Materials Science

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XAFS analysis of Bismuth Nanoparticles

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Introduction

Bismuth has a hierarchic structure which would bring about exotic characters to the Bi nanoparticles. Raman scattering measurements of Bi nanoparticles exhibit a phase transition from rhombohedral Bi nanocrystalline to amorphous like nanoparticles depending on nanoparticles size [1].

XAFS is a powerful tool for studying the local structure of disordered and nanoparticles[2] [3]. For some materials (for examples, the Bi nanoparticles) it is difficult to deduce reasonable XAFS functions from X-ray absorption spectrum. In the present study we report a method for obtaining reasonable XAFS functions for Bi LIII-edge.

Experimental

Bismuth and NaCl were slowly deposited alternately onto substrates cooled by water. The ratio of the thickness of Bi to that of NaCl was 1:20. The formed Bi films were discontinuous with isolated island formation. The XAFS spectra were obtained on Bi LIII edge with transmission mode at BL12C of Photon Factory.

Results and Discussion

One of the most difficult problems for obtaining of XAFS functions is the extraction of absorption by a hypothetically isolated atoms. We have used a method proposed by Matsubayashi et al. [4] . But in the case of the Bi nanoparticles it is difficult to extract the hypothetically isolated atoms. In the curve for $\Delta\mu t$ of the 0.5 nm-thick-films the oscillation above 4 A^{-1} is severalfold larger than that below 4 A^{-1}, which induces the difficulty for obtaining the XAFS functions. The backscattering amplitude of c-Bi has large value around 3 A^{-1}, while it is close to zero around 6 A^{-1}.

In order to avoid the difficulty we try to restrict the region for extracting the XAFS functions. Figure 1 shows the XAFS functions obtained with two different regions. One is above 2.0 A^{-1} and the other is above 4.0 A^{-1}. The XAFS oscillations above 6 A^{-1} are same, but those below 6 A^{-1} are different.

Fourier transforms (FT) of the two XAFS functions were performed with the two k-ranges of 2.0-18.0 and 4.0 -18.0 A^{-1}, respectively. To reduce ripples, Hamming window function was used for truncation of the k-range. FT of the kχ (k) of the 0.5 nm-thick-films at 25 K are shown in Fig. 2. Both of FT have peaks at the same distance of 3.0 ˚A, but FT which is Fourier transformed at the region of 4.0-18.0 A^{-1} has low background. It is better that the XAFS functions are extracted and Fourier transformed in the region above 4.0 A^{-1}.

References

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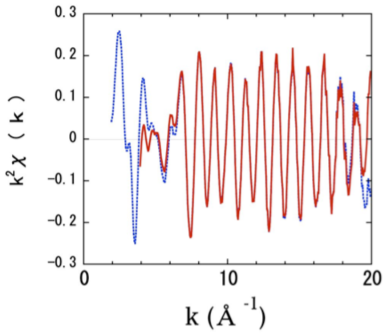

Figure 1. EXAFS functions measured at 25K for the 0.5 nm thick- films obtained with different region for the extraction of the EXAFS functions. Blue dotted line: above 2.0 A^{-1}, Red solid line: above 4.0 A^{-1}.

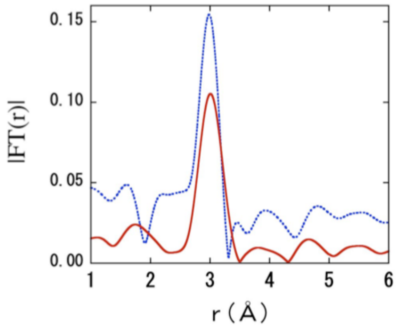

Figure 2. Fourier transform of $k\chi$ (k) measured at 25K for the 0.5 nm-thick-films obtained with different Fourier trasnform regions. Blue dotted line: 2.0-18.0 A^{-1}, Red solid line: 4.0-18.0 A^{-1}. the 0.5 nmthick- films obtained with different region for the extraction of the EXAFS functions. Blue dotted line: above 2.0 A^{-1}, Red solid line: above 4.0 A^{-1}.