iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** XI **Month of publication:** November 2020

DOI: https://doi.org/10.22214/ijraset.2020.32347

Electrical Study on PI and PI+ITO+GO Polymeric Composite Thin Films

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Abstract: The study and analysis of insulating materials and insulating systems are the topic of great interest. The possibility of producing unusual electronic properties in polymer composite i.e. electrets effect has led to develop several research activity and new technological products in recent years. This research paper is an attempt to under stand the charge storage and transport mechanism in a better way. Hence, the study will help to overcome the problems like charge leakage in microphones and field dielectric breakdown in insulating systems fo PI_ITO+GO polymeric composite thin films.
Keywords: Polyimide, Indium Tin Oxide, Graphene Oxide, Transient Current Measurement.

I. INTRODUCTION

The transient current measurements being carried out over a long time is not a popular study but nevertheless it is very useful one which gives far more consistent results than the others. This being so on account of electrical and other perturbing influences affecting the discharge process far less than in other experiments involving fast decay processes. Transient current measurements is a subject of analytical studies, where the origin of absorption and desorption currents was studied. Moreover, it also helps to understand the mechanisms involved in the transient absorption and desorption current flow. The knowledge of basic electrical properties, such as the type and origin of charge carriers, their storage and transport in the polymeric dielectrics are extremely important for making stable and useful electrets. Transient current measurement is one of the basic and important experimental techniques to explore the said properties.

The charge storage properties are observed in most instances when dielectric material is exposed to electric field due to microscopic structural defects, microscopic heterogeneity, electrode polarization. The dipole formation and orientation charge can be built into dielectric by means of charged particle injection [1]-[5]. Charge once the charge generated and applied field is removed persists will stay over an extremely long period of time.

Materials that are electrically neutral on a microscope scale contain no excess charge and no polarization of separately trapped positive and negative carriers can be thermally activated at any time. The transient currents are essentially governed by dipolar mechanisms and hence very much dependent on the temperature ranges of the various molecular relaxation processes of the material.

The detail related to preparation, various mixed solution concentrations and designations was reported in published research paper by Rajiv et. al. [6].

II. CHARACTERIZATION

A. Experimental Detail

Transient current measurements were carried out on pure PI and PITOGO composite thin films where films were sandwiched between electrodes of the measuring cell, which was mounted inside the oven. The sample was kept at this desire temperature for ½ hour that allows the sample to attain uniform temperature. Thereafter a constant step voltage was applied and the charging currents versus time characteristic were recorded.

Further, after 1 hour the field was removed and the discharging current versus time measurements were recorded. Discharging the sample produces a negative charge current.

If the charge current (I_0) in the equilibrium state is subtracted from the charging current, the charge and discharge current are identical for many dielectrics. Therefore, the transient current I (t) as a function of time is obtained from both the charge and discharge current as given by the following relation.

$$I_{Charge}(t) = I(T) + I_0$$

$$I_{Discharge}(t) = -I(T)$$

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue XI Nov 2020- Available at www.ijraset.com

III.RESULT AND DISCUSSION

The origin of transient charging and discharging currents can't be decided exactly, but it helps to analysis the dependence of the current on various experimental parameters such as field strength, time and temperature, etc., a tentative discrimination can definitely be made between the various mechanism. The charging and discharging transient observed for the pure PI and PITOGO composite thin films for different temperature figure 1-6. The charging and discharging currents are in general mirror images of each other where current depart from their mirror image nature at shorter times as temperature is increased. On careful observation it was found that current profile tends to shift towards high temperature at shorter times. The transient currents thus exhibit the thermally activated behavior. The charging and discharging transient at fixed times show thermal dependence and exhibit a complex dependence on electric field. Thus it seems that tunneling of empty traps can be ruled out as a possible mechanism for the observed transients. The transient currents in time domain have actually been observed to follow the power law of the type, I (t) $\square\square t^{-n}$; however, the logarithmic plot of the current are much steeper than the genuine characteristic (value of n>1). The observed current transient in the time domain are due to dipolar mechanism, then the time domain response is made of two sequential decay processes. Thus, in conclusion it may be suggests that the observed transient-current curves are composite in nature and can be explained on the basis of dipolar and space charge effects. The space charge polarization sets up with a fast setting time of 10^{-14} to 10^{-15} sec., while the dipolar polarization requires a longer time period because of inertia of dipoles and molecules. It appears that at shorter times, hopping charge and space charges contribute significantly resulting in a complex dependence on the charging field.

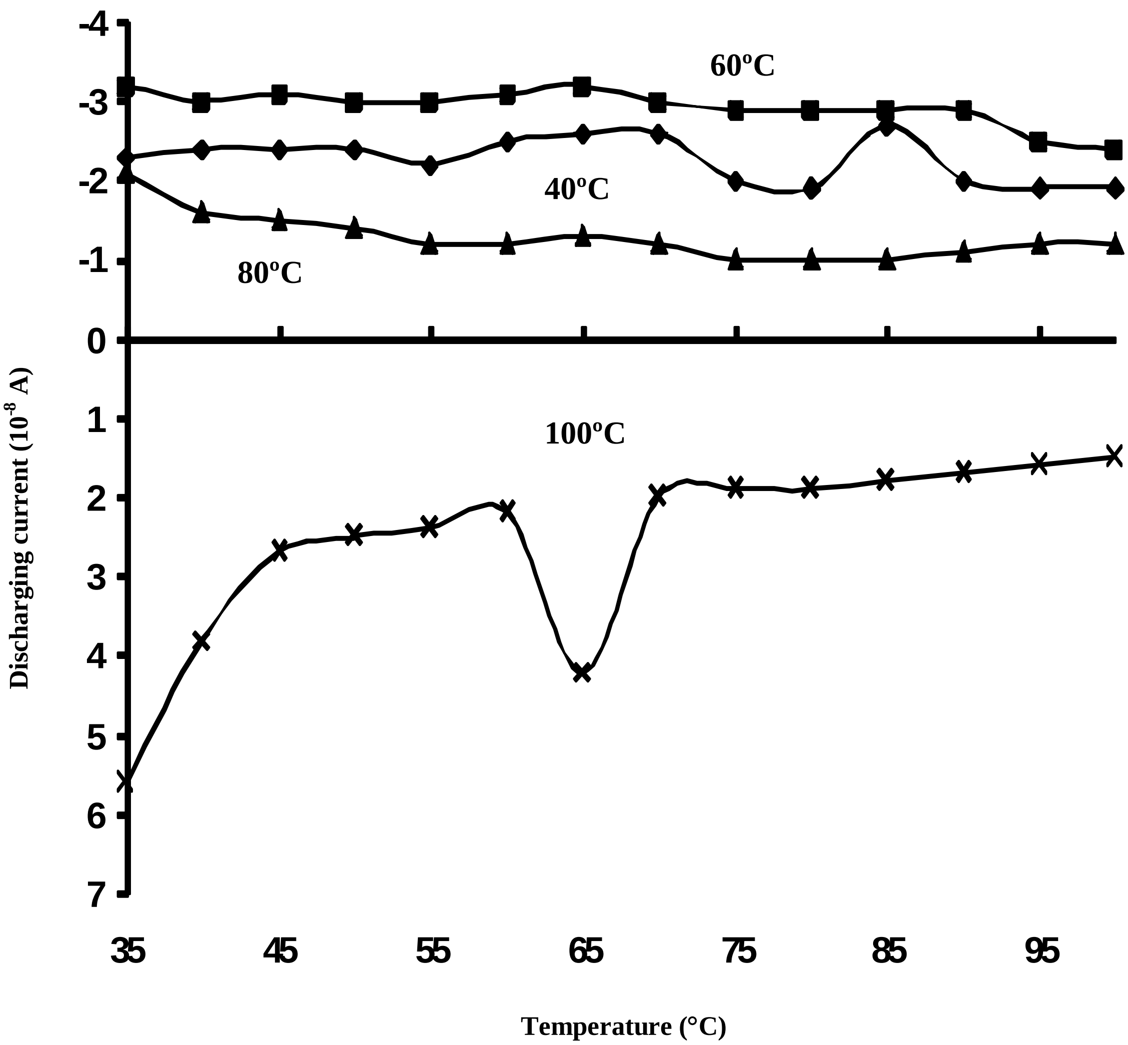

Figure 1: Shows the transient current measurement at different temperature for pure PI thin film.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
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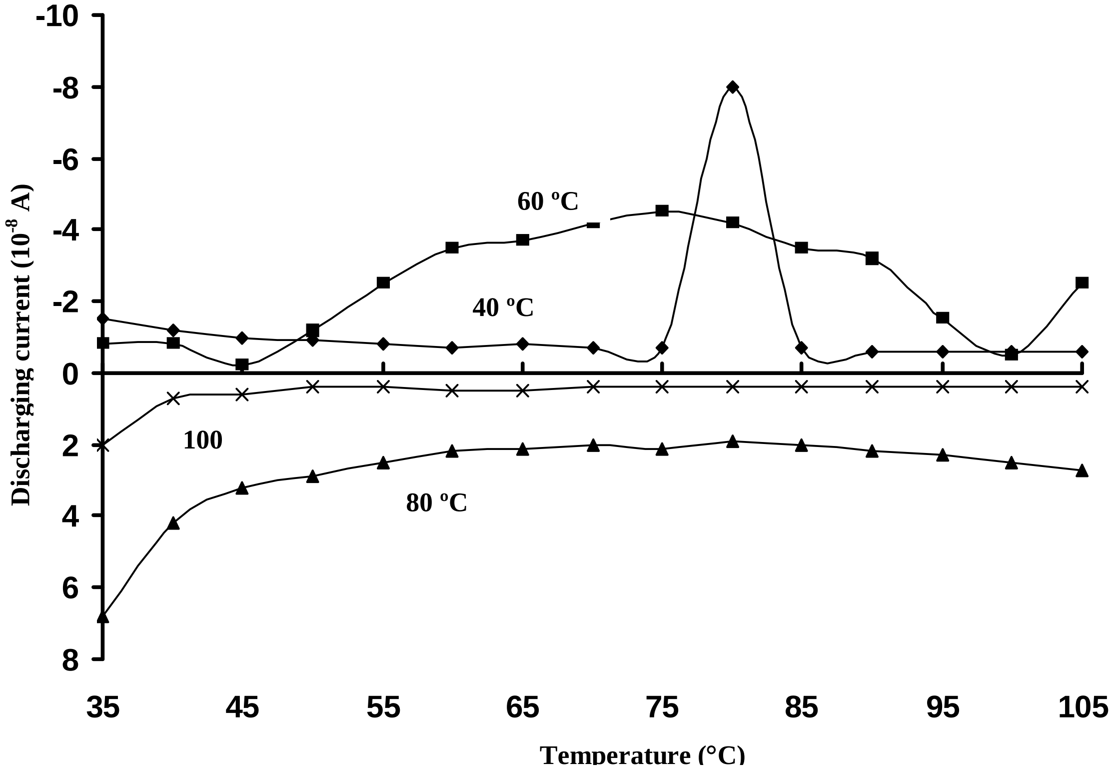

Figure 2: Shows the transient current measurement at different temperature for PITOGO-1 composite thin film.

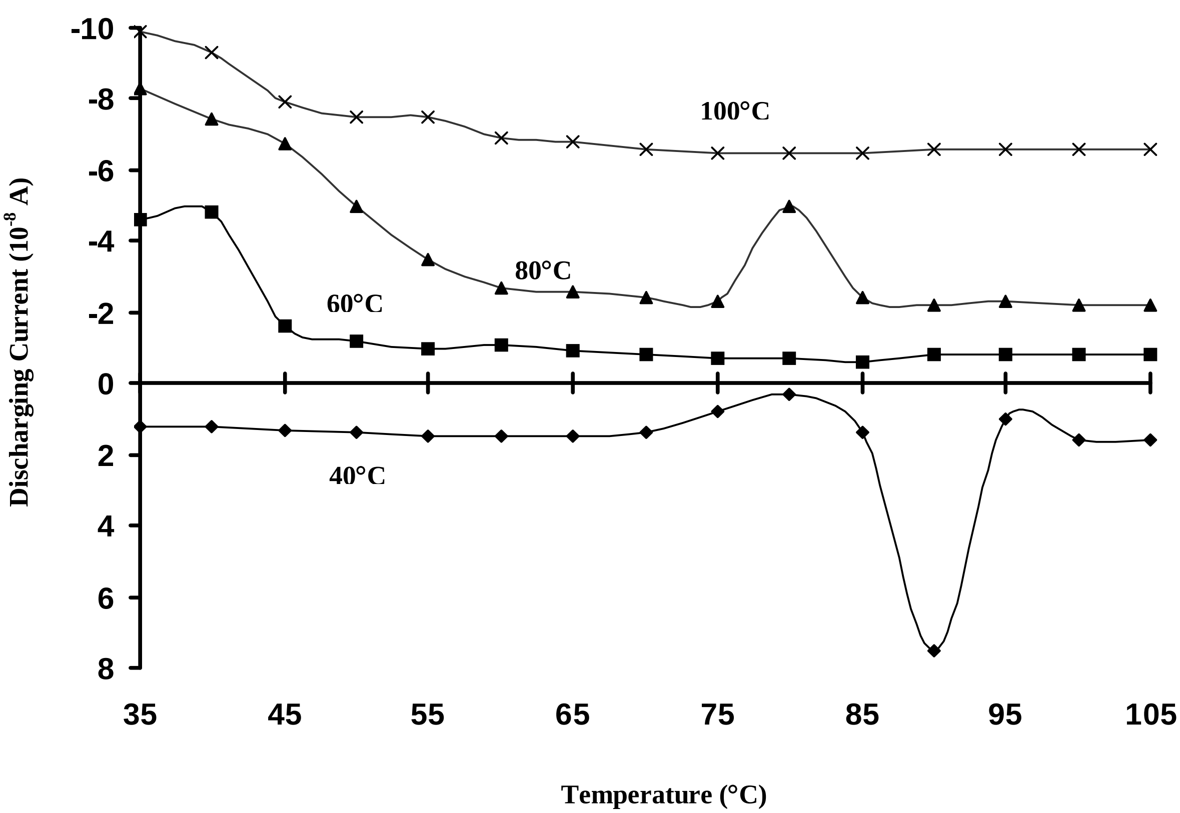

Figure 3: Shows the transient current measurement at different temperature for PITOGO-2 composite thin film.

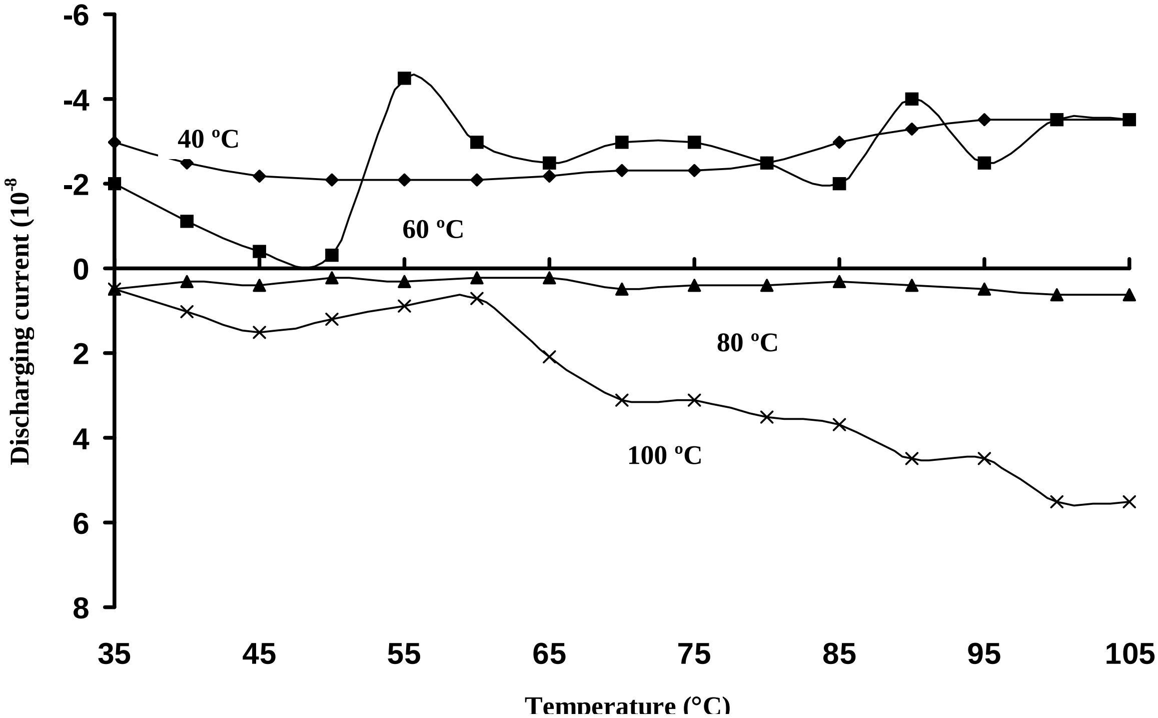

Figure 4: Shows the transient current measurement at different temperature for PITOGO-3 composite thin film.

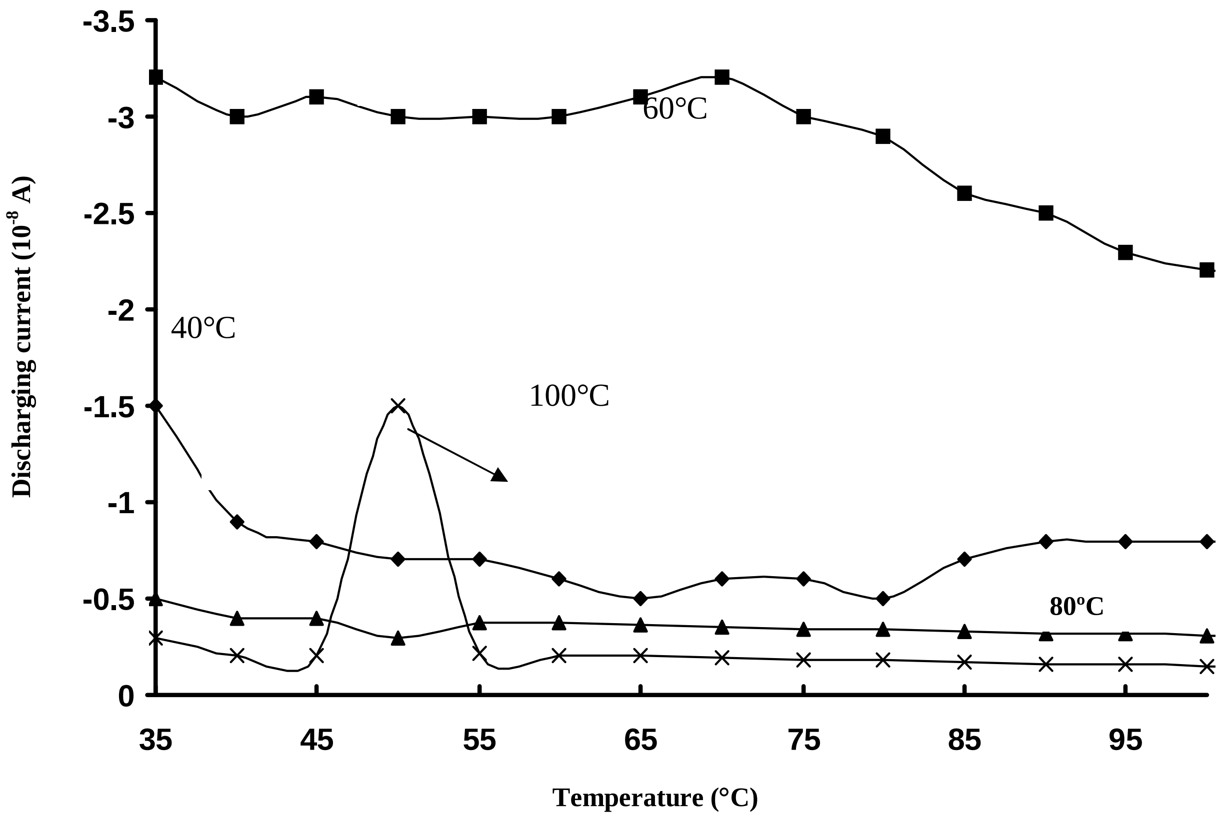

Figure 5: Shows the transient current measurement at different temperature for PITOGO-4 composite thin film.

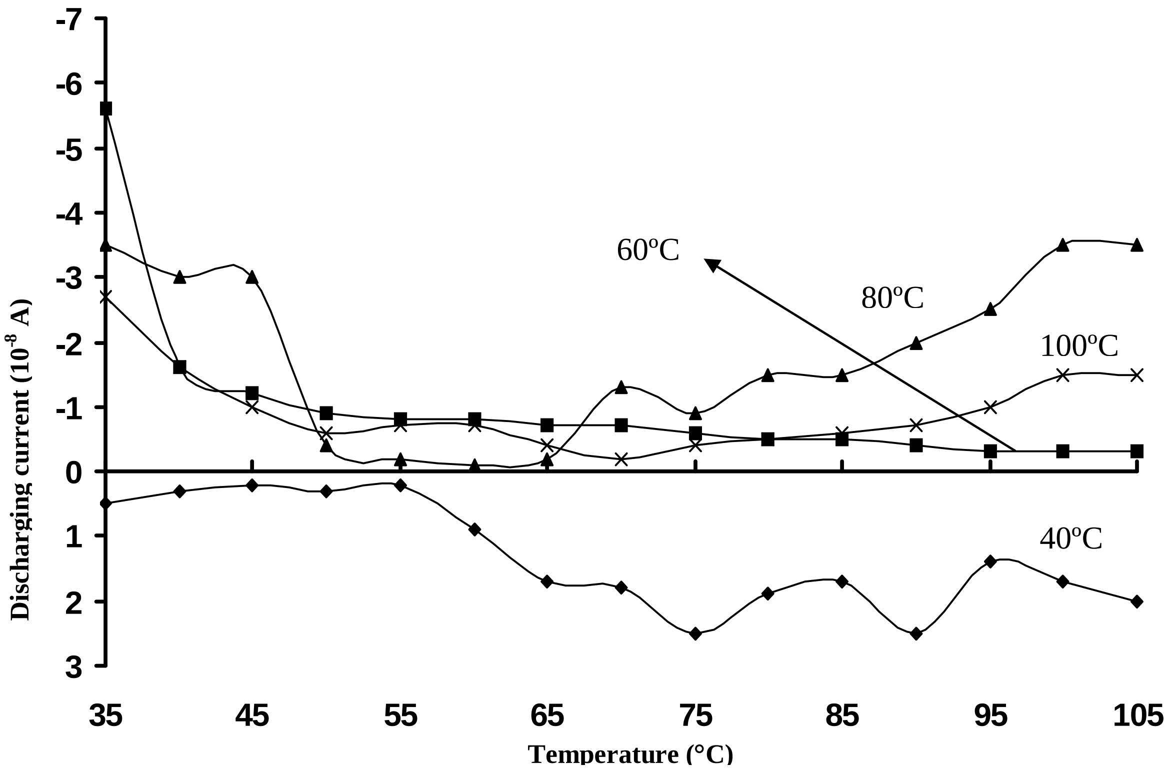

Figure 6: Shows the transient current measurement at different temperature for PITOGO-5 composite thin film.

IV. CONCLUSIONS

The electrical properties was transient current measurement technique helps to provide the information about dipolar and space charge effects along with temperature dependence. All these improved properties is attribute the uniform dispersion of ITO and GO particles within PI matrix in micro/ nano meter regime.

V. ACKNOWLEDGMENT

The authors are really grateful and obliged to the Inter Department of Physics, RDVV, Jabalpur, MP, India for providing us the experimental facilities.

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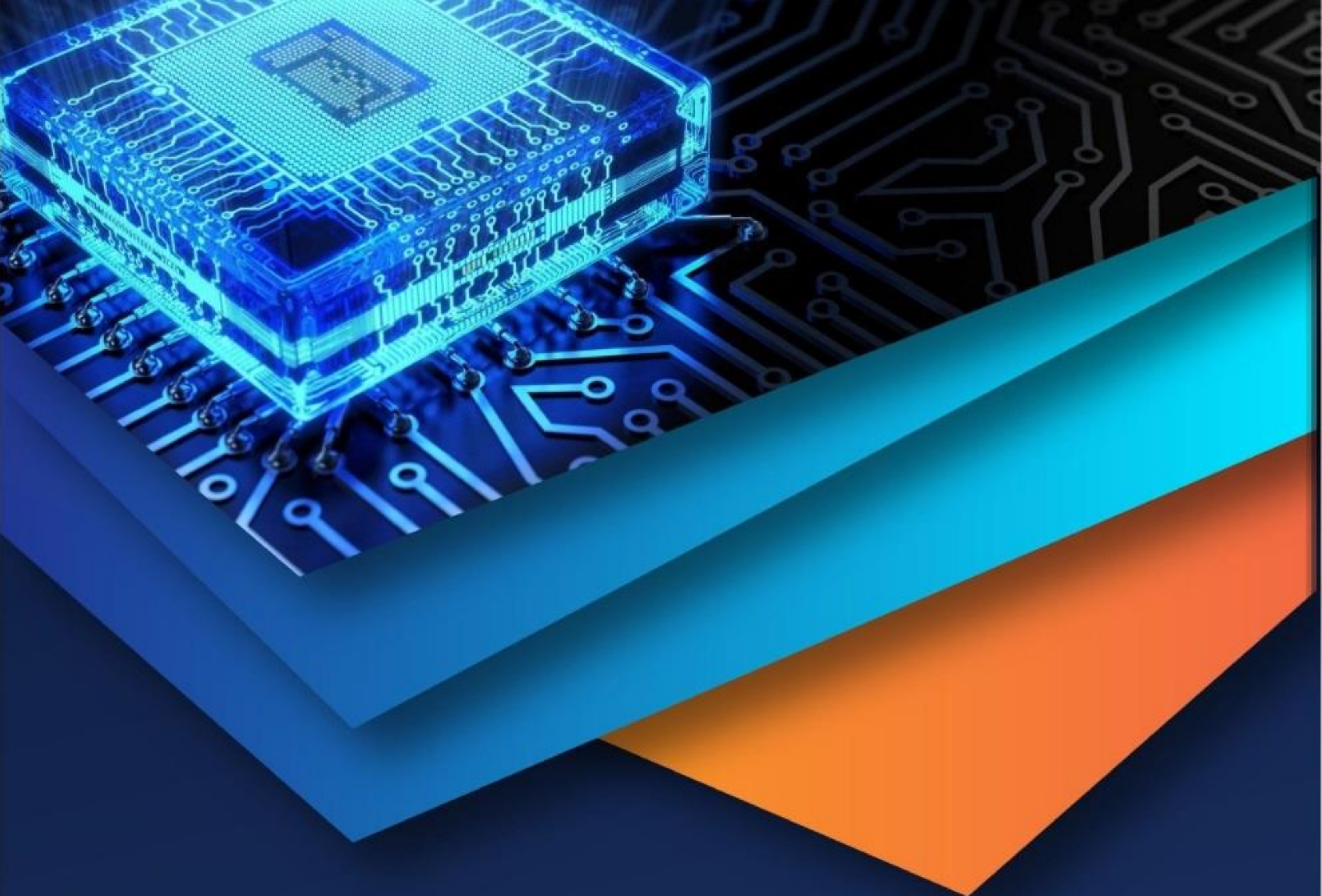

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