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In situ Grazing Incidence Small Angle X-Ray Scattering Study of Permalloy Thin Film Growth on Nanorippled Si

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Abstract : Nanostructured magnetic thin films have gained significant relevance due to its applications in magnetic storage and recording media. Self-organized arrays of nanoparticles and nanowires can be produced by depositing metal thin films on nano-rippled substrates. The substrate topography strongly affects the film growth giving rise to anisotropic properties (optical, magnetic, electronic transport). Ion-beam erosion (IBE) method can provide large-area patterned substrates with the valuable possibility to widely modify pattern length scale by simply acting on ion beam parameters (i.e. energy, ions, geometry, etc.). In this work, investigation of the growth mechanism of Permalloy thin films on such nano-rippled Si (100) substrates using in situ grazing incidence small angle x-ray scattering measurements (GISAXS) have been done. In situ GISAXS measurements during the deposition of thin films have been carried out at the P03/MiNaXS beam line of PETRA III storage ring of DESY, Hamburg. Nanorippled Si substrates prepared by low energy ion beam sputtering with an average wavelength of 33 nm and 1 nm have been used as templates. It has been found that the film replicates the morphology up to larger thickness regimes and also the growth is highly anisotropic along and normal to the ripple wave vectors. Various growth regimes have been observed. Further, magnetic measurements have been done using magneto-optical Kerr effect by rotating the sample in the azimuthal direction. Strong uniaxial magnetic anisotropy with its easy axis in a direction normal to the ripple wave vector has been observed. The strength of the magnetic anisotropy is found to be decreasing with increasing thin film thickness values. The mechanism of the observed strong uniaxial magnetic anisotropy and its depends on the thickness of the film has been explained by correlating it with the GISAXS results. In conclusion, we have done a detailed growth analysis of Permalloy thin films deposited on nanorippled Si templates and tried to explain the correlation between structure, morphology to the observed magnetic properties.

Keywords : grazing incidence small angle x-ray scattering, magnetic thin films, magnetic anisotropy, nanoripples
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