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# Synthesis, Characterization and Study of Cadmium and Zinc Sulphide Multilayer Thin Film using CBD

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***Abstract:*** ***Cadmium sulphide and cadmium zinc sulphide multilayer thin film was successfully deposited on glass substrate using chemical bath deposition (CBD) technique. Both groups II-VI compounds have semiconducting properties. In nano range the properties of the material changes and these properties can be used in improving many photovoltaic and opto-electronic devices. Thin films have many applications such as multilayer light emmiting diodes, photodetectors, gas sensors, thin film field effect transistors, optoelecronic modulators, electroluminescent devices etc. Variety of manufacture techniques have been used to fabricate thin films. Physical vapour deposition, spray pyrolysis, sputtering, spin coating, molecular beam epitaxy, thermal evaporation, chemical vapour deposition, electro-deposition, silar method, chemical bath method etc are some of the fabrication methods. The present invention relates to providing an improved method and product formed by the method for producing a cadmium sulphide and cadmium zinc sulphide multilayer thin film. Different solutions were prepared having a varying concentration of both cadmium sulphide and cadmium zinc sulphide. The composition of the thin film material is like first layer CdS, second layer(CdZn)S(80/20) and top most third layer (CdZn)S(50/50).***

***The synthesized films are characterized by different techniques and properties are studied. The arrangement of the composite cascaded film will be proposed .The thickness measurement study is done by multiple beam interferometers. The thickness showed that the films prepared were getting deposited and were in the thin film range. The film thickness depends on the bath parameter like time duration for magnetic stirring, temperature and time duration for chemical bath. The thickness of the film is measured after each film deposition.The absorbance spectrum studies for the multilayer bulk thin film is better than mono layer and double layer thin film. The double layer nano thin film shows better absorbance spectrum than the mono layer nano thin film and multilayer nano thin film. Absorbance spectral study provided by UV-visible spectroscopy gives a measure of absorbance as a nature of band gap of semiconductor nano material and the value of band gap and particle size. The band gap energy of the CdS films was calculated and it was found to be as per the generalized results. The main objective of this work is to propose multilayer thin film for solar cell application. The band gap of the bulk and nano thin films has been calculated. The thin film has been proposed as an anti reflecting coating with less light absorption losses for solar cell application***

***Keywords: CdS, (CdZn)S, CBD, multilayer thin film, multiple beam interferometer, UV-visible spectroscopy ,XRD, SEM .***

## I. INTRODUCTION

Broad information over the thin film of nanomaterials is a significant aspect in crafting devices with required functions. Due to this motive, well-organized efforts have been made to produce thin films in nanoscale. The assembly of thin films one over the other also called as multilayer thin films have some enhanced properties than a single layer thin film. In recent time's cadmium and zinc chalcogenides have found a vast area for research [1]. The reason behind the wide research is possiblities for their applications in the field of optical and electronic devices. CdS is a good candidate for wide band gap material for photovoltaic and photoconducting devices. Its band gap ranges from 2.37 to 2.43 eV. The addition of ZnS to CdS enhances the band gap and hence can reduce the absorption losses. Zinc sulphide itself has a band gap of 3.65 eV. Various deposition techniques such
as spray pyrolysis, metal organic chemical vapour deposition (MOCVD) and chemical bath deposition (CBD) have been used to deposit Cadmium Sulphide and Cadmium Zinc Sulphide thin films [2]. The chemical bath deposition (CBD) technique due to its moderately low cost and simple method for the deposition of high quality and large area films is used as the synthesis technique. In present work, thiourea is used as the sulphiding agent. The assembly of thin films, in other words the multilayer thin film is deposited on glass substrate. The layers are a combination of different ratio of cadmium sulphide and zinc sulphide. The wide band-gap CdZnS thin films have been widely used as a buffer and window material in hetero-junction solar cells and in photoconductive devices [3].

In this present work we describe the deposition of CdS and Cd-ZnS thin films by CBD method and compare their structural and optical properties with parameters like thickness crystallite size, lattice constant, band gap energy etc.

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## II. EXPERIMENTAL PROCEDURE

### *A. Multilayer Bulk Thin Film*

The multilayer thin film was deposited on glass slides using the Chemical Bath Deposition (CBD) technique. All the apparatus required to prepare the solution were initially degreased in HCl, followed by acetone and lastly cleaned with triple distilled water [4]. They were allowed to dry in open air. For the first layer deposition of CdS bulk thin film, the solution of cadmium acetate, triethanolamine, aqueous ammonia and thiourea was prepared. Instantly the solution is stirred on magnetic stirrer for 60 minutes. The bath temperature was set to $60^0$C and glass slides were placed vertically in the solution. The deposition of film in chemical bath was carried for 2 hours. The film was taken out from the bath and left to dry at room temperature overnight. The second layer of cadmium sulphide and zinc sulphide was deposited on the first layer. The solution prepared has cadmium acetate and zinc acetate in a certain ratio followed by trietanolamine, aqueous ammonia and thiourea. The solution was stirred for one hour. The bath was set to $60^0$C and the glass slide with earlier deposited thin film of CdS was placed vertically in the solution for 2 hours. Similarly the third layer of cadmium sulphide and zinc sulphide (different in concentration ratio from the second layer) was deposited on the second layer. This procedure resulted in the formation of cadmium sulphide and zinc sulphide multilayer bulk thin film.

### *B. Multilayer Nano Thin Film*

The similar procedure detailed above for the bulk film deposition was carried for the cadmium sulphide and zinc sulphide multilayer nano thin film deposition. The only difference was polyvinylpyrolidone (PVP) which acted as the capping agent for the nano thin film formation. The solution is prepared in the similar manner for all the three films just that before stirring, PVP is added to the solution. After deposition of each layer of film, it is left to dry at room temperature.

Thickness of the film was measured using multiple beam interferometery. Each film's thickness was measured after the deposition of another layer and so on. The absorbance spectrums of the deposited films were characterized using UV-visible spectrophotometer. Band gap was calculated using tauc's plot. The XRD, SEM characterization techniques were used for the study of the properties of the film. A comparative study was also carried out on the basis of thickness and band gap.

## III. RESULTS

### *A. Thickness of The Film*

Table I Thickness Measurement

| S no | Sample | Thickness(nm) |
|---|---|---|
| 1 | Bulk CdS thin film | 397.543 |
| 2 | Bulk CdS, $(Cd_{0.8}Zn_{0.2})S$ thin film | 499.852 |
| 3 | Bulk CdS, $(Cd_{0.8}Zn_{0.2})S$, $(Cd_{0.5}Zn_{0.5})S$ thin film | 655.669 |
| 4 | Nano CdS thin film | 204.724 |
| 5 | Nano CdS, $(Cd_{0.8}Zn_{0.2})S$ thin film | 306.070 |
| 6 | Nano CdS, $(Cd_{0.8}Zn_{0.2})S$, $(Cd_{0.5}Zn_{0.5})S$ thin film | 476.154 |

The table above shows the measurement of the thickness of the films on each depositition. The thickness of the film goes on increasing as the next layer of thin film is deposited on the previous film. It is also observed that the film is in nanoscale.

*B. Absorption Spectrum*

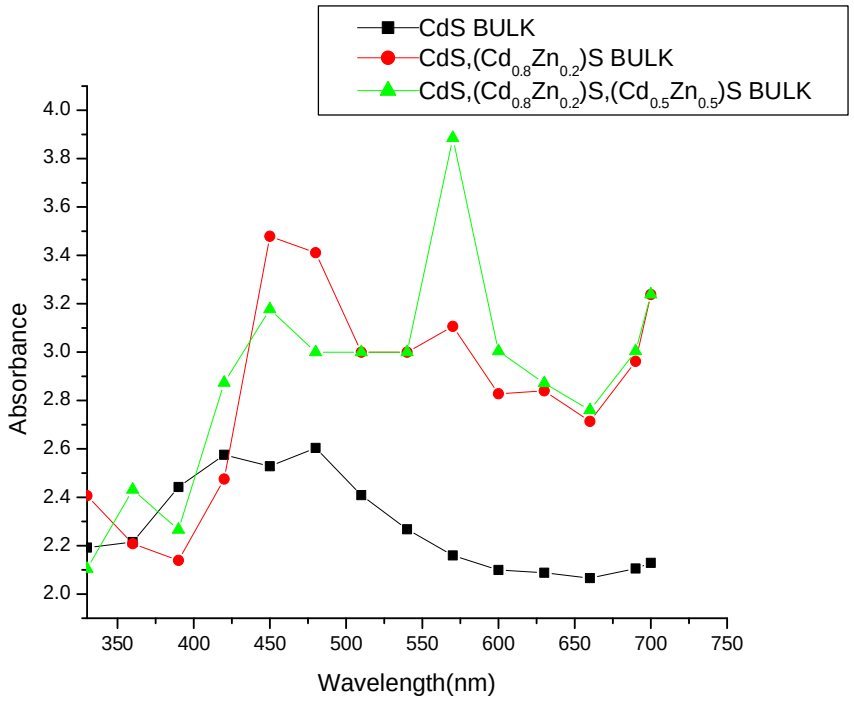


Fig 1. Absorption spectrum of bulk multilayer thin film.

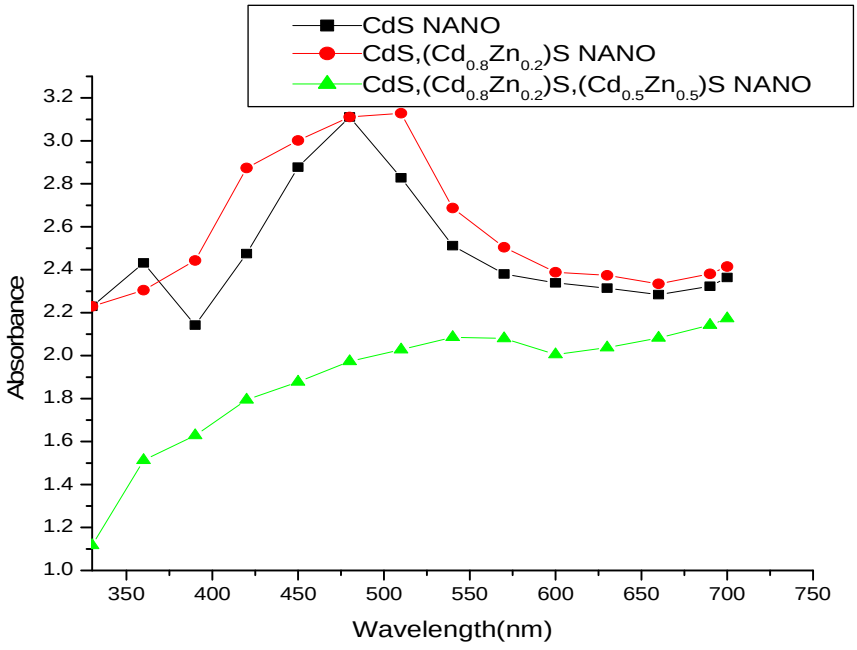


Fig 2. Absorption spectrum of nano multilayer thin film

Figure 1 and figure 2 shows the absorption spectrum of the multilayer bulk and nano thin films respectively. The absorption spectrum of each deposited thin film (bulk and nano) is found to be different and in visible range of group II-VI alignment. From both the figures it is evident that the absorbance of monolayer, double layer and multi layer thin films are dissimilar. All the deposited films exhibit absorption edges, which are blue shifted. The shift in absorption edge is a shows the quantum confinement effect observed in these nanocrystalline thin films

*C. Tauc's Plot*

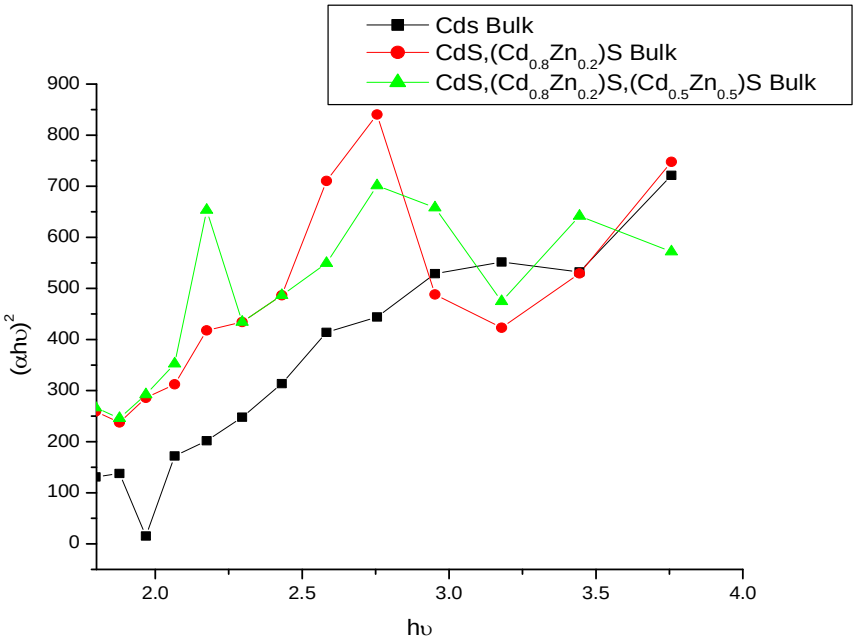


Fig 3. Tauc's plot bulk multilayer thin film

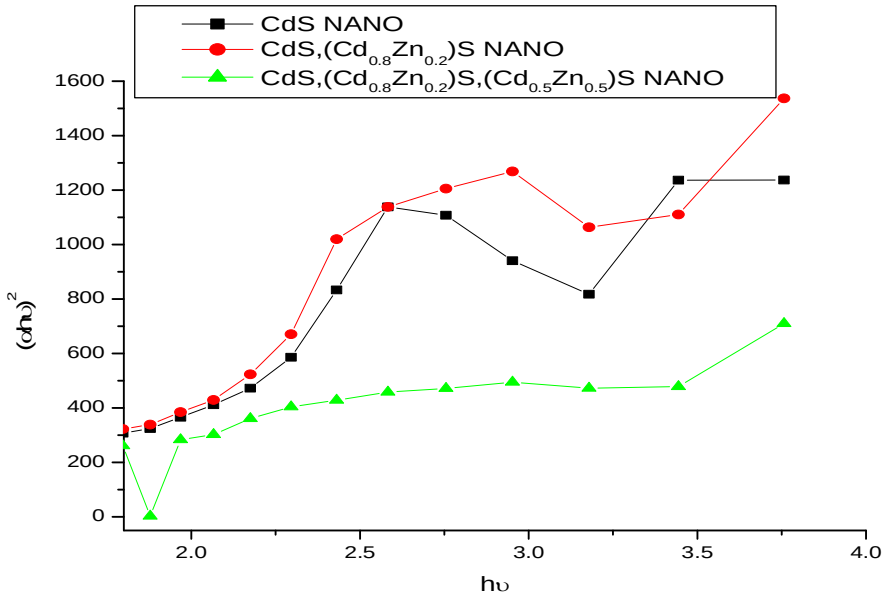


Fig 4. Tauc's plot nano multilayer thin film

From the figure 3 and figure 4 the band gap energy of the bulk and nano thin films for mono layer, double layer and multilayer have been achieved.

The nano multilayer thin films band gap energy is also found to be in nano range higher than the bulk multilayer thin films. It is evident from the band gap table.

*D. Band Gap*

Table Ii Band Gap

| S no | Sample | Band gap(eV) |
|---|---|---|
| 1 | Bulk CdS thin film | 2.49 |
| 2 | Bulk CdS, (Cd0.8 Zn0.2)S thin film | 2.7 |
| 3 | Bulk CdS, (Cd0.8 Zn0.2)S, (Cd0.5 Zn0.5)S thin film | 2.3 |
| 4 | Nano CdS thin film | 2.6 |
| 5 | Nano CdS, (Cd0.8 Zn0.2)S thin film | 2.65 |
| 6 | Nano CdS, (Cd0.8 Zn0.2)S, (Cd0.5 Zn0.5)S thin film | 2.75 |

From the band gap table it is observed that for multilayer nano thin film highest band gap energy is achieved. This band gap will help in reducing absorption losses of solar energy which a single CdS thin film is not capable of.

*E. XRD*

The x-ray diffraction pattern observed for the multilayer nano thin film shows the growth of the polycrystalline film. The particle size calculated from the XRD data is found to be in 74 nm. The planes observed from XRD patterns are those of CdS as well as of ZnS which means the both the materials will participate in any operation jointly reflecting the best properties.

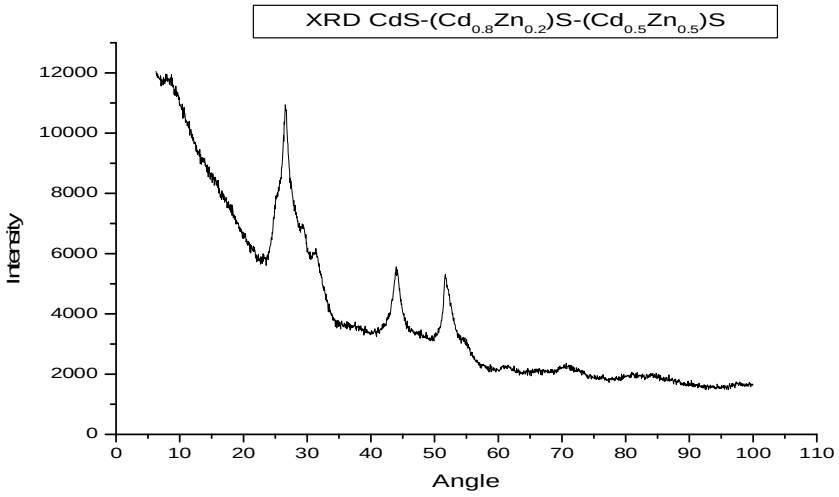


Fig 5. XRD pattern of nano multilayer thin film of CdS-(Cd $_{0.8}$ Zn $_{0.2}$)S-(Cd $_{0.5}$ Zn $_{0.5}$)S.

*F. SEM*

Scanning electron microscopy is a high-resolution image technique. The scanning electron microscope (SEM) uses a focused beam of high-energy electrons to generate a certain range of signals at the surface of solid sample. The signals that originate from electron-sample interactions expose information about the sample including external morphology, chemical composition, and crystalline structure.

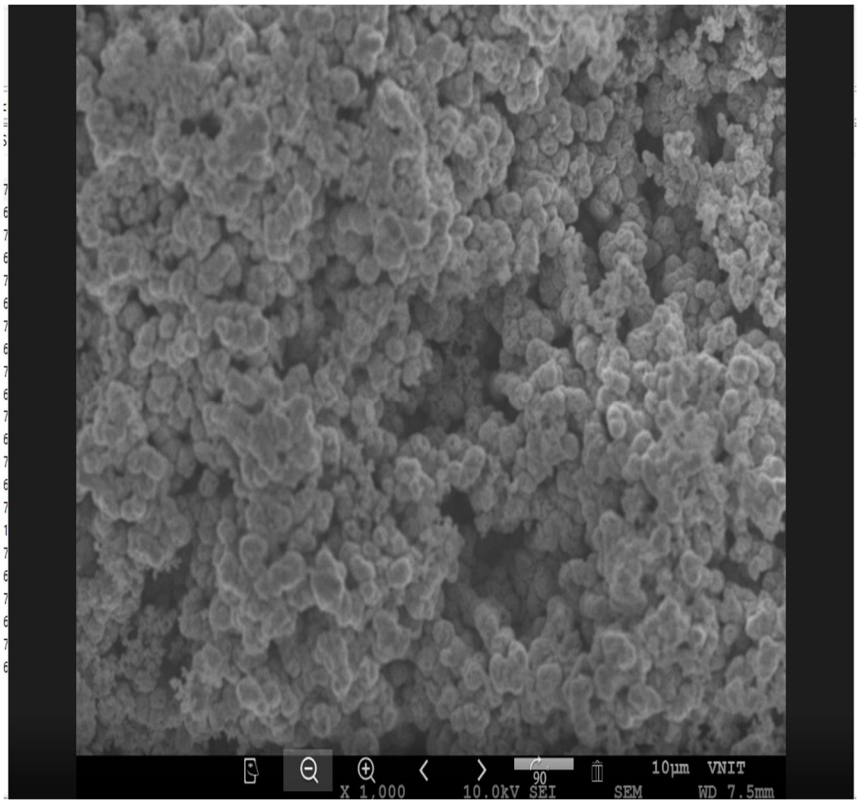


Fig 6 SEM image of nano multilayer thin film of CdS-(Cd $_{0.8}$ Zn $_{0.2}$)S-(Cd $_{0.5}$ Zn $_{0.5}$)S.

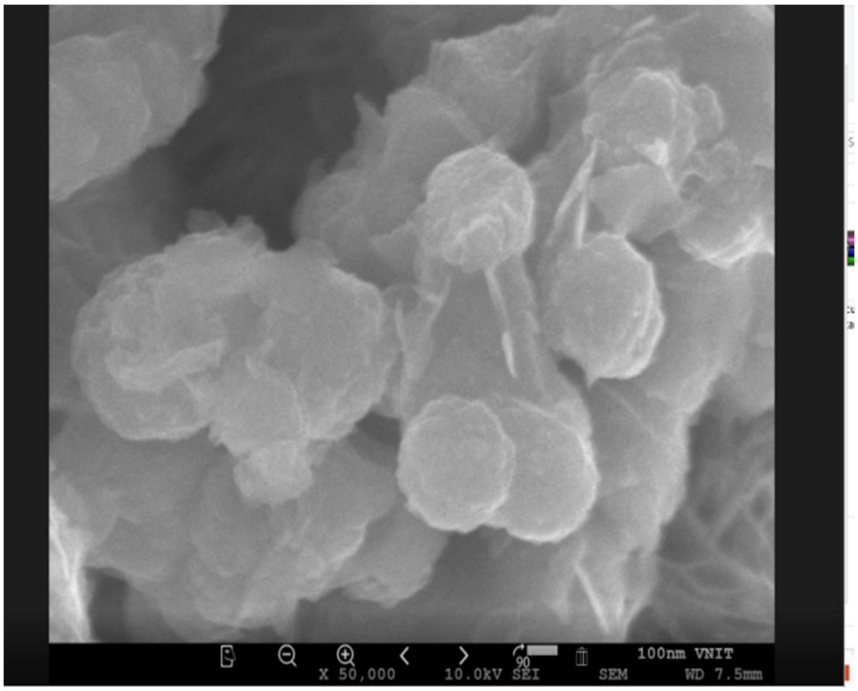


Fig 7. SEM image of nano multilayer thin film of CdS-(Cd $_{0.8}$ Zn $_{0.2}$)S-(Cd $_{0.5}$ Zn $_{0.5}$)S.

The micrograph in figures 6 and figure 7 shows some spheroid granules on the film surfaces which are uniformly distributed throughout the surface. It is observed that a uniform film is formed. In addition the multilayer deposition is also observed.

## IV. CONCLUSION

The cadmium sulphide and cadmium zinc sulphide multilayer thin film was successfully deposited on glass substrate using chemical bath deposition (CBD) technique. The thickness measurement studies showed that the films prepared were getting deposited and were in the thin film range. The absorbance spectrum studies for the multilayer bulk thin film is better than mono layer and double layer thin film. The double layer nano thin film shows better absorbance spectrum than the mono layer nano thin film and multilayer nano thin film. The band gap energy of the CdS films was calculated and it was found to be as per the generalized results. The assignment of different peaks obtained was made by comparison with ASTM data and lattice constants calculated shows agreement with reported values. SEM images are in accordance with the standard.

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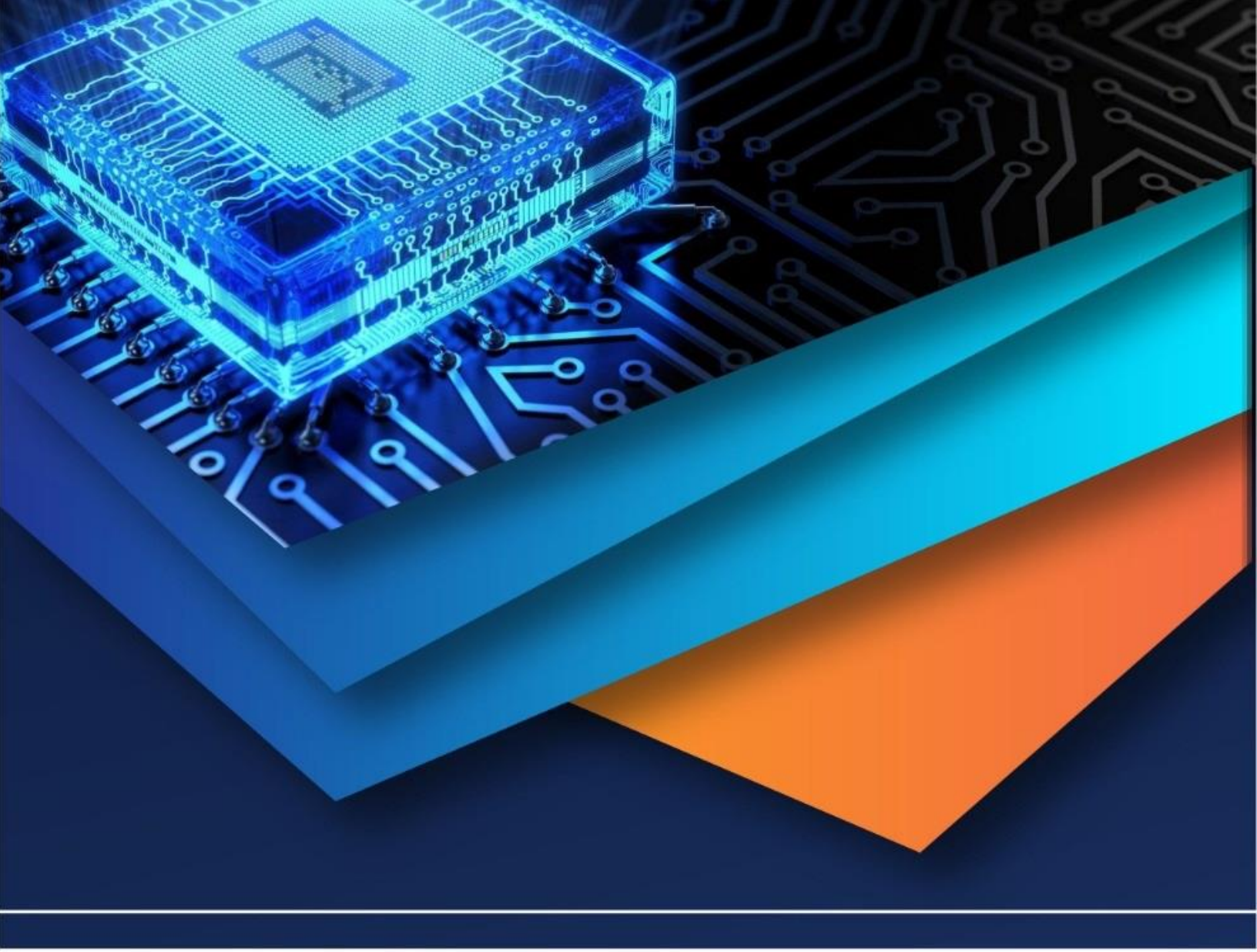

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