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Pressure-Induced Structural Change in Liquid $Ge_{0.15}Te_{0.85}$ alloy

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Introduction

Pressure-induced phase transitions commonly occur in crystalline phase of various materials. Recently in the disordered materials, in which a long range order disappears, pressure- induced sharp structural changes have been reported in several liquids [1,2]. In the eutectic alloy $Ge_{0.15}Te_{0.85}$ anomalous temperature dependence of the density and the diffraction pattern has been reported [3,4]. In this liquid, atoms are covalently bonded with anisotropic interaction. Pressure should cause anisotropic contraction similar to liquid Te and liquid GeTe [5,6]. Therefore the local structure of the liquid was investigated by the x-ray diffraction measurements in a wide pressure and temperature region.

Experimental

X-ray diffraction patterns were taken by an energy-dispersive method using the synchrotron radiation. Pressure was generated by using the multi-anvil high-pressure apparatus, MAX80, installed at PF-AR-NE5C. A powdered mixture of $Ge_{0.15}Te_{0.85}$ and NaCl was placed in a NaCl capsule. Energy-dispersive diffraction profiles were measured at 11 different scattering angles, 2θ, between 2.5° and 25° with white x-rays of 30–120 keV. From the measured diffraction intensities, the static structure factors $S(Q)$ of liquid metals were deduced.

Results and discussion

X-ray diffraction was measured at the temperature at 20 degree above the melting temperature along the melting curve from 0.9 GPa to 2.4 GPa. With increasing pressure, the height of the first peak $I(Q_1)$ increases while the height of the second peak $I(Q_2)$ decreases. This behavior of the pressure dependence of S(Q) is corresponds to that of the temperature dependence of S(Q) at ambient pressure reported by Bergman et al.[4].

In Figure 1 the ratio of $R(=I(Q_1)/ I(Q_2))$ is shown as a function of pressure. A drastic increase of the ratio occurs around 1.5 GPa in a narrow pressure width which indicates the pressure-induced structural change.

With increasing temperature at 1.1 GPa, the ratio increases continuously from 726 K to 906 K. The slope of $I(Q_1)/ I(Q_2)$ vs. temperature curve has a relatively large value around 820 K. At 0.5 GPa, similar temperature dependence was observer. At ambient pressure, a drastic change in the ratio was reported between 648 K and 798 K [4]. We can plot the boundary from the low-temperature and low-pressure phase to the high-temperature and high pressure phase in a P-T phase diagram. The boundary between the low-temperature and low-pressure phase and the high-temperature and high pressure phase has a negative slope. As the high-temperature and high- pressure phase has a smaller volume than that of the low-temperature and low pressure phase, from the Clausius-Clapeyron equation the high-temperature and high-pressure phase has a larger entropy than the low-temperature and low-pressure phase.

At the eutectic composition, Ge-Te alloy has a lower melting temperature than those of pure Te and GeTe alloys. In liquid pure Te, the drastic structural change was reported in a supercooled temperature region [3], the observed structural anomaly in liquid $Ge_{0.15}Te_{0.85}$ alloy should be similar to that in pure Te.

Detailed structural analysis of both phases is in progress.

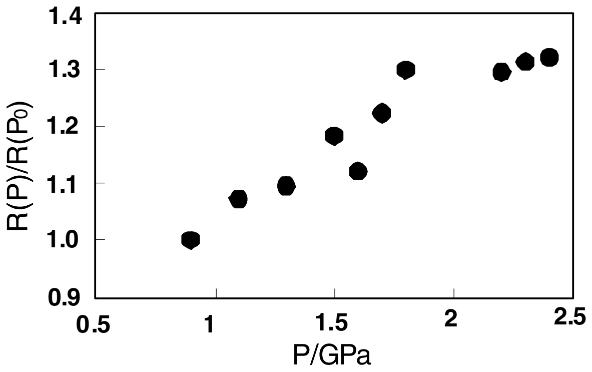

Figure 1 The ratio $R(=I(Q_1)/I(Q_2))$ of liquid $Ge_{0.15}Te_{0.85}$ alloy as a function of pressure .

References

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