Domain Structures of Co Thin Films on Cu (110) Surface Studied by Photoemission Electron Microscope

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The phenomenon observed at magnetic ultrathin films such as the spin-reorientation and exchange-bias in layered structures continuously attract research attentions in both scientific and industrial communities. From the viewpoint of application, the study of magnetic domain structures of ultrathin films can help us to understand the physical mechanism for constructing ultrahigh density magnetic recording media. For the Co/Cu(110) system, the Co layer has a thickness-dependent growth mode whose magnetic easy axis was observed to lying on surface initially but would rotate 90^o upon the subsequent carbon monoxide adsorption[1]. It is interesting to examine how the surface orientations post their impact on the properties of Co thin film such as the domain structures at their initial stage. It is also interesting to explore the finite dimension effect on the thin film systems as the real thin film devices always have finite dimension.

In this study, we employed the X-ray photoemission electron microscope (X-PEEM) to construct images with magnetic contrast. The experiments were carried out in two different but connected ultrahigh vacuum (UHV) chambers. The preparation chamber equips with a specially designed dual-slot sample holder for placing an *in-situ* mask in front of the substrate at a fixed 200 μm distance. After sample cleaning, a mask with 80 x 80 μm^2 mesh was placed in front of the substrate to cover it partially. The Co was then evaporated from the electron-beam evaporator at room temperature at a constant rate of 1ML/min to prepare two regions on the substrate surface simultaneously; continuous film with several mm^2 and patterned film with 80 x 80 μm^2 in their lateral dimensions.

The results of our experiments are shown in figure 1 and 2. For the Co (3.6 ML)/Cu(110) system, we could not observe any magnetic domain from the PEEM images nor could we measure the XMCD effect from the absorption spectra. However, for the Co (6 ML)/Cu(110) system, we found strong magnetic ordering from both domain images and XMCD measurements. As shown in figure 1(a) and (c), there exists distinct boundary between two major magnetization directions (regions of bright and dark), and each region has extended lateral dimension that estimates to be in the order of mm. Such clear separation between different domains was observed on the patterned film as well. In figure 1(b) and (d), the single domain configuration for both magnetization orientations was clearly identified for the 80 x 80 μm^2 squares.

From our current experimental setup, it is difficult to distinguish what the easy direction is for the Co/Cu(110) system. However, considering the time required for adjusting microscope and acquiring image, we believed the domain configuration observed here should be the one that experienced 90^o magnetization switching. Such statement is indirectly confirmed when we observed identical image after placing the sample in our UHV system over night.

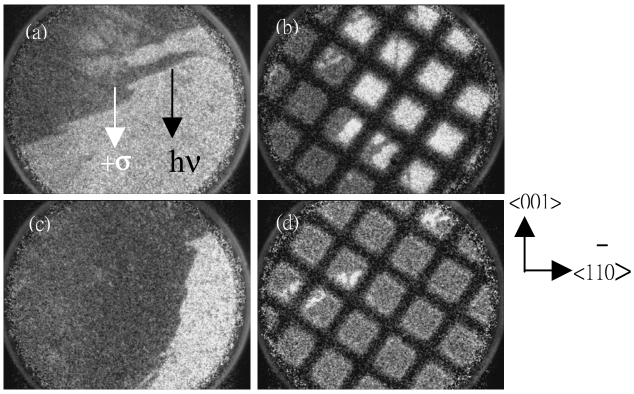

Figure 1. The domain configurations of 6ML Co layer deposited on Cu(110). From (a) and (b), it appears neither surface crystal orientation nor patterning the film would induce significant change in domain configuration. In both continuous and patterned regions, extended domain areas were observed for both magnetization directions as shown in (c) and (d).

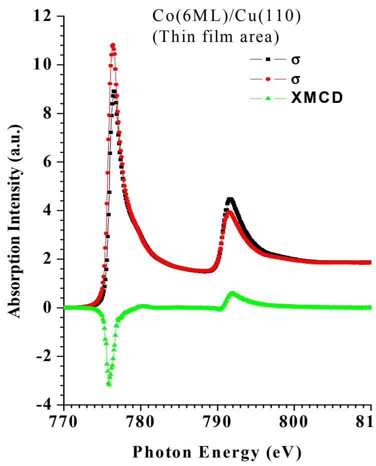

Figure 2. Absorption measurement at Co $L_{2,3}$ edges confirms the presence of the net-magnetization for the as deposited Co film.

References:

[1] S. Hope, M. Tselepi, E. Gu, T. M. Parker, J. A. C. Bland: J. Appl. Phys **85**, 6094 (1999) 6094.