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EXAFS measurements for liquid Ge-Si alloys II

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Introduction

Ge and Si are typical semiconductors with a diamond structure in the solid states. Ge-Si alloys form solid solutions in the entire concentration region and the lattice parameter is known to change according to Vegard's law[1]. EXAFS spectra of crystalline Ge-Si alloys were measured around the Ge-K absorption edge to investigate the bond-length relaxation in the solid solution [2,3]. The results by Kajiyama el al [2] show that Si and Ge atoms are randomly distributed and that Ge-Ge and Ge-Si bond lengths scarecely depend on the composition.

Mousseau and Thorpe [4] discussed the EXAFS results [2] based on a topological rigidity model. In the model, when the network of the bonds is floppy, each bond keeps its own natural length. D. B. Aldrich et al [3] confirmed the slight composition dependence of Ge-Ge and Ge-Si bonds expected by the topological rigidity model. Recently Si and Ge K-edge XAFS spectra of the crystalline alloys were observed by J. C. Aubry et al [5] and they reported more reliable composition dependence of Ge-Ge, Ge-Si and Si-Si bond lengths.

When these elements are melted, their dc conductivities increase up to $10^4(\Omega\text{cm})^{-1}$ and they become liquid metals. It is interesting to study the local structure by means of EXAFS spectroscopy. EXAFS results of Ge fine droplets in carbon powder up to 1340°C are reported by Filipponi and Di Cicco [6], and we have carried out EXAFS measurements for bulky liquid (l-) Ge with the thickness of 40 μm up to 1400 °C (97G010). However EXAFS measurement for l-Ge-Si alloys has not been reported to date. It prompts us to measure EXAFS spectra of the liquid alloys. In this article the results of EXAFS measurements for l-Ge-Si alloys are presented. The brief results were already published in the literature [7].

Experimental

EXAFS measurements were carried out by transmission method using the spectrometer installed at BL10B, using a newly developed sample cell made of polycrystalline sapphire (97G010). Ge-Si alloys (99.999%) from $Ge_{0.1}Si_{0.9}$ to $Ge_{0.3}Si_{0.7}$ were prepared by Rare Metallic Co. Ltd. EXAFS spectra were obtained above the melting temperatures to 1450°C and those of the crystalline powder were measured at room temperature as references.

Results and discussion

Figure 1 shows EXAFS functions, $\chi(k)$, of l-$Ge_{1-x}Si_x$ (x=0, 0.1, 0.2, 0.3, 0.4, 0.5 and 0.6) near the melting temperatures and at higher ones. Clear oscillations in $\chi(k)$ are observed. With increasing Si concentration up to $Ge_{0.6}Si_{0.4}$, the amplitude of the oscillation near $3A^{-1}$ becomes small and the amplitude becomes again large at $Ge_{0.5}Si_{0.5}$ and $Ge_{0.4}Si_{0.6}$. Clear concentration dependence of the amplitude suggests that neighboring atoms around a central Ge atom change with the composition. The results of Gaussian fitting have already been reported in the literature [7]. Further analysis is now in progress.

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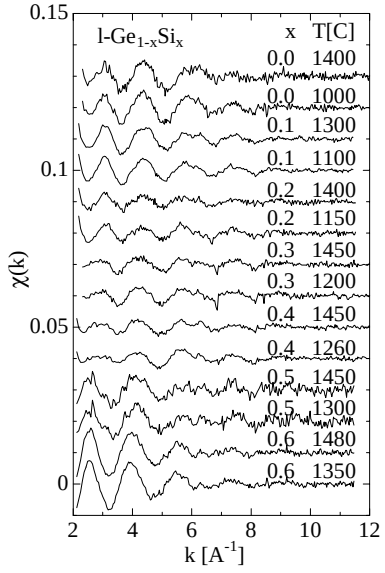

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