Crystallization and phase separation in chalcogenide glasses

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Abstract

Chalcogenide glasses are the counterparts of oxide glasses where the oxygen ion is replaced by a chalcogen (S2-, Se2-, Te2-). Because of the presence of chalcogen, more polarizable than oxygen, and the presence of a more active pair of free electrons, the chalcogenide glasses have very different properties than their oxide counterparts and therefore, found applications in specific domains, e.g optical components for the development of night vision devices or IR waveguides for environmental metrology, phase change materials for electric memory development or even, electrolytes for all-solid-state battery and ionic memory development,.
In many applications, total or partial crystallization of the material plays an important role. Indispensable in electrical and optical memories in which amorphous and crystalline phases are 0 and 1 bits of the operative part, the crystallization becomes an element of optimization in the case of optical components to improve the mechanical resistance of the material, or in the case of solid electrolytes to produce an electrochemically stable material and to improve the ion conductivity. On the other hand, the presence of phase separation allows the ultra-fast switching of ionic memories based upon Ag+-conductive chalcogenide films.

In all cases, investigation to identify a crystalline phase with optimal properties needs to be carry out first with outcomes like evidence of new unreported or metastable phases. Their stabilization in a glassy matrix is then another challenge. Recent work coupling the sensitivity of neutron thermodiffraction with the versatility of spark plasma sintering procedures helped in stabilizing a unique, either stable or metastable, phase in a glassy matrix and in producing glass-ceramics with improved thermoelectric properties in the system Cu-As-Te. Similarly, investigation of phase separation and evaluation of derived morphology is required to control the glass properties and therefore, design optimized compositions for applications. Recent work in Ag-Ge-Se system coupling synthesis conditions and structural experiments such as small angle neutron-ray scattering and Raman will be used as an illustration.

Keywords: Chalcogenide, Glass, Crystallization, Phase separation

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