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Swift Heavy Ion Induced Opto-Effects in Ethylene-Chlorotrifluoroethylene Copolymer (E-CTFE)

Kusam Devgan
Department of Physics, S.R. Government College For Women
Amritsar, Punjab, India.

Abstract---The results due to ion induced effects in the optical properties of pristine and lithium ion irradiated ethylene-chlorotrifluoroethylene (E-CTFE) samples have been studied. Samples were irradiated in vacuum at room temperature by lithium (50 MeV) with the fluence in the range of 1 x 10^{11}–3 x 10^{12} ions cm^{-2}.
Keywords: Polymer; irradiation; thin films; crosslinking; UV-Visible.

I. INTRODUCTION

E-CTFE (ethylene-chlorotrifluoroethylene) copolymer is produced by combining CH_2-CH_2 and CClF-CF_2 co-monomer entity alternatively. Ion irradiation of polymers can induce irreversible alterations in their macroscopic properties such as electrical and optical properties [1]. Interest in ion beam treatment of polymers has increased in recent years, prompted by the ion beam induced improvements ofthe mechanical, optical and electrical properties ofvarious polymer substrates [2-4]. Chemical bond characterization and new induced properties in several polymers irradiated with different ions have been analyzed by Davenas et al. [5]. Modifications of polymers by irradiation, with ionizing radiation in particular, are an expanding field of research and application because of its technological implications. The modifications in the chemical structure and physico-chemical properties of polymers, induced by ion bombardment, are being extensively studied [6,7]. Different studies reveal that carbonaceous clusters are formed along latent tracks of energetic ions in polymers [8-10]. The formation of these carbonaceous clusters can be studied from the absorption edge of ultraviolet-visible (UV-Vis) spectra of irradiated polymers. UV-Vis spectroscopy gives an idea about the value of optical band gap (Eg) with Tauc's expression [11].

II. EXPERIMENTAL SECTION

The specimens of E-CTFE, in the form of flat polished films were procured from Good Fellow Ltd. (UK) having thickness range 25μm. The films of E-CTFE were used as-received form without any further treatment in the size of 1 cm x 1 cm. The samples were mounted on the sliding ladder and irradiated with lithium (50 MeV) ion beams using 15 UD pelletron facility for the general purpose scattering chamber (GPSC) under vacuum of ~10^{-6} Torr at Inter-University Accelerator Center, New Delhi, India. The ion range, electronic energy loss and nuclear energy loss of characterize lithium (50MeV) ions in E-CTFE polymer is shown in table 1 [12]. The ion beam fluence was varied from 1 x 10^{11} to 3 x 10^{12} ions cm^{-2}. In order to expose the whole target area, the beam was scanned in the x-y plane. The beam current was kept low to suppress thermal decomposition and was monitored intermittently with a Faraday cup. The samples were analyzed with UV-VIS spectroscopy using Lambda 35 Perkin Elmer UV-Vis spectrophotometer in the range 200-800 nm to observe the variation in optical properties of the polymer. Doses for the given fluence and different studied ion types were calculated using the formula [13] as given below.

$$\text{Dose} = 1.602 \times 10^{-10} \times \frac{1}{\rho} \times \frac{dE}{dx} \times \phi \qquad (1)$$

ϕ : Ion fluence,

ρ: Density of polymer,

$\frac{dE}{dx}$: Stopping power of ion

TABLE 1

ELECTRONIC, NUCLEAR ENERGY LOSS AND ION RANGE OF POLYMER				
Polymer	Ion Beam	Ion range (μm)	Electronic Energy loss (eV/Å)	Nuclear Energy loss (eV/Å)
ECTFE	Lithium (50MeV)	514.51	7.75	2.993 E-03

TABLE 2

DOSES FOR GIVEN FLUENCE AND ION TYPE OF STUDIED POLYMER		
Polymer	Ion Fluence (ions/cm^2)	lithium (50 MeV) (kGy)
E-CTFE	Pristine	0.00
	1 x10^{11}	7.38
	3 x 10^{11}	22.14
	1x10^{12}	73.81
	3 x 10^{12}	221.43

III. RESULTS AND DISCUSSION

Fig. 1. depicts UV-Visible spectra of swift heavy ion irradiated E-CTFE films. It has been observed that there is shift in absorption edge from ultraviolet to visible region due to ion irradiation.

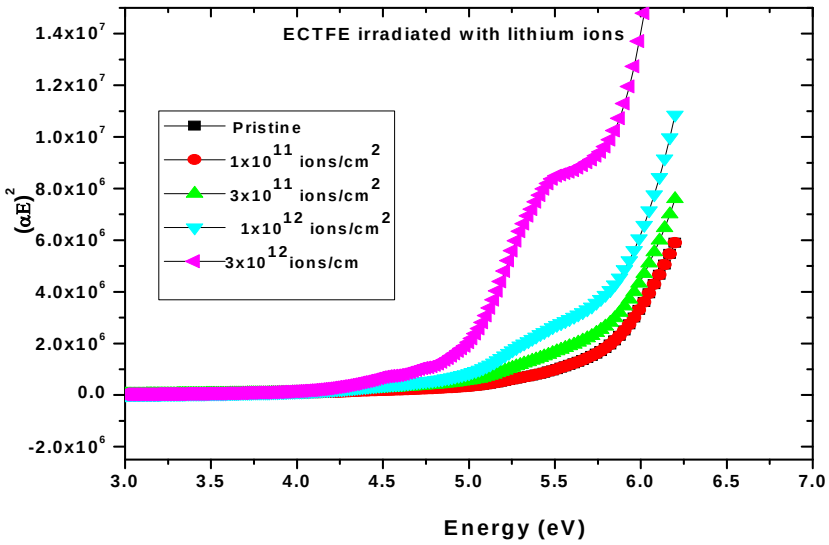

Fig 1. UV-VIS spectra of swift heavy ion irradiated E-CTFE at varying fluence.

It is also clear that there is decreasing trend of the optical band gap energy with increasing ion fluence in case of studied ion beam.

IV. CONCLUSION

Results summarized in this paper suggest that swift heavy ion irradiation of E-CTFE leads to its optical degradation.

V. ACKNOWLEDGMENT

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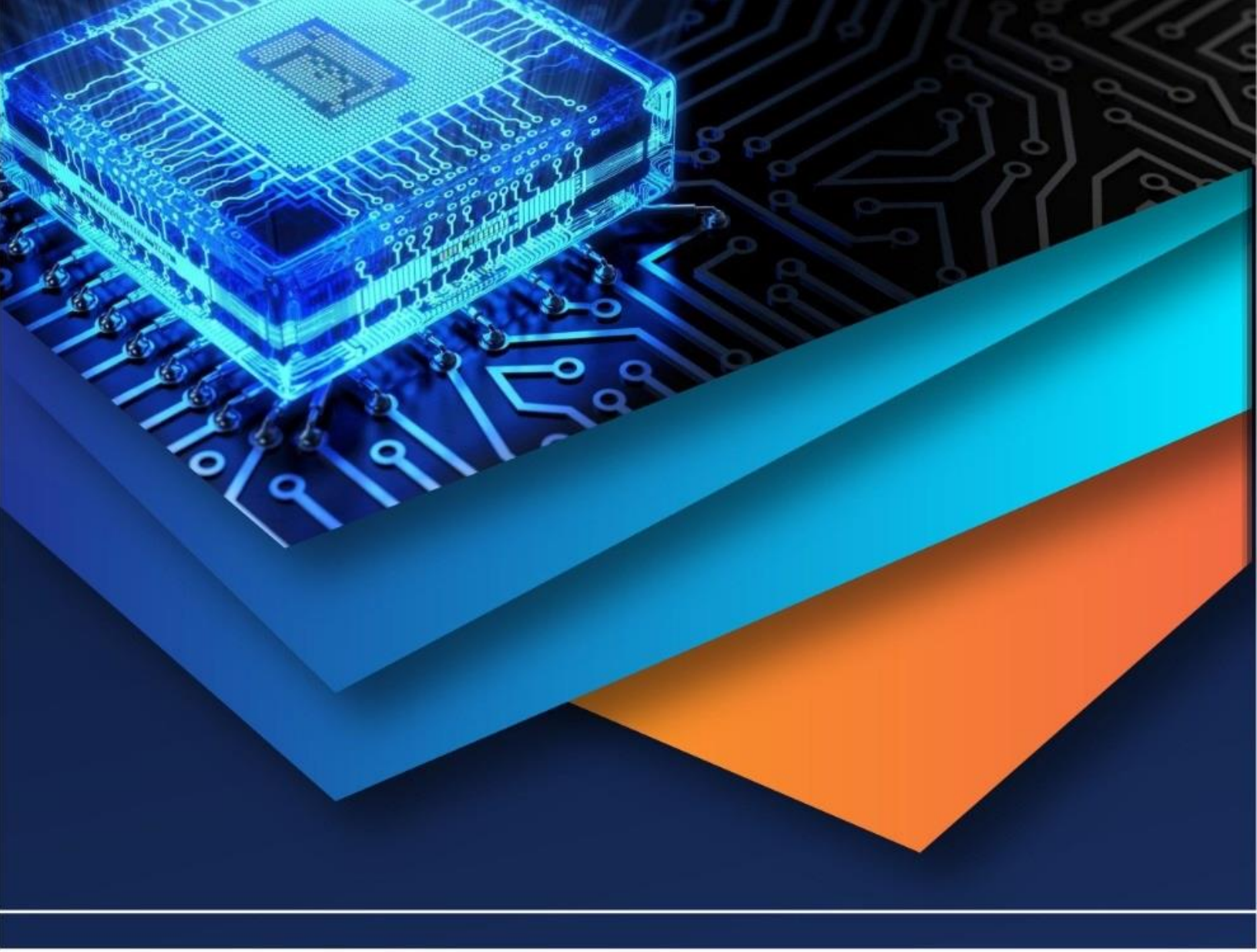

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