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Effects of annealing temperatures on optical and electrical properties of vacuum evaporated $Ga_{15}Se_{77}In_8$ chalcogenide thin films

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ABSTRACT

The optical constants (absorption coefficient, optical band gap, refractive index, extinction coefficient, real and imaginary parts of dielectric constants) of amorphous and thermally annealed thin films of $Ga_{15}Se_{77}In_8$ chalcogenide glasses with thickness 4000 Å have been investigated from absorption and reflection spectra as a function of photon energy in the wave length region 400–800 nm. Thin films of $Ga_{15}Se_{77}In_8$ chalcogenide glasses were thermally annealed for 2 h at three different annealing temperatures 333 K, 348 K and 363 K, which are in between the glass transition and crystallization temperature of $Ga_{15}Se_{77}In_8$ glasses. Analysis of the optical absorption data shows that the rule of non-direct transitions predominates. It was found that the optical band gap decreases with increasing annealing temperature. It has been observed that the value of absorption coefficient and extinction coefficient increases while the values of refractive index decrease with increasing annealing temperature. The decrease in optical band gap is explained on the basis of the change in nature of films, from amorphous to crystalline state. The dc conductivity of amorphous and thermally annealed thin films of $Ga_{15}Se_{77}In_8$ chalcogenide glasses is also reported for the temperature range 298–393 K. It has been observed that the conduction is due to thermally assisted tunneling of the carriers in the localized states near the band edges. The dc conductivity was observed to increase with the corresponding decrease in activation energy on increasing annealing temperature in the present system. These results were analyzed in terms of the Davis–Mott model.

1. Introduction

Few decades have elapsed since the discovery of chalcogenide glasses in the 1960's. What attracted researchers to the above materials is the ability to control and change their properties even after fabrication, just by exposing them to external, non-mechanical effects, as γ-rays, X-rays, light, laser beam, and heat. Some of the induced effects are reversible (amorphous to crystalline and back). A phenomena which was utilized successfully and commercially in building, optical memories and optical data storage [1] writable CD's, with great capacity of data storage 5 GB/disk [2]. The other interesting property of chalcogenide glasses is the great transparency for IR radiation, which is obviously utilized in IR lenses, and building short fibers. Long fibers, more than few meters, proved to be fragile in comparison to the SiO_2 standard fibers [3]. Some groups of chalcogenide glasses, which contain silver, are very sensitive for ions, so good ionic-sensors could be fabricated.

Thermal processes are known to be important in inducing crystallization in semiconducting chalcogenide glasses. The optical storage based on the amorphous-crystalline phase transition utilizes the large optical reflectivity and optical absorption changes obtained in some semiconductors-semimetal thin films by heat treatment or other radiation [4]. Due to the technological importance, the influence of heat treatment, gamma irradiation, laser-irradiation, light-induced changes, ultraviolet irradiation etc. on optical properties and electrical properties of chalcogenide thin films have been subjected to a lot of investigations [5–11]. So many authors have studied [12–16] the effect of annealing temperature, γ-irradiation, photoinduced crystallization, influence of ultraviolet irradiation, laser irradiation etc on optical properties of chalcogenide thin films. Salunkhe et al [17] have studied the annealing effects on structural, electrical and optical studies of silver deposited cadmium oxide thin films, Alnajjar [18] has shown the role of thermal treatment on the optical properties of Ge–Se system, Shamshad et al [19–22] have investigated the effects of annealing on crystallization process in amorphous Ge–Se–Te thin films, laser induced a morphization and crystallization in a Se–Te–Pb thin films, influence of laser irradiation on the optical constants

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