N.D. Evans, pp. 429-432 in Inst. Phys. Conf. Ser. No 168, Proc. EMAG2001 (Dundee), IOP Publishing, Bristol, 2001.
[4] Financial support from the Information Storage Industry Consortium is gratefully acknowledged. Research at the Oak Ridge National Laboratory SHaRE Collaborative Research Center was sponsored by the Division of Materials Sciences and Engineering, U.S. Department of Energy, under contract DE-AC05-00OR22725 with UT-Battelle, LLC.

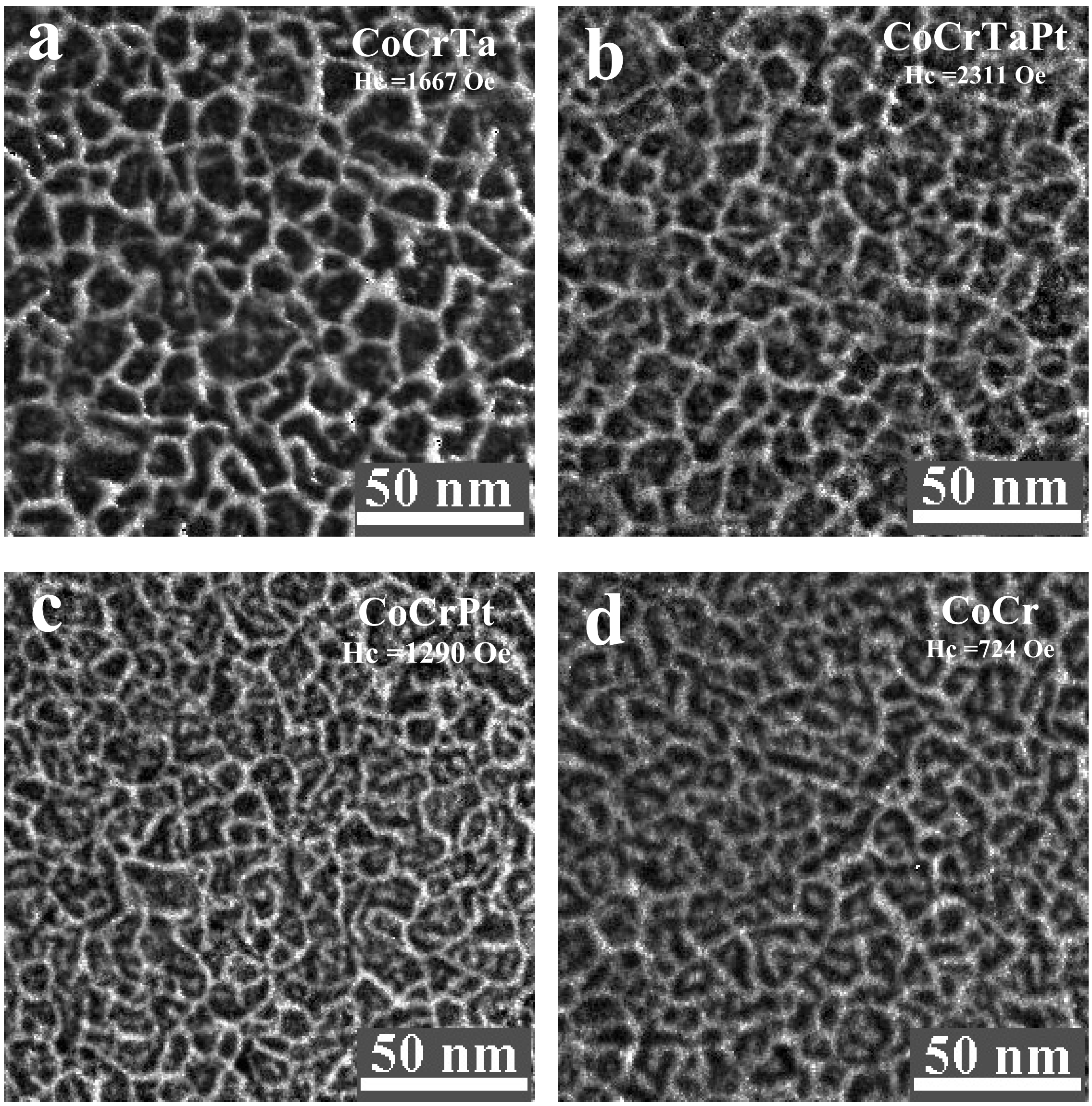

Figure 1 –EFTEM Cr/Co intensity ratio images of (a) $Co_{80}Cr_{16}Ta_4$, (b) $Co_{76}Cr_{16}Pt_4Ta_4$, (c) $Co_{80}Cr_{16}Pt_4$, and (d) $Co_{84}Cr_{16}$

https://doi.org/10.1017/S143192760344258X Published online by Cambridge University Press