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Effect of Field Frequency on the Properties of Mixed Composite: MgTiO₃ and ZnO

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ABSTRACT: An endeavour is made to study photo dielectric effect in the composite of magnesium titanate and zinc oxide with diverse proportion. The blended composite of magnesium titanate and zinc oxide is made by heat treatment technique. The specimen is produced by heating the mixture (magnesium titanate and zinc oxide) at temperature 600⁰C – 900⁰C in a tube shaped heater for 40 - 55 minutes. The material is squeezed in the middle of parallel plate capacitor. The estimations are done at temperature range 30⁰C - 95⁰C in the frequency range (100 Hz - 50 kHz) with illumination intensity. The variation of conductance (G), capacitance (C) and loss factor (tanδ) is investigated with field frequency.

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

I. INTRODUCTION

Photo dielectric effect may be considered as expansion of photoconductivity phenomena. The Scientist Kallman [1, 2] experimentally investigated the decay of CdS and observed that photo induced capacity reduces swiftly. Although, measurements carried out in the process of increasing photoconductivity exhibits the presence of deep traps. Dropkin investigated the importance of dipole layer at grain boundaries in the powder form. Garlick & Gibson also explained the photo dielectric effect; they postulated that trapped electrons cause photo dielectric effect. Many other investigations have been carried out by Kronenberg and Accardo [3] on different material. Their measurement indicated that some material showed photo dielectric effect, which might well be associated simply with photoconductivity. In Electrets, made up of 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 [2].

In the recent years photo dielectric effect in TiO₂ [4] and SnS [5] have been reported [6]. Photo dielectric investigation have been made on other compound i.e. GaAs [6], Ge [7], ZnS [7] activated with Cu, tetra-amino-diphenyl (TADP) [8] etc. The photo dielectric studies have been made in several material like zinc sulphide (ZnS), zinc oxide (ZnO) [9] or CdS powder and also in single crystal [10]. The photo dielectric effect is reduced in the presence of impurities which poison the luminescence of ZnS phosphors [11, 12].

On the basis of various experimental facts Roux observed that dielectric charges induced in mixture of ZnO and the paraffin could be quenched out by radiation with infrared, which normally takes several days to decay. Karmer, Kallman, Permuter suggested that photo dielectric effect is due to conduction process in the crystal gain. Products

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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. With the advancement in materials research, miniature electret microphones integrated on silicon chips as microelectro- mechanical systems (MEMS) have been produced.

II. MATERIAL AND EXPERIMENTATION DETAIL

For the preparation of the mixed system, high purity magnesium (Mg), titanium oxide (TiO_3) and zinc oxide (ZnO) are taken in different proportions by weight and grind properly in order to get homogeneous mixture. The homogeneous mixture is then fired in a ceramic tube in cylindrical furnace at 600°C to 800°C in controlled for 45 minutes. The heated material is then suddenly quenched at room temperature and again grinded in order to get microcrystalline form. The sample is preserved in desiccators in order to avoid moisture. For the measurement purpose, the cell is fabricated in the form of parallel plate capacitors by embedding the sensitive material in polystyrene binder and sandwiching it between the two conducting glass plates. Measurements are made on four electrode cell system with area of 2 cm^2 and thickness of (0 – 0.05 cm). Two additional conducting glass plates are fixed on the two end faces of the capacitor. This makes the cell a four electrode system. The cell is placed in complete dark chamber. The radiation from Hg-lamp (300 W) was allowed through a window over transparent surface of the cell. Intensity of illumination can be changed by changing the slit width. The capacitance and conductance are measured through an ac bridge LCR –Q meter operated at 100 Hz to 1 KHz ac with dc field. The external field is obtained through an oscillator. A high stabilized field is applied across the cell and the resulting current is noted through electrometer.

III. RESULTS AND DISCUSSION

A. EFFECT OF FIELD FREQUENCY ON CAPACITANCE

The graph (Figure 1) shows variation of field frequency (F) with capacitance (C). The variation of capacitance (C) with applied frequency (F) is plotted both in dark and under illumination. The capacitance measured in dark and under illumination is denoted by C_D and C_I respectively. The variation of capacitance is measured in pico-farad (pf) and frequency is measured in hertz (Hz).

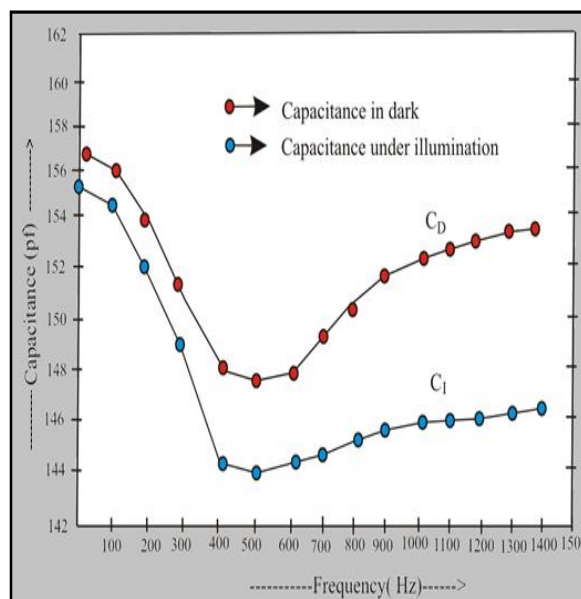


FIGURE 1: CAPACITANCE VERSUS FREQUENCY

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From the graph it is observed that as we increase the field frequency, the capacitance is also decreases in both dark and under illumination. From the graph (figure 1) it is clear that in lower frequency region the decrement in capacitance (C_D and C_I) is rapid. Further increase in field frequency shows sub-linear increment in capacitance.

In the lower frequency region, the variation of capacitance is due to space charge or interfacial polarization. The space charge formed around the boundaries restricts the transportation of charge carriers from one grain to another grain; as a result its conductivity is reduced on increasing the frequency. But in higher frequency region the formation of space charge is not possible therefore on further increasing the frequency the capacitance is also increases.

B. EFFECT OF FIELD FREQUENCY ON CONDUCTANCE

The graph (Figure 2) shows the variation between conductance (G) and field frequency (F). The variation of conductance (G) with applied frequency (F) is plotted both in dark and under illumination. The conductance measured in dark and under illumination is denoted by G_D and G_I respectively. The variation of conductance is measured in $(K\text{-Ohm})^{-1}$ and frequency is measured in hertz (Hz).

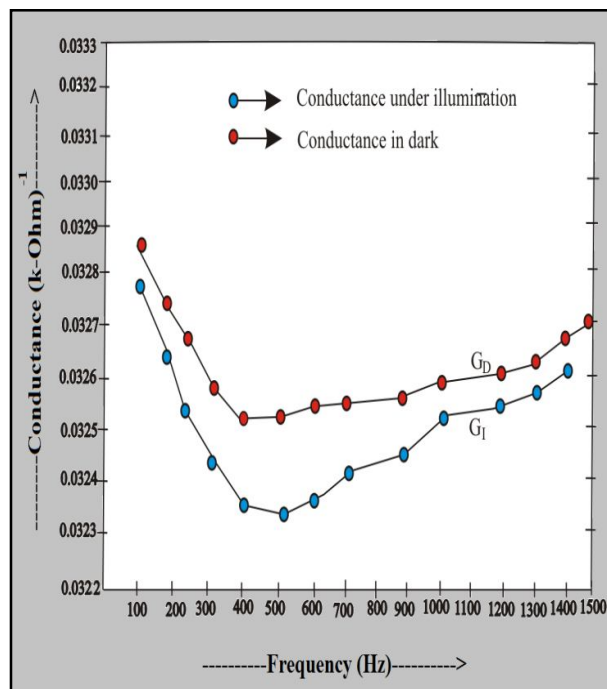


FIGURE 2: CONDUCTANCE VERSUS FREQUENCY

From the graph (figure 2) it has been observed that in the lower frequency range conductance decreases with increasing frequency and in the middle frequency range it starts increasing but the value is low as compared to that observed in lower frequency range. It has also been observed that graph shows similar variation for both dark and under illumination. In the low frequency region, the decrease in conductance is also faster. The variation of ac conductance with frequency may be due to variation in the formation of space charge. The space charge formed around the boundaries restricts the transport of charge carriers from one grain to another grain. Hence reduces the conductivity with increasing frequency.

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C. EFFECT OF FIELD FREQUENCY ON LOSS FACTOR

The loss factor ($\tan \delta$) depends on the field frequency. The figure 3 shows variation between loss factors ($\tan \delta$) and ac frequency. The variation of loss factor under illumination is denoted by $\tan \delta_I$ and in dark is denoted by $\tan \delta_D$.

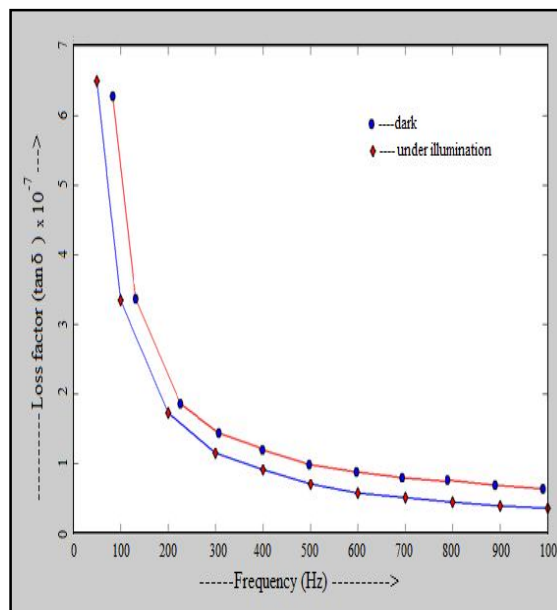


FIGURE 3: LOSS FACTOR VERSUS FREQUENCY

From the graph it is observed that loss factor ($\tan \delta$) decreases with increase in frequency. The capacitance increases with the increasing intensity of illumination. The 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. The dc conductivity increases with intensity of illumination. It is observed that as frequency is increased; less and less charge is formed which reduces the dielectric loss.

IV. CONCLUSION

The alteration of capacitance is because of space charge or interfacial polarization. The space charge framed around the limits confines the transportation of charge transporters starting with one grain then onto the next grain; subsequently its conductivity is diminished on expanding the frequency. The variety of ac conductance with frequency may be due to variety in the development of space charge. The ac conductivity is really an entirety of the frequency free dc conductivity and the real ac conductivity. The dc conductivity is incremented by the power of illumination. Subsequently builds the aggregate ac conductivity.

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