Materials Science

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Zn-*K*α X-ray fluorescence holography of γ-ray detector material $Cd_{0.96}Zn_{0.04}Te$

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Introduction

The II-VI mixed semiconductor $Cd_{1-x}Zn_xTe$ is used for a γ–ray detector because of the high stopping power. The high-x sample is effective for thermal noise, however, the only low–x (< 0.1) single crystal could be obtained due to the large lattice mismatch between the CdTe and ZnTe. On the other hand, while having the large distortions, the diluted magnetic semiconductors $Cd_{1-x}Mn_xTe$ and $Zn_{1-x}Mn_xTe$ have the high–x (x ~ 0.7) single crystals, although the lattice mismatches are smaller than that of the $Cd_{1-x}Zn_xTe$. In order to investigate the distortions, we have performed the x–ray fluorescence holography (XFH) experiments for the $Cd_{0.6}Mn_{0.4}Te$ [1] and $Zn_{0.4}Mn_{0.6}Te$ [2-4], and the wide-ranging local structure around the Mn and Zn atoms have been clarified. In this study, the XFH measurement on the $Cd_{0.94}Zn_{0.04}Te$ was carried out.

Experimental procedure

The $Cd_{0.94}Zn_{0.04}Te$ (111) single crystal sample was a commercial product of Keystone Crystal. The experimental setup is shown in Fig. 1. The Zn-*K*α XFH data were recorded at nine incident X-ray energies of 10-14 keV in steps of 0.5 keV by rotating two axes ($0° \le \phi \le 360°$ in steps of ~0.4°, $0° \le \theta_1 \le 74°$ in steps of 1°). The fluorescent X-rays were collected using an avalanche photodiode detector (APD) with a cylindrical crystal energy-analyzer at RT. The 3D atomic image was constructed using Barton's algorithm [5] by superimposing the holograms, which can highly suppress the false twin images.

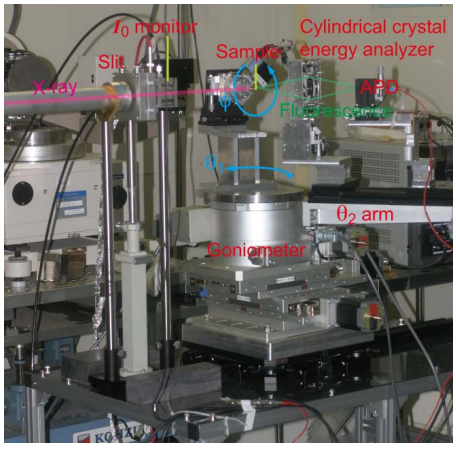

Fig. 1 XFH experimental setup.

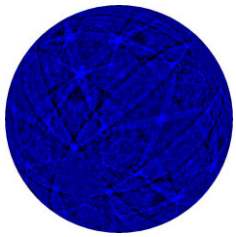

Fig. 2 Hologram obtained at 11.5 keV.

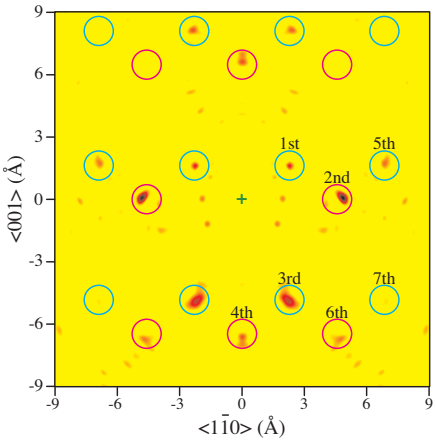

Fig. 3 Atomic images on (110) plane.

Results and discussion

The obtained hologram at 11.5 keV was given in Fig. 2. The standing wave lines are clearly seen because of the good crystallinity. The constructed atomic images on the (110) plane were shown in Fig. 3. The central Zn atom is at the center of the figure. The pink and blue open circles indicate the zinc blende atomic positions of Cd and Te, respectively, in the pure CdTe, and the atomic images are observed in the circles up to the sixth neighbor. It has been confirmed that the Zn atoms replace the Cd atoms in the base material CdTe, because the zinc blende structure was seen around the central Zn atom. It is supposed that the positions of the first neighbor Te atoms are largely fluctuated in the mixed crystal $Cd_{0.96}Zn_{0.04}Te$, because the image intensities are highly suppressed as shown in Fig. 3.

References

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