# SEGREGATION IN CoCrPtTa/Cr MAGNETIC RECORDING MEDIA STUDIED BY ENERGY-FILTERED TRANSMISSION ELECTRON MICROSCOPY

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Development of high-density longitudinal magnetic recording media with good noise performance and high thermal stability requires optimization of both alloy composition and processing methods. However, the nanoscale structural and chemical details that are needed for modeling and for guiding material development are not well understood. In CoCr(PtTa) thin film media, it is well established that intergranular Cr segregation is critical for good properties. We have used energy-filtered transmission electron microscopy (EFTEM) to characterize a series of CoCrTa/Cr, CoCrPt/Cr, and CoCrPtTa/Cr media sputtered under various processing conditions, in order to understand their structure-property-processing relationships. The typically 30-nm-thick Co-alloy films and Cr underlayers were d.c. magnetron sputtered onto NiP-plated Al substrates pre-heated to 250°C. The columnar grained Cr and Co-based films have <100> and <1120> textures, respectively, with edge-on (0001)//{011} giving the possibility of 90° grain boundaries in the media from the two crystallographic variants on a single Cr grain.

Elemental maps were produced by EFTEM methods that have been refined and optimized in a wide range of applications at the ORNL SHaRE User Facility employing a Gatan Imaging Filter (GIF) interfaced to a $LaB_6$ Philips CM30T operated at 300 kV. Jump-ratio images for Cr and Co $L_{23}$ edges reveal the intergranular segregation of Cr and depletion of Co that is typically <4 nm wide (fig. 1). Quantitative compositions cannot be extracted from jump-ratio images, but they are ideal for grain size measurements, since grains with sufficient intergranular segregation to be considered as isolated magnetic units are clearly defined. However, some image processing issues remain to be solved for automatic extraction of grain size distributions from such images.

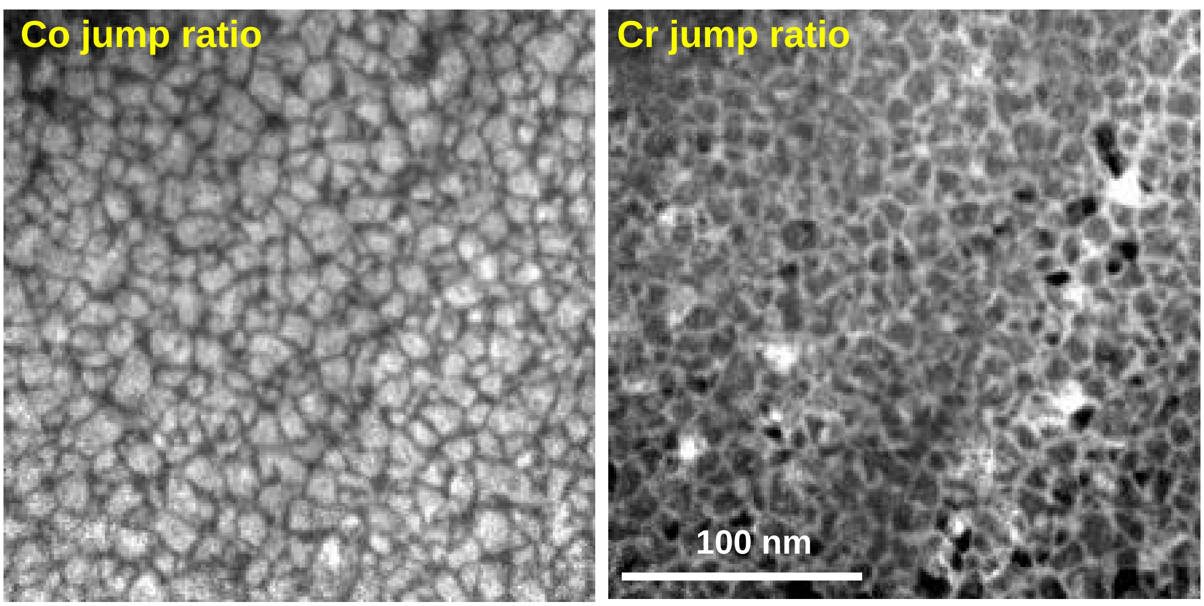


**Figure 1: Co and Cr jump-ratio images of a 30-nm-thick film of $Co_{84}Cr_{12}Ta_4$**

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EFTEM of cross-sectioned specimens has revealed no enhanced intergranular segregation near the Cr underlayer, effectively dispelling the conjecture that grain boundary diffusion from the underlayer is responsible for the segregation in the media.

Extraction of quantitative compositions at a spatial resolution approaching 1 nm involves treatments for diffraction contrast, variations in specimen thickness, and closely spaced oxygen K and chromium $L_{23}$ ionization edges. The oxygen arises primarily as a result of surface oxidation of the TEM specimen. Two procedures have been used. The first yields concentration “maps” in which image intensities scale linearly with atoms/vol. The second yields the Cr/Co concentration ratio. There are many practical issues that have to be addressed to obtain reliable concentration measurements and avoid the numerous possible pitfalls.

An example for a “model” 60-nm-thick film of $Co_{84}Cr_{12}Ta_4$ is shown in fig. 2. The intergranular Cr segregation typically reaches 25 at.% Cr at random-angle boundaries, and 15 at.% Cr at 90° boundaries. Adjacent regions are depleted to less than 5 at.% Cr. Compositions for hundreds of grain boundaries can be readily extracted from a single concentration map. Traditional AEM measurements are so tedious as to preclude such a statistically significant sampling. The elemental maps have also revealed local intragranular segregation at defects that can reach levels of ~25 at.% Cr. The implications of this finding are expected to be important in modeling magnetic properties. Results also suggest that even though the Ta is distributed uniformly, it may be more effective in promoting intergranular segregation than Pt (e.g., for $Co_{76}Cr_{12}Pt_{12}$, no Cr segregation was observed).

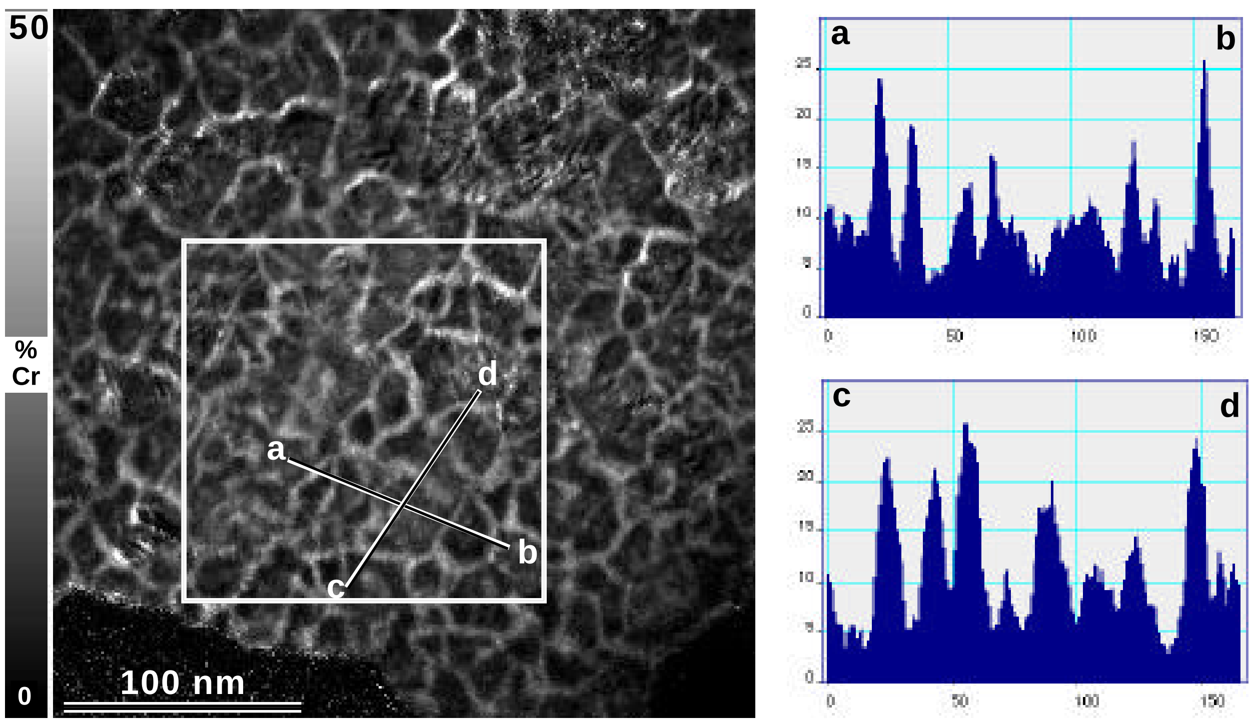


**Figure 2: Cr concentration map and profiles for 60-nm-thick film of $Co_{84}Cr_{12}Ta_4$**

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