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SPIN REORIENTATION TRANSITION OF ULTRATHIN Co FILMS ON ARTIFICIALLY ROUGHENED Pd(111) SINGLE CRYSTAL

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블록 공중합체를 이용한 CoCrPt 나노점 배열의 자기적 성질 연구

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I. INTORDUCTION

It is well known that surface and interface roughnesses greatly affect the magnetic properties such as magnetic domain structure, magnetization reversal, magnetoresistance, and spin reorientation transition (SRT) of ultrathin magnetic films. Therefore, recent studies focus on artificially roughened surface, since it could be possible to systematically understand the effect of roughness on the magnetic properties as well as to obtain the desirable magnetic properties by artificially creating the surface structure and morphology. In this study, SRT of ultrathin Co films on various roughened Pd(111) single crystal substrates, artificially prepared by an ion bombardment with different incident angle, were investigated using scanning tunneling microscopy (STM), reflection high energy electron diffraction (RHEED), and three-configurational surface magneto-optical Kerr effects (SMOKE) measurement.

II. EXPERIMENTS

The experiments have been performed in an ultrahigh vacuum (UHV) chamber equipped with an *in-situ* surface magneto-optical Kerr effects (SMOKE) measurement as well as a scanning tunneling microscope (STM). The single crystal Pd(111) substrate was cleaned with cycles of 1 keV Ar^+ ions sputtering and subsequent annealing at 800 °C to obtain a clean and atomically smooth surface, which was verified with RHEED and STM. The artificially roughened Pd(111) surface was achieved through 10 minutes Ar^+ ions sputtering with different sputtering angle, α, varying from 0° to 80°. The angle α is measured from the film normal. Co films were prepared on the roughened Pd(111) substrate of 10 mm×10 mm ×1 mm(t) at ambient temperature by e-beam evaporation. The base pressure was less than 1×10^{-10} Torr and typical deposition rate, obtained under a Co flux of 25 nA, was 0.8 Å/m. The SMOKE measurement was performed at the same position in the film preparation chamber without any translation of a sample. STM images were obtained at room temperature under the constant current mode at the tip voltage, V_t, and the tunneling current, I_t, denoted in the respective figure captions.

III. RESULTS AND DISCUSSION

After the repeated cycles of Ar^+ ion sputtering and annealing, an atomically flat and smooth Pd(111) surface having large regular terraces of about 30 - 100 nm wide was obtained. This smooth Pd(111) surface was sputtered by Ar^+ ions with different ion incident angle α varying from 0° to 80° to obtain the artificially roughened Pd(111) surface. Fig. 1(a) shows the surface topography of Pd(111) after 1 keV Ar^+ ion sputtering for 10 minutes at a normal incidence (α=0°). As shown in the Fig. 1(a), the moundlike surface structure could be observed with the mound height of ~ 2 nm and the width of ~ 8 nm. As we decrease the incident angle of sputtering ions, the surface topography of Pd(111) was interestingly modified. In Fig. 1(b), we demonstrate the Pd(111) surface sputtered at α=80°. Instead of the moundlike structure, atomic steplike structures were created along the direction of the ion incidence. It is worthwhile to note that the atomic steps still retain, but the surface of terrace is no longer atomically flat. On these artificially roughened surfaces, we have deposited Co films and carried out *in-situ* SMOKE measurements. In Fig. 2, we summarize the onset thickness of SRT as a function of the ion incident angle α. Interestingly enough, compared to the smooth substrate, SRT occurs at thicker Co films for the substrate prepared at large sputtering angle of $\alpha \gtrsim 65°$, while it occurs at thinner Co films for $\alpha \lesssim 65°$. The combined SMOKE and STM study enables us to find the different onset thickness of the SRT closely related with growth morphology of Co sensitively dependent on substrate topography. We find that the variation of the onset thickness of SRT in Co films on artificially roughened Pd(111) surface mainly arises from an interplay of two contributions: The reduction of magnetic shape anisotropy due to the magnetic dipoles induced at the rough surface of a films and the reduction of surface anisotropy caused by locally existed thick Co film in the valley of roughened substrate.

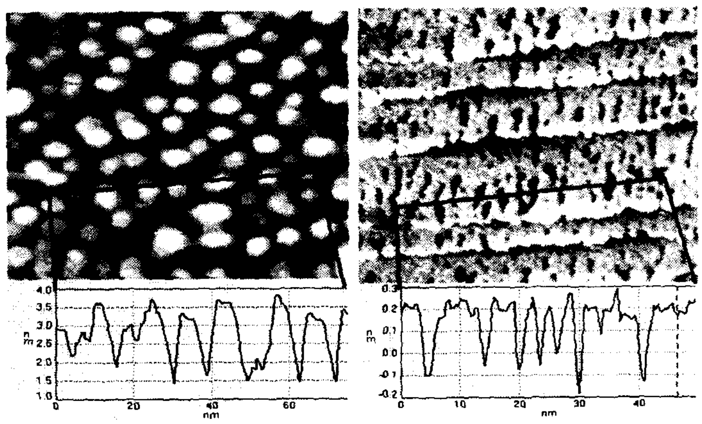

Fig. 1. (a) 80 nm × 80 nm STM images of Pd(111) single crystal surface (V_t =0.09 V, I_t =0.8 nA) after 10 min. Ar^+ ions sputtering at α=0°(V_t= 0.089 V, I_t=0.81 nA) and (b) α=80° (V_t= 0.09 V, I_t=0.79 nA).

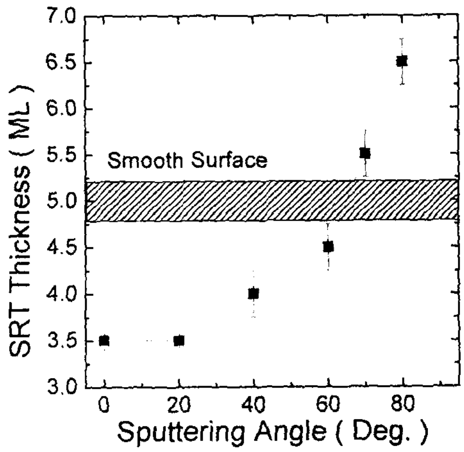

Fig. 2. Dependence of the SRT onset thickness on the sputtering angle. The dashed area corresponds to the SRT region of Co film deposited on the smooth Pd(111) surface.

IV.ACKNOWLEDGEMENT

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V. REFERENCES

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