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Effect of High-Pressure on the Thermal Properties of a $Li_2O{\cdot}2SiO_2$ glass

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Abstract –The investigation of the pressure effect on the thermal properties and crystallization kinetics of glasses is of great interest from both practical and theoretical points of view. In this work, the variation in the glass transition temperature (Tg) and the crystallization peak temperature (Tp) of a glass with the stoichiometric composition $Li_2O{\cdot}2SiO_2$ (LS_2) was investigated as a function of pressure applied before annealing. Monolithic LS_2 glass samples were submitted to pressures at 2.5 GPa, 4 GPa and 7.7 GPa during 5 min at room temperature and then studied by differential thermal analysis (DTA).

Glass-ceramics are polycrystalline materials produced by controlled crystallization of suitable glasses during heat treatment processes. The glass-ceramic production process starts with the preparation of a homogeneous glass, followed by the shaping of the glass and, finally, by the application of a controlled heat treatment process. Controlled crystallization consists of two steps at high temperatures: nucleation and crystal growth [1].

The investigation of the effect of pressure on the thermal properties and crystallization kinetics of glasses is of great interest from both practical and theoretical points of view [2, 3]. It is also important to a better understanding of several geological or manufacture processes [4].

In this work, the crystallization of a glass with the stoichiometric composition $Li_2O{\cdot}2SiO_2$ (LS_2) was investigated as a function of pressure applied before annealing to crystallization. Monolithic LS_2 glass samples were submitted to pressures at 2.5 GPa, 4 GPa and 7.7 GPa during 5 min at room temperature and, after that, they were analyzed by differential thermal analysis (DTA). DTA experiments were performed by heating 30 ± 1 mg monolithic glass samples in a Pt-crucible from 20 °C to 1000 °C at different rates.

The values of the glass transition temperature (Tg) and the crystallization peak temperature (Tp) were measured (fig.1), and the effective activation energy for crystallization (E) (fig.2) was determined using the Kissinger model [5] for an untreated LS_2 monolithic glass and samples treated at high pressures. The results showed that Tg remained practically constant, while Tp decreased as the applied pressure increased. The high pressure treatment before heating in the DTA probably introduced heterogeneous nucleation centers in the monolithic glass samples affecting the crystallization kinetics.

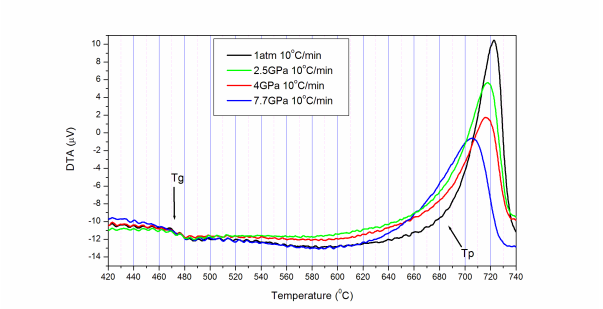

Figure 1: DTA exotherms experiment for undensified (1atm) and densified (2.5 GPa, 4 GPa and 7.7GPa) samples at a heating rate of 10 °C/min.

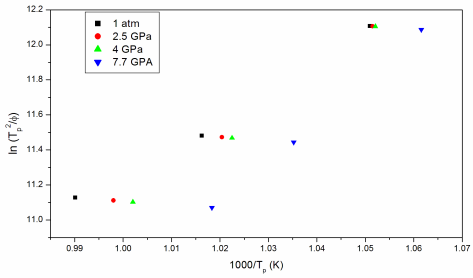

Figure 2: Ln (Tp^2/ϕ) vs $1/T_p$ plots (Kissinger) for undensified and densified (2.5 GPa, 4 GPa and 7.7 GPa) $Li_2O{\cdot}2SiO_2$ glass monolithic samples for different heating rates. Furnace atmosphere: nitrogen.

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