

Photo Dielectric Effect Study in the Composite of Magnesium Titanate and Zinc Oxide

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ABSTRACT: An attempt is made to study photo dielectric effect in the composite of magnesium titanate and zinc oxide with different ratio. The mixed composite of magnesium titanate and zinc oxide is prepared by heat treatment method. The sample is prepared by firing the mixture (magnesium titanate and zinc oxide) at temperature 600⁰C – 900⁰C in a cylindrical furnace for 40- 55 minute. The sensitive material is sandwiched in between the parallel plate capacitor. The measurements are carried out in temperature range 30⁰C - 95⁰C in the frequency range (100 Hz -50000 Hz) with illumination intensity up to 5000 lux. The variation of conductance (G), capacitance (C) and loss factor (tanδ) is observed with illumination intensity.

KEYWORDS: MgTiO₃, ZnO, PDE, Loss factor, Conductance, Capacitance.

I. INTRODUCTION

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]. The space charge is formed nearby electrode, around the boundaries and both in the volume and at the surface of the bulk. The capacitance increases with increasing intensity of illumination. The space charge formed 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.

Many other investigations 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 [10].

When certain photo conducting material are placed as a dielectric in sandwiched 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).

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II. RELATED WORK

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 [18], tetra-amino-diphenyl (TADP)[5,16,17] etc. In the recent years photo dielectric effect in TiO₂[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[8,14,15]. 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]. Nikam, P.S. et al. (1994) have studied electric and dielectric properties of solution-gas interface grown AgCl thin film capacitors (Al/AgCl/Al) of various thicknesses. Chassaing, P.M. et al. (2007) have investigated dielectric effect in surface optical phonons in freestanding cylindrical ZnO nanoparticles surrounded by organic molecules. Li, J., Chen, F. et al. (2007) have investigated dielectric properties in α -Si₃N₄ alloy prepared by MgO and Al₂O₃ as the sintering additives and spark plasma sintering (SPS) technique. Dielectric constant of barium titanate is strongly influenced by its grain-size [11]. Ceramics with finer grain-size (~1 μ m) show higher values of K at room temperature, whereas peak in permittivity at Curie-temperature is lower, as compared to ceramics with grain-size larger than 2 μ m. Dubrovski, G.B. et al. (1998) have elicited considerable interest in the investigations of the crystal structure and electrical and optical properties of layered compounds of type MX₂ (where M is a metal and X is a chalcogen).

III. MATERIAL AND EXPERIMENTAL DETAILS

For the preparation of the mixed system, high purity MgTiO₃ and ZnO are taken in different proportions. The two base material pure magnesium titanate (MgTiO₃) and pure zinc oxide (ZnO) are taken in the powder form. All the base material are taken in different proportion by weight. These proportions are grind properly in order to get homogeneous mixture. The homogeneous mixture is then fired in a cylindrical furnace (Muffle furnace) at 600^oC to 900^oC in controlled atmosphere. The heated material is then cooled and again grinded in order to make a fine mixture in the form of powder. For measurement purpose, cell is constructed in the shape of parallel plate capacitors by inserting the receptive material in polystyrene binder and squeeze in it between the two conducting glass plates. The four electrode cell arrangement having thickness of (0 – 0.05 cm) and area of 2 cm² is used for measurement. The two end faces of the capacitor are fitted with two additional transparent glass plates. By varying slit width, intensity of illumination may be altered. An ac bridge LCR-Q meter is used to measure the conductance and capacitance. A high stabilized field is subjected across the cell and resulting current is noted through electrometer. 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.

IV. RESULTS AND DISCUSSION

A. EFFECT OF ILLUMINATION INTENSITY ON CONDUCTANCE

The graph (figure 1) plotted between illumination intensity and conductance shows non-linear behavior. In lower region, conductance increases speedily with increasing intensity of illumination, whereas in higher region of illumination intensity, conductance increases slowly and be likely to saturate. The ac conductivity is in fact a sum of

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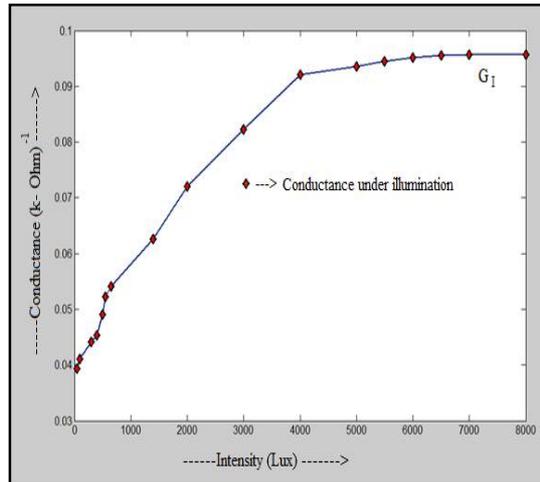


Figure 1: Variation of conductance with intensity

frequency independent dc conductivity and true ac conductivity. When intensity of illumination is increased, large number of charge carriers are generated due to which dc conductivity is increased. Therefore on increasing the intensity of illumination, total conductance may be increased.

B. EFFECT OF INTENSITY ON CAPACITANCE

It is observed from the graph (figure 2) that capacitance of the sample increases rapidly with increasing intensity illumination upto 5000 Lux. On further increasing the intensity of illumination, capacitance increases slowly and

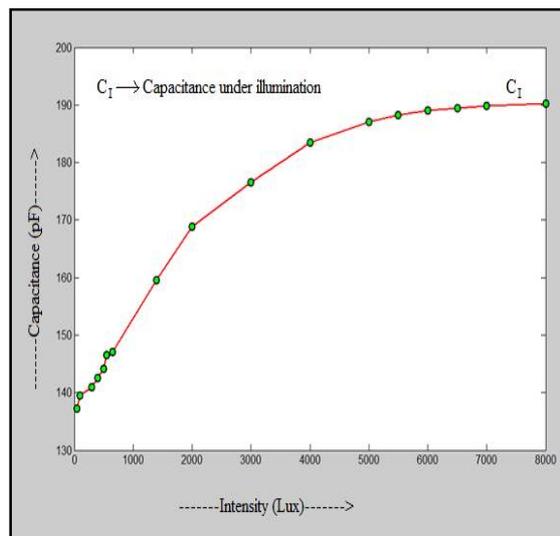


Figure 2: Variation of capacitance with intensity

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gradually tends to saturate. This is due to the fact that charges of the capacitor are accompanied by the relatively fast changes of electrical conductivity which reaches quite rapidly its saturation value with the increasing illumination intensity.

C. EFFECT OF INTENSITY ON LOSS FACTOR (TAN δ)

It is observed from the graph (figure 3) that loss factor decreases with increasing intensity of illumination. In lower region of illumination intensity (upto 1000 Lux), loss factor decreases rapidly whereas in higher region (above 1000

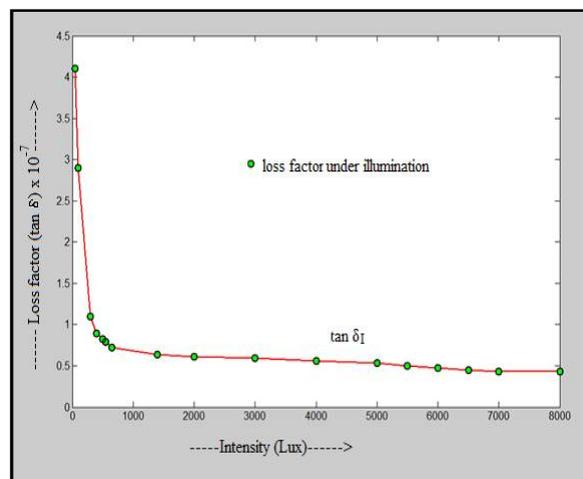


Figure 3: Variation of Loss factor with intensity

Lux), the loss factor decreases steadily and have a tendency to saturate on further increasing the intensity. It is based on the fact that on increasing the intensity, less and less space charge is produced due to which dielectric loss gets reduced.

V. CONCLUSION

The ac conductivity is in fact a sum of frequency independent dc conductivity and true ac conductivity. When intensity of illumination is increased, large number of charge carriers are generated due to which dc conductivity is increased. Therefore on increasing the intensity of illumination, total conductance may be increased. The loss factors decreases steadily and have a tendency to saturate on further increasing the intensity. It is based on the fact that on increasing the intensity, less and less space charge is produced due to which dielectric loss gets reduced.

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REFERENCES

- [1] R. K. Srivastava, S.G. Prakash, "Photoelectret study of Sm doped ZnO and ZnO-Pb3O4 mixed lattice", Indian Journal of Pure & Applied Physics", vol.46, pp. 266-269, 2008
- [2] J. Raux, "L'effet photodiélectrique", J. Phys. Radium, vol. 15, no. 3, pp. 176-188, 1954
- [3] V. K. Farkya and N. L. Porwal, "Photodilectric investigation of some compound semiconductors at low frequencies", Ind. J. Pure & Appl. Phys., vol. 22, no. 12, pp. 703-707, 1984

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 11, November 2016

- [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. Chayanov, "The fractal nature of the cluster model dielectric response functions", Sov. Phys solid state (USA), vol. 27, pp. 515 -518, 1985
- [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, pp. 3031-36, 1998
- [7] G. B. Dubrouskii, A. I. Shelyph, "Photoelectric properties of tin disulfide", Phys. Solid state (USA), vol. 40, no.8, pp.1295-1296, 1998
- [8] NitinPandey, R.K. Srivastave, "Study of photoelectret effect in dysprosium doped zinc oxide", Indian J. Pure Applied Phys., vol. 50, pp. 260-264, 2012
- [9] MaltiGoel, "Electret sensors, filters and MEMS devices: New challenges in materials research", CURRENT SCIENCE, vol. 85, no. 4, pp. 443-453, 2003
- [10] Kallmann, Kramer and Parlmutter, "Induced Conductivity in Luminescent Powders. II. AC Impedance Measurements", Phys. Review, vol. 89, no. 4, pp. 700-707, 1953
- [11] Kallmann, Kramer and Mark, "Impedance measurements on CdS crystals", Phys. Review, vol. 99, pp. 1328-1330, 1955
- [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, pp. 237 – 243, 1955
- [13] S. Kronenberg and C.A. Accardo, "Dielectric Changes in Inorganic Phosphors", Phys. Review, vol 101, pp. 989-992, 1956
- [14] 14.J. J. Dropkin et.al. "The dielectric properties of photoconducting 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 HG12= CDS SYSTEM", India J. Pure & Applied Phys., vol. 14, no. 10, pp. 826-828, 1976
- [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, pp. 731-736, 1949
- [19] J. Raux, "L'effetphotodiélectriqueobtenue avec Zns(Cu, Co) et Zns(Cu. Ni)", J. Phys. Radium ,vol. 17, p. 813-814, 1956