Fabrication of L1$_0$-FeNi by using Pulsed Laser Deposition (PLD) system

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Magnetic thin films with high magnetic anisotropy (K_u) have been attracting huge attention for realization of next-generation spintronics devices. L1$_0$ type FeNi ordered alloy (L1$_0$-FeNi) is a candidate for such applications because of large K_u and rare-metal free material [1]. For these industrial and environmental demands, the research of artificial fabrication is rapidly progressing in these days. Kojima *et. al.* reported that K_u is proportional to chemical order parameter S [2]. Shen *et. al.* also reported the comparison of surface morphology and perpendicular magnetization between molecular beam epitaxy (MBE) and pulsed laser deposition (PLD) mainly for iron thin films [3]. These reports point out that growth technique and interface roughness must be key issue to improve K_u. Here, we investigate how the magnetic anisotropy correlates with surface morphology, lattice structure and growth temperature of FeNi. We utilized PLD system, which can carry out almost ideal layer-by-layer epitaxial growth, to fabricate L1$_0$-FeNi films.

Samples were prepared by PLD with Nd: YAG laser (wave length: 266 nm). Iron seed layer (1nm) and Au, Cu layer were deposited on the MgO(100) substrate. Substrate temperature during Cu deposition was 300 ˚C, which is optimized in the previous study by surface observation using atomic force microscope (AFM). Fe/Ni (50ML) multilayer was deposited by alternate monoatomic deposition. We varied substrate temperature (T_s) during FeNi deposition from RT to 400 ˚C. Surface morphology of sample was observed by AFM. Synchrotron radiation XRD(SR-XRD) measurement was conducted to reveal structural properties and estimate S. Magnetic properties were estimated by a superconducting quantum interference device (SQUID) magnetometer.

Figure 1(a) and 1(b) show the diffraction pattern of SR-XRD around FeNi(110) superlattice peak and FeNi(220) fundamental peak, respectively. FeNi(110) superlattice peak was clearly observed for all samples. This indicates L1$_0$ structure was formed for all samples. Superlattice peak shows maximum intensity at 300 ˚C of T_s, suggesting that L1$_0$-ordering was promoted by annealing. This temperature almost corresponds to order-disorder transition temperature (320 ˚C) of L1$_0$-FeNi phase. Surface roughness is also investigated by AFM, and atomically flat surface was observed for around 90 % of observed area.

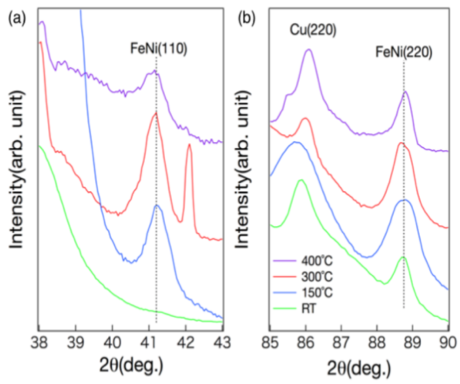

Fig. 1 Diffraction patterns of SR-XRD using X-ray with 7.11 keV.

Figure 2 shows magnetization curves for the sample of T_s = 300 ˚C. Saturation magnetization (M_s) was 800 emu/cc and its easy axis was in-plane. K_u was estimated to 1.60 × 10^6 erg/cc, and it was the largest value among various deposition temperature.

It is concluded that magnetic anisotropy was improved by structural ordering through annealing, and optimum annealing temperature (300˚C) almost corresponds to order-disorder transition temperature (320 ˚C) of FeNi phase. It suggests that improvement of magnetic anisotropy is promoted by atomic flatness in terms of crystallographic structure and morphology.

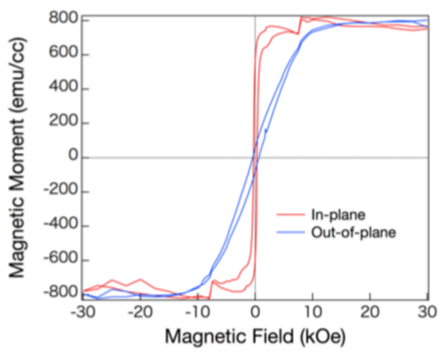

Fig. 2 Magnetization curve of FeNi for 300 ˚C of T_s.

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