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Tuning magnetization reversal and anisotropy in nanoporous networks

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Magnetic nanostructures have critical technological applications, such as in ultrahigh density bit patterned recording media, magnetic memory and logic devices. Deposition of magnetic films onto nanoporous host matrices is a simple and cost-effective method to achieve nanostructures over macroscopic areas. We have synthesized and investigated networks of Co/Pt and Co/Pd multilayer films with perpendicular magnetic anisotropy grown onto nanoporous anodized aluminum oxide (AAO) templates.

In an earlier study, we found that the relative amount of material deposited on the porous surface versus the amount that settles inside the pores or along the pore edges depends critically on the AAO pore aspect ratio. The lateral confinement of the surface material by the nanopores provides a means to tailor the magnetization reversal mechanisms from domain nucleation and propagation to magnetization rotation [1]. More recently, polarized neutron reflectometry has been used to resolve depth-dependent magnetization profiles. As the pores become wider and shallower, the surface Co/Pt multilayers have progressively smaller near-saturation magnetization and become magnetically softer, consistent with increased magnetic disorder and a reduction of the perpendicular anisotropy near the pore rims.

Furthermore, by varying the sputtering angle between normal and angled incidence, we can control the magnetic interactions and magnetization reversal behavior in similar (Co/Pd)/AAO composites. Using both bulk and surface sensitive first-order reversal curve (FORC) method, we have observed opposite trends in reversal characteristics with increasing AAO pore diameter. In the perpendicular case, materials deposited into the pores are disordered and disconnected from those deposited on the AAO surface for large pores. The pores act as domain wall pinning sites, progressively impeding magnetic reversal with increasing pore diameter, as in the Co/Pt case. The coercivity increases by up to a factor of 3.1 compared to continuous films. Conversely, the sputtered films with angled incidence are exchange coupled to materials deposited on the sidewalls and into the pores. The pores now act as domain wall nucleation sites, easing the reversal of the surface film with increasing pore diameter, decreasing coercivity by a factor of 2.4 compared to continuous films. These results demonstrate an effective method of achieving networked media with tunable coercivity and thermal stability.

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