*IOSR Journal of Applied Physics (IOSR-JAP)*
*e-ISSN: 2278-4861.Volume 10, Issue 1 Ver. II (Jan. – Feb. 2018), PP 51-53*
*www.iosrjournals.org*

# Synthesis and Characterization of Cds Quantum Dot by Silar Technique

N.I Azubuike[1], Prof. A.J Ekpunobi[2]
*[1-2] Department of Physics & Industrial Physics, NnamdiAzikiwe University, P.M.B 5025 Awka, Anambra State, Nigeria*

**Abstract:** *Successive ionic layer adsorption and reaction (SILAR) process was used for the deposition of cadmium sulphide quantum dot on mesoporous $TiO_2$ film. The change in colour of the $TiO_2$ film from white to deep orange was the primary indicator of the growth of CdS quantum dot on the film. The UV-vis spectroscopy result confirmed both the presence and quantum confinement effect of CdS on $TiO_2$. The absorption spectra showed that the sensitized film absorbs radiation at higher wavelength with the peak at 410nm. A band gap of 2.46ev was obtained for the CdS sensitized $TiO_2$.*

**Keywords:** *CdS, Quantum Dot, SILAR,Thin Films, $TiO_2$*

Date of Submission: 29-01-2018 Date of acceptance: 19-02-2018

## I. Introduction

When a solid exhibits a distinct variation of optical and electronic properties with a variation of particle size < 100nm, it can be called a nanostructure and is categorized as 1) two dimensional e.g. thin films or quantum wells 2) one dimensional e.g. quantum wires or 3) zero dimensional or dots. During the last decades, a great deal of attention has been focused on the opto-electronic properties of nanostructured semiconductors or quantum dots as many fundamental properties are size dependent in the nanometer range[1].

Among various kinds of II-VI compound semiconductors, CdS is widely studied due to the band energy (2.4ev) existing in the visible region[2] which is suitable for photovoltaic cells[3] and light emitting diode[4]. A significant amount of current research is aimed at using the unique optical properties of quantum dots in devices such as LED, solar cells and biological marker. However, the use of the quantum dot properties requires sufficient control during synthesis because their intrinsic properties are determined by different factors such as size, impurities, shape, defect and crystallinity. Substantive efforts have been made in the last decade to synthesize CdS thin films by several methods such as electrochemical synthesis[5], chemical bath deposition[6],solvothermal route[7],chemical vapour deposition[8], spray pyrolysis[9] etc. The methods of preparation of CDS also have significant impact on the thickness, particle size which is important for photo catalytic applications. CdS is an interesting material for quantum dots because it is a direct band gap semiconductor with band gap of 2.42eV. By tailoring its composition and size, or surface functionality, it is possible to enhance luminescence emission and quantum yield of the quantum dots. [10]

In the present work, a chemical dipping technique has been utilized to synthesize the Cadmium sulphide quantum dot. The technique is referred to as successive ionic layer adsorption and reaction (SILAR) which is a step-wise process of chemical deposition. SILAR is generally reported for preparation of thin films of cadmium sulphide[11] and other compound semiconductor. It is a unique method in which thin films of compound semiconductor can be deposited by alternate dipping of a substrate into separately placed aqueous cationic and anionic precursors. Between every immersion the substrate is rinsed in water. This method provides the control of the film thickness at atomic level.

## II. Materials & Methods

All reagents used for the synthesis of cadmium sulphide quantum dot were of analytical grade and were used without further purification.

Materials: Titanium oxide ($TiO_2$) from Solaronix, Cadmium acetate from BDH reagent, aqueous ammonia, ethanol, aqueous polysulphide, substrates and distilled water.

Preparation of $TiO_2$Thin Film: The $TiO_2$ was screen printed on the substrate and annealed at $450^oC$ for about 40mins, after which it was allowed to cool gradually.

Cationic Precursor: The cationic precursor was prepared by putting 0.1M of Cadmium acetate in a 100ml beaker to which 40ml of distilled water was added followed by a gradual addition of 10ml of aqueous ammonia. Then 50ml of absolute ethanol was also gradually added to the solutionresulting in the formation of precipitates.

Synthesis of CdS Quantum Dot: The TiO2 film was dipped first in the cationic precursor for 20seconds, retracted and rinsed properly in distilled water for 20secs, dipped in the anionic precursor for 20secs and rinsed again for 20sec. This whole process completes one cycle of cadmium sulphide quantum dot deposition. The procedure was repeated for 6cycles at the end of which the CdS quantum dot was rinsed thoroughly, allowed to air dry and annealed at 150$^o$C. The deposition time was fixed at 80sec for each cycle.

## III. Results & Discussion

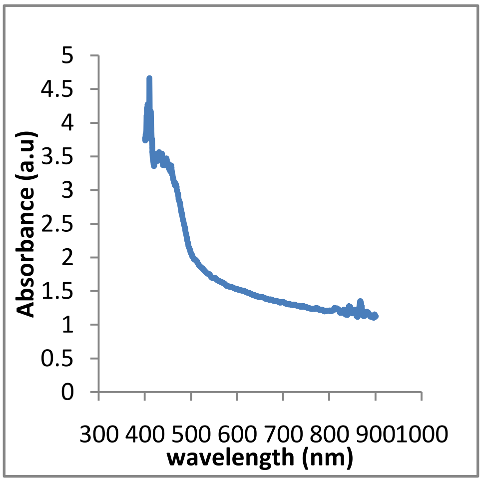
In the process of depositing the CdSquantum dot, the primary indicator of the successful deposition was the film colour change. At the end of the first cycle, the $TiO_2$ film colour changed from white to light yellow indicating sparse deposition of the Cds quantum dot. As the SILAR cycle increased, the colourchanged to deep orange.

The UV-visible absorption spectra of the CdS quantum dot were obtained with a UV-vis spectrophotometer Axiom UV752 in the range of 400nm-1000nm. $TiO_2$ film absorbs only in the ultraviolet range, ($\lambda$<375nm)[12]. Fig 1 presents the UV-visible absorption spectra of the CdS sensitized $TiO_2$. It indicates that sensitized film exhibits an absorbance at wavelengths higher than 400nm with the highest absorbance value at 410nm wavelength.

The absorbance of the CdS sensitized $TiO_2$ film at higher wavelength of 400nm and above confirms the growth of the CdS quantum dot (M.Ghazzalet.al.,2014). The value of the absorption coefficient is dependent upon the radiation energy as well as the composition of films. The band gap energy (Eg) was derived from the mathematical treatment of the data obtained from the absorbance Vs wavelength with the following relation;

$$\alpha h\nu = A(h\nu - Eg)^n$$

Where α is the absorption coefficient,hν is the photon energy, A is a function of refractive index and electron/hole effective masses and n is a constant depending on whether the material has direct or indirect band gap. The band gap was determined by extrapolating the straight line to base line where the value $(\alpha h\nu)^2$ is zero in the plot of $(\alpha h\nu)^2$ against hν as presented in Fig 2.



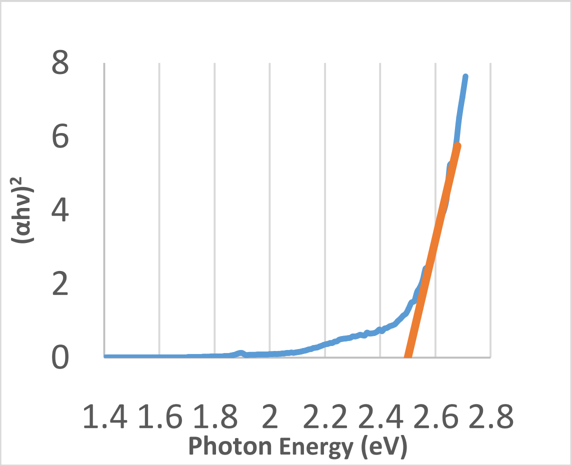


**Figure 1:** UV-vis absorption spectra of CdS/TiO2

Figure2: Absorption coefficient of the CdS/TiO2

The band gap of $TiO_2$ is 3.2eV which is larger than that of bulk CdS with band gap 2.42eV. However, the CdS sensitized $TiO_2$ film has band gap of 2.46ev as deduced from fig 2. This reduction in band gap of the CdS/$TiO_2$ is as a result of the absorbance of the film being redshifted to 410nm with increased deposition of CdS quantum dot. The 2.46eV band gap of the CdS/$TiO_2$ for 6cycles is consistent with the results of M. Ghazzal et al., 2014 for 7cycles.

## IV. Conclusion

The SILAR technique is the commonest technique for quantum dot deposition as it allows for control of dot size. The $TiO_2$ film was coated with tiny particles of CdS quantum dot whose size increased with the deposition cycle. The presence of the dot on $TiO_2$ was confirmed by the absorbance spectra response of the CdS sensitized $TiO_2$ and the reduced band gap from 3.0ev to 2.4ev. The absorption onset was at 410nm which is above the UV range within which the $TiO_2$ can absorb light.

## References

[1]. D. Bera, L. Qian, T. Tseng and P. Holloway (2010): Materials 3, 2260-2345

[2]. X. Fan, M.L. Zhang, I. Shafiq, W.J Zhang, C.S. Lee, And S.T. Lee (2009): Crystal Growth Des.,9,1375

[3]. P.V.Kamat (2008): J.Physic.Chem. C, 112, 18737

[4]. J.L.Zhao, J.A. Bardecker, A.M. Munro, M.S. Liu, Y.H. Niu, I.K Ding, J. D. Luo, B.Q Chen, A.K.Y Jen And D. Ginger (2006): Nano Lett., 6, 463

[5]. D.Mo, J.Liu, H.J.Yao, J.L. Duan, M.D.Hou, Y.M.Sun, Y.F.Chen, Z.H.XueAndL.LZhang (2008): Cryst. Growth,310,612

[6]. F.Liu, J. Liu, B.Wang, S.Kuang, Z. Zhang, J.Li, Y. Liu (2010): J. Alloys and Comp. 493, 305

[7]. J. Jang, U. Joshi and J. Lee (2007): J. Phys. Chem. C 111, 13280

[8]. A. Aabdi, L. Titova, L. Smith, H. Jackson, J. Yarrison-Rice, J. Lensch and L.Lauhon (2006): Appl. Phys. Lett. 88, 43118

[9]. S. Ikhmayies and R. Ahmad-Ritar (2010): Appl. Surf. Sci. 256, 3541

[10]. L. Liu, Si Hu, Y. Pan, J. Zhang, Y. Feng and X Zhang (2014): Beilstein J. Nano. 5, 105, 919

[11]. M. Sasagawa and Y. Nosaka (2001): Phys. Chem. C. 3, 16, 3371

[12]. M. Ghazzal, R. Wojcieszak, G. Raj and E. Gaigneaux (2014): Beilstein J. Nano. 5, 68

N.I Azubuike1" Synthesis And Characterization of Cds Quantum Dot By Silar Technique .” IOSR Journal of Applied Physics (IOSR-JAP) , vol. 10, no. 1, 2018, pp. 51-53.