Development of Materials for Optoelectronics: Understanding the Local Structure and Optical Properties of Ternary Chalcogenide Glasses

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Semiconducting ternary chalcogenide glasses are used in many important technological applications such as optical data storage, waveguides, optical amplifiers etc. However, development of materials with predefined device parameters and broadening their application is hampered by lack of complete understanding of atomic arrangement in these materials and its correlation with optical properties. Study of glassy materials is hindered due to the absence of long-range order. The problem is further complicated in ternaries as compositional disorder is introduced in addition to structural disorder. This project used a combination of complementary techniques to reveal information on local structure and optical parameters of Ge-As-Se glasses. This system exhibits the broadest glass-forming region among similar ternaries and is considered as a model system for compositional manipulations. We analyzed atomic radial distribution functions, calculated from X-ray powder patterns, along with Raman scattering data. It was revealed that atomic arrangement and bonding structure in these glasses can be well described within the model of chemically ordered glasses with preference of heteropolar bonds. The results suggested that in selenium-deficient glasses, beyond the “chemical threshold”, homopolar bonds were more likely to form. Strong correlation between optical parameters and local structure was revealed using temperature-dependent spectroscopic ellipsometry measurements. In addition, a possibility of using these materials for flexible electronic devices was tested by depositing filmed samples onto polymeric substrates. The results are important for development of inexpensive materials with tailored properties for optoelectronic devices and the emerging field of flexible electronics.

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