Study Characterization of White Light Generation from Light Emitting Device

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ABSTRACT

From the previous work one can summarized the conclusions as follows:

Fabrication of EL-device from semiconductors material (ZnS QDs) with hole injection organic polymer (TPD) was effective in white light generation and can be the color of emerged light. After adding the Alq3 layer of the hybrid device form ITO/TPD:PMMA/ZnS QDs/Alq3/Al was obtained as follows:

1. The alignment of OLED between two organic molecules leads to the generation of high energy improves the properties of the hybrid device.
2. The output current from I-V characteristics is good compared that with Alq3 few voltages (at 6V).
3. Recombination processes would give rise to the forward bias current flow is faster.
4. The intensity emission of EL hybrid device is very high.
   White light generated is very clear and high efficiency

Keywords: Operational-investigative activity, customs crimes, crimes in the field of customs activities, operational departments of customs authorities semiconductors material , injection organic polymer

Introduction

Hybrid organic-quantum dot light-emitting devices (QDLEDs) combine the color purity and durability of QDs with the efficiency, flexibility, and low processing cost of (OLEDs) The organic light-emitting diode (OLED) has displayed significant potentiality in the applications of flat panel display and lighting, which is mainly because of its low power consumption .

The QD/polymer hybrid devices can be made also by blending the QDs into a host polymer matrix. In this case, the single QD/polymer hybrid layer can be made simply by the solution process when both of the QDs and the host polymer have high solubility in the same solvent . Polymer matrix is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials. The polymer matrix materials have wide applications among these applications is considered to enhanced of light emitter in LED.

Highly luminescent II-VI semiconductor nano-crystals or colloidal quantum dots (QDs) are interesting materials because of their applications in optoelectronics, nonlinear optics, and biology . One of the important characteristics of nanocrystalline semiconductors concerns the influence of the surface on the optical and electrical properties, and the need to embed semiconductors clusters in a passivating medium .

Monochrome QD-LEDs with lower efficiencies have also been fabricated using inorganic transport layers, which replaced some of the environmentally sensitive organic films Specifically, the QD-dominant EL spectra indicate the QD emission is mainly from the direct injection and radiative recombination of carriers rather than the radiative and nonradiative (Förster) energy transfers from excitons in organic materials .

The doped QDs play a role in improving the charge balance in the host matrix as electron trapping sites as well as in increasing luminance as excitons trapping sites via Förster energy transfer (is a mechanism describing energy transfer between two light-sensitive molecules) [8]. In general, their properties make QDs attractive materials for fabrication of hybrid semiconductor QDs organic LEDs with a highly saturated emission color. All these unique properties have made semiconductor QDs promising candidates for developing high-performance and low-cost light sources for a broad range of applications .

There are two main classes of OLED devices: those made with small organic molecules and those made with organic polymers. OLEDs have the unique properties of lightweight, flexible, transparent and color tune ability, which makes them an ideal modern light source

An OLED is a solid-state semiconductor device that is 100 to 500 nanometers thick and consists of a conducting layer and an emissive layer, all together sandwiched between two electrodes and deposited on a substrate .

The conducting layer is made of organic plastic molecules that transport "holes" from the anode. The emissive layer is a film of organic compound that transport electrons from the cathode and emits light in response to an electric current as shown in figure (1.1).

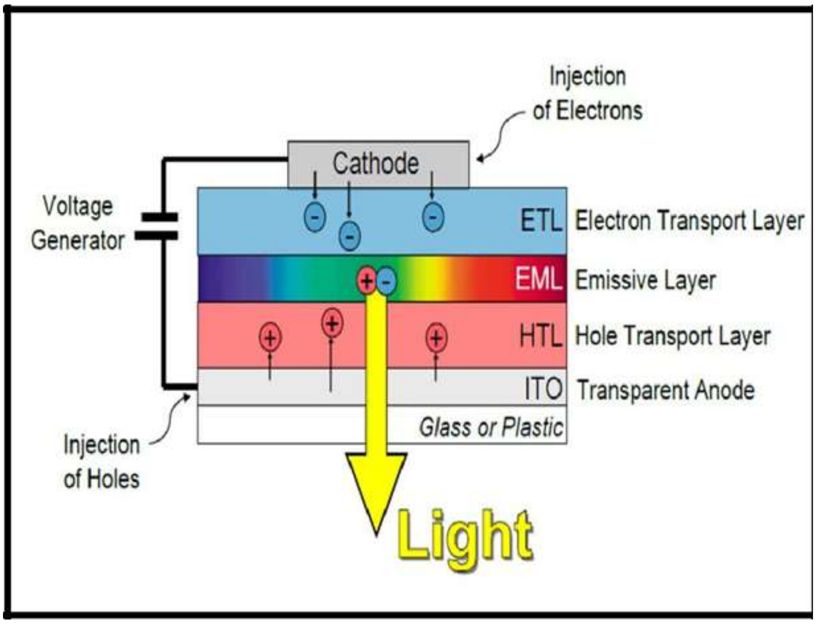


Figure (1.1): Light emitting device structure

Transparent Anode films are thin films of optically transparent and electrically conductive material. While indium tin oxide (ITO) is the most widely used, alternatives include other transparent conductive oxides (TCOs) .

The organic layers consist of a hole transporting layer (HTL), an emissive layer containing a dopant and a host material, and an electron transporting layer (ETL). When a potential is applied, the injected positive and negative charges recombine in the emissive layer to produce light (electroluminescence) .

Under the influence of an applied electric field, the injected holes and electrons each migrate toward the oppositely charged electrode following a hopping transport regime which consists in a series of "jumps" of the charge from molecule to molecule. In the organic emissive layer (EML), when an electron and hole localize on the same molecule are spatially close, a fraction of them recombine to form an exciton (a bound state of the electron and hole); which is a localized electronhole pair having an excited energy state The electronic structure of colloidal QDs, which typically range from 3-12 nm in diameter, is dominated by quantum size effects. This gives colloidal QDs their signature narrowband emission that can be spectrally for example ZnS QDs of different sizes provide emission from the blue through the red, while QDs made of a larger band gap material .

The electroluminescent (EL) performance of QD-LEDs using ZnS QDs can be improved by the optimization of device structure and materials for the carrier balance in the multi-layered LED structure .

1.2 Recombination

Recombination is a process in which the electrons combine with holes in one or multiple steps and eventually disappear. The energy difference between the initial and final state of the electron is released and can leads to one or more possible classification of the recombination processes, e.g. radiative recombination, Auger recombination and Shockley-Read-Hall recombination (SRH), as shown in figure (1.2)

1.2.1 Radiative Recombination (Band to Band Recombination)

In radiative recombination the electron in the conduction band directly combines with the hole in the valance band and releases a photon therefore it is also called band to band recombination. The light produced from a light emitting diode (LED) is the most obvious example of radiative recombination in a semiconductor device .

1.2.2 Auger Recombination

In Auger recombination the electron and a hole recombine, but no electromagnetic radiation is emitted, and the excess energy and momentum of the recombining electron is given up to another electron. Auger recombination is mostly important at high temperatures and in heavily doped materials.

1.2.3 Shockley-Read-Hall Recombination or (Trap-Assisted Recombination)

Recombination through defects or Shockley-Read-Hall (SRH) recombination occurs when an electron trapped by defect level within the band gap. One can envision this process as a two-step transition of an electron from the conduction band to the valence band [20].

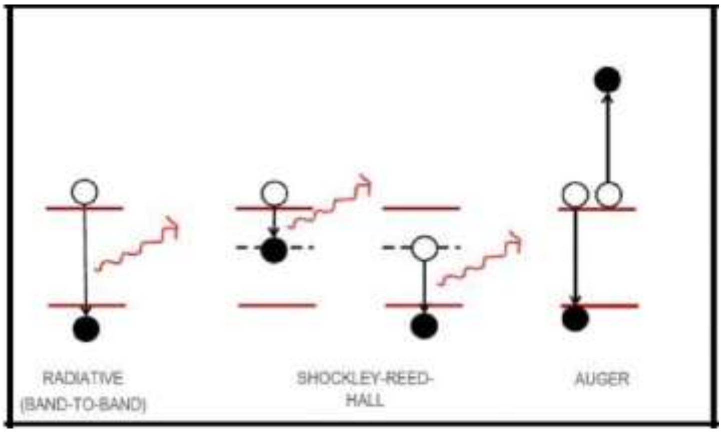


Figure (1.2): Carrier recombination mechanisms in semiconductors [20].

1.3 Sources of Light Generation

1- Incandescence: is light from heat energy. If you heat something to a high enough temperature, it will begin to glow. When an electric heater or metal in a flame begin to glow (red hot), that is incandescent. When the tungsten filament of an ordinary incandescent light bulb is heated still hotter, it glows brightly white hot by the same means. The sun and stars glow by incandescence. The incandescence light bulb invention in 1879.

2- Luminescence: is cold light that can be emitted at normal and lower temperature. In luminescence, some energy source kicks an electron of an atom out of its lowest energy (ground state) into a higher energy (excited state); then the electron returns the energy in the from of light, so it can fall back to its ground state. With few exceptions, the excitation energy is always greater than energy (wavelength, color) of the emitted light. This can be classified into .

A- Fluorescence and **Photoluminescence** are luminescence where the energy is supplied by electromagnetic radiation.

B- Electroluminescence is luminescence caused by electric current.

C- Cathodluminescence is electroluminescence caused by electron beams; this is how television pictures are formed.

3- Radioluminescence that describes excited by other fast particles or high

energy radiation.

1.4 Quantum Confinement in Semiconductors

Quantum confinement is responsible for the increase of energy difference between energy states and band gap. A phenomenon tightly related with the optical and electronic properties of the materials.

A particle behaves as if it was free when the confining dimension is large compared to the wavelength of the particle During this state, band gap remains at its original energy due to continuous energy state. However, as the confining dimension decreases and reaches a certain limit, typically in nanoscale, the energy spectrum turns to discrete. As a result, band gap becomes size dependent i.e. band gap increase when particle size decrease .

In unconfined (bulk) semiconductor, an electron-hole pair is typically bound within a characteristic length is called the exciton Bohr radius. If the electron and hole are constrained further, then the semiconductor's properties change. This effect is form of quantum confinement, and it is a key feature in many emerging electronic structures .The quantum size confinement effect becomes significant particularly when the particle size becomes comparable to or smaller than the excitons Bohr radius, a_B, which is given by .

$$a_{B}=\frac{\xi\varepsilon h^{2}}{\pi\mu e^{2}} \quad (1.1)$$

where an an the permittivity of vacuum an is Plank s constant e is the electron charge an hole (m_h):

relative permittivity of the semiconductor

μ is the reduced mass of the electron (m_e) and

$$\frac{1}{\mu} = \frac{1}{m_e^*} + \frac{1}{m_h^*} \quad (1.2)$$

Such bound electron-hole pair is often referred to as an (Mott- Wannier) exciton, and can be described in a similar way to the hydrogen-like bound state between the proton and the electron of the hydrogen atom. The spatial occupation of an exciton can be expressed in terms of an exciton Bohr radius (a_B) .

$$a_B = \frac{4\pi\varepsilon_r\hbar^2}{m \cdot e^2}\left(\frac{1}{m_e^*} + \frac{1}{m_h^*}\right) \quad (1.3)$$

where $_r$ is the relative dielectric constant of the medium and ħ is the reduced Planck constant or Dirac constant. When the particle size approaches that of the exciton Bohr radius, the exciton wave function becomes confined by the spatial limitations of the crystal.

Three different types of confinement that have been realized among inorganic semiconductors are described below and shown in figure (1.3).

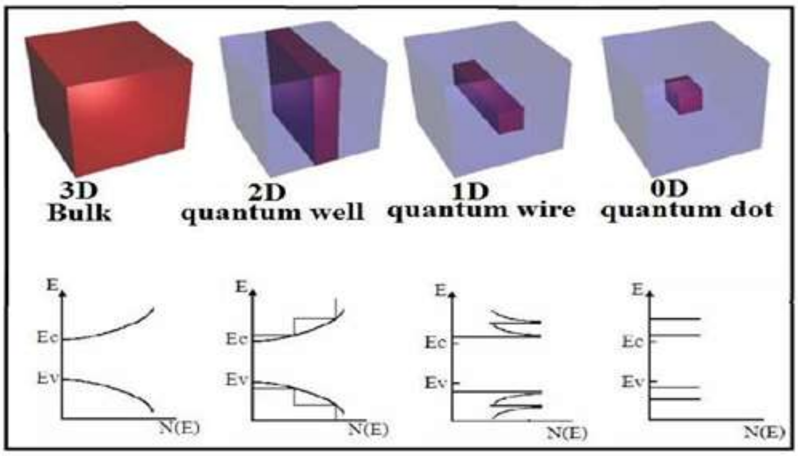


Figure (1.3): Simplified representation of the density of states in 3D, 2D, 1D and 0D semiconductor [28].

The formation of discrete energy levels can be clearly observed in absorbance spectra of colloidal NPs with decreasing size in figure (1.4a). The figure shows the presence of clear an excitonic absorption peak, followed by a second and third absorption feature as a result of the formation of discrete transitions above the band gap.

1.5 Solid State Lighting (SSL)

Solid state lighting (SSL) based on inorganic semiconductor light emitting diodes (LEDs) has the potential to fundamentally change the nature of lighting that people have experienced over the last 100 years.

1.5.1 Photoluminescence

Generation of light from nanoparticles illuminated by UV-LED, where utilized from the defect states in nanoparticle. Since the nanostructure have a large number of surface atoms compare with the bulk. Thus the characteristics of the surface atoms have more effect on the main physical and chemical properties of the material .

1.5.2 Electroluminescence

Electroluminescence devices are the devices that convert electrical energy into optical radiation. As important semiconductor light source, EL devices have found widespread use in myriad areas in our daily lives as well as scientific fields like communication and medicine

The emission of radiation results from the combination of the minority carriers injected by the electric current with majority carriers [30]. A LED is a semiconductor p-n junction. When the junction is forward biased, minority carriers will be injected to the junction from both sides. Recombination will take place at the vicinity of the junction with the release of photons .

The ideal current-voltage (I-V) characteristic of a p-n junction follows the equation of

Shockley diode equation

$$\mathbf{I} = \mathbf{I_s}\left(\mathbf{e}^{\frac{eV}{nk_BT}} - \mathbf{1}\right) \quad (1.5)$$

where k_B is the Boltzmann's constant, V is the bias voltage, T is the temperature, I_s is the

reverse saturation current, n is the ideality factorand k_BT/q is the thermal voltage

(VT=26mV) The energy of photons emitted from the semiconductor is approximately

equal to the band gap energy

E_g, i.e.

$$E_g = hv \Rightarrow E_g(eV) = \frac{1240}{\lambda(nm)} \quad (1.6)$$

where υ is the frequency of the photon The conservation of energy requires that the energy of the injected electron is equal to the photon energy. So, the diode voltage V_d can be given by [30]:

$$V_d = \frac{hv}{e} = \frac{E_g}{e} \quad (1.7)$$

The emission corresponding closely in energy to band gap is just one type of recombination transitions. There are also transitions involving chemical impurities or physical defects, in which the energy of the emitted light is smaller than the band gap energy [30].

The LEDs available on the market have plenty of color options ranging from ultraviolet to infrared. The lights of different colors are related to different wavelengths.

1.6 Types of EL Devices

There are three types of EL devices, namely .

1.6.1 Inorganic Light Emitting Devices

Light emitting diodes (LEDs) were developed in the 1960s as an outgrowth of semiconductors technology. The devices emit light when a forward bias voltage is applied to P-N junction in a single crystal of II-VI compounds. The use crystals containing III-V materials, it is possible to produce emissions of red, green and blue light .

When a doped semiconductor contains mostly free holes it is called "p-type", and when it contains mostly free electrons it is known as "n-type". The semiconductor materials used in electronic devices are doped under precise conditions to control the concentration and regions of p- and n-type dopants. A single semiconductor crystal can have many p- and n-type regions; the p–n junctions between these regions are responsible for the useful electronic behavior .

Heterojunction occurs when two differently doped semiconducting materials are joined together. This results in an exchange of electrons and holes between the differently doped semiconducting materials. The n-type would have an excess of electrons, and the p- type would have an excess of holes .

The transfer occurs until equilibrium is reached by a process called recombination, which causes the migrating electrons from the n-type to come in contact with the migrating holes from the p-type. A product of this process is charged ions, which result in an electric field .

The recombination can be non-radiative with indirect band gap semiconductors or radiative for direct band gap semiconductors The LED uses direct band gap semiconductors and the wavelength of the emitted light depends thus on the energy gap of the semiconductor materials .

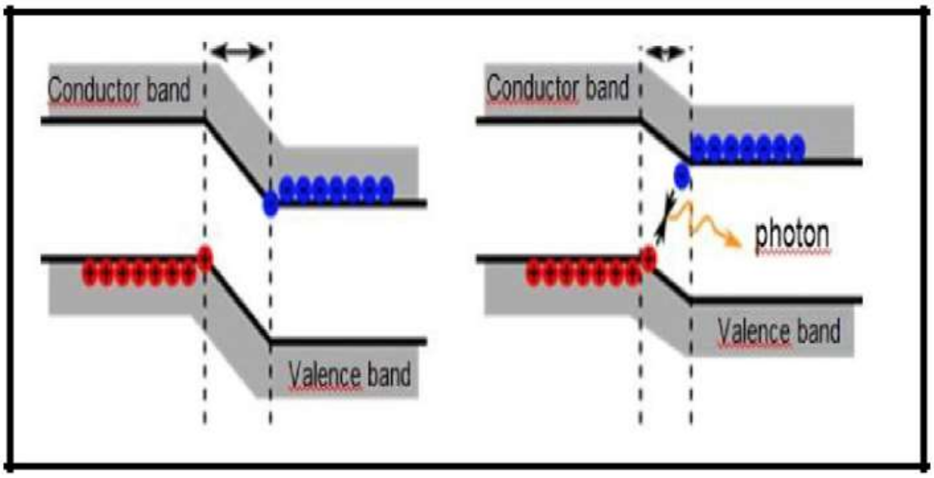


Figure (1.4): Schematic energy band diagram shows charge carriers injection [36].

1.6.2 Organic Light Emitting Devices (OLEDs)

The main enabler of the energy conservation effort will be new lighting technologies such as SSL (Solid State Lighting), specifically Light Emitting Diodes (LEDs) and Organic Light Emitting Diodes (OLEDs) .

SSL have the promise of replacing the existing light sources, and at the same time .

1. Contribute to the reduction of energy consumption.
2. Positively affect the greenhouse effect by reducing the emission of CO_2.

3. Create new industry and new jobs.

OLEDs eventually displace area (distributed) sources such as fluorescent lamps, but in many applications also incandescent lamps. OLEDs also create new lighting possibilities by enabling large area illumination sources, panels, ceilings, walls, partitions, fabrics etc.

OLEDs have all the attributes to effectively compete with incandescent and fluorescent lighting, because they will.

1. Be much more energy efficient.
2. Generate pleasing white light with high CRI (Color Rendition Index).
3. Enable "designer color" on demand.
4. Provide new design opportunities for architects.

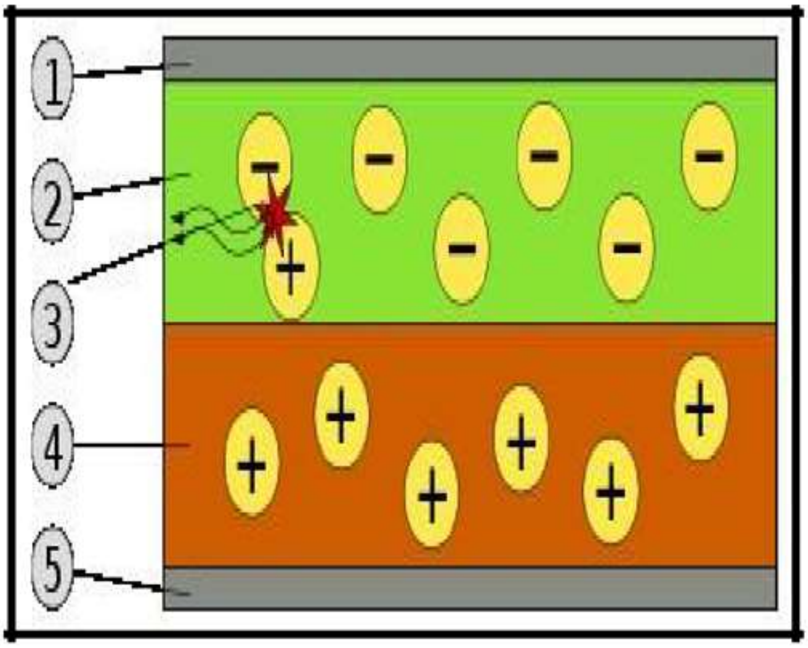


Figure (1.5): Schematic energy band diagram shows charge carriers injection and recombination in an organic light emitting diode (1) Cathode (2) Emissive Layer (3) Emission of Radiation (4) Conductive Layer (5) Anode .

Another advantage of OLED is that they are current-driven devices, where brightness can be varied over a very wide dynamic range and they operate uniformly, without flicker. All this has created a great deal of optimism that OLEDs will be accepted and welcome by the general public - as long as they are inexpensive .

1.6.3 Hybrid Organic/QDs Light Emitting Devices

Hybrid organic light-emitting devices (HOLEDs) have been identified as a dominant new technology poised to realize the next generation of flat panel displays. OLED performance is exemplified by wide viewing angles, high color contrast, and low power consumption as compared to emissive liquid crystal displays .

Indeed, internal quantum efficiencies can approach 100% when organic phosphorescent molecules are use as the emitting materials. A significant challenge of to ay's OLED technology remains the identification and synthesis of organic lumophores compatible with electrically pumped device structures .

Only a handful of efficient and long-lived organic phosphors have been incorporated into laboratory devices, while the on going research is aimed at the chemical design of new molecules, especially in the blue part of the spectrum. As such, inorganic quantum dots (QDs) have generated interest in the OLED community as efficient alternative lumophores, whose saturated color emission can be tuned across the visible spectrum [.

1.7 Electroluminescence Mechanisms in QDs-LEDs

The EL is most frequently attributed to two processes, taking place at the same time; direct charge carrier injection into the particles and energy transfer from the host matrix or from organic support layers to the particles. Both processes result in formation of excitons on the nanocrystals and their defect sates, which recombine and emit light .

Also, surface defects in the crystal structure can act as charge carrier traps. Both processes result in formation of excitons on the nanocrystals and their defect sates, which recombine and emit light In case of nanoparticles embedded in an isolating host matrix or pure inorganic LED without additional organic support layers. The excitons formation may not purely be attributed to direct charge carrier injection, but impact ionization has to be considered as well The EL mechanisms in NC-LED or QDs-LED are briefly introduced in the following sections.

1.7.1 Direct Charge Injection

The exact operating mechanism of QDs-LEDs has been a major area of study. Three theories exist to describe exactly how excitons are generated in the QDs layer of the device

In the first, electrons and holes are injected directly into the QDs from the cathode (Metallic Contact) (Me) and Transparent Conductive Oxide (TCO) respectively. However, the band alignments are such that there is typically a large barrier to hole injection from most organic semiconductors materials, into most QDs materials .

A second possible method for exciton formation is to first from the excitons on one of the organic materials and then Förster transfer them to the QDs. A third the resulting efficiency of the LEDs depends on a careful alignment of the charge injection layers according to the valence and conduction band position of the active light emitting nanocrystals as well as balanced hole electron injection as shown in figure (1.6) . Work done on LEDs with inorganic charge transport layers suggest that these all organic/inorganic device operate primarily by mean the direct charge injection mechanism, however, evidence from hybrid organic/inorganic devices could be interpreted as supporting either of the proposed mechanism .

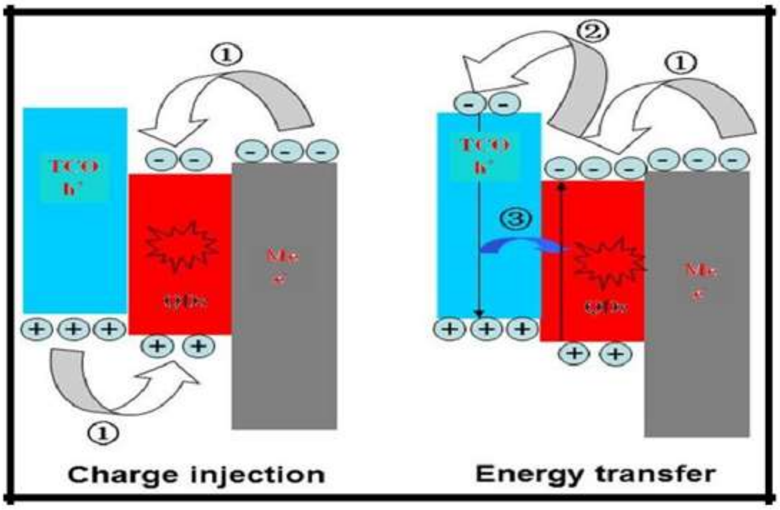


Figure (1.6): Schematic diagram of the direct charge injection mechanism for the organic hybrid or inorganic-QDs LED

1.7.2 Exciton Energy Transfer

The interaction energy between the organic molecules imposes embodies in a quasi-particle called an exciton. Two types of exciton considered here are the Frenkel and charge-transfer exciton. The Frenkel exciton is a correlated electron-hole pair localized on organic molecule, with radius comparable to the size of the organic molecule .

A charge transfer exciton is un-relaxed pair with the positive and negative polarons located on discrete, neighbouring organic molecules. In most organic hole and electron injection and transport layers, excitons can also be formed on the involved organic molecules shown in figure (1-7) .

In this case they are formed in close proximity to the embedded nanocrystals; their energy can be radiationless transferred to QDs Figure (1.7) shows, the charge carrier injection into organic layers, followed by excitons formation on the organic molecules and the energy transfer and excitons formation and recombination on the nanocrystals the excitons energy transfer process was proposed to the dominating effect in case of some organic – inorganic hybrid NPs-LEDs though the direct charge injection.

This process the formed excitons recombine radiatively frequently referred as Forster resonance energy transfer (FRET) is a mechanism describing energy transfer between two light sensitive molecules .

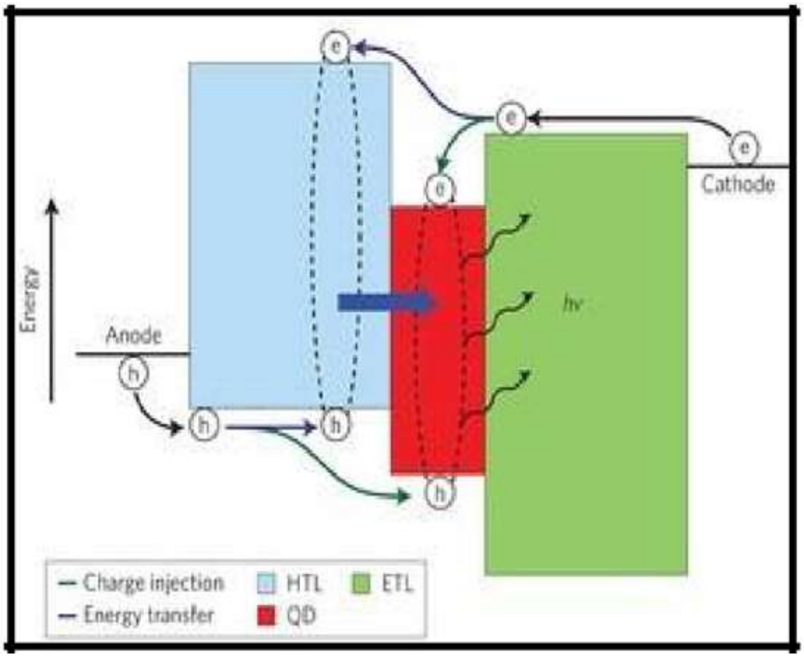


Figure (1.7): Schematic diagram of the exciton energy transfer mechanism for the organic-QDs hybrid LED [.

1.8 Current Transport Mechanisms in QDs- LEDs

The current-transport mechanism in these devices, such as metal–semiconductor, metal–insulator–semiconductor, light emitting diodes (LEDs), and solar cells, is dependent on various parameters, such as the process of surface preparation, formation of an insulator layer between the metal and semiconductor, Shockley barrier height (SBH) inhomogeneity,

impurity concentration of a semiconductor, density of interface states, defects, or dislocations .

In these devices, a number of carrier transport mechanisms, such as quantum mechanical tunnelling, thermionic-emission (TE), thermionic-field-emission, minority carrier injection, recombination–generation, and multi-step tunnelling, compete and usually one of them may dominate over the others at a certain temperature and in certain voltage regions. Tunnelling current and thermionic field emission are both considered as dominant current transport mechanism , On the other hand, determining the dominant mechanism can give a route for the efficiency improvement of the device performance, since the limiting factors can then be identified and influenced .

However, considerable carrier injection is necessary to achieve enough optical output from QDs-LED. Therefore, reducing the barrier thickness at value where direct tunnelling occurs could be a solution to decrease the driving-voltage, thus making more reliable devices .

1.9 Chemical Materials Properties

1.9.1 Zinc Sulfide (ZnS)

Amongst other II-VI bulk semiconductors, ZnS shows a prospect and opportunities for new applications in a wide variety of areas due to its direct wide band gap (3.4 eV at room temperature) with a large free exciton binding energy (~40 meV) and a small exciton Bohr

Table (1.3) shows basic physical properties bulk of ZnS

Table (1.3): Basic physical properties of ZnS bulk at R.T.

Parameters	ZnS	Parameters	ZnS
Band gap energy (eV)	3.3	Melting point (˚C)	1185
Electron mobility (nm^2/Vs)	180	Thermal conductivity	25.1
Hole mobility (nm^2/Vs)	5	Static dielectric constant	9.6
Exciton binding energy (meV)	40	Refractive index	2.35, 2.37
Lattice constant (nm)	a=0.382 c=0.626	Bulk Young's modulus E(GPa)	75
Density (g nm^{-3})	4.090	Electron effective mass	0.27m$_0$
	Wurtzite	Hole effective mass	0.59m$_0$

Stable Phase at R.T.	

There are four Zn atoms with equal distance surrounded by one S atom. The nearest neighbour bond lengths Zn-S are closely equal in the both cubic and hexagonal crystal structure as shown in figure (1.8) .

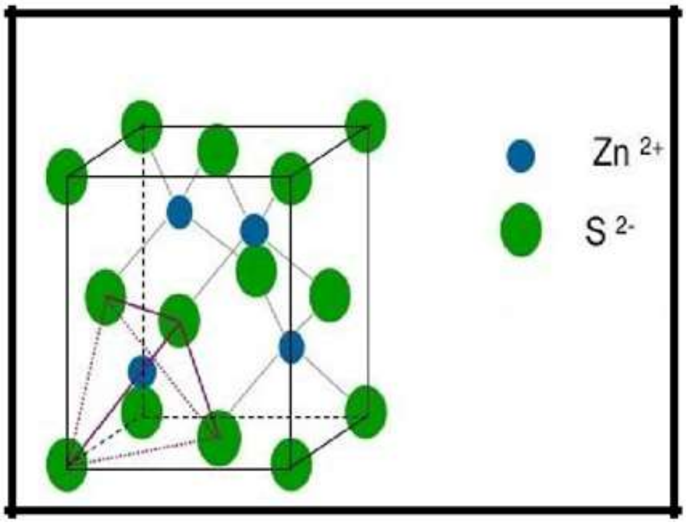


Figure (1.8): Structure of ZnS .

Zinc sulfide (ZnS) is a wide band gap and direct transition semiconductor Consequently, it is a potentially important material to be used as an antireflection coating for heterojunction solar cells and important device material for the detection, emission and modulation of visible and near ultra violet light.

In particular, ZnS is believed to be one of the most promising materials for blue light emitting laser diodes and thin film electro luminescent displays .

Zinc sulfide is an inorganic compound with the chemical formula of ZnS. This is the main form of zinc found in nature, where it mainly occurs as the mineral sphalerite. Although this mineral is usually black because of various impurities, the pure material is white, and it is widely used as a pigment. In its dense synthetic form, zinc sulfide can be transparent, and it is used as a window for visible optics and infrared optics .

1.10 Conductive Polymer

Conductive polymers or, more precisely, intrinsically conducting polymers (ICPs) are organic polymers that conduct electricity. Such compounds may have metallic conductivity or can be semiconductors. The biggest advantage of conductive polymers is their processability, mainly by dispersion. The electrical properties can be fine-tuned using the methods of organic synthesis and by advanced dispersion techniques. Since the late 1980s, organic light-emitting diodes (OLEDs) have emerged as an important application of conducting polymers [61].

The properties that make these conductors attractive include a wide range of electrical conductivity, which can be achieved with various doping level, while maintaining mechanical flexibility and high thermal stability. Even for rugged applications including LED lighting and electrical supercapacitors, conducting polymers have advantages over other materials candidates such as conductive metal oxide .

The linear-backbone "polymer blacks" (polyacetylene, polypyrrole, polyaniline, Poly (pphenylene vinylene and Tetra-Phenyl Diaminobiphenyl) its soluble derivatives have emerged as the prototypical electroluminescent semiconducting polymers.

Tetra-Phenyl Diaminobiphenyl is the most commonly used polymer among the phenyl family in light emitting device .

1.10.1 Tetra-Phenyl Diaminobiphenyl (TPD)

The chemical polymer of N,N8-Bis3-methylphenyl-N,N8-bisphenylbenzidine TPD like diamine serves as a hole transporting layer which enhances the hole injection and increases the quantum efficiency dramatically. The chemical structure of TPD is shown in figure (1.15) .

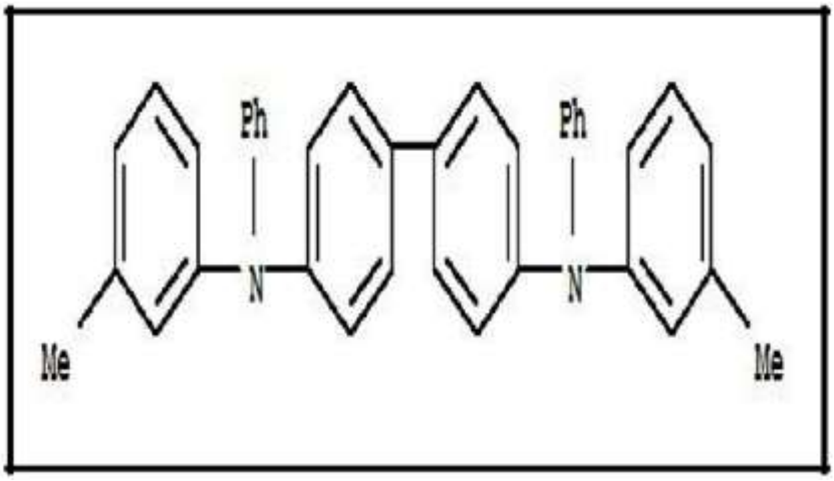


Figure (1.9): Repeating units of TPD .

A TPD series of novel styrene derived monomers with triphenylamine- ase units an their polymers have een synthesize an compare with the well-known structure of polymer of N N is(3-methylphenyl -N N-diphenylbenzidine with respect to their hole-transporting behaviour in phosphorescent polymer light-emitting diodes (PLEDs) [110]. In addition to the hole-transporting host polymer, the polymer blend includes a phosphorescent dopant [Ir(Me-ppy)3] and an electron transporting molecule (2(4biphenyl)-5-(4-tertbutylphenyl)-1,3,4-oxadiazole) .

The two polymers are excellent hole-transporting matrix materials for these blend systems because of their good overall electroluminescent performances and their comparatively high glass transition temperatures. Thus, the light emission of a conjugated polymer, generated by fluorescence, is restricted by spin statistics to an efficiency of 25%,

unless spin-dependent exciton recombination takes place TPD polymers charge-transporting materials have to meet a wide range of demands, primarily electronic characteristics in respect to efficiency and brightness, adaptable energy levels, high purity, availability, processability, high glass-transition temperatures, and a long-term stability. Table (1.4) shows basic physical properties of TPD polymer at room temperature .

Table (1.4): Basic physical properties of TPD polymer at R.T

Parameter	**TPD**
Chemical formula	**$C_{38}H_{32}N_2$**
Molecular Weight	**516.69**
Melting Point (°C)	**169**
Density (g/cm^3)	**1.149**

λ_{max} Absorption (nm)	374
λ_{max} Emission (nm)	431

1.11 Tris (8-hydroxyquinolinato) aluminium (Alq_3)

Organic materials show significant potential in future display applications from small area handheld telecom devices to large area displays due to their high luminance, low fabrication costs, ease to fabricate large area devices and the ability of adjusting the emission wavelength . Tris (8-hydroxyquinolinato) aluminium is the chemical compound with the

formula Al $(C_9H_6NO)_3$. Widely abbreviated Alq_3, it is a coordination complex where in aluminium is bonded in a bidentate manner to the conjugate base of three 8-hydroxyquinoline ligands .

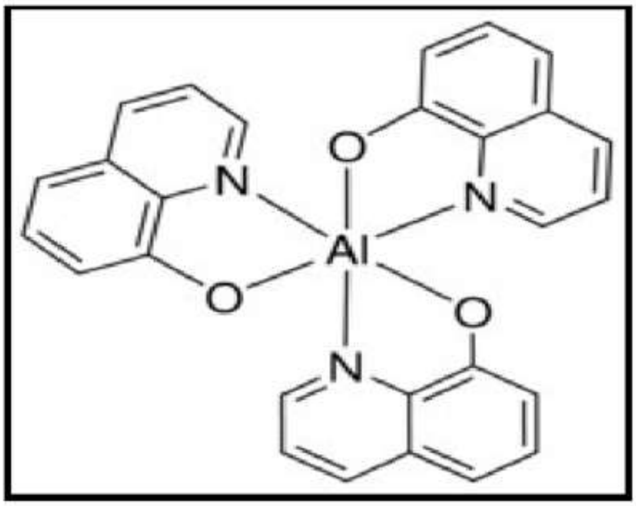
Tris-(8-hydroxyquinoline) aluminium (Alq_3) is one of the materials which are the most commonly used in molecular organic light emitting diodes (OLEDs). It is typically used as an electron-transport material and emitting layer. Variations in the substituents on the quinolone rings affect its luminescence properties which are given in table (1.5) .

Table (1.5): Basic physical properties of Alq_3 molecules at R.T.

Parameter	Alq_3
Chemical formula	C27H18AlN3O3
Molar mass	459.43

Melting point (°C)	**300**
λ_{max} Absorption (nm)	**392**
λmax Emission (nm)	**519**
[redacted]	[redacted]

In 1987 Tang and VanSlyke reported an efficient OLED using Alq_3 as the electron-transport layer and emitting material. Since Alq_3 has an Al^{3+} ion in the centre, one can make use of it as a probe to monitor the electronic distribution in the molecule. The chemical structure of Alq_3 shows in figure (1.16)



1.12 Aim of the Work

The aim of work is preparation of ZnS quantum dots by chemical reaction method in order to generation of white light from hybrid organic light emitting device.

Fabrication of two types of the hybrid organic light emitting devices (electroluminescence devices); the first type configuration consist of two layers deposited successively on the ITO glass substrate. The first layer was of TPD mixed with PMMA in ratio 1:1, while the second layer was 0.05%wt Zns QDs . The second type configuration

consists of three layers deposited successively on the ITO glass substrate. The first layer was of TPD mixed with PMMA in ratio 1:1, while the second layer was 0.05%wt Zns QDs

Finally deposition Alq3 layer above the QDs layer.

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