Structural investigation of M2O-SiO2-B2O3-Al2O3 glasses by Raman spectroscopy and the influence of thermal history.

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Abstract

Alkali-borosilicate glasses are one of the most used glasses with a high technical and commercially importance. Due to their high chemical and thermo-shock resistance, hardness, fracture toughness and good optical properties, they are suitable for a wide range of different applications such as substrates in electronic devices or as household and laboratory ware. As the macroscopic properties of glasses (i.e. mechanical properties) are directly correlated to their microscopic structure, the understanding of the glass topology is therefore one of the most important key parameter in order to design/optimize glass.
To investigate the effect of the modifier cation size on the boron structure, the Na oxide is substituted by Li and K oxide on the following compositions 74SiO2-10B2O3-16Na2O and 74SiO2-20.7B2O3-4.3Na2O-1Al2O3. To analyze also the influence of Al2O3 addition and thermal history on the glass structure, glasses of both series with different amounts of Al2O3 and tempering methods were produced.
The change in the connectivity and sort to medium-range order were observed with the help of Raman spectroscopy, where the influence on the local connectivity can be determined by changes in the vibration bands. Based on the frequency bands between 700-850 cm-1 (borate and boroxol ring modes), 1000-1200 cm-1 (silicate, borate and mixed B-O-Si stretching modes) and 1250-1600 cm-1 (trigonal borate entities) we were able to observe the change in boron and silica coordination. In combination with mechanical testing, i.e. testing of the Vickers hardness, we want to correlate changes in mechanical properties to atomic local structure for different compositions and thermal histories. With this model we want to predict better new mechanical properties.

Keywords: Raman, Borosilicates, Ultra, Strong, Glasses

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