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Homogeneity of Li_2O-SiO_2 Glasses as Prepared Under Microgravity and 1-*g* Melting Conditions

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Glasses and glass ceramics are very important materials of modern life. Long known are the products of the flat and hollow glass industry. However, in recent years special optical glasses, optical glass fibers, bioglass-ceramic materials or radiation-protective glasses increasingly attract the interest both of scientists and technologists. Even space technology as practiced by the shuttle flights would be impossible without the heat-insulating action of the tiles (essentially silica glass products) at the outer mantle of the spacecraft.
One main research aspect, therefore, is directed to the improvement of already known or the development of new glass and glass-ceramic materials, e.g. by extending the glass-forming region, changing the microstructure or looking for new compositions [1, 2]. The experiment D1-WL-IHF 05 "Homogeneity of Glasses" was related to this field.

Experiment

Three glass samples of the system Li_2O-SiO_2 (for compositions see Fig. 1) without and with additions of 0.01 mol% $PtCl_2$ as a nucleating agent, were subjected to the temperature-time treatments shown in Fig. 2. These experimental runs were done in the Isothermal Heating Facility (IHF) of

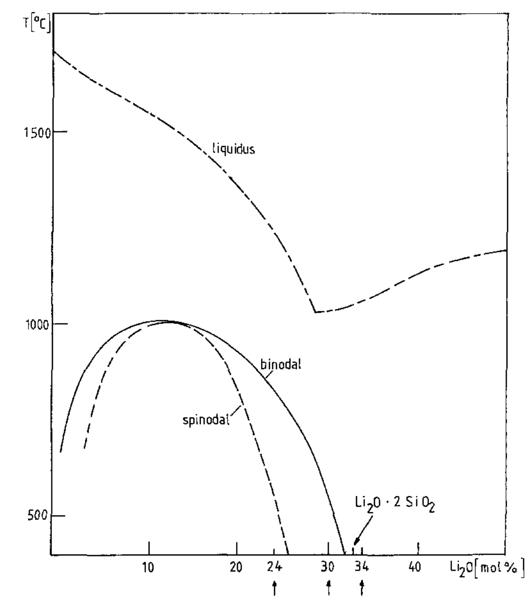

Fig. 1. Phase diagram of the system Li_2O-SiO_2 (after [3]). Arrows denote the compositions of the glass samples investigated

the Werkstofflabor (WL) of Spacelab on board Space Shuttle Challenger during its flight between October 28 and November 5, 1985. A normal gravity 1-*g* reference experiment under similar conditions was conducted recently. Thus far only some parts of the flight samples could be inspected by scanning electron microscopy (SEM) and compared with samples prepared in the system Li_2O-SiO_2.

Results and Discussion

A part of the phase diagram of the binary system Li_2O-SiO_2, which may be regarded as a model system for technical glasses and glass ceramics, is shown in Fig. 1 [3]. If Li_2O-SiO_2 melts are cooled from above the liquidus to room temperature, bulk phase separation and/or crystallization may occur, depending on composition, number of homogeneous/heterogeneous nuclei and on cooling rates. If the melts are kept in a container, heterogeneous nucleation/crystallization will start from the walls. Under 1-*g* conditions these nuclei will also be distributed in the bulk of the melt by buoyancy convection, whereas under microgravity conditions (μg) these nuclei will remain seated near the walls. The homogeneity and/or microstructure of the resulting materials should be totally different under 1-*g* and μg conditions.
Despite the short period of time since the retrieval of the flight samples, it can be stated that the basic ideas of this experiment could be confirmed. Figures 3a and b show micrographs of crystallized

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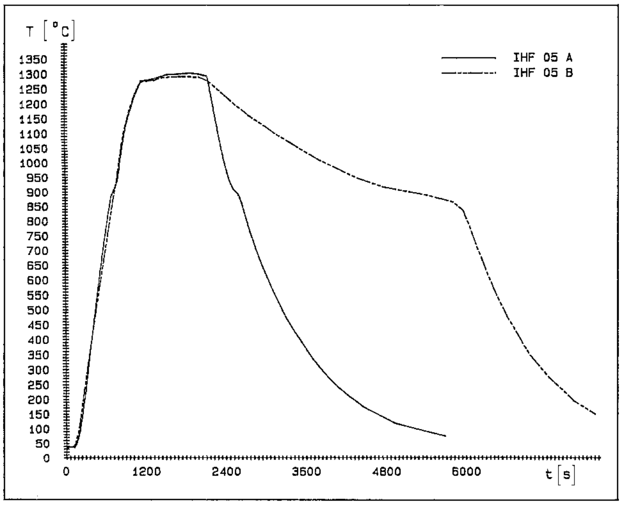

Fig. 2. Temperature-time profiles during the D1 mission

Li_2O-SiO_2 samples under 1-*g* and μ*g* conditions. Whereas the $Li_2O \cdot 2SiO_2$ crystals display spherolithic growth under normal conditions, those crystals grown in space show dendritic morphology. Moreover, as may be seen from Fig. 3c, where part of a flight sample near the container walls is shown, the contact zone is completely crystallized. The microstructure in the bulk beneath the contact zone could show evidence for a phase separation process.

Outlook

Further evaluation of the flight samples in comparison to the 1-*g* reference samples is underway, especially with regard to composition, cooling rates and nucleating agents. It is also expected to gain insight into the mechanisms of phase separation, crystallization and homogeneous/heterogeneous nucleation in glass melts.

This report is restricted to the system Li_2O-SiO_2. Our space experiment also contained glasses of the Vycor-type system $Na_2O-B_2O_3-SiO_2$. The results should enable us to extend the experiments to unknown systems and to answer more general questions on glass formation. Moreover, the experiment has also shown that containerless glass processing under μ*g* conditions could be a meaningful step for further work.

As previous μ*g* experiments on glasses [4] have shown the present project also proved the usefulness of space research in this field.

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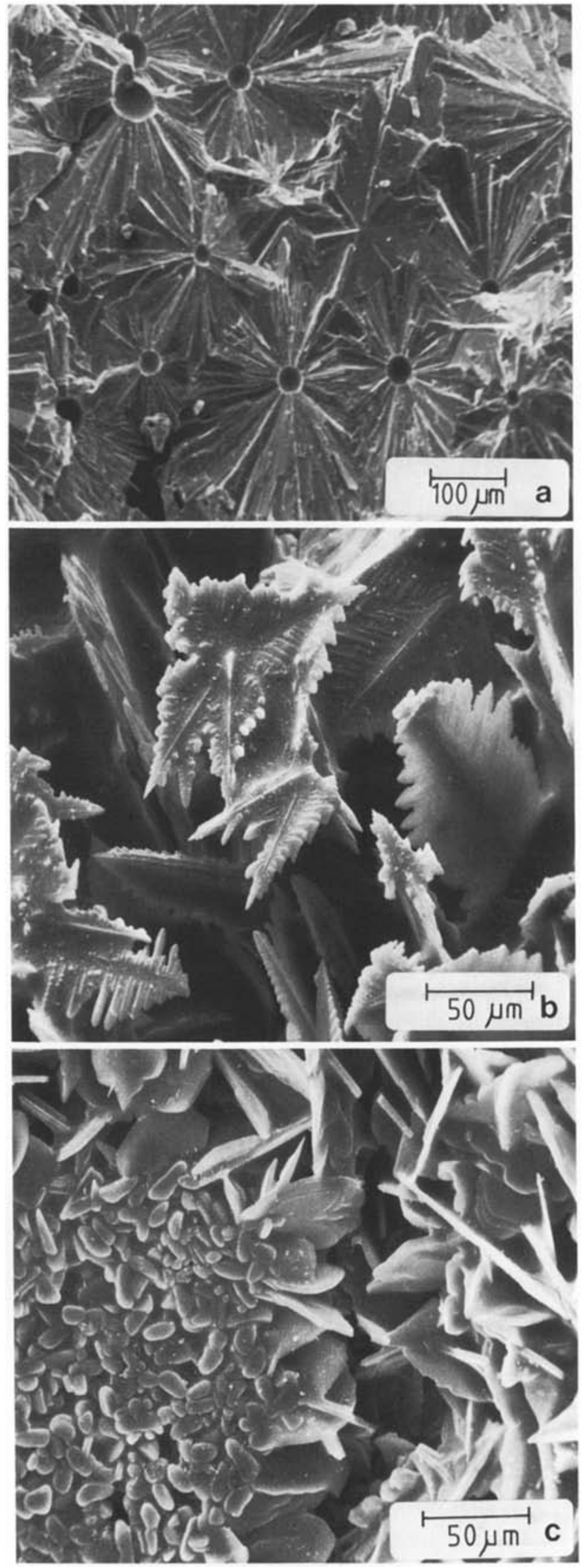

Fig. 3. SEM micrographs of a) a 30% $Li_2O-70\%$ SiO_2 sample as processed under 1-*g* conditions, b) a 30% $Li_2O-70\%$ SiO_2 sample and c) a 24% $Li_2O-76\%$ SiO_2 sample as processed under μ*g* conditions