1. Title
FY2001 Ground-based Research Announcement for Space Utilization Research Report

2. Research Term
FY2001~2003

3. Research Fields
Microgravity Science

4. Research Categories
Phase IB Research

5. Research Theme
Effect of magnetic field on mass transfer in glass melts

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8. Summary of Research
After a recent progress in the generation of high magnetic field above 10 T using superconducting and hybrid magnets, high magnetic field has been applied to the control of flow and thermal convection in melting and solidification processes for the production of metals and semiconductors. Generally, the effect of magnetic field on flow and convection can be explained by magnetohydrodynamics (MHD) in the metal and semiconductor liquids. According to the MHD, it is expected from MHD that the flow and convection are less affected by magnetic field in non-magnetic oxide melts with low electronic conductivity, because the melts themselves consist of both positively and negatively charged ions with no conduction electrons, and is neutrally charged as a whole. Nevertheless, it has been reported that the flow behavior of non-magnetic liquids of insulators is changed by the application of magnetic field. This suggests that magnetic field can be utilized to control the flow and convection of glass melts, which

Fig. 1. Brock diagram of the in-situ observation system under high magnetic field.
is an important subject in the fabrication process of homogeneous and clear glass materials. There are, however, no systematic studies on the effect of magnetic field upon flow and convection in terms of glass composition, glass structure, and so on. In this study, we have developed in-situ observation systems for glass melts, which works under magnetic field higher than 10 T. Figure 1 shows a block diagram of the observation system under high magnetic field. Moving image of the glass melt in a silica glass crucible was recorded by using a small CCD camera through two quartz glass windows as shown in the figure.

A simple pattern of the thermal convection flow was observed in the $x\text{R}_2\text{O}-2\text{P}_2\text{O}_5 (\text{R}=\text{Li, K}: x=1, 3)$ glass melts due to the temperature distribution of the melts in the crucible. The velocity of the flow at the surface of the melt was changed by applying vertical magnetic field. Figure 2 shows the normalized flow velocity of the melts under magnetic field. The behavior of the change in the velocity under magnetic field did not depend on the kind of alkali ion (Li, K). The velocity was suppressed to one-third of the flow velocity at 0 T by applying magnetic field above 1 T in the melt of low alkali content glass ($x=1$). On the other hand, the velocity slightly increased with the increase of magnetic field in the melt of high alkali content glass ($x=3$). It was deduced that positively charged alkali metal ions and negatively charged clusters consisting of $\text{PO}_4$ tetrahedra act as charge carriers and that the movement of these carriers under magnetic field affects the overall flow behavior of glass melts, based on MHD. The field at about 1 T is probably a critical field strength at which alkali metal ions get rid of the restriction by the clusters. The effect of magnetic field on the convection would be useful for the control of flow in glass melt under microgravity environment.

Fig. 2. The flow velocity of the thermal convection in the melt of alkali phosphate glasses.

9. Publication List


10. URL