Ministry of Education, Science, Youth and Sports of Ukraine
Lviv Polytechnic National University

Proceedings

International Conference on

Oxide Materials
for Electronic Engineering – fabrication, properties and applications

OMEE-2012

September 3–7, 2012
Lviv, Ukraine

Lviv
Publishing House of Lviv Polytechnic
2012

On the Application of Chalcogenide Glasses in Temperature Sensors

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Abstract. *In this paper we report about a possibility of application of chalcogenide glasses as active media in optoelectronic temperature sensors. All investigations were performed on a sample of $Ge_{18}As_{18}Se_{64}$ chalcogenide glass as typical covalent network glass with rigid structure. Temperature dependence of optical transmission in the fundamental optical absorption edge region was studied through the glass transition interval. A monotonic increasing temperature dependence of position of the fundamental optical absorption edge at the half maximum of its intensity is observed through the whole investigated temperature range as well as quasi-linear dependence upon the temperature in the region below glass transition*

Key words: chalcogenide glass, temperature sensor, optical spectroscopy.

I. Introduction

Nowadays, covalent-bonded network glasses have found their wide applications in modern optoelectronics, photonics, telecommunications, acoustooptics, xerography, lithography and sensors [1]. The main feature of such glasses is presence of the elements from the VIA group of Periodic Table (oxygen or chalcogen – sulfur, selenium, tellurium). In particular, chalcogenide glasses (ChG) acquire numerous potential applications in civil, medical and military areas, including chemical sensing, laser power delivery, imaging, scanning near field microscopy/spectroscopy, fiber IR sources, lasers, optical amplifiers, switches, etc [2].

In this paper we report about the possibility of application of ChG as active media in temperature sensors. All investigations were performed on the sample of the $Ge_{18}As_{18}Se_{64}$ ChG as typical covalent network glass with rigid structure [3]. As rigid glass, $Ge_{18}As_{18}Se_{64}$ ChG should be resistant to the physical ageing processes [4] that is one of the main conditions for sensing application.

II. Experimental

Samples were prepared by conventional melt-quench method from a mixture of the high-purity elemental germanium, elemental selenium and As_2Se_3 glass in evacuated to the 10^{-6} Torr quartz ampoule. The sealed ampoule containing 10 g of the raw ingredients was gradually heated (2 °C/min) up to 950 °C in a rocking furnace. It was rocked during 48 h at this temperature in order to make the melt homogenous. The melt was quenched by switching off the furnace that cooled down to ambient temperature in about 14 hours.

Temperature dependence of optical transmission for $Ge_{18}As_{18}Se_{64}$ ChG in the fundamental optical absorption edge region was recorded with AvaSpec-2048 spectrometer (*Avantes*, Netherlands). The air-flow heating of samples was provided in specially constructed temperature chamber with temperature control accuracy of 0.5 °C. The temperature was changes by 10 °C per 2 min period.

III. Results and Discussion

The temperature behavior of the optical transmission for $Ge_{18}As_{18}Se_{64}$ ChG in its fundamental optical absorption edge region was investigated in the range from the room temperature up to the end of glass transition region. Experimentally obtained optical transmission spectra of $Ge_{18}As_{18}Se_{64}$ ChG are shown on the Fig. 1. Position of the fundamental optical absorption edge strongly depends on the temperature: the higher the temperature, the larger is the long-wave shift of transmission spectrum.

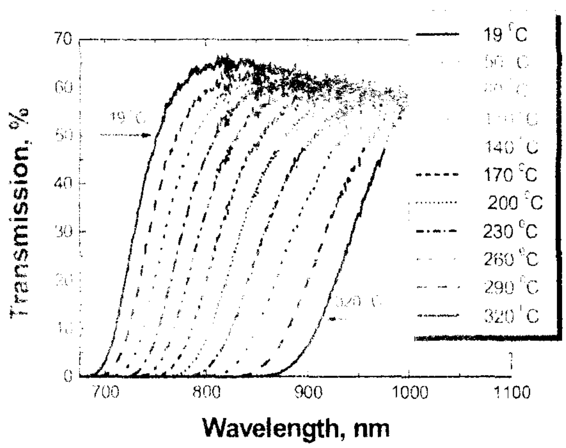

Fig. 1. Optical transmission spectra of $Ge_{18}As_{18}Se_{64}$ ChG for different temperatures

The position of the fundamental optical absorption edge at the half maximum of its intensity is chosen as a numerical characteristic of the value of temperature-induced optical changes in ChG. Its temperature dependence is shown on the Fig. 2. This parameter exhibits quasi-linear dependence upon the temperature in the region below glass transition. Such behavior fully corresponds to the known data on the quasi-linear temperature behavior of the optical gap of ChG [5,6]. Temperature dependence deviates from the quasi-linear behavior in the glass transition region. The same effects were occurred in the case of the temperature dependence of

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mechanical properties of $Ge_{22}As_{20}Se_{58}$ ChG in [7]. According to these experimental results the $Ge_{18}As_{18}Se_{64}$ ChG is expected to demonstrate a good stability and linearity of optical properties up to temperatures of 180-200 °C. In addition to the low costs of ChG it gives a promising possibility of effective usage of these ChG as active media for temperature sensing.

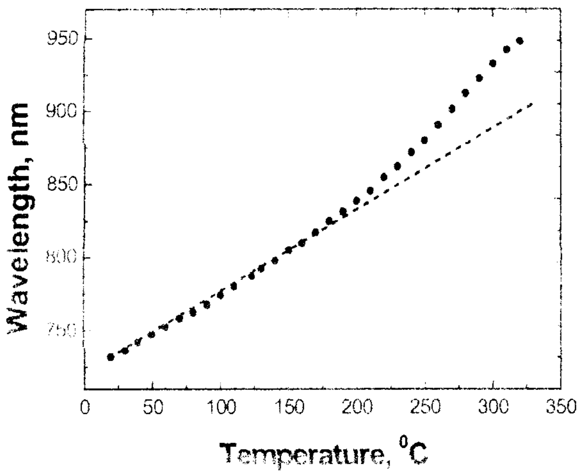

Fig. 2. Temperature dependence of position of the fundamental optical absorption edge at the half maximum of its intensity (points). Dash line corresponding to the linear range is drawn as guide for eyes.

IV. Conclusions

The possibility of application of ChG as active media in temperature sensors was demonstrated. Temperature dependence of position of the fundamental optical absorption edge at the half maximum of its intensity of the $Ge_{18}As_{18}Se_{64}$ ChG sample demonstrates the quasi-linear behavior in the region below glass transition. Some deviations from the linearity are observed in the glass transition region. All these results suggest on the possibility of application of ChG as active media in temperature sensing.

Acknowledgment

This work was done within Research Grant of the Lviv Polytechnic National University for Young Scientists GLP-12/2.

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