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Size Dependence of Lattice Constants of Bismuth Nanocrystallines

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Introduction

Rhombohedral bismuth has a layer structure and the bondings between the three-fold co-ordinated Bi atoms are mainly covalent. The layers are stacked, which constracts the crystalline. It means that Bi has a hierarchic strucure. The effect of the hierarchic structure to the crystalline structure is interesting subject in the nanoscience. The Bi nanoparticles are investigated by the Raman scattering measruments [1].

In the present study we report the structural change obtained from the x-ray diffraction (XRD) for the Bi nanocrysatalline.

Experimental

Thin Bi layers and NaCl layers were deposited alternately onto a water-cooled alumina substrate from an alumina crucible. The Bi nanoparticles are isolated and dispersed within the NaCl matrix. The ration of the film thickness between Bi and NaCl is 1:20 for all samples.

The XRD patterns were measured with synchrotron radiation at the BL-8B in the Photon Factory of High Energy Accelerator Research Organization KEK-PF. The X-ray energy used for the XRD measurements was 12.40keV. The XRD measurements were carried out at room temperature.

Result and Discussion

All Bragg peaks are assigned to the rhombohedral Bi and the cubic NaCl. Intensities are normalized by integrated intensities of NaCl (200) peaks which do not overlap with any other peaks.

Figure 1 shows the (202) surface of the Bi nanocrystallines. The Bragg peaks of the Bi nanoparticles broaden with the decrease of the Bi film thickness, implying that the Bi nanoparticles become small. It is interesting that the peak position shift to shorter length with decreasing the film thickness. This implies that the lattice constants change with the size of the Bi nanocrystallines.

Figure 2 shows the size dependence of the lattice constants of the Bi nanocrystallines. With decreasing the film thickness of the Bi layer the lenghes of a- and c-axis shorten. The a-axis shrinks of 0.4%, and the c-axis shrinks of 1.2%. The c-axis shrinks than the a-axis, which reflects the hierarchic structure. The length of the a-axis is nearly constant above 10 nm, but it shrink below 10nm. But that of the c-axis shrinks gradually.

Figure 3 shows the variation of the covalent bond length. The bond length is nearly constant above 10 nm, but it shrinks below 10 nm.

References

[1] M. G. Mitch, S.J.Chase, J Fortner, R.Q. Yu, and J. S. Lannin, Phys. Rev. Lett. **67**, 875(1991) .

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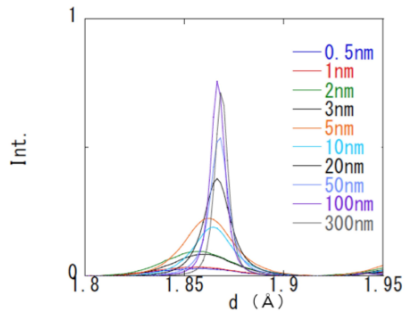

Fig. 1 Bragg peaks of Bi (202) surface for the Bi nanocrystallines.

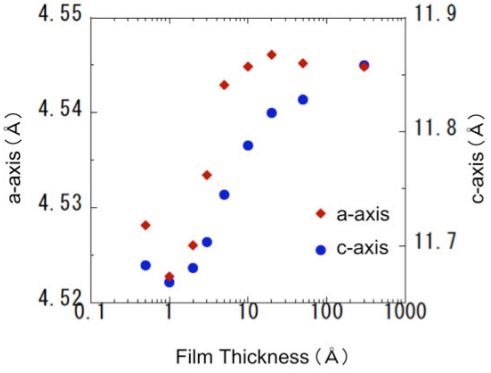

Fig. 2 The lattice constants of the Bi nanoparticles. Red and blue denote the lattice constants of the a-axis and the c-axis,respectively.

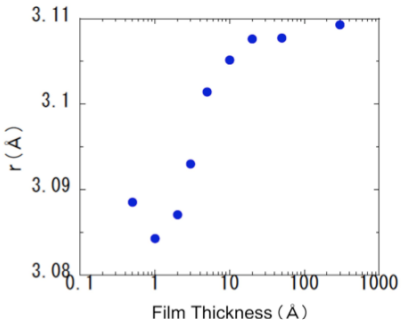

Fig. 3 The covalent bond length of the Bi nano-crystallines.