Magnetic Anisotropy in Metallic Multilayers and Ultra-Thin Films

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As many of the talks at this conference will address, high quality multilayer films with very thin layers and smooth interfaces are needed for near-normal-incidence optics at short wavelengths. For a similar reason, *i.e.* the short length scale of the interaction, high quality multilayers also are needed for studies of magnetism. As this talk will discuss, the structural perfection of multilayer thin-film materials can vary considerably; from "incoherent" multilayers with short range order, to high quality crystalline superlattices with long range structural coherence in all three dimensions. Along with x-ray optics, interesting and useful phenomena exhibited by these materials include new collective magnetic excitations, unusual electronic properties, elastic property anomalies, and dimensionality crossover effects in superconductivity. In this talk we will describe some of our group's recent results using molecular beam epitaxy (MBE) for the growth of high quality multilayer materials, as well as provide examples of several of their magnetic properties.

One property, the magnetic anisotropy, is particularly sensitive to the perfection of interfaces in the thin-film materials, and hence serves as a good indirect measure of the quality of the deposition process. Further, the fundamental mechanism underlying the phenomena of surface and interface magnetic anisotropy remains an interesting unresolved problem in modern magnetism. This strong anisotropy appears at either a free surface or at the interface between two different materials. For thin film systems, it is often the dominant anisotropy energy, determining the overall magnetization easy-direction.

Recently, we have been studying the magnetic interface anisotropy of MBE-grown multilayers and ultra-thin films. In particular, we have focussed on X/Co/Y sandwich structures, where X and Y are each one of the non-magnetic metals Ag, Au, Cu or Pd. Using *in situ* polar Kerr effect measurements, we have reported an anomalous magnetic behavior in the monolayer coverage regime. Surprisingly, the magnitude of the perpendicular magnetic anisotropy is strongly peaked at ~1 atomic layer non-magnetic overlayer coverage.

We will report recent work on growth, by MBE, and investigations of the influence of layering order and composition on this anomalous anisotropy behavior. Our measurements indicate that the unusual peak in perpendicular anisotropy is present regardless of layer order, *i.e.* X/Co/Y or Y/Co/X. However, we find layer-order-dependent behavior when a different material is deposited at the Co interface, *i.e.* X/Co/Y/X or X/Y/Co/X.

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