

Structure and properties of $\text{Ag}_2\text{O}-\text{GeO}_2-\text{P}_2\text{O}_5$ glasses

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Phosphate glasses of the $\text{Ag}_2\text{O}-\text{GeO}_2-\text{P}_2\text{O}_5$ were studied in two compositional series $(50-x)\text{Ag}_2\text{O}-x\text{GeO}_2-50\text{P}_2\text{O}_5$ with 0-50 mol% GeO_2 and $50\text{Ag}_2\text{O}-x\text{GeO}_2-(50-x)\text{P}_2\text{O}_5$ with 0-20 mol% GeO_2 . Basic physical properties were determined, and thermal properties studied by differential thermal analysis, thermomechanical analysis, and hot-stage microscopy. The glass structure was investigated using Raman spectroscopy and ^{31}P MAS NMR by both 1D and 2D techniques. The electrical properties of the glasses were obtained by using impedance spectroscopy.

In both glass series glass transition temperature increases with GeO_2 additions and all glasses containing GeO_2 crystallizes in temperature range 500-750 °C. The dependence of the coefficient of thermal expansion in both cases sharply decreased with the addition of GeO_2 , which is a typical phenomenon when T_g increases, and indicates the strengthening of the structural network of the glass due to the increase in the occurrence of Ge-O bonds. ^{31}P MAS NMR spectra of $(50-x)\text{Ag}_2\text{O}-x\text{GeO}_2-50\text{P}_2\text{O}_5$ series were dominated by one major resonance which shifts to more negative values with increase of GeO_2 content. Position and the shift of the peak indicates that network of the glass is mainly built from Q^2 structural units. By using 2D ^{31}P INADEQUATE sequence was confirmed that phosphate chains are gradually shortened due to the formation of Ge-O-P bonds. ^{31}P MAS NMR spectra of $50\text{Ag}_2\text{O}-x\text{GeO}_2-(50-x)\text{P}_2\text{O}_5$ consist of multiple peaks that mainly belong to structural units Q^1 and Q^2 . Spectra of this series are also influenced by hygroscopicity of the glasses. Raman spectra of the glasses includes dominant vibrational band in the region $1000-1300\text{ cm}^{-1}$, changes in this region reveals transformation of phosphate glass network. Another dominant vibrational bands can be found in the region $500-800\text{ cm}^{-1}$. This region reflects evolution of P-O-P connections to P-O-Ge and Ge-O-Ge connections through the series.