Surface Roughness, Mass Density and Ordering Evolution in *In-Situ* Annealed FePt Thin Films

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$L1_0$ disordering-ordering superlattice FePt alloy have been drawn much attention due to its excellent magnetic properties and stability, which could increase the storage density up to 1 Tb/in^2. Furthermore, the behavior of disordering to ordering transition has been emphasized recently because of therein importance on not only industry facility but physically crystallographic realization. The single layer, nearly equi-atomic FePt thin films were characterized by means of XRD, x-ray reflectivity (XRR). The disorder-order transformation, especially in low temperature regime, accompanying the macrostructural, crystallographic, magnetic properties and local atomic environments were investigated via synchrotron X-ray diffraction at NSRRC BL17B1 beam and BL17C lines.

X-ray diffraction (XRD), x-ray specular reflectivity (XRR), and extended x-ray absorption near edge (EXAFS) have been used to characterize surface roughness, mass density, crystallographic structural, magnetic properties and local atomic environments of single layer FePt thin films as a function of substrate temperatures, T_s (25-700^{o}C). The nearly equi-atomic FePt films, with nominal thickness of 40 nm, were prepared by magnetron sputtering onto quartz substrates. XRD data disclose the appearance of long-range-order (LRO) $L1_0$ phase for samples deposited at $T_s \geq 400^o$C. Surface roughness and mass densities of the FePt films were obtained via XRR curves using computational fitting. The surface roughness of the films increases (3.8-11.0 Å) as T_s rises in Regime I (25-275^{o}C), then drops from 11.0 to 3.2 Å as T_s further increases in Regime II (275-375^{o}C), then from 3.2 to 38.0 Å with increasing T_s at 375-700^{o}C (Regime III). On the other hand, the abrupt drop in mass density to a minimum value of 12.90 g/cm^3 (~90% of the film deposited at room temperature) was observed as T_s was raised from Regime I to II. The EXAFS results implied that the short-range-order (SRO) likely appeared for sample deposited at $T_s > 200^o$C. It is proposed that the appearance of SRO accompanying excess detects, in conjunction with XRD analysis, can account for anomalous features of the surface roughness, abrupt drop in mass density, and coercivity enhancement for the films in prior to LRO transformation.

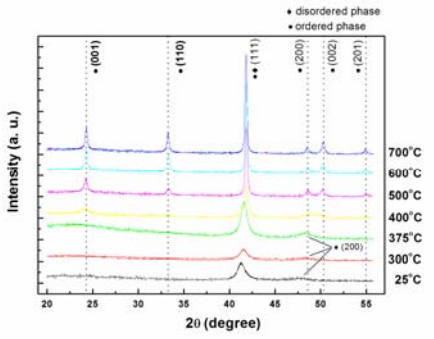

Figure 1. X-ray diffraction patterns of FePt thin films with substrate temperature T_S of 25 -700^{o}C. The dash lines indicate the angular positions of superlattice reflections of the $L1_0$ FePt phases.

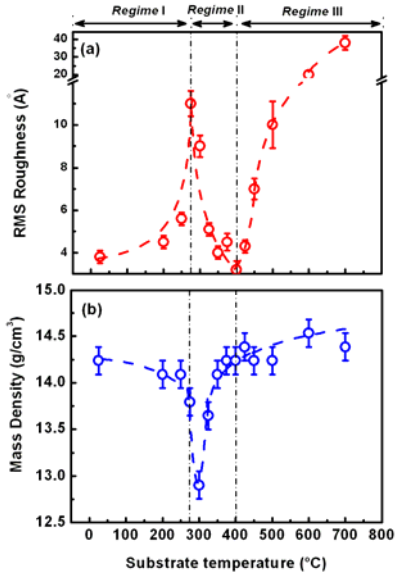

Figure 4. (a) Root-means square surface roughness and (b) mass density of FePt films as a function of substrate temperatures. Triangle data and solid line present the experimental data and fitting curve. Dash-dot lines added to guide the eyes for distinguishing the temperature regimes: Regime I (25-275^{o}C), Regime II (275-400^{o}C), and Regime III (400-700^{o}C).