[II-9]

The growth of Co on Cu(111) studied by the local work-function finger-printing method

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I. Introduction

The magnetic thin films and nanostructures have attracted much attentions for the unexpected magnetic phases and couplings. Especially, the Co/Cu system, the magnetic coupling between magnetic Co layers with a non-magnetic Cu spacer layer, have shown the oscillatory coupling behavior from ferromagnetic to antiferromagnetic according to the Cu spacer-layer thickness.[1] Hence, it is essential prior to nanostructure fabrication to understand the growth fashion of Co on Cu(111), since the vicinal Cu(111) has the reasonable number of steps acting as nucleation sites.[2] In the present studies, Co growth on the normal Cu(111) was first investigated for the pre-requisite studies to the Co growth on the vicinal Cu(111) surfaces.

II. Experimental

The Cu(111) ($\pm 0.5o$) was Ar+ sputtered and annealed at 500℃ repeatedly until the clear 1×1 pattern was checked by LEED and no impurity was detected by XPS. Then the valence bands were monitored by UPS. For the measurement of the average and local work-functions at the same time, the sample was biased with -22V relative to the earth-ground connected the hemispherical energy analyzer. Then the variation of the secondary cut-off implies the work-function variation, and the difference between the photon energy($h\nu$ =21.2eV) and the valence band width does the absolution value of work-function, respectively. Thermal contacting with the cold-head of He-refrigerator, the clean Cu(111) was rapidly cooled to 40K within a few minutes for Xe to be adsorbed. The PAX (photoemission of adsorbed Xenon) was conducted up to the multi-layer coverage of Xe.[3] After Xe-desorption, the surface chemical composition was checked by XPS.

III. Results and Discussions

From the clean Cu(111), the intensity attenuation of Cu 3d indicates that Xe adsorbed in the layer by layer mode. It has been confirmed by both the average and local work-functions variation that the first Xe-layer lowered the surface work-function by 0.6eV. On the other hand the second layer lowered the local work-function by 0.2eV, which is confirmed by the 3rd layer. The unique shapes and the positions of Xe 5p1/2 on the clean surface was used as a finger print for the clean Cu(111).

Initially the cold and clean Cu(111) surface was fully covered with the amorphous Co layers (>4ML). The average work-function was 0.3eV lower than that of the clean Cu(111). Contrary to Cu(111), the Xe layer does not grow in the layer-by-layer mode, but the thickened Xe was confirmed by the intensity attenuation of Co and Cu 3d levels in the valence bands. The surface was annealed up to 200℃, but the distinct change was not monitored. Annealing at 300℃ induced the drastic inversion of intensity ratio of Cu 3d to Co 3d in the valence bands. The average work-function was 0.5eV higher than that of the clean Cu(111). The adsorbed Xe initially grew in the layer-by-layer mode like on the clean Cu(111), but later another species like Xe on Co appeared. This confirms the segregation of Cu through Co layers at this annealing temperature. The Co film grown at 300K(RT) Cu(111) (~3ML) was quite similar to that of previously shown Co films deposited at 40K and post-annealed at 300℃.

Besides these films, self-assembled Co clusters were formed on the Xe buffer layer. The growth fashion of adsorbed Xe was neither that on the clean Cu nor those on the Co deposited surfaces. From the initial Xe adsorption, two adsorption sites with 0.3eV work-function difference appeared. These are due to two-different local areas, i.e., one is the area affected by the ferromagnetic self-assembled Co clusters and the other is the remaining clean Cu(111).

Ⅳ. Conclusion

It has been confirmed by the local work-function finger-printing method using the average work-function, the local work-function, and the growth fashion of Xe multilayers that Co layers can be grown on Cu(111) in the different morphologies. At 300K deposition, it has been confirmed that the Co film can not evenly cover the Cu surface, and the well-ordered Co island is covered with segregated Cu atoms. At 40K deposition, the amorphous Co layer was initially formed. The subsequent annealing at 300℃ converts the amorphous Co layer to the well-ordered Co island covered with segregated and ordered Cu atoms similar to RT deposited film. The self-assembled Co clusters formed on the Xe-buffer affected the large area surrounding the clusters.

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