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Electrical properties of light Emitting diode preparation fromFTO/CdSe (MPA)/ZnO artificial atoms emitting white color

Mohamed Anwar Batal[1], Kaesar Salah AL Yamani[2*]

[1]*Prof,* [2]*dr, department of Physics, Aleppo University, Syria*
Mbatal2001@yahoo.com[1],alyamani.k@gmail.com[2]

Abstract

Objective: To design Light Emitting Diode (LED) based on artificial atoms quantum confinement effect using spin coating method and to study its electrical properties to determine emission wavelength and emit color of this LED.

Methods: This LED was prepared using spin coating and all layers were prepared by chemical method. By using Keitithley (28775) Current-voltage characteristic was carried out at room temperature in direct and reverse bias,*C-V*characteristic measurements was carried out using RLC meter (6379) at 100 Hz Frequency. Tunneling conductance spectra was measured also using RLC meter.AC measurement (impedance spectra) was carried out using Gain Phase Analyzer (Schlumberger-SI1253). A complex impedance Spectrum was in a frequency range (1-20000HZ) and at constant voltage (V=5V).

Finding: FTO micro Slide with low resistance (10-13Ω) using hot spray, CdSe (MPA) was prepared using chemical method and ZnO was prepared using sol-gel method. I-V characteristic was used to determine ideal factor (which was 18) and reverse current (0.44 mA). C-V spectra shows multi high barrier in this structure due to quantum confinement effect. Electronic transition in tunneling conductance spectra are indicated with electronic transition in absorption and PL spectra. Impedance spectra confirm the quantum size effect in layers of LEDs and interpret white color emission.

Improvement: We can enhance performance of this LED by adding active layer of artificial atoms acting as hole transporting layer to increase emitting green and red color, which enhances the intensity of white color clearly**.**
Keywords: CdSe, artificial atoms, LED, electrical properties, tunneling conductance spectra.

1. Introduction

Quantum Dots (QDs) (artificial atom)are quickly emerging as the next major technology in the solar industry [1].They provide unique properties that can be easily manipulated to suit specific application requirements. QDs were first discovered in the early 1980s and have been attracting a surge of interest related to their application in photovoltaic in the last ten years [2]. While group II-VI and IV-VI cadmium or lead-based QDs have been the focus of greatest interest, other materials such as groupI-III-VI semiconductors combining group I (Cu, Ag), group III (Al, Ga, In, Tl), and group VI (S, Se, Te) elements have been identified as potentially less toxic materials [3]. Products containing cadmium or lead are hindered by environmental regulations. Considering the quantum confinement effect of I-III-VI semiconductors cover a broad range of optical and electronic properties with tunable band gaps covering and emitting a wide wavelength ranging from the near-infrared region, through visible, to the UV region [4]. This makes artificial atoms of semiconductor an excellent candidate for use in LED applications [5].

In this research, we show a new technique to prepare artificial atom as an active layer in light emitting diode multi layers. N-type of CdSe capped with (MPA) in LED multi layers acts as active layer to fabricate first type of quantum confinement. Electrical properties of this LED were studied using AC and DC measurement.

2. Materials

Microscopic Slides, $K_2Cr_2O_7$ for cleaning glass slides, HF (fluoric acid), SnCl2.2H2O, Ethylenglycol, metapraponic acids (MPA), CuCl2,KI , Se powder , $Cd(CH_3COO)_2$.$4H_2O$,Hydrazine, deionized water 2.1.***2.1.***

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Synthesis of FTO/ZnO/CdSe (artificial atoms) /FTO

2.1.1. Preparing Transparent Conducting Fluoride Tin Oxide (FTO)

We treat Microscopic slides with $K_2Cr_2O_7$, the surface of slides was activate by submerge it in diluted fluoric acid (HF) for 10 minutes. After that it was heated in electrical oven to $500C^{\circ}$ [6]. Tin chloride dissolved in 20ml of Ethylene glycol and sprayed on Microscopic slides for a lot of time [7]. The deposited resistance of FTO was low $(13-40)\Omega$.

2.1.2. Preparation ZnO

ZnO Colloidal solution was prepared by dissolving 0.1 mol of $(CH_3COO)_2Zn.2H_2O$ in 100ml of ethanol and heated to $50C^{\circ}$ [8] .

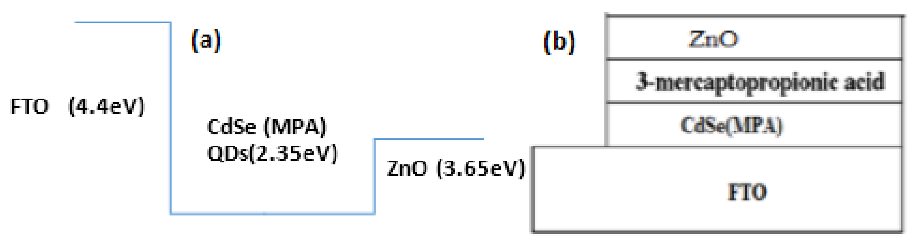
2.1.3. Preparation CdSe artificial atoms

Depending on chemical solution method CdSe Artificial atoms was prepared by0.1 mol of Cadmium Citrate (Cd $(CH_3COO)_2 .4H_2O$)solution prepared as cadmium source(solution A). Sodium selenosulfate (Na_2SeSO_3) 0.1 mol solution was prepared using refluxing method at70 C° for 3 hours as solution (B). 20 ml of solution (A) was added to 5 ml of solution (B). After that we added5ml of ethylene glycol and 5ml hydrazine hydrate to the mixed solution (A,B). CdSe colloidal solution was adjusted to 10 by adding 1 ml NaOH solution [9].

2.2. Preparing FTO/ZnO/CdSe (artificial atoms) /FTO

Using spin coating method FTO/ZnO/CdSe (artificial atoms) /FTO was prepared as shown in Figure 1.

Figure 1a.Energy diagram of quantum well confinement of structure (b) box layer diagram of FTO/CdSe (MPA)/MPA/ZnO.

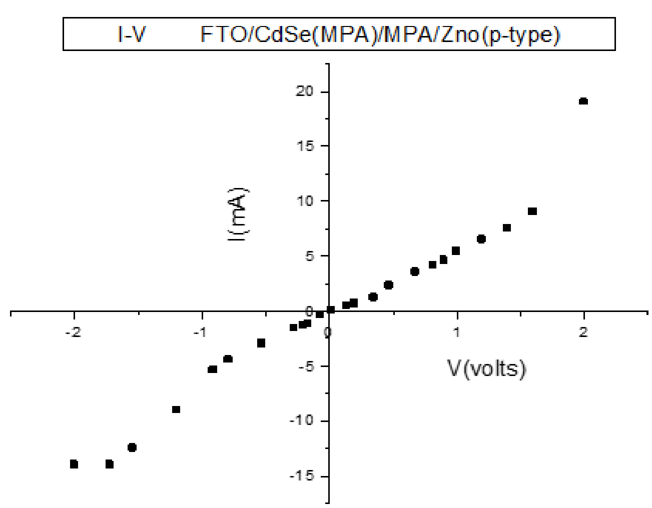


3. Results and discussion

I-V characteristic of FTO/ZnO/CdSe (MPA)

Using keitithley (28775) Current-voltage characteristic was carried out at room temperature. As revealedin Figure2,the maximum value of current was 20 mA at 2 V in direct bias and 15 mA in reverse bias.

Figure 2. I-V characteristic of FTO/CdSe(MPA)/ZnO.



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Calculation of Reverse saturation current and junction ideality factor of FTO/ZnO/CdSe (MPA) artificial Atoms

Current equation of Shockley diode reveals exponentially variation between current and voltage as shown [10]:

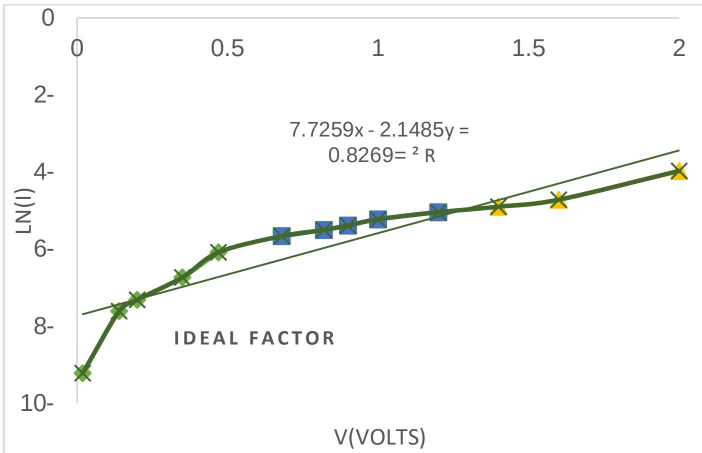
$$I = I_0\left(\exp\left(\frac{qV}{nKT}\right)-1\right) \qquad (2)$$

Where q is electron charge, I_0 is reverse saturation current, n is junction ideality factor, K is Boltzmann constant and T is absolute temperature. By reforming above equation by taking logarithm:

$$Ln(I) = Ln(I_0) + \frac{qV}{nKT}$$

By plotting Ln(I) as function of V as shown in Figure 3, Ideal factor can be calculated from a slop, saturation current can be calculate from y-intercept [11]. Ideality factor and reverse saturation currents were found to be (n=18, I_0=0.44 mA at room temperature.

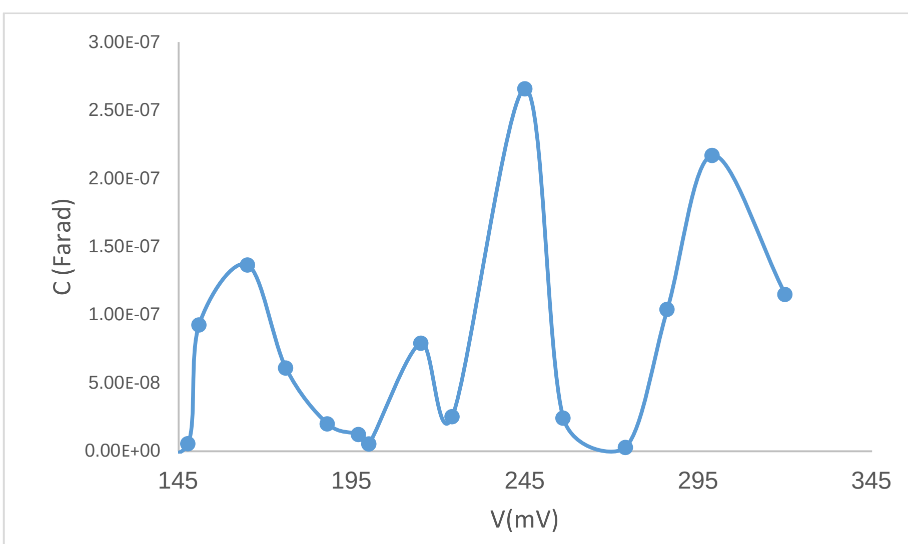
Figure 3. ln(I)-applied voltage characteristic.



Capacitance versus Voltage characterization of FTO/ZnO/CdSe (MPA) artificial Atoms

At room temperature *C-V* characteristic measurements were carried out using RLC meter (6379) at 100 Hz Frequency. Several fluctuation appeared (Figure4) for FTO/ZnO/CdSe (MPA) artificial Atoms that means multi quantum well (high barriers)was formed in this structure [12].

Figure 4. C-V spectra of FTO/CdSe (MPA)/ZnO

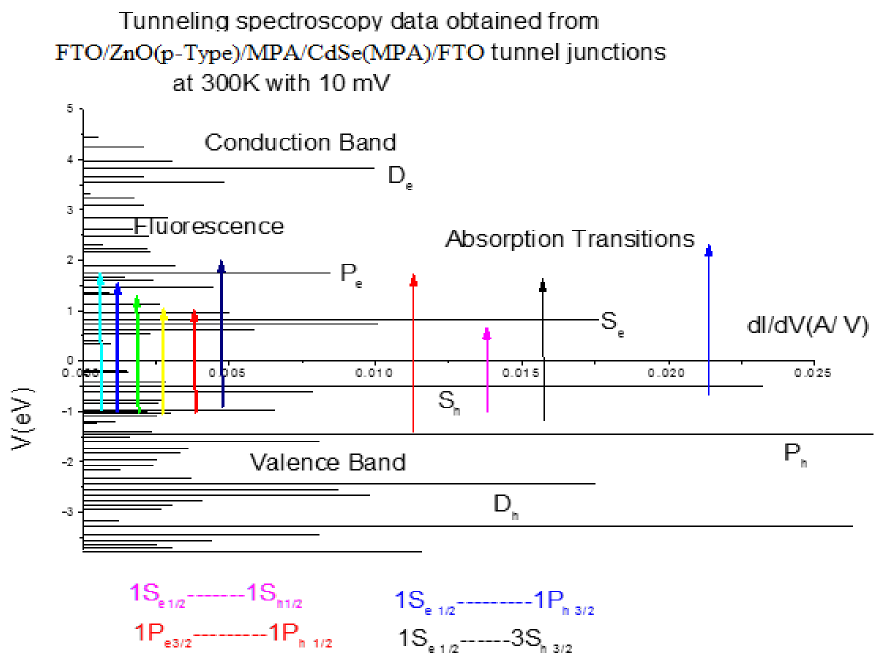


It is clear that there are multi high barrier in system FTO/CdSe (MPA), which means tunneling conductivity was well dominated in wide range of frequency with variation of volts due to quantum confinement in this system.

Tunneling Spectra of FTO/ZnO/CdSe (MPA) artificial Atoms

The tunneling current (I) and conductance (dI/dV) were obtained at 300K as shown in Figure 5. The conductance spectra were also compared with Spectra obtained from absorption and florescence spectra. dI/dV Spectra was measured between applied bias voltage -4 and 4V. In general, the conductance spectra were very reproducible, although discrete shifts of the spectra along the voltage axis observed in some cases. Trapping of a charge in the surroundings of the artificial atoms that acts as alocal "gate" can lead to a shift of all there sonances [13].

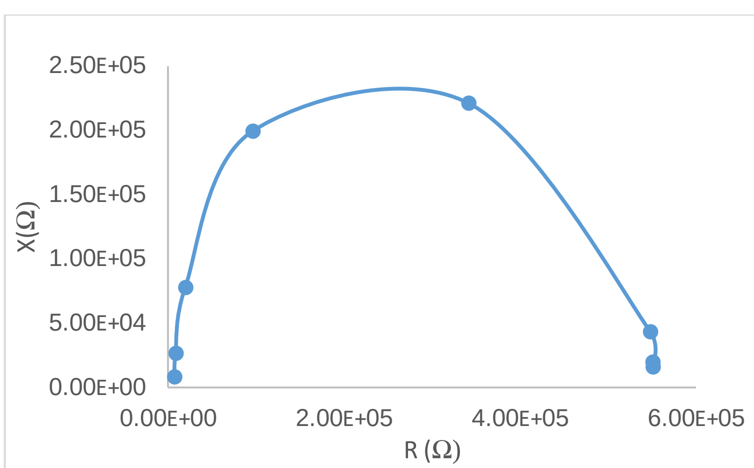
Figure 5. Tunneling conductance spectra of FTO/CdSe (MPA)/ZnO



Impedance spectroscopy of system FTO/ZnO/CdSe (MPA)

AC measurement was done out using Gain Phase Analyzer (Schlumberger-SI1253). A complex impedance Spectrum was in frequency range of (1-20000HZ)andatconstantvoltage(v=5V).Figure 6 shows the impedance spectra of the FTO/CdSe (MPA)/ZnO artificial atoms measured under forward bias (1 V) and light conditions.

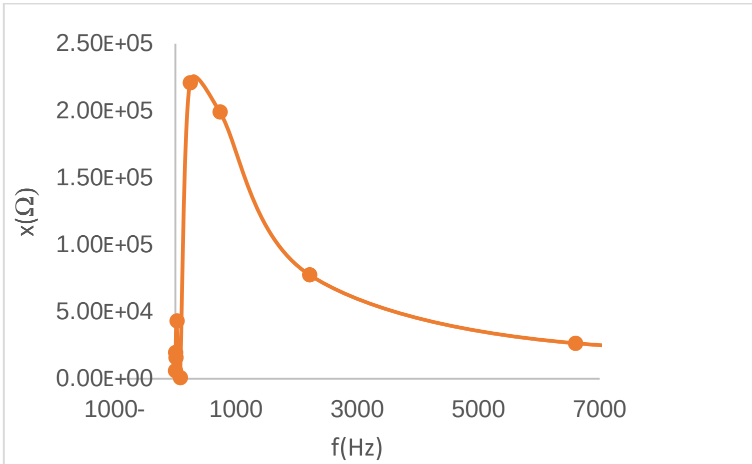
Figure 6.Impedance spectra of FTO/CdSe (MPA)/ZnO.



We noted that impedance spectrum has a semicycle which means that it is due to Debye Modelwhichinvolves th e grainto behomogenous. By taking variation of X as function of frequency as shown in Figure 7. The curve peak of the spectrum shows the electron lifetime in the FTO/ZnO/CdSe (MPA) core shell according to the following equation [14]:

$$X_C = \frac{1}{\omega C} \Rightarrow f = \frac{1}{2\pi X_C C}$$

Figure 7. X-f spectra of FTO/CdSe (MPA)/ZnO



4. Conclusion

Light emitting diode emits white color(due to quantum size effect)which consists of multi quantum layers, and CdSe (MPA)core shell was active layer sandwich between two layers FTO and ZnO. Energy of Electronic transitions in the Tunneling conductance spectra has corresponding absorption and PL spectra. Impedance spectra shows that prepared artificial atoms was inhomogeneous size, which confirms quantum confinement in first type of core shell in FTO/CdSe (MPA)/ZnO structure.

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