Quantifying Interfacial Magnetic Roughness in Multilayers

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Soft x-ray resonant magnetic scattering (XRMS) has a demonstrated capability to separately determine magnetic and chemical roughness parameters of an interface. In addition, XRMS can statistically quantify magnetic domain correlations at the appropriate length scale, elucidating the role of magnetic roughness and interlayer coupling. After a brief tutorial on the fundamental aspects of XRMS in the soft X-ray region, recent data for single and multilayer magnetic thin films intentionally grown with different roughness values will be described. These results show conclusively that the interfacial chemical and magnetic roughness for both the perpendicular rms roughness and the in-plane correlation lengths are different, but related. The measurements show convincingly that different aspects of the magnetic roughness control macroscopic magnetic material parameters (e.g. the coercive field is controlled by the in-plane roughness). Furthermore, this variation in the magnetic roughness leads to inter and intralayer magnetic interactions which form correlations in the domain structure. Angle and magnetic field dependent XRMS scans used in conjunction with element-specific magnetic hysteresis loops are used to statistically determine the magnetic domains vertical correlations, indicating the presence of both interlayer dipole coupling and interlayer anti-ferromagnetic exchange coupling.