High Anisotropy CoPtCrB Magnetic Recording Media

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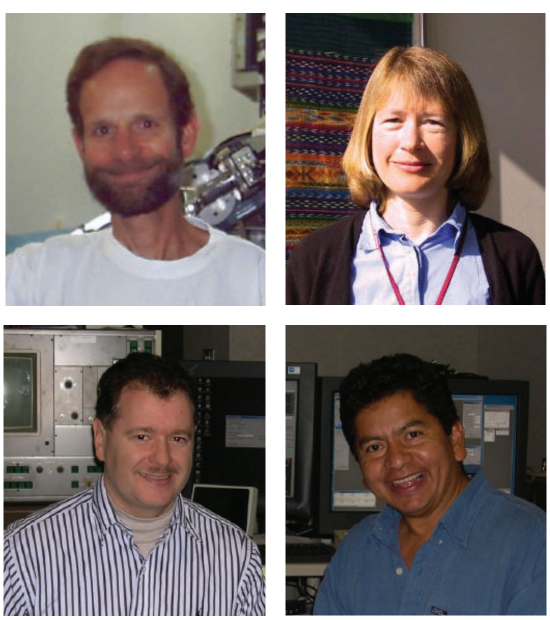
Scientists from the Stanford Synchrotron Radiation Laboratory, Hitachi Global Storage Technologies, and the IBM Almaden Research Center have used x-ray diffraction (XRD) at the National Synchrotron Light Source to understand the microstructure of advanced magnetic recording media and to relate this physical structure to the magnetic properties of the media. The studies were conducted on thin film CoPtCrB media with platinum (Pt) concentrations varying from 10 to 43 percent. We find that the magnetic anisotropy and coercivity of the media, which determine the media's stability and the strength of the field needed to flip the media's magnetization, increase as Pt concentration increases to about 30 percent, plateau, and then decrease for concentrations greater than 40 percent Pt. The x-ray diffraction data show that, with increasing Pt, a face-centered cubic (fcc) cobalt (Co)-alloy phase is progressively formed at the expense of the hexagonal close-packed (hcp) Co-alloy, and that this fraction becomes significant for Pt concentrations greater than 35 percent. The formation of the fcc phase likely causes the behavior in the anisotropy.

The development of thermally stable, small-grain recording media is pivotal to achieving magnetic recording densities beyond 200 Gbits/in^2, in accordance with consumer demands for better and better recording devices. This requires media with high magnetic anisotropy (which determines its stability) and coercivity (field-flipping strength). There are several alternative materials under investigation that provide adequately high anisotropy, including chemically-ordered alloys, such as FePt and CoPt, and rare-earth transition-metal alloys. Another way to achieve this goal is to increase the magnetocrystalline anisotropy of current state-of-the-art CoPtCrB alloys. The anisotropy is enhanced by substituting Pt atoms for the Co atoms in the hexagonal-close packed (hcp) structure. This approach is advantageous because it only requires a relatively small change in the disk manufacturing process.

The disk structures consisted of a glass or nickel-phosphorus substrate, followed by thin films of a seedlayer, a chromium (Cr)-based underlayer, the CoPtCrB media, and a protective carbon coating. The media films were 10 to 20 nanometers thick, with 10 to 43 percent Pt, 15 to 17 percent Cr, and nine to 11 percent boron (B). **Figures 1a** and **b** show, respectively, the magnetic anisotropy (Hk) and coercivity (Hc) as a function of Pt concentration. Large Hk and Hc are needed for stable media. As is evident, Hk increases



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BEAMLINES
X20C, X20A

Funding
U.S. Department of Energy
Office of Science

Publications
M.F. Toney, E.E. Marinero, M.F. Doerner, P.M. Rice, "High Anisotropy CoPtCrB Magnetic Recording Media," *J. Appl. Phys.*, **94**, 4018 (2003).

M.F. Doerner et al., "Demonstration of 35 Gbit/in^2 Media on a Glass Substrate," *IEEE Trans. Magn.*, **37**, 1052 (2001).

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nearly linearly up to about 30 percent Pt, then plateaus, and finally drops above about 40 percent Pt; Hc follows a similar trend. The thermal decay rate of our CoPtCrB media decreases with increasing Pt (from about 15 percent per decade to about one percent per decade), which is consistent with the increase in Hk.

To understand the structural origins of this behavior, x-ray diffraction measurements were done to determine the lattice parameters, the film texture, the stacking fault densities and the fraction of fcc regions in the media. An example of diffraction scans that pass through the fcc(200) and hcp(10$\bar{1}$1) peaks are shown in **Figure 2** for media with 10, 17, 36, and 41 percent Pt. As is evident, the intensity of the fcc(200) peak, and hence the amount of fcc CoPtCrB alloy, increases significantly with increasing Pt concentration. However, since x-ray diffraction is performed over the entire volume of the media, we cannot determine if the fcc regions form isolated grains or are inter-granular.

The fcc concentration was quantified from the integrated intensity of the fcc(200) peak to that of the hcp(10$\bar{1}$1) peak. This is shown in **Figure 1c**. From these data, it is apparent that the fcc fraction is approximately linear until about 35 percent Pt. Above this Pt concentration, the fcc fraction increases more quickly. The fcc phase of Co has a much lower magnetic anisotropy than the hcp phase, suggesting that the increasing presence of the fcc phase with increasing Pt causes the plateau, and then the drop, in Hk that is shown in **Figure 1**.

Interestingly, for all Pt concentrations studied, both the growth and deformation fault densities (specific defects in the way atoms stack in an fcc crystal) do not show a significant trend with increasing Pt concentration, except, perhaps, for a slight increase in the growth faults above about 35 percent Pt. This lack of an increase in fault density with increasing Pt concentration is rather surprising, since high fault concentrations are found in Co-alloys near the fcc-hcp transition region.

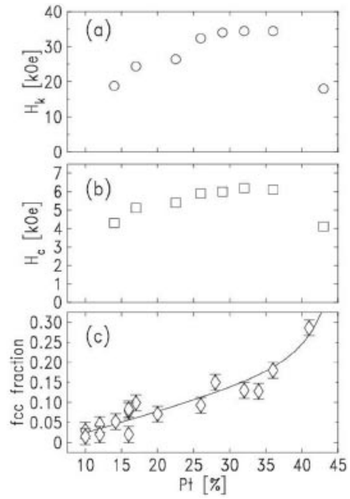

Figure 1. Anisotropy field (Hk), coercivity (Hc), and fcc concentration as a function of Pt concentration in (a), (b), and (c), respectively. Present media have Hc ≈ 4 kilo-Oersteds (kOe) and Hk ≈ 20 kOe, while Hk for pure, bulk Co is 6.4 kOe.

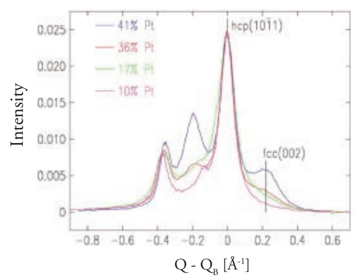

Figure 2. Radial diffraction scans for several media with varying Pt concentration. These diffraction scans pass through the fcc(200) and hcp (10$\bar{1}$1) peaks. To facilitate comparison, the intensity is plotted relative to the position of the hcp peak (QB), the background scattering has been subtracted, and the intensities have been normalized to the peak intensity of the hcp(10$\bar{1}$1) peak. The peak near Q-QB = -0.2 Å^{-1} is the media fcc(111) diffraction peak overlapping the under/seed layer (110) diffraction peak, while the peak near -0.4 Å^{-1} corresponds to hcp(10$\bar{1}$0).