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Zn-K_α X-ray fluorescence holography of diluted magnetic semiconductor $Zn_{0.4}Mn_{0.6}Te$

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Introduction

From an X-ray diffraction [1], the lattice constant of diluted magnetic semiconductor $Zn_{1-x}Mn_xTe$ linearly changes with varying x (Vegard's law), while an XAFS results [2] showed almost unchanged Mn-Te and Zn-Te bond lengths (Pauling's rule). This discrepancy led to a question of how the large $MnTe_4$ tetrahedra can be squeezed into the small $ZnTe_4$ lattice. X-ray fluorescence holography (XFH) is a new technique that allows one to visualize a three-dimensional (3D) local structure around a specific element [3]. Recently, we have measured Mn-K_α XFH of $Zn_{0.4}Mn_{0.6}Te$ to obtain the local structure around the Mn atoms [4]. From this experiment, images of Te sublattice were clearly seen, while the second-nearest-neighbor Zn or Mn atoms were barely visible. It is, however, unclear whether the small scattering cross-sections of Zn and Mn atoms or a highly distorted cation sublattice causes such an experimental result. In this Zn-K_α XFH study, we have attempted to obtain a local atomic image of $Zn_{0.4}Mn_{0.6}Te$ around the Zn atoms, and solve the above question.

Experiment

The experimental setup is shown in Fig. 1. The Zn-K_α XFH data were recorded at nine incident X-ray energies of 11-15 keV in steps of 0.5 keV by rotating two axes ($0° \leq \phi \leq 360°$ in steps of 0.5°, $0° \leq \theta \leq 70°$ in steps of 1°) of a single-crystal sample. The fluorescent X-rays were collected using an avalanche photodiode detector with a cylindrical graphite energy-analyzer at RT. The $Zn_{0.4}Mn_{0.6}Te$ sample was grown by a Bridgeman method, and the incident X-rays were irradiated onto its (110) surface. From hologram patterns obtained with different incident X-ray energies, a 3D atomic configuration image was constructed using Barton's algorithm [5].

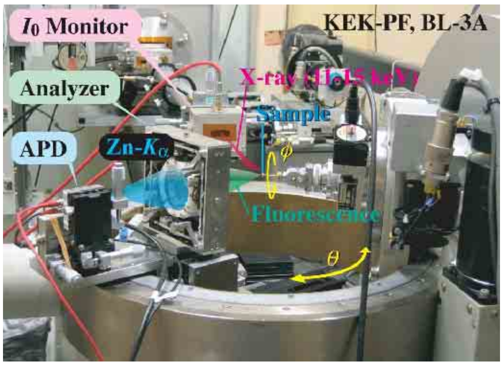

Fig. 1. The XFH experimental setup.

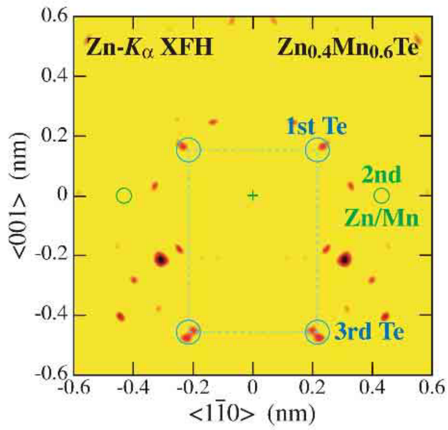

Fig. 2. The atomic image for the (110) plane of $Zn_{0.4}Mn_{0.6}Te$.

Results and Discussion

The obtained atomic image of $Zn_{0.4}Mn_{0.6}Te$ is depicted in Fig. 2, for the (110) plane around the Zn atoms. The green cross at the center of figure indicates the position of the central Zn atom, and the red and black colors represent the positions of neighboring atoms. The first- and third-nearest-neighbor Te atoms are clearly visualized. However, the second-nearest-neighbor Zn or Mn atoms are barely visible in this image. Thus, it was found that Te sublattice is rigid and the cation sublattice is highly distorted, which contradicts a structural model for a similar diluted magnetic semiconductor $Cd_{1-x}Mn_xTe$ by Balzarotti *et al.* [6].

References

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