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Physical Properties and Structure of a New Class of Low Phonon-Energy Chalcohalide Glasses for Optical Fibres

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Abstract

We report the physical properties and structure of a new class of low phonon-energy chalcohalide glasses in the system of Ga_2S_3-La_2S_3-CsCl suitable for making optical fibres. The physical properties investigated include refractive index, UV/Visible absorption edge, density, thermal expansion coefficient, viscosity and thermal characteristic temperatures, ie. glass transition and crystallization etc. The glasses studied have the formulas, $65GaS_{1.5}$ $(35-X)LaS_{1.5}$ XCsCl, where X = 0, 5, 10, 15, 20, 25 and 30.

All of the properties measured show a similar trend having a minimum or a maximum at around X=25 when CsCl is introduced. The structural change with increasing CsCl content is best illustrated in the viscosity measurement. Initially, the glass melt becomes fragile in terms of the viscosity characteristics, as the CsCl is added to the system. Gradually, it becomes much less fragile when the CsCl introduced increases to 20 mol% and becomes the least fragile at 25 mol%. Structurally, this indicates the formation of non-bridging structural units, -S-Ga-Cl, that disconnect the original network and, therefore, the melt becomes fragile. When increasing the CsCl content to about 20 mol%, the chlorine starts to form bridging structural units, -S-Ga-Cl-Ga-S-, which enhance the connectivity of the glass forming network. Thus, the melt becomes less fragile.

This structural behaviour as the CsCl is introduced, clearly explains all the physical properties measured. This is particularly true in terms of the thermal stability of the glasses we investigated. As a result, we have achieved some extremely stable glass compositions from this system suitable for making optical fibres. These glasses show excellent chemical and mechanical durabilities. Plus, they have low-phonon energy, good UV/Visible transmission and excellent rare-earth solubility, making them ideal materials for future generation of fibres for optical applications.