Materials Science

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An XAFS study of sulfur supersaturated silicon

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Introduction

Silicon crystal supersaturated with chalcogen (sulfur, selenium, and tellurium) has been formed by the pulsed laser melting (PLM) and a strong sub-bandgap light absorption of the supersaturated Si of S has been reported [1-3]. This has opened up possibilities for fabricating several infrared optoelectronic devices. However, the mechanism of the optical absorption is still under discussion. To gain the insights into the absorption mechanism the investigation of the chemical states of chalcogen in Si is important because it relates to the electronic states in Si bandgap. In this work we measured X-ray absorption fine structure (XAFS) spectrum to investigate the chemical state of sulfur supersaturated Si and the change in the spectrum by thermal annealing.

Experimental

For the sample preparation ion implantation and PLM were employed to form single crystal Si supersaturated with sulfur. The Si amorphized by the implantation was completely crystallized by PLM. Subsequently some samples were annealed in a furnace. Sulfur atoms in the Si after PLM were distributed with a peak at ~120 nm from the surface and the peak S concentration was less than 1 at%. The spectrum of X-ray absorption near-edge structure (XAFS) was measured by the conversion electron yield (CEY) method at BL-9A in PF.

Results and Discussions

The measurements of S K-edge XANES spectrum were carried out for the S supersaturated Si samples and the reference materials. Figure 1 shows the XANES spectra for the samples crystallized by PLM (a) and annealed at 550 ºC after PLM (b). The spectra of GeS and sulfur crystals were also shown in the figure as references. The jump and peak at S K-edge were clearly seen in the spectra of the samples and the edge structure is partly similar to GeS.

The magnitude of the peak at the edge significantly decreased after thermal annealing at 550 ºC. We have found that the higher temperature annealing caused the decrease of infrared absorption of Si supersaturated with S. This change in XANES spectrum suggests the correlation between the infrared absorption and the chemical states of S.

The measurement of S core-level spectrum by X-ray photoelectron spectroscopy was also performed for analysis of the bonding states. The detailed analysis is still in progress. We will report the relation between the chemical bonding states and the sub-bandgap optical absorption in the near future.

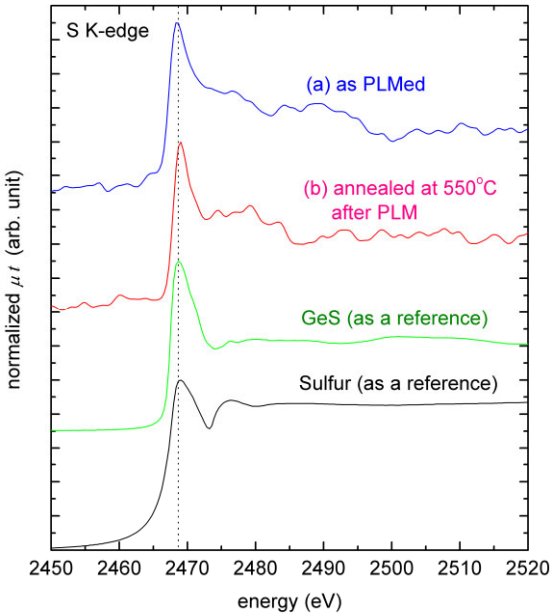

Fig. 1 S K-edge XANES spectra of S supersaturated Si for the samples crystallized by PLM (a) and annealed at 550ºC after PLM (b). The spectra of GeS and sulfur are also shown as references.

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