Study on the structural property of Bi films by EXAFS

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Abstract

We report on the extended X-ray absorption fine structure (EXAFS) of (0001) bismuth grown on (111) Si substrate by molecular beam epitaxy. Bi L_3-edge (13.419 keV) EXAFS spectra of a series of Bi thin films were measured by fluorescence mode at beam line TLS-BL17C1 in the National Synchrotron Radiation Research Center, Hsinchu, Taiwan. Athena and Artemis codes were used to analyze the spectra and the results are listed in Table 1. The intralayer first nearest neighbor (1NN) distance is within 3.063~3.075 Å, very close to 3071 Å, the value reported in literature for bulk bismuth [1]. The fitted mean square variation of distance σ^2 ranges from 0.58×10^{-3} Å^2 to 3.5×10^{-3} Å^2, which is one order of magnitude smaller than the σ^2 values reported in Ref. [2]. The films in Ref. [2] were deposited at 77K and could have greater structural disorder than our films. However, the σ^2 of our films shows a large variation which could be attributed to their texture behavior. From the measurement of electron backscatter diffraction (EBSD) as shown in Fig. 1, the MBE grown films contain grains with two different orientations, (003) and (102). The ratio of these two grains can be determined either from EBSD figures or from X-ray diffraction (XRD) intensities. From the results listed in Table 2, we found that σ^2 increases with the increasing (102) to (003) ratio. Our XRD results also show that the Bragg's angle of (102) grains has larger variation than that of (003) grains, suggesting that the (102) grains in the films could suffer from different stresses and result in large variation in bond length. Details experimental results will be shown in our poster.

Table 1. Sample information and EXAFS fitting results

Sample	Thickness (nm)	Structure	R (Å)	NS_0^2	σ^2 (Å^2)
S0712A	140	Bi/p^+-Si(111)	3.075	1.51	0.00167
S0730A	135	Bi/p^+-Si(111)	3.063	1.88	0.00351
S0730B	135	Bi/n^--Si(111)	3.077	1.99	0.00233
S0733B	350	Bi/n^--Si(111)	3.073	1.47	0.00149
S0733C	350	Bi/p^--Si(111)	3.068	1.20	0.00058

Table 2. Mean square variation of distance σ^2 and Bi (102) to (003) ratios

Sample	σ^2 (Å^2)	Area ratio from EBSD	Peak intensity ratio from XRD
S0733C	0.00058	<0.001	0.66
S0733B	0.00149	0.0042	0.04
S0712A	0.00167	0.027	0.07
S0730B	0.00233	0.125	12.08
S0730A	0.00351	0.428	31.65

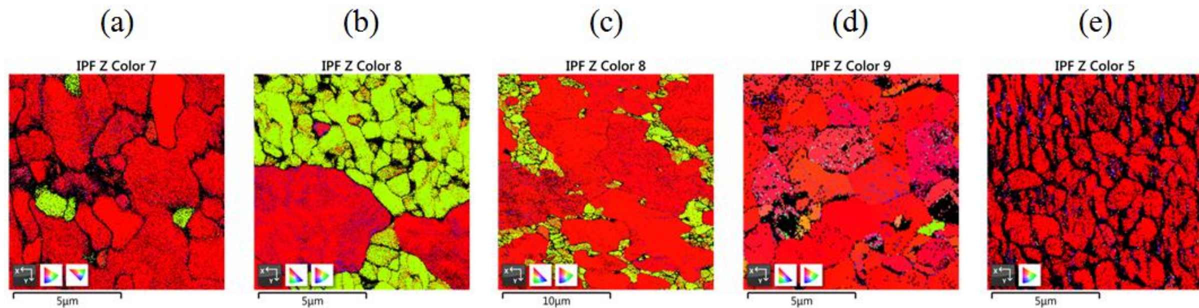

Fig. 1. EBSD inverse polar figures of (a) S0712A (b) S0730A (c) S0730B (d) S0733B (e) S0733C. Red and yellow represent Bi(003) and Bi(102), respectively.

Keywords - Bismuth, EXAFS, EBSD, XRD, grain.

References:

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