Dynamics of Meso-scale fluctuations in liquid chalcogens near the metal-nonmetal transition

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Liquid Te-Se mixtures exhibit a metal-nonmetal (M-NM) transition in a relatively narrow temperature range [1]. This transition is accompanied by anomalies in thermodynamic properties such as the thermal expansion coefficient and compressibility. Recently, sound attenuation measurements for liquid Te-Se mixtures revealed that there occur dynamic anomalies in the M-NM transition region [2]. From the frequency dependence of the sound attenuation coefficient α, their relaxation time is estimated to be of the order of nano-seconds. These anomalies may be related to the relaxation between the metallic and non-metallic states in the liquid, and it is interesting to study the space- and time-structure of the mesoscale fluctuations. Neutron spin-echo (NSE) is a powerful technique which gives information on the intermediate scattering function $I(Q,t)$. However, to our knowledge, there is no NSE measurement under such high temperature conditions.

In the present work, we developed a new electric furnace which can be used for NSE measurements up to $\sim 600^{o}$C. In order not to disturb the magnetic field around the sample, we used non-inductive resistance heaters. By using this furnace, we measured NSE signals for liquid Te_7Se_3 mixture.

Figure 1 shows the intermediate scattering function $I(Q,t)/I(Q,0)$ observed at 490°C. It is noticed that $I(Q,t)/I(Q,0)$ increases with decreasing the wave vector Q. These data can be expressed by a superposition of two exponential relaxation processes as follows:

$$I(Q,t)/I(Q,0) = A_{\mathrm{fast}} \exp(-t/\tau_{\mathrm{fast}}) + A_{\mathrm{slow}} \exp(-t/\tau_{\mathrm{slow}}).$$

Here A_{fast} and A_{slow} represent the fraction of the fast and slow components, satisfying $A_{\mathrm{fast}} + A_{\mathrm{slow}} = 1$, and τ_{fast} and τ_{slow} are the relaxation times of the fast and slow dynamics, respectively. From a curve fitting analysis, the relaxation times are estimated as $\tau_{\mathrm{fast}} \sim 0.1$nsec and $\tau_{\mathrm{slow}} \geq 10$nsec. The slow component becomes dominant in the low-Q region, and this process may lead to the anomalous sound attenuation.

References

[1] M. Yao and H. Endo, J. Non-Cryst. Solids **205-207** (1996) 85, and references therein.
[2] M. Yao, N. Itokawa, H. Kohno, Y. Kajihara and Y. Hiejima, J. Phys.: Condens. Matter **12** (2000) 7323

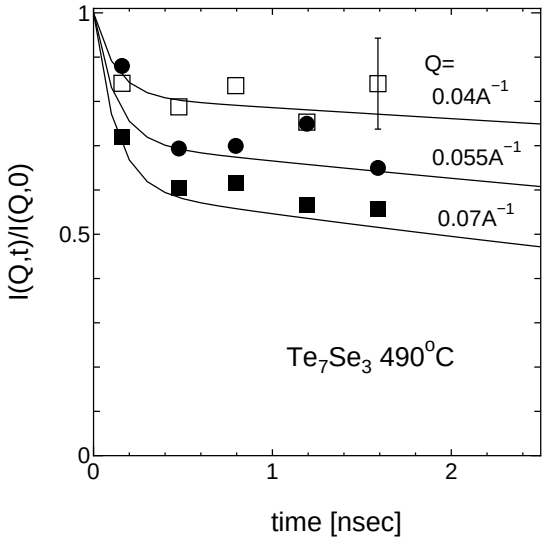

Fig. 1. Intermediate scattering function I(Q,t)/I(Q,0) for liquid Te7Se3 at 490C. The solid lines indicate the fitting curves expressed as a superposition of two exponential relaxation functions.