Compositional Effects on the Thermo-optic Coefficients of Potassium Aluminophosphate Glasses

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Abstract

The central wavelength of lightwave devices such as gratings is sensitive to temperature, due to the temperature dependence of the devices' optical path lengths. One way to solve this problem is to use an athermal device. Phosphate glasses are ideal hosts for such devices as they exhibit negative thermo-optic coefficient (dn/dT), which counters the effect of expansion. For this study, fourteen different compositions of potassium aluminophosphate glasses, of the K_2O-Al_2O_3-P_2O_5 system, were prepared with O/P ranging from 2.8 to 3.1. Refractive indices, glass transition temperature (T_g), coefficient of thermal expansion (CTE) and thermo-optic coefficient (dn/dT) measured for the glasses are what is expected with the addition of aluminium : an increase in T_g and a reduction in CTE. T_g changes in the range of 272°C to 621°C while CTE decreases from 21×10^{-6}/°C to 7×10^{-6}/°C as the aluminium content increases. We are able to achieve dn/dT value as negative as -16×10^{-6}/°C. In addition, the glasses are thermally stable, judging by the large difference between T_g and the temperature of onset of crystallisation. Athermal glasses have been achieved at low aluminium content with high CTE, which in turn leads to negative dn/dT. These results are consistent with the polarisability effect in the glasses as low aluminium content lowers polarisability, which gives rise to negative dn/dT. The CTE of glasses must be more than 10×10^{-6}/°C to achieve negative dn/dT. Any deficit or excess P_2O_5 does not seem to affect the CTE and dn/dT.