08-008

The Mixed Network Former Effect in Glasses: Structure-Property Correlations in Phosphate-Based Glass Systems

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Non-linear changes in the physical properties of glasses containing more than one type of network former species are often exploited for optimizing the technological performance of glasses for optical and electrical applications. Issues at the structural level concern (1) the identification of the coordination polyhedra arising from the specific interactions between the network former species involved, (2) their connectivity distribution, and (3) the competition of both network formers for the network modifier species. Modern multinuclear solid state nuclear magnetic resonance (NMR) techniques present a new element-selective, inherently quantitative approach to this problem. Complementary information is available from O-1s X-ray photoelectron spectroscopy, which allows a quantitative differentiation of different types of bridging and non-bridging oxygen species. Combining both methods, the detailed quantitative distribution of network former connectivities can be derived. Results will be presented for the three glass systems Na2O-B2O3-P2O5, Na2O-GeO2-P2O5, and Na2O-TeO2-P2O5, and discussed in relation to the compositional dependences of glass transition temperatures and ionic conductivities.