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Photoconductivity Study of (Al_2O_3 - ZnS) and its Mixed Composite

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Abstract- Investigation of photoconductivity with respect to the number of parameter has been made in (Al2O3- ZnS) Cu, Cl composites. The sample is prepared by firing the appropriate mixture at 8000C for 45 minute. For measurement purpose, the sandwich type of cell is used in which electrodes are in direct contact with the sample. The effect of field intensity, wavelength of illumination and temperature has been reported.

Index Terms: Intensity, Photoconductivity, Photocurrent, Temperature, Voltage, Wavelength.

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1 INTRODUCTION

In some materials the electrical conductivity increases by absorption of radiation. In case of homogeneous material, the density of holes and electrons are uniform throughout the materials. The photoconductivity study gives us the substantial information regarding the electronic transition in semiconductor [1, 2]. Photoconductivity is considered to be an important tool for providing information, regarding the nature of the photo-excitations. Since last decade the photoconductive properties of the inorganic nanoparticles have become subject of intensive study [3]. Not only because of fundamental interests in the nature of the electronic excitations but also due to their applications in wide range of optical and electronic devices. A good photoconductive device requires not only efficient charge separation but also efficient transport of charge carriers to electrode [4]. Photoconducting properties of various materials have been investigated by many markers [5, 6]. Recently the property of gallium doped ZnO deposited on glass by spray analysis [7], optical and electrical characteristics of aluminum doped ZnO thin film prepared by solgel technique [8], and application of the inorganic nano crystal in polymer-net work [9] have been studied. ZnO has been reported to display good photoconductivity and high transparency in the visible region and used as transparent electrodes for solar cells [10]. Although many authors have reported the measurement of photoconductivity in ZnO thin films [11].

The value of the number of electron and holes in insulators may be much larger than the corresponding free carrier densities in the dark. In the steady state, the rate of generation of electrons and holes must be equal to the rate of recombination and the rate of trapping must be equal to the rate of detrapping (or re-excitation). To analyze carrier transport problems involving these processes, it is important to set a quantitative criterion to separate trapping and recombination centers. Rose [1, 12] has used demarcation levels to separate them. The demarcation level for electron traps, EDn, is defined as the level at which a captured electron has an equal probability of being excited into the conduction band and of recombining with a hole from the valence band. Similarly, the demarcation level for hole traps, EDp, is defined as the level at which a captured hole has an equal probability of being excited into the valence band and of recombining with an electron from the conduction band. In semiconductor the reverse is often true and the influence of radiation may be considered as a small perturbation on a large dark carrier density. Two assumptions have been made in the discussion of photo-conductivity: first, the conductivity is dominated by one of the carriers so that the contribution of the other may be effectively neglected and second, the crystal remains neutral during the photoconductivity process without a build up of appreciable space charge in the crystal. Two-photon carrier generation processes are directly associated with the generation of two photo-excited states (i.e., excitons), which interact, resulting in a direct transition of an electron from the valence band to the conduction band or to an auto ionization state above Ec [13, 14]. There are several possible processes leading to the generation of intrinsic electron – hole pairs, such as singlet exciton–singlet exciton collision ionization and singlet exciton–triplet exiton collision ionization [15, 16, 13, 14, 17, 18, 19]. The conductivity is dominated by one of the carriers so that the contribution of the other may be effectively neglected. The crystal remains neutral during the photoconductivity process without a build up of appreciable space charge in the crystal. Several investigators have also analyzed the

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light intensity dependence of photoconductivity, based on the charge neutrality condition with the gap states assumed to be distributed in energy but not necessary exponentially [20] or based on the assumption that each localized gap state has three possible charge values; neutral, negative, or positive [21, 22]. Schellenberg and Kao [23] have generalized Rose's original expression in two ways; first, by extending the contribution of gap states to recombination from those above the midgap states to any states between electron and hole quasi–Fermi levels and second, by including the effect of the asymmetry of gap state distributions and the charge neutrality condition This analysis has shown that the odd values of the exponent m may occur in solids with gap states distributed discretely or continually [1, 2, 20-23, 24]. Investigation of photocurrent with respect to number of parameters such as light intensity, voltage, temperature, energy of illumination etc. provides us good information of the materials. The photocurrent can become saturated if the concentration of majority carriers injected from the ohmic contact is suppressed at high fields by minority carriers injected from the opposite blocking contact through a recombination process, particularly in relaxation semiconductors [25, 26, 27] or if the bulk-limited regime is changed to an electrode-limited regime at high fields [28].The temperature dependence of dark and photocurrent provides a fairly useful information about the energy depth of Fermi-level and the localized defect states at a given temperatures the band gap of ZnS crystals changes from 3.6eV at room temperature to about 3.4eV at 300°C [29, 30]. Obviously, the optical absorption edge and hence the photoconductivity peaks will shift toward longer wavelength as the temperature is increased. Zinc sulphide (ZnS) is also is an important optoelectronic device material for its use in the violet and blue regions owing to its wide band gap (~3.7eV) and having exciton binding energy of 40 meV [31].

2 EXPERIMENTAL DETAIL

For the preparation of sample, two base material Al2O3 and ZnS of high purity are taken in different proportion by weight and then ground properly, in order to get homogeneous mixture. The mixture is then fired at 8000 C for 45 minute in cylindrical furnaces in air atmosphere. The cell is constructed in the form of parallel plate capacitors by embedding the sensitive material in polystyrene binder and sandwitching it between the two conducting glass plates. All the measurements are taken with the help of parallel plate capacitor. For the measurement of photoconductivity, the cell is mounted in a chamber in complete darkness and the radiations from a 300 W Hg –lamp is allowed through a window on the cell. By changing the slit width and the distance between the lamp and hole, the intensity upon the upper surface of cell could be varied.

3 RESULT AND DISCUSSION

3.1 Effect of Voltage

The figure (1) shows the variation between photocurrent and voltage. In presence of light, the sample (Al2O3 50% - ZnS 50%) Cu (0.1%) and Cl (1%) shows nonlinear characteristics upto around 4.5 V and above this voltage, the photocurrent Ip tends to saturation. The saturation effect of Ip versus V curves at higher voltage may be explained on the basis of class II states, which are the imperfection centers lying close to valence band and having higher capture cross section for holes than for electrons [32].

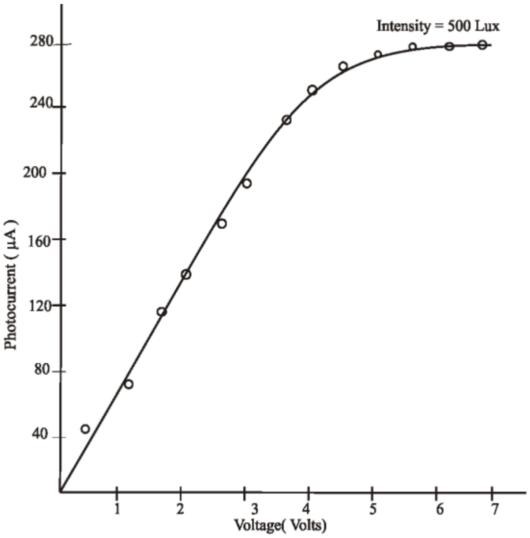

Fig. 1: Variation of Photocurrent with voltage

3.2 Effect of Temperature

The figure (2) shows the variation of photocurrent with temperature for (Al2O3 50% - ZnS 50%) Cu (0.1%) and Cl (1%) sample. By increasing the temperature, photocurrent is also increased. The graphs plotted between photocurrent and temperature is linear but at higher voltage there is change of slope. Thermal quenching of photocurrent occurring in higher temperature region can be explained on the basis of Rose Model. According to this model, the steady state Fermi levels are shifted towards their respective band edge with an increase in the intensity of illumination. During this shift of Fermi levels, a large number of traps are converted into recombination centers. Thus, life time of the electron increases and the photoconductivity is sensitized. Fermi levels are shifted towards the middle of the gap with an increase in temperature.

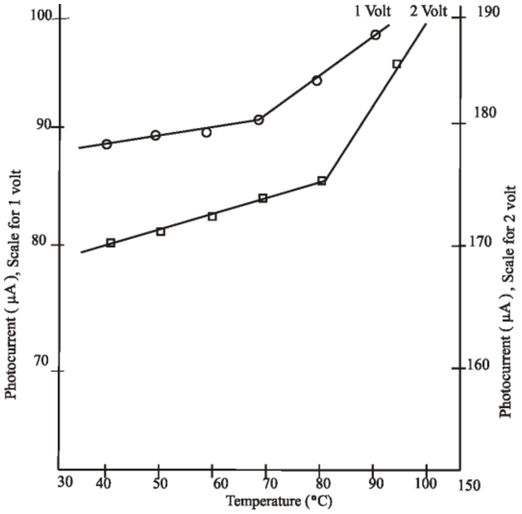

Fig. 2: Variation of Photocurrent with temperature

3.3 Effect of Intensity

The figure (3) shows the variation of photocurrent with intensity at different fixed voltage for (Al2O3 50% - ZnS 50%) Cu (0.1%) and Cl (1%) sample. The curves plotted between photocurrent and intensity is straight line having different slopes at lower and higher intensities of illumination. The variation can be represented by Ip Vs L, where S is the slope of any straight line section and L is intensity in Lux. The nature of variation, changes from super-linear to sub-linear. This can be explained by using the concept of class I and class II states. Class I consist of states, which have roughly similar cross section for electron and holes. While the class II states have a higher capture cross section for holes than for electrons and lie close to the valence band.

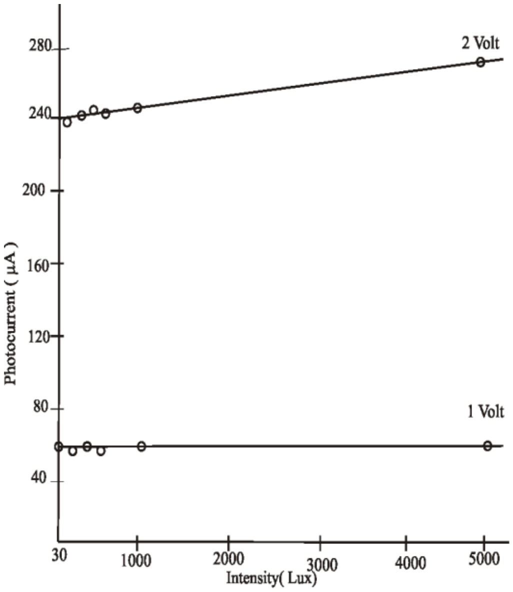

Fig. 3: Variation of Photocurrent with intensity

3.4 Effect of Wavelength

Figure (4) shows the variation of photocurrent with wavelength. The photocurrent initially decreases as the wavelength increases. It shows a dip at about 5000 Å, but start increasing as wavelength further increases, and after 5460 Å photocurrent again start decreasing. The dip in photocurrent may be due to absorption of radiation by non radiation centers.

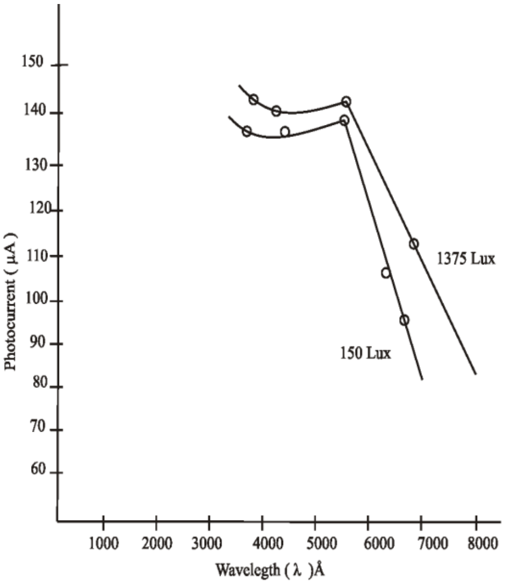

Fig.4: Variation of Photocurrent with wavelegth

4 CONCLUSION

The study of photoconductivity of (Al2O3-ZnS) Cu and Cl composites with respect to the number of parameters such as voltage, temperature, intensity and wavelength shows the variation in photocurrent. When voltage increases the photocurrent saturates, which can be explained on the basis of class II states. Similarly on increasing the temperature, photoconductivity is also increased. The life time of electron increases and the photoconductivity is sensitized. Hence the Fermi levels are shifted towards the middle of the gap with an increase in temperature. When wavelength increases, the photoconductivity initially decreases, a dip is observed at 5000 Å, but start increasing as wavelength further increases, and after 5460 Å photocurrent again start decreasing. This is due to absorption of radiation by non – radiation centers.

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