Fabrication of glasses with low softening temperatures for mold-processing by ion-exchange

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Introduction

Recently, molding techniques have received much attention for producing aspherical lenses and lens arrays. These techniques are also applied to the fabrication of micron- and sub-micron-structured glass optics. It is desired that the mold processes are carried out under low temperature as possible because this suppresses the deterioration of the molds. Eventually, this resulting in the reduction of the cost. Glass systems which have low softening temperatures and are suitable for mold processing are extensively explored. In order to decrease the softening temperatures, however, it is often necessary to incorporate heavy metal elements such as lead restricted to be used.

On the other hand, it is well known that the glass transition and softening temperatures are decreased by ion-doping using a technique such as ion-exchange. Here, we examined the thermal and mechanical properties of glasses which were ion-exchanged under various conditions in order to obtain the glasses suitable for mold processing. Molding experiments have been performed for the glasses both before and after ion-exchange at various temperatures.

Experimental

Conclusions

The absorption edge for ion-exchanged glasses shifted from below 300 nm to beyond 400 nm. The transmittance at 500 nm decreased with the ion-exchange time; the transmittance at 500 nm decreased to less than 60% for the glass ion-exchanged at 400 °C for two day in the molten salt 25AgNO3-75NaNO3. Silver was introduced deeply with the ion-exchange time, and diffused about 0.45 mm in depth for the glass ion-exchanged for seven days. The glass transition and softening temperatures of the glasses before ion-exchange were 575 °C and 605 °C, and decreased by 80 K and 70 K, respectively, by the ion-exchange. The thermal expansion coefficient of the glasses decreased from 9.1x10⁻⁶ μm/m·°C to 7.0x10⁻⁶ μm/m·°C by the ion-exchange. Molding experiments at 500 °C were performed for the glasses both before and after ion-exchange. The periodical structures of the mold were successfully transferred for the ion-exchanged glasses but not for the glasses before ion-exchange.

Results and Discussion

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