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Laser-induced changes on optical band gap of amorphous and crystallized thin films of $Se_{75}S_{25-x}AG_x$

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ABSTRACT

Optical band gap of amorphous, crystallized, laser induced amorphous and laser induced crystallized films of $Se_{75}S_{25-x}Ag_x$ ($x=4$, 6 and 8) glassy alloys was studied from absorption spectra. The amorphous and crystallized films were induced by pulse laser for 10 min. After laser irradiation on amorphous and crystalline films, optical band gap was measured. It has been found that the mechanism of the optical absorption follows the rule of indirect transition. The amorphous thin films show an increase in the optical band gap, while the crystallized (thermally annealed) thin films show a decrease in the optical band gap by inducing laser irradiation. Crystallization and amorphization of chalcogenide films were accompanied with the change in the optical band gap. The change in optical energy gap could be determined by identification of the transformed phase. These results are interpreted in terms of concentration of localized states due to shift in Fermi level.

1. Introduction

Chalcogenide glasses are one of the most widely known families of amorphous materials. Thin films of chalcogenide glasses have been extensively studied because of their interesting fundamental properties and their potential applications in optical imaging, optical recording, integrated optics, microelectronics, optical communications and nanotechnology [1–6]. Several photo-induced and laser-induced phenomena are observed in amorphous chalcogenide thin films. These changes are accompanied with the change in the optical constants, i.e., change in the optical band gap, refractive index and optical absorption coefficient. Annealing and laser irradiation can affect the photo-induced changes, in particular irreversible effects occur in amorphous thin films, while reversible effects occur in crystallized thin films. Laser irradiation to chalcogenide glasses has been regarded as a process for spatially selected structural modification and/or crystallization in glasses. Laser induced changes in amorphous chalcogenide are an object of systematic investigation with a view to better understanding the mechanism of the phenomena taking place in them as well as their practical applications. In the production of flat panel displays, laser crystallization increases the carrier mobility in thin film transistors. Suitable laser intensity profiles in combination with multi-pulse scanning sequence have been used to reduce the number of grain boundaries. Development of information technology demands new optical recording materials and, therefore, good knowledge of their linear optical properties is of great interest. The determination of the optical band gap during the phase transformation is of great importance for understanding the mechanism of the optical processing and for their application in practice. A lot of research work [7–11] is going on for the effect of laser irradiation, annealing, ultraviolet irradiation, γ-irradiation, etc. on optical and electrical properties of amorphous thin films. Takahashi et al. [12] have studied increase in the fluorescence intensity of ZnO nanoparticle by laser irradiation. Huajun et al. [13] have studied the structural change of laser-irradiated $Ge_2Sb_2Te_5$ films studied by electrical property measurement. The work on femtosecond laser-induced microfeatures in glasses and their applications by Qiu et al. [14], writing of crystal line patterns in glass by laser irradiation by Honma et al. [15] are also worth mentioning.

The aim of the present research work is to study the effect of laser irradiation on optical band gap of amorphous and crystallized thin films of $Se_{75}S_{25-x}Ag_x$ ($x=2$, 4 and 6) chalcogenide. Selenium has been selected because of its wide commercial applications. Its device applications like switching, memory and xerography, etc. made it attractive. It also exhibits a unique property of reversible transformation. This property is very useful in optical memory devices. Here we have chosen sulfur as an additive material with selenium. In the present research work, we have incorporated silver in the Se–S system. The addition of third element will create compositional and configurational disorder in

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