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Laser Irradiation Effect & Photoconductivity in Amorphous Semiconductor

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About this Monograph
This monograph is the part of a thesis of the author approved by the Department of Physics, Faculty of Natural Sciences, Jamia Millia Islamia, New Delhi, India as a partial fulfilment for Ph.D. Degree in Physics in 2012. The original thesis title was " Design and Fabrication of Photon Drag – Detectors and TEA CO_2 Laser as their Evaluation, and Study the Effect of the Laser Irradiation on Amorphous Semiconductor" written under the guidance of following supervisors-

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Dedicated

to

My Parents

Contents

Preface

Laser irradiation effect on optical properties of Se-Te based chalcogenide thin films with different metallic additives has been studied using TEA N_2 laser as an irradiation source. Melt-quenching technique has been adopted to prepare all compositions of the investigated glassy systems. The as-quenched glassy alloys have been grounded and the resulting fine powder has been used to prepare the thin films by PVD method on pre-cleaned glass substrate. The optical absorbance (*A)* and transmittance (*T)* measurement have been done using Camspec (model M550) UV/VIS/NIR double beam. Laser irradiation has been carried out using pulsed transverse electrical excitation at atmospheric pressure (TEA) nitrogen laser (wavelength 337.1 nm, peak power 100 kW, and pulse width 1 ns) with peak average energy density of ~3.5 x 10^5 W/cm^2 for different time. Effect of Al and Hg metallic additives on photoconductivity of Se-Te based glassy alloy has also been studied. Thin films of Se-Te-Al and Se-Te-Hg alloy have been used for photoconductivity study. Observed photoconductivity effect and laser irradiation effect on optical properties, thermal properties have been reported in this monograph.

Effect of laser irradiation on optical properties of a-$Se_{100-x}Te_x$ thin films shows that Tail energy width (E_U) increases with increasing irradiation time as well as Te content reveals that the laser irradiation produces disorder in material, causing an increase in the number of localized states in the band gap. As a result, optical band gap (E_g) decreases with increasing irradiation time as well as Te content. Laser irradiation effect on the optical properties of amorphous $Se_{88}Te_{12-X}$ Al_x & Se_{96-X} Te_4 Hg_x thin films also shows optical band gap (E_g) decreases with increasing irradiation time. Furthermore, optical energy gap decreases rapidly with increasing in Hg%. However, addition of Al content does not affect that rapidly. In addition, laser irradiation shows strong effect at higher Hg concentration (12%) however at higher Al concentration only slight change in optical band gap is observed. It concludes that alloy with rich Hg content is more sensitive to laser irradiation and alloys with rich Aluminum content is less sensitive. Laser irradiation on the optical properties of amorphous $Se_{96-x}Te_4Ga_x$ thin films also show that Optical band gap (E_g) decreasing after laser irradiation, however the optical band gap (E_g) increases by increasing Ga content in $Se_{96-x}Te_4Ga_x$ system. Increase in Optical band gap with Ga content make it behave differently than effect of other metallic impurities, as increase in Te, Al and Hg concentration leads to a decrease in optical band.

Laser irradiation effect on thermal properties of Se-Te glassy alloy shows that onset crystallization temperature (T_c) increases with increasing laser irradiation time however, there is no significant change in the glass transition temperature (Tg). The extent of super cooled liquid region (ΔT) decreases with increasing of laser irradiation time. Degree of crystallization is increases with increasing irradiation time. The enthalpy of crystallization which is closely associated with the metastability of glasses, first decreases after laser irradiation and then

slightly increases with increasing of irradiation time. The decrease of ΔT with irradiation time leads to the conclusion that glassy $Se_{96}Te_4$ alloy is unstable against laser irradiation.

Photo-induced Effect on $Se_{88}Te_{12-X}$ Al_x thin films shows that dark conductivity and photo conductivity increased with Al%. I-V graph confirm that increase in conductivity is due to increase in metallic additive Al. It indicates increment of density of the defect states due to addition of Al content. Dark and photo activation energies decreases with increasing Al content. The value of γ found from 0.62 to 0.66 which confirms presence of localized or traps states in the gap of the material. Decrease in photosensitivity and increase in PPC with increasing in Al content also shows structural defect production due to addition of Al content. Analysis of transient photoconductivity shows that τ_d increases with increasing Al content. Slope of decay curve shows that the traps exist at all the energies in the band gap and hence delay the recombination rate. Carrier lifetime (τ_c) also found to be increasing with Al content. Photoinduced Effect on Se_{96-X} Te_4Hg_x Thin Films shows that photoconduction is an activated process and activation energy (ΔE_{ph}) decreases with increasing Hg content. The intensity dependence of photocurrent follows power law and value of γ is found to be approx 0.5 for all samples. It confirms that recombination process takes place in present glassy system is bimolecular. $I_{ph} > I_{dc}$ in all samples at room temperature and intensity dependence of photocurrent for all compositions are exponential and consists of two parts. Photosensitivity (σ_{ph}/σ_{dc}) decreases with increasing Hg content. However effective decay time constant (τ_{eff}) increases with Hg content. It confirms an increment in density of localized states in the energy gap with increasing Hg content. Photosensitivity of alloy with minimum Hg concentration is higher however in the system with Al additive photosensitivity was almost half of alloy with Hg additive. Same pattern was found in the study of laser irradiation effect on optical properties however in case of laser irradiation effect, alloy with higher concentration of Hg is more sensitive to irradiation.

Dr. Adam A. Bahishti

About the Author

Dr. Adam Abdullah Bahishti had obtained his Doctorate Degree (Ph.D.) in Physics from Faculty of Natural Sciences, Jamia Millia Islamia (Central University), New Delhi, India in 2012. He is working as Assistant Professor at Physics Department, College of Science in Zulfi, Majmaah University, Kingdom of Saudi Arabia since 2014.

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