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EXAFS study of the local structure of Bismuth film deposited at liquid nitrogen temperature

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1 Introduction

Bismuth crystallizes in the α-As structure[1].In bismuth crystal (c-Bi) Bi atoms are covalently bonded with three nearest neighbor atoms and form bilayers. The bilayers stack along the trigonal [001] axis. Thus c-Bi is charactered by hierarchic structure.

It is interesting to know what kind of structure an amorphous bismuth (a-Bi) takes shape of in the point of view of the hierarchic structure. We report the local structure of bismuth film deposited at low temperature to investigate the local structure of a-Bi.

2 Experiment

NaCl was deposited on a carbon substrate which was kept at room temperature. After the depositions, Bi was deposited on the substrate cooled with LN_2. The Bi film thickness was 300nm.

After the deposition of Bi the XAFS measurements were done with maintaining the sample temperature at liquid nitrogen temperature. In order to the investigate anneal effect the XAFS measurements were done after the short warm at the room temperature.

X-ray absorption spectra measurements for Bi L_{III}-edge were carried out at the BL12C of the PF in the KEK.

3 Results and Discussion

FT provides clear information for atomic correlations. Fig 1 shows FT of kχ(k) for the as-deposited and the annealed Bi films. For comparison FT for the Bi film deposited at room temperature is shown in Fig 1. The peak of around 3Å and 3.5Å are assigned to the nearest 'intra-bilayer bonds', and 'inter-bilayer bonds', respectively.

In FT for the as-deposited Bi film the peak for the intra-bilayer located at the same position for c-Bi with decrease in height. In contrast, the peak originated from the inter-bilayer disrupted. These features imply that the intra-bilayer structure remains while the inter-bilayer structure is disappeared in the LN_2-deposited.

Table 1 shows the structure parameter obtained with the nonlinear least squares calculations. The atomic distance of the intra-bilayer for the as-deposited Bi film slightly shorter compared with that for c-Bi.

The above mentioned structure of the as-deposited Bi sample suggest that the intra-bilayer structure is preserved in the as-deposited Bi sample while the stacking of the bilayer are disrupted. This mean that the as-deposited Bi sample is amorphous, which is confirmed with FT of the annealed Bi film. While the room temperature is not sufficient for annealing, the peak originated from the inter-bilayer appears again.

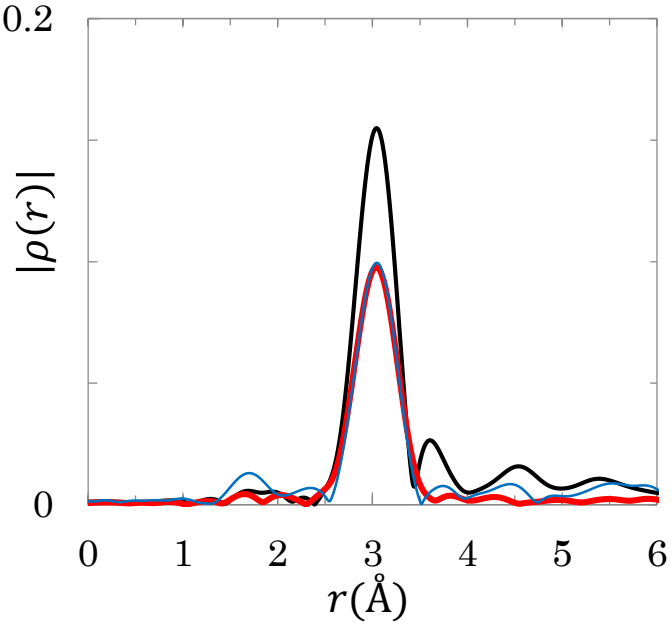

Fig. 1: FT of the EXAFS function kχ(k).
The black solid, red solid, and blue solid lines denote the 300nm, LN_2-deposited, annealed respectively.

Table.1: Structure parameters atomic distance (r), coordination number (N), and Debye Waller factor (DW).

	r(Å)	N	DW(Å²)
c-Bi	3.064	2.926	0.0584
as-deposited	3.042	1.455	0.0543
annealed	3.064	1.644	0.0547

References

1) Shin Yaginuma et al, PHYSICAL REVIEW B 82, 045422(2010)

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