Materials Science

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# X-ray fluorescence holography of $In_{1-x}Ga_xSb$ mixed crystal

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## Introduction

$In_{1-x}Ga_xSb$ mixed crystals are widely used for infrared (IR) telecommunication as raw materials of detecting and emitting IR devices, because the narrow band gap of this system can be controlled simply by the change of the concentration of cations. Due to the large difference of lattice constants of InSb and GaSb crystals, however, it is hard to make a single crystal except in the very low In or Ga concentration ranges of some %.

In a similar mixed crystal $Ga_{1-x}In_xAs$, a conflict on its structural studies were reported between X-ray diffraction (XD) and extended X-ray absorption fine-structure (XAFS) experiments [1]. The former indicates Vegard's law, i.e., the lattice constant linearly changes with varying the concentration *x*, while the latter reveals a Pauling's bond length, i.e., an almost constant Ga-As or In-As interatomic distance is preserved all over the concentration range. From a detailed XAFS analysis, they proposed a model that the anion (As) sublattice is more distorted with two distributions of As-As distances, while the cation (Ga,In) sublattice approximates a rigid fcc lattice. On the other hand, our recent study of X-ray fluorescence holography (XFH) on $Zn_{1-x}Mn_xTe$ diluted magnetic semiconductor with the same zinc-blende structure indicates the completely opposite conclusion of the lattice distortion [2].

We have recently measured Ga $K_\alpha$ XFH on $In_{0.995}Ga_{0.005}Sb$ for observing a three-dimensional (3D) atomic image around the Ga atoms. In this paper, we report results of the XFH measurement and discuss the local structure of mixed crystal around the Ga atoms.

## Experimental procedure

An $In_{0.995}Ga_{0.005}Sb$ single crystal was grown by using a Czochralski method at the Advanced Research Center of Metallic Glasses, Institute of Materials Research, Tohoku University. The XFH experiments were carried out by using a multi-purpose diffractometer installed at BL6C of PF/KEK. The Ga $K_\alpha$ fluorescent X-rays were collected using an avalanche photodiode detector with a cylindrical graphite crystal energy-analyzer. Details of the experimental setup were given elsewhere [3]. A 3D atomic image was constructed using Barton's algorithm.

## Results and discussion

Recently a similar conflict between the XD and XAFS was observed also in $In_{1-x}Ga_xSb$ mixed crystal [4]. Figure 1 shows a preliminary result of the atomic image on the (110) plane. The black circles represent atomic positions in pure InSb single crystal, and the green circles the approximated positions from our XAFS result [4].

Although the atomic images locate almost on the atomic positions of the InSb crystal, some deviations (the distortion of the lattice) can be observed, in particular for the first-, and second-nearest-neighboring atoms. The image for the first neighboring Sb atoms are rather scattered and locate from the approximated positions by the XAFS result to those with the atomic distance longer than the pure InSb lattice positions. The second neighboring cation sites also have a large spatial distribution. Thus it is concluded that the lattice distortions induced by mixing cause in both the cation and anion sublattice in the limited distance from the central Ga atom up to about second neighboring atoms.

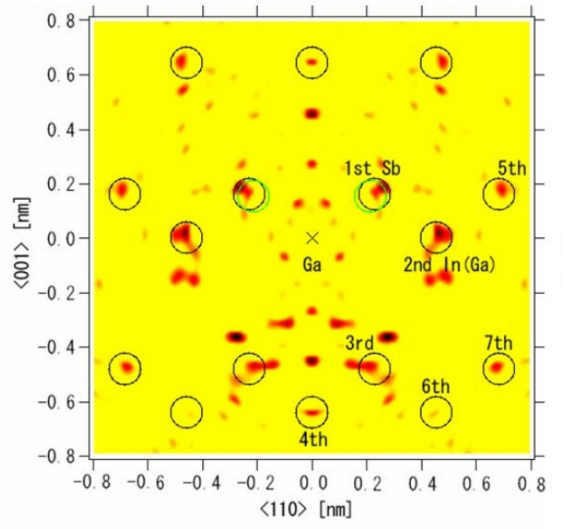


Fig. 1 Atomic image of $In_{0.995}Ga_{0.005}Sb$ on the (110) plane.

## References

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