3A/2007G199

Structural studies of Co nanoparticle arrays on fluorite surfaces

Nikolai SOKOLOV*[1], Sergey SUTURIN[1], Reginald KYUTT[1], Andrey LOMOV[2], Masao TABUCHI[3] and Yoshikazu TAKEDA[4]
[1]Ioffe Physical-Technical Institute, St.Petersburg 194021, Russia
[2]Shubnikov Institute of Crystallography, Moscow 17333, Russia
[3]Venture Business Laboratory, Nagoya University, Nagoya 464-8603, Japan
[4]Department of Crystalline Materials Science, Nagoya University, Nagoya 464-8603, Japan

Introduction

The demand for new magnetic memories with higher density of information storage is well-known. Cobalt on fluorite (CaF_2) surfaces is an interesting materials system for studies in this field. CaF_2(111) surface can be grown atomically flat, while CaF_2(110) surface is {111}-facetted with grooves and ridges running along [1-10] direction. Epitaxial commensurate (3:2) growth of Co on CaF_2 was earlier demonstrated by electron diffraction [1,2]; however no detailed structural information was obtained.

Experimental

The samples were grown on Si(111) by molecular beam epitaxy (MBE). Calcium fluoride buffer layer was deposited on atomically clean Si(111) or Si(001) surface providing isotropic (111) or anisotropic (110) template for further Co overgrowth. Studied in this work, arrays of Co nanoparticles were grown at 300-500ºC using E-beam source and covered with thin (2-3 nm) CaF_2 cap layer. Prior to GIXRD studies, the structures were characterized by electron diffraction and atomic force microscopy.

The GIXRD measurements were carried out at the BL-3A using radiation with the wavelength of λ=1.033 Å and point YAP or two-dimensional CCD detectors. Intensity distributions along 0 0 L, ±1 0 L of CaF_2 and Co rods as well as a number of transverse scans have been measured.

Results and discussion

Figure 1 shows intensity distribution along -1 0 L rod measured for the sample #6031 (14 nm Co@500ºC on CaF_2/Si(111)). One can see that the strongest peaks are due to the metastable at room temperature fcc phase with 11-1 and 220 reflections corresponding to the A-type epitaxial relation (not rotated by 180º) at the Co(111)/ CaF_2(111) interface; weaker 002 peak belongs to the rotational twin. Less intense peaks at L=0.5 and 1.0 can be associated with minor amount of the hcp phase.

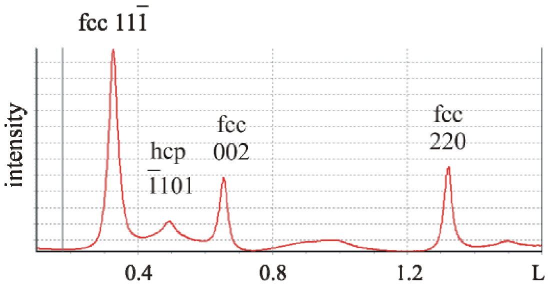

Fig.1 Intensity distribution along $(-1\ 0\ L)_{Co}$ rod for #6031

To analyse shapes of Co and CaF_2 reflections a CCD detector was used for measurements of intensity distribution. For the sample with Co nanoparticles grown at 500ºC on the grooved and ridged CaF_2(110) surface a series of 2D images was taken around the Co(111) reflection (see upper part of Fig.2). By carrying out a 3D reconstruction of the CCD images, one can conclude that the Co reflection has two inclined CTRs indicating that the nanoparticles have 100 and 010 facets (see lower part in Fig.2). Interestingly, the revealed ridges of Co nanoparticles are rotated by 90º relative to the ridges of CaF_2(110) buffer layer.

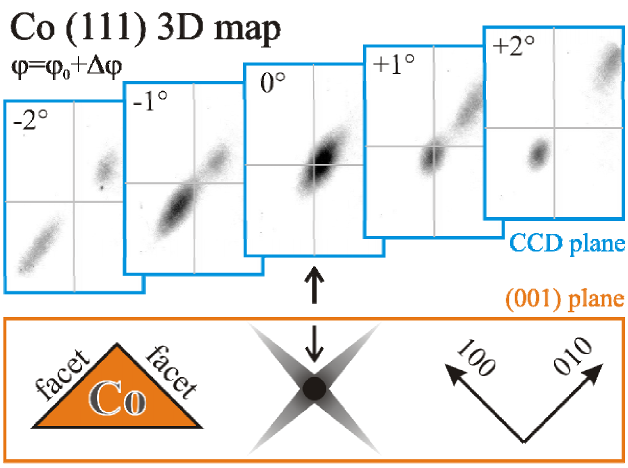

Fig.2. Series of 2D images taken at different azimuthal angle φ and revealing (100) and (010) facets of Co nanoparticles grown on the grooved and ridged CaF_2(110) surface (#6039).

Similar measurements were carried out for the Co nanoparticles grown on the (111) surface where the reflection maps revealed Co and CaF_2 CTRs normal to the substrate surface. Thus the measurements allowed determination of crystal structure and epitaxial relations. Moreover, 3D analysis of the reflection shape revealed Co nanoparticle faceting, which was not observed by atomic force microscopy because of its insufficient resolution.

References

[1] L. Pasquali et al., Surf. Sci. 600, 4170 (2006).
[2] N. Yakovlev et al., Curr. Appl. Phys. 6, 575 (2006).

* nsokolov@fl.ioffe.ru