Comparative Photoelectret Studies in ZnS Mixed Material

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ABSTRACT

The photoelectret studies of (50% ZnS-50% CdS) and (50% ZnS-50% CdS : Cu) mixed material have been given in this paper. Comparative dependence of photoelectret charge on various parameters such as applied field (E), intensity of illumination (I), Photopolarization time (t_{pp}) and dark-depolarization time (t_{dd}) have been studied. The (50% ZnS-50% CdS) stores more charges in comparison to (50% ZnS-50% CdS : Cu) system.

Keywords: Photoelectret, Mixed material, ZnS, CdS, Polarization

INTRODUCTION

The investigation of photoelectret state though not new but is of considerable importance. The Electret (formed of elektr – from "electricity" and – et from " magnet") is a dielectric material that has a quasi- permanent electric charge or dipole polarization. An electret generates internal and external electric fields, and is the electrostatics equivalent of permanent magnet. Oliver Heaviside coined this term [1]. The photoelectret was discovered by the Bulgarian physicist G. Nadzakov in 1937 [2]. Nadzakov observed the photoelectret effect by exposing a photoconducting dielectric to light radiation and electric field simultaneously. Space charge accumulated during photoconduction is retained for long time even after removal of electric field and illumination. The photoelectrets [3] are generally formed with photosensitive materials which have deep traps. The studies of Photoelectret state is widely used nowadays such as Electrophotography, Xerography, Electrofax, Radiation Dosimeters, prosthetic devices, microphones etc. The photoelectret properties of both organic, inorganic materials [4],[5] and single base material [6],[7] have been studied by several researchers. Some workers also studied electret effect on monocrystalline [8], rare earth doped material [9], glasses and thin film [10]. Here an attempted has been made to study photoelectret properties on mixed materials. The mixed materials of two or three base materials possess interesting problems. Mixed materials are supposed to have an intermediate energy gap. By varying the relative proportion of two compounds [11] in mixed materials, the resultant energy gap is adjusted accordingly.

ZnS, a wide energy gap (3.7 eV) material shows photoelectret characteristics [12]. Many workers [13] studied the photoelectret properties of ZnS. CdS[14-17] with energy gap (2.43 eV) also shows photoelectret properties. The mixed lattices are supposed to have an intermediate energy gap. In this section the comparative photoelectret studies of (ZnS-CdS) and (ZnS-CdS-Cu) mixed system have been studied. The comparative dependence of photoelectret charge(Qph) on various parameters, such as applied Electric field, Intensity of illumination, time of polarization(t_{pp}) and dark depolarization(t_{dd}) has been studied.

EXPERIMENTAL

The (50% ZnS-50% CdS) sample was prepared by the heat treatment technique[18]. For this the base materials were mixed properly and filled in ceramic tube with carbon cap and then fired in cylindrical furnace. The firing temperature for optimum photopolarization

has been found to be 700°C for 30 minutes. The (50% ZnS-50% CdS – 1% Cu) mixed systems were prepared by mixing the 1% Cu in the mixture of (50% ZnS-50% CdS), then firing in a cylindrical furnace at 700°C for 30 minutes.

The electret cells were fabricated in the form of parallel plate capacitors as described earlier[19]. The area of the cell was ~ 1.4cm^2 with layer thickness ~ 0.05cm. To measure the photoeletret charge the cell was kept in a dark wooden chamber with slit, where from the light is allowed to fall over the with the help of 300 W mercury lamp. . For the measurements of photelectret charge (Qph) , the cell was first illuminated in presence of stabilized dc field (from 5 kV/cm to 50 kV /cm) this gave photopolarization of the sample. The detailed measurement technique describe in paper[19-20].

RESULTS AND DISCUSSIONS

The (50% ZnS-50% CdS) mixed systems fired at 700°C for 30 minute stores more charges in comparison to (50% ZnS-50% CdS – 1% Cu) sample fired under similar conditions. The comparative study of Q_{ph} on various parameters i.e. voltage (or Applied Electric Field), intensity of illumination, time of polarization(t_{pp}) and dark depolarization(t_{dd}) have been made. The results are as following:

(i)   **Effect of Electric Filed**

The variation of Q_{ph} with voltage has been shown in Fig. 1 . The Q_{ph} increases slowly with voltage for (50% ZnS -50% CdS - Cu) sample. For (50% ZnS-50% CdS) sample the rapid increase in Q_{ph} with field has been observed. The experimental conditions are same for both the samples. In a photosensitive dielectric, illumination causes generation of charge carriers to be available for trapping polarizing field drifts these charge carriers through the dielectric giving rise to an accumulation of trapped carriers towards the surface of the photoconductor. When the field is increased, the spatial shift of the carriers increases which in turn decreases the recombination probability. This explains why Qph increases with polarizing field.
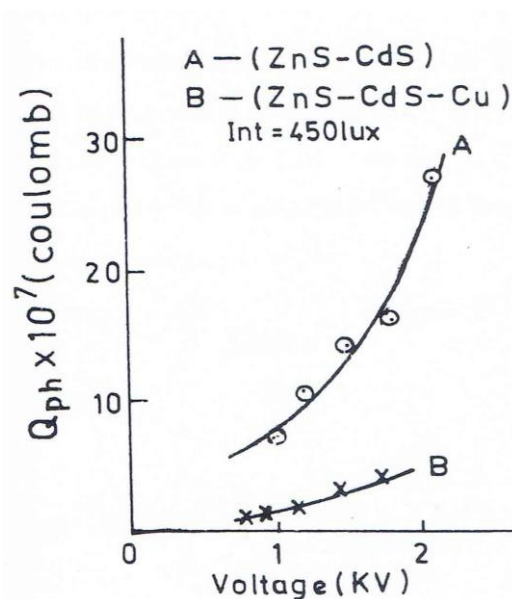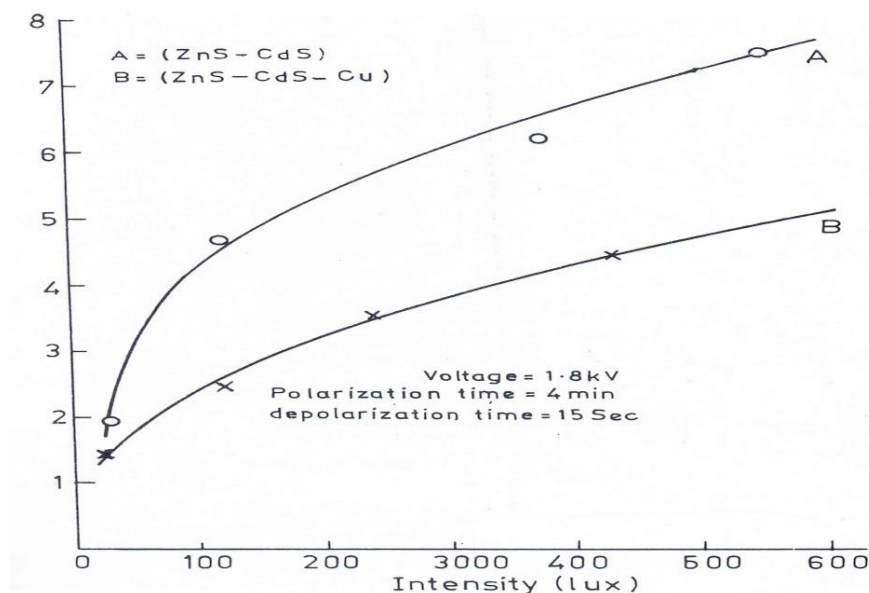

Fig. 1: Variation of Q_{ph} as a function of voltage (t_{pp}=4 min, t_{dd}=15 sec)

Fig. 2: Variation of photoelectret charge as a function of intensity of Illumination (Temp=30°C)

(ii)   Effect of Intensity of Illumination

The variation of photoelectret charge with changing intensity of illumination has been shown has been shown in Fig. 2. The photoelectret charge is larger for (50% ZnS-50% CdS) sample. The Q_{ph} increases with increasing intensity for both the samples. As the intensity increases, more and more charge carriers are generated, thereby, increasing the density of free carriers available for trapping which are subsequently released during photo depolarization. The saturation in photoelectret charge cannot be due to space charge accumulation. It is due to dynamical equilibrium established between the trapping levels and the respective bands under the influence of light modified Fermi levels. At saturation only a small fraction of total number of trap levels are filled with the electrons [21].

(iii)   Effect of Polarization Time(tpp)

Figure .3 shows the variation of Q_{ph} with polarization time(tpp). With increase in polarization time i.e. time for which the field and light are kept on together, initially Q_{ph} increaes rapidly but later saturates. At saturation the Q_{ph} is larger for (50% ZnS-50% CdS) sample than for (50% ZnS-50% CdS – 1% Cu) sample. For both samples photoelectret charge(Qph) increases in the beginning and then tends to saturate. As the charging time(t_{pp}) increases, more and more charge carriers are generated due to which density of free carriers for trapping also increases. These carriers are subsequently released during photo-depolarization. At saturation, equilibrium is established between the rate of generation of carriers and the rate of trapping plus recombination. According to Kallmann and Rosenberg[20], the dependence of polarization (P) of photoelectret charge on the duration of polarization, t, obeys the following empirical law:

$P = P_{max} (1 - e^{-t/\tau})$

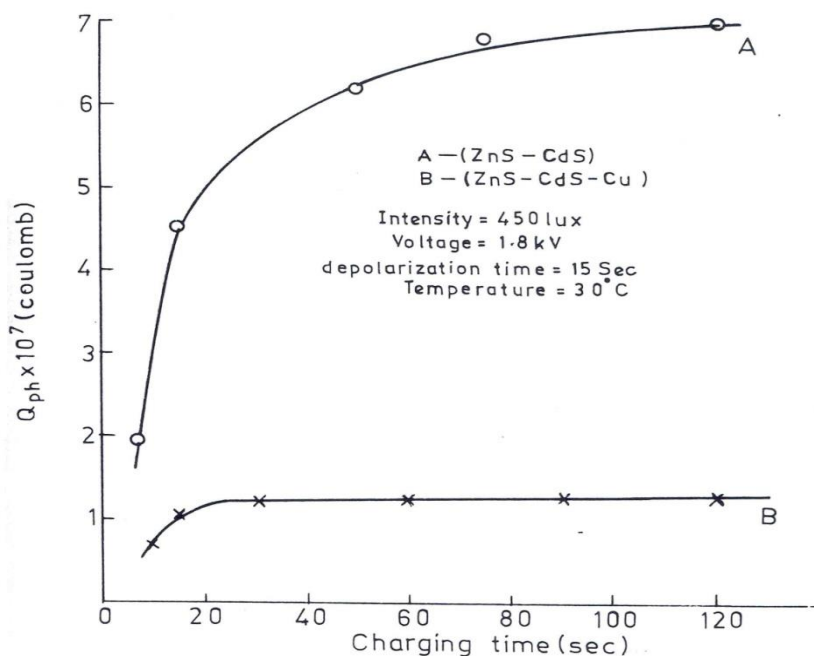Where τ is the response time. This has also been reported by Kallmann et al.

Fig.3: Variation of photoelectret charge with charging time (t_{pp})

(iv)   Effect of Time of Dark-depolarization(t_{dd})

It is observed that with increase in the time of dark depolarization, the photoelectret charge decreases (Fig. 4). The decrease in charge is fast in the beginning then tends to saturation. It is clear from the figure that Q_{ph} is larger for (50% ZnS-50% CdS) sample than (50% ZnS-50% CdS - Cu) sample. Dark depolarization of photoelectret charge arises due to charge carriers which belong to shallow trap levels[20]. These charge carriers are released thermally at room temperature and recombine under the action of internal field in dark. With increased dark depolarization time, the charge carriers trapped at shallow levels have more chance to get released thermally. Charges trapped in deep levels only remained to be depolarized by illumination.
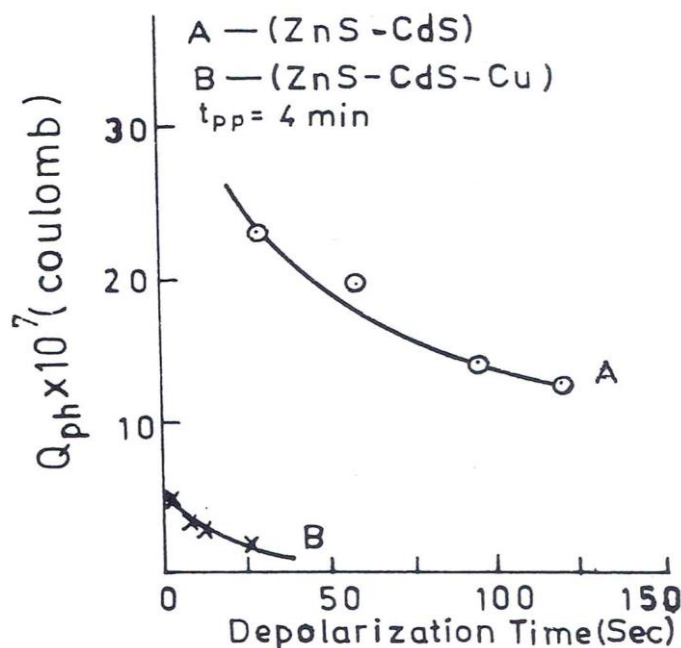

Fig. 4: Variation of Q_{ph} as a function of depolarization time. (V=1.8KV, Int.=450 lux)

CONCLUSIONS

The photoelectret charge is decreased by mixing the Cu. The sudden increase in Q_{ph} with voltage and charging time has been found for (50% ZnS-50% CdS) sample. The research on mechanism of electret formation in mixed materials is going on and in future it will play major role. There are large applications of electret technology in energy and health sensors.

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