Local structure analysis of MgB$_2$ thin films by polarized XAFS

Mami Seo$^1$, Takafumi Miyanaga$^1$, Tomoe Kanno$^1$, Kouki Takeda$^2$, Daichi Hatanaka$^2$, Masahito Yoshizawa$^2$

$^1$Department of Advanced Physics, Hirosaki University, Hirosaki, Aomori, 036-8561, Japan
$^2$Graduate School of Engineering, Iwate University, Morioka, Iwate, 020-8551, Japan

1 Introduction
MgB$_2$ discovered in 2001 shows the superconducting transition temperature of 39K, which is the highest among metallic ones. The superconducting mechanism and applications as a device are attracting great interest. An important issue for the application to a device is the production of high-quality MgB$_2$ thin films. Although MgB$_2$ thin film grown-up on ZnO forms a reactive region in the interface, its crystallinity and superconductivity performance have been improved. The lattice distance of ZnO is close to that of MgB$_2$ (the lattice mismatch is about 5%). For studying the local structure of such thin films, EXAFS (extended X-ray absorption fine structure) is a powerful tool and the polarized EXAFS analyses are available, using a synchrotron radiation source. We analyzed the local structure of 50nm and 150nm MgB$_2$ thin films until now [1]. In this paper we present the results for the local structure of 10nm, 20nm and 30nm MgB$_2$ thin films.

2 Experiment
10nm, 20nm and 30nm MgB$_2$ films were prepared by co-evaporation MBE (molecular beam epitaxy) method [2]. Mg K-edge (1309eV) X-ray absorption spectra measured on BL11A at Photon Factory, KEK, Tsukuba, using fluorescence mode with silicon drift detector (SDD). Polarization-dependent XAFS measurement was applied to two directions: (a) The horizontal direction of the sample in which the electric vector of X-ray, $E$, is perpendicular to the c-axis of MgB$_2$ thin film: (b) The vertical direction in which $E$ is parallel to the c-axis. The EXAFS analyses were performed by XANADU code and FEFF 8.10 code. We applied the non-linear least square fitting (curve fitting) method to EXAFS data and obtained the structural parameters.

3 Results and Discussion
Fig. 1 and Fig. 2 show Fourier transform (FT) of $\chi(k)$ for the horizontal direction and for the vertical direction for MgB$_2$ thin films. Peaks around 2.0Å, 2.8Å and 3.5Å correspond to 1NN (1st nearest neighbor) Mg-B, 2NN Mg-Mg and 3NN Mg-Mg, respectively. FT for 30nm MgB$_2$ film is similar to that for 50nm. On the other hand, FT for 10nm and 20nm films have different structure from 30 and 50 nm films. Peak for 1NN Mg-B shifts to shorter distance and FT of 10nm film shows no clear polarization dependence.

Fig. 3 is atomic distance value, which is obtained by curve fitting as a function of film thickness.

4 Reference