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Study of Photo Dielectric Effect in Mixed Lattice of (Al_2O_3-ZnS) Cu, Cl

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Abstract- An attempt has been made to study the photo dielectric effect in mixed lattice of (Al_2O_3-ZnS) Cu, Cl with different proportion .The mixed lattice of (Al_2O_3-ZnS) Cu, Cl were prepared by heat treatment technique taking firing temperature 820^0C at 45 minute. Polystyrene was used as binder for sandwitching sensitive material in form of parallel plate capacitor .The measurement were carried out in frequency range (100 Hz -50 Hz) with illumination of intensity up to 5000 lux and for temperature range between 40^0C to 90^0C. The capacitance (C), conductance (G) and loss factor (tanδ) were measured under various parameters, such as field intensity, intensity of illumination and temperature of sample.

***Index Terms* -** Photo dielectric effect (PDE), Capacitance, Conductance, Loss factor, Field frequency, Illumination

I. INTRODUCTION

When certain photo conducting material are placed as a dielectric in sandwitched type cell in presence of alternating field ,the radiation absorbed by the photoconductor increases the capacitance and dielectric loss .This phenomenon is known as photo dielectric effect(PDE). The photo dielectric studies have been made in several material like zinc sulphide (ZnS), zinc oxide (ZnO)[1] or CdS powder and also in single crystal[2]. Photo dielectric investigation have been made on other compound i.e. GaAs[3], Ge[4], ZnS[4] activated with Cu , tetra-amino-diphenyl (TADP)[5] etc. In the recent years photo dielectric effect in TiO_2[6] and SnS[7] have been reported [3] .The photo dielectric effect is reduced in presence of impurities which poison the luminescence of ZnS phosphors[8,19] . With the advancement in materials research, miniature electret microphones integrated on silicon chips as microelectro-mechanical systems (MEMS) have been produced. Products employing electrets have been put into practical use in almost all walks of life. Use of electrets has been suggested for biomedical applications such as replacement of heart valve, bone implants and artificial muscles in robotic paradigm. Such developments have thrown new challenges in materials science research [9, 19]. The photo dielectric effect is explained by means of three principal hypotheses.

1) It is the result of real change in the dielectric constant of the material which is caused due to presence of various highly polarizable centers in the photo excited material. Such centers may have the loosely bound material.
2) The another way for measuring the normal photoconductivity of the material .Because of the heterogeneity of the material, the presence of photoconductivity in certain portion of the cell effectively decreases the distance between the plates of the capacitor and hence increases the capacitance and the apparent dielectric constant.
3) It is the result of the change in the dielectric constant of the material which is caused due to the existence of space charge possibly being held in trapping centers. But this hypothesizes is applicable only in the photo dielectric effect of polycrystalline specimen.

Photo dielectric effect is essentially another manifestation of photoconductivity. This was investigated by the Kallman[11,12] result of measurement on CdS, has shown that the decay of the photo induced capacity is change rapidly, even though the presence of deep trap can be demonstrated through measurement of the rise of photoconductivity. Garlick & Gibson propounded the hypotheses that the photoelectric effect is associated with trapped electrons. In electrets made from polar materials the disorientation of dipoles plays a prominent role. This disorientation tends to destroy the persistent dipole polarization by redistribution of all the dipoles at random. The disorientation of dipoles involves the rotation of coupled pair of positive or negative charges and requires certain activation energy per dipole [12]. Many other investigation have been carried out by Kronenberg and Accardo[13] on different material. Their measurement indicated that some material showed photo dielectric effect, which might well be associated simply with photoconductivity. The decay of capacitance is being independent of temperature. Dropkin [14] investigated the importance of dipole layer at grain boundaries in the powder.
The photo dielectric effect is controlled by the intensity of illumination field frequency and temperature [15, 16]. The capacitance increases with increasing intensity of illumination. The space charge is observed only in the lower frequency region. The variation of the ac conductance with frequency may be due to the variation in the formation of space charge. The photo capacitance and dark capacitance decreases with temperature in lower temperature side. But at higher side dark capacitance increases while photo capacitance decreases.

II. EXPERIMENTAL DETAIL

For the preparation of the mixed systems ,high purity Al_2O_3 and ZnS were taken in different proportions by weight and ground properly in order to get homogeneous mixture .The Cu (0.01 %) and Cl (1%) added in form of $CuSO_4$ and NH_4Cl .The mixture was then heated in a ceramic tube in a closed cylindrical furnace at 820^0C for 45 min. For the measurement purpose, the cell were fabricated in the form of parallel plate capacitors by embedding the sensitive material in polystyrene binder and sandwitching it between the two conducting glass plate .Measurement were made on four electrode cell system with area of 2 cm^2 and thickness of (0 – 0.05 cm).Two additional conducting glass plates were fixed on the two end faces of the capacitor .This makes the cell a four electrode system. The capacitance and conductance were measured through an ac bridge LCR –Q meter if operated at 100 Hz to 1 KHz ac with dc field. The external field was obtained through an oscillator .The cell was placed in complete dark chamber. The radiation from Hg-lamp (300 W) were allowed through a window over transparent surface of the cell. Intensity of illumination can be changed by changing the slit width.

III. RESULT & DISCUSSION

The general measurement have been made under various parameter such as field frequency, intensity of illumination, temperature with (10% Al_2O_3 – 90 % ZnS) Cu 0.1%, Cl 1% sample.

A. EFFECT OF FIELD FREQUENCY

Under fixed illumination of 5000 lux and 2 volt a.c field of variable frequency ,the variation of capacitance (C) and conductance (G) have been shown in fig.(1). The capacitance and conductance of layer decrease with increasing frequency both in dark and under illumination. The decrease is faster for low frequency region .In the frequency region, the variation of capacitance is due to space charge or interfacial polarization [15]. At the higher frequency it is not possible for the space formation to be in step with the variation of the applied field. Space charge is an electrical homogeneity appearing in material [17**]**, which causes dielectric losses. At higher frequency it is not possible for the formation of space charge, but at low frequency such a thing is possible [8].

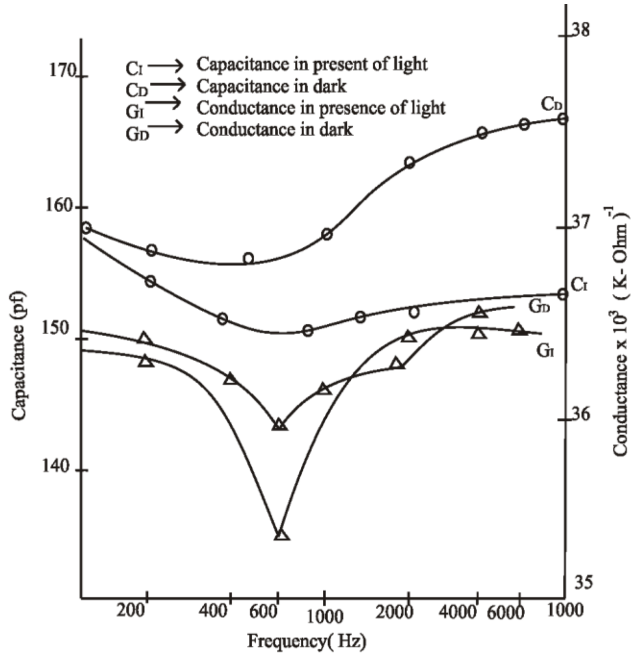

Figure 1. Variation of CD, CI, GD, GI with frequency

VARIATION OF LOSS FACTOR

The variation of loss factor (tanδ) with a.c frequency shown in fig.(2).The tanδ decreases with increasing frequency .The behavior is same both in dark and under illumination .As frequency is increased, less and less space charge is formed. There by decreasing the dielectric losses.

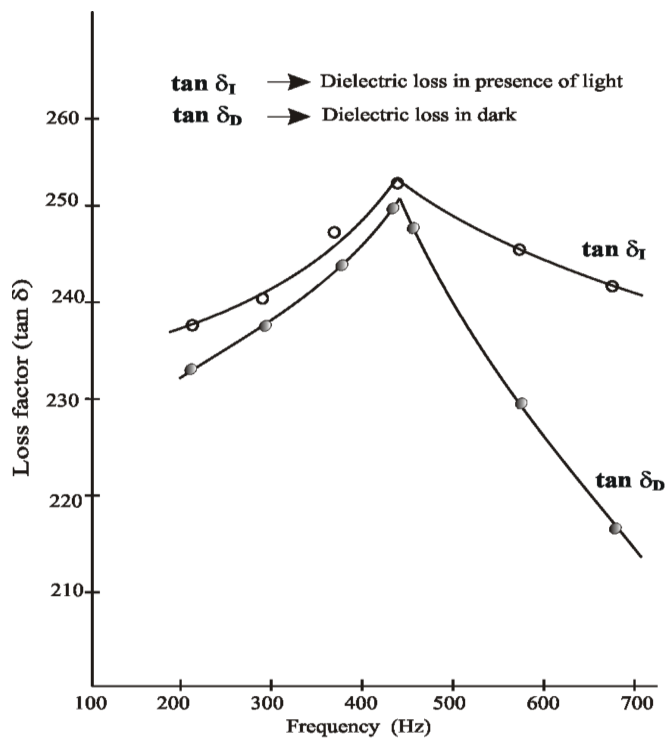

Figure 2. Variation of $\tan \delta_I$, $\tan \delta_D$ with intensity

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B. EFFECT OF INTENSITY

The variation of capacitance (C) and conductance (G) with illumination has shown in fig. (3). Capacitance (C) and conductance (G) for low intensity first increase rapidly and then tend to saturate [16]. More and more charge carriers are generated with increasing intensity of illumination. The dc conductivity increases with intensity, hence total conductance increases with intensity of illumination.

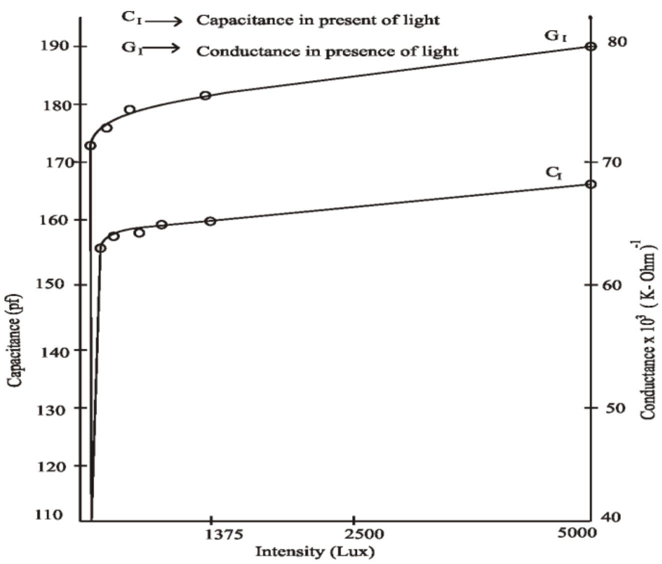

Figure 3. Variation of C_I & G_I with intensity

VARIATION OF LOSS FACTOR

The variation of loss factor shown in fig (4) .The loss factor tanδ initially decreases with increases in intensity and then saturates. This may be explained by the formula tan $\delta = G / \omega C$), G increases less rapidly as C increases with intensity.

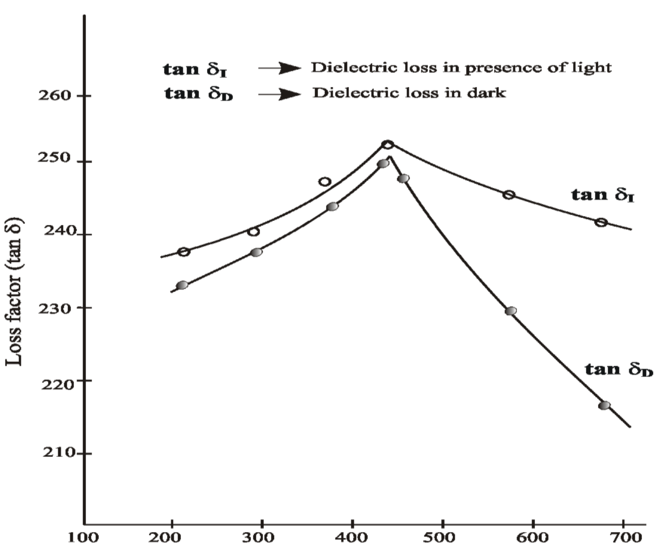

Figure 2. Variation of $\tan\delta_I$, $\tan\delta_D$ with intensity

C. EFFECT OF TEMPERATURE

The variation of capacitance with temperature has shown in fig.(5). The capacitance and conductance decreases with temperature upto 50^0C beyond this they show increasing trend .The decrease in capacitance and conductance with increasing temperature is indicative of dependence of capacitance on same filled traps [2]. More and more de-trapping takes place with increasing temperature .Thus a fall in capacitance is observed.

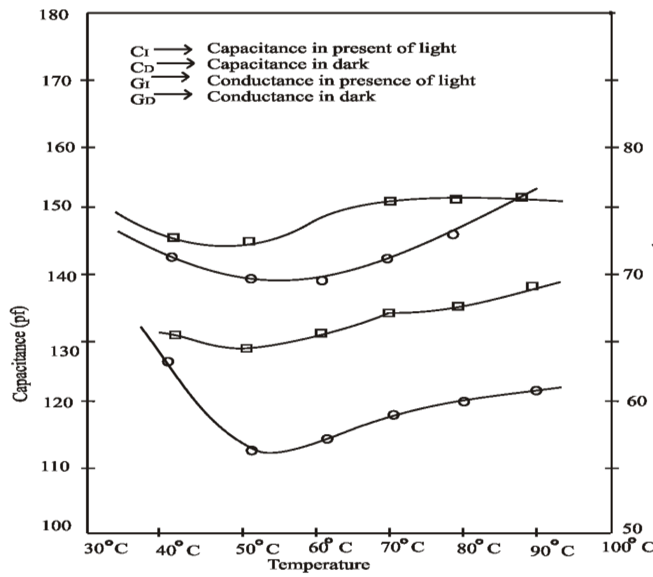

Figure 1. Variation of C_D, C_I, G_D, G_I with temperature

VARIATION OF LOSS FACTOR

The variation of loss factor shown in fig (6) .The variation of loss factor (tanδ) with temperature may be attributed to the contribution of the dc conductivity towards the measured loss factors.

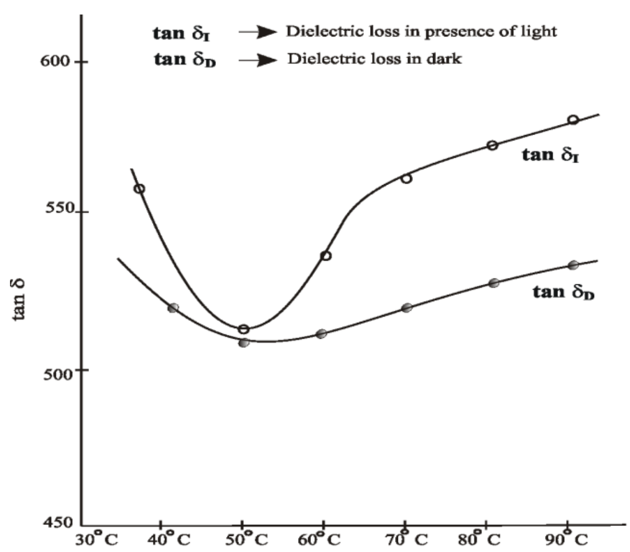

Figure 6. Variation of $\tan\delta_I$, $\tan\delta_D$ with temperature

IV. CONCLUSION

In this paper the effect of field frequency, explains the higher values of dark capacitance and photo capacitance at a lower frequency. Increases in the capacitance at higher frequency suggest the Doppler retardation effect. The variation of ac conductance with frequency is due to the variation in the formation of space charge. The space charge formed around the boundaries, restricts the transport of charge carrier from one grain to another grain, thereby reducing the conductivity with increasing frequency. At a higher value of G_D, G_I in the higher frequency region is due to Dopler retardation effect. For the variation of loss factor, the behavior can be explained on the basis of space charge formation in a dielectric. In case of intensity the dc conductivity increases with intensity, hence total conductance increases with intensity of illumination. For the effect of temperature, an increase in C_D and C_I with temperature may be attributed to the creation and destruction of dipoles, leading to appreciable space charge polarization.

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REFERENCES

[1] R. K. Srivastava, S.G. Prakash,"Photoelectret study of Sm doped ZnO and ZnO-Pb_3O_4 mixed lattice", Indian Journal of Pure & Applied Physics", vol. 46, 2008, pp. 266-269.

[2] J. Raux, "L'effet photodiélectrique", J. Phys. Radium, vol. 15, no. 3, 1954, pp. 176-188.

[3] V. K. Farkya and N. L. Porwal, "Photodielectric investigation of some compound semiconductors at low frequencies", Ind. J. Pure & Appl. Phys., vol. 22, no. 12, 1984, pp. 703-707.

[4] A.V. Petrov, E. E. Godik and V. P. Sinis, Sov., **"**Observation of a photodielectric effect associated with the excited states of shallow acceptors in germanium", Phys. Semicond. (USA), vol. 15, no. 7, 1980, pp. 459-463**.**

[5] Yu. P. Piryatinskii and B. N. Chayanev, "The fractal nature of the cluster model dielectric response functions", Sov. Phys solid state (USA), vol. 27,1985, pp. 515 -518.

[6] R. Janes, M. Edge, J. Robinson, N. S. Allen, F. Thompson ," Microwave photodielectric and photoconductivity studies of commercial titanium dioxide pigments: the influence of transition metal dopants", J. Mater Sci.(USA) vol. 33, no. 12, 1998, pp. 3031-36.

[7] G. B. Dubrouskii, A. I. Shelyph, "Photoelectric properties of tin disulfide", Phys. Solid state (USA), vol. 40, 1998, no.8, pp. 1295-1296.

[8] Nitin Pandey, R.K. Srivastave," Study of photoelectret effect in dysprosium doped zinc oxide", Indian J. Pure Applied Phys., vol. 50, 2012, pp. 260-264.

[9] Malti Goel, "Electret sensors, filters and MEMS devices: New challenges in materials research", CURRENT SCIENCE, vol. 85, no. 4, 2003, pp. 443-453.

[10] Kallmann, Kramer and Parlmutter," Induced Conductivity in Luminescent Powders. II. AC Impedance Measurements", Phys. Review, vol. 89, no. 4, 1953, pp. 700-707.

[11] Kallmann, Kramer and Mark," Impedance measurements on CdS crystals", Phys. Review, vol. 99, 1958, pp. 1328-1330.

[12] Rajesh Kalia, Sunil Kumar, H. S. BhattI, J. K. Sharma, "Study of dielectric behavior of nanoporous polycarbonate membrane for future nano-electret applications", Digest Journal of Nanomaterials and Biostructures, vol. 3, no.4, 2008, pp. 237 – 243.

[13] S. Kronenberg and C.A. Accardo, "Dielectric Changes in Inorganic Phosphors", Phys, Review, vol 101,1956, pp. 989-992.

[14] J. J. Dropkin et.al. "The dielectric properties of photoeonducting phosphors", ONR Rep. N60nr 36212(1952); N60nr 26313(1953).

[15] P. J. Harrop, *Dielectric*, John Willey, NewYork, 1972**.**

[16] P. K. C. Pillai, R. Nath & R. C. Ahuja," *PHOTODIELECTRIC EFFECT IN HGI2= CDS SYSTEM***"***,* India J. Pure & Applied Phys., vol. 14, no. 10, 1976, pp. 826-828.

[17] B.Tareev , *Physics of Dielectric Material*, Mir Publishers, Moscow, 147, 1975.

[18] G.F.J.Garlick and A.F. Gibson, "Dielectric changes in phosphors containing more than one activator", Proc. Phys. Soc., vol. 62, 1949, pp. 731-736.

[19] 19. J. Raux," L'effet photodiélectrique obtenu avec Zns(Cu, Co) et Zns(Cu. Ni)", J. Phys. Radium ,vol. 17, 1956, pp. 813-814.

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