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STRUCTURAL AND OPTICAL PROPERTIES OF ALQ_3/TPD MULTILAYER ORGANIC THIN FILM

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Abstract— **Organic light emitting diodes (OLED) based on small molecular organic materials have promising application to full-color flat panel displays. Tris-(8-hydroxyquinoline)aluminium(Alq_3) is a widely utilized component in organic electroluminescent devices.N, N'-Bis(3-methyphenyl) -N, N'-diphenylbenzidine (TPD) is used as hole transport layers in organic light emitting diodes and also works as thin film laser material.Multilayer Alq_3/TPD thin films were prepared using a physical vapor deposition technique. The structural properties of the prepared films were studied using XRD and FTIR. The XRD studies reveal that Alq_3/TPD film is amorphous in nature and FTIR studies confirm the vibration mode of quinoline. The optical properties were studied using UV-Visible spectroscopy and Photoluminescence spectroscopy(PL). From the transmittance spectrumthe optical energy band gap was determined as 3.24 eV (Alq_3) and 2.72 eV (TPD). The PL studies show that characteristic emission peak was observed at 504 nm and 420 nm whichis corresponding to Alq_3 and TPD respectively.**

Index terms- **Organic LED; Multilayer; Optical properties; Photoluminescence; Alq3; TPD.**

I. INTRODUCTION

In recent years, new optoelectronic devices based on organic thin films have entered the market. Organic light emitting diodes (OLED), organic thin film transistors (OTFT) and organic solar cells (OSC) are the most prominent applications known for unique properties including flexibility and transparency. Organic thin films enable to fabricate low cost devices such as organic light emitting diodes (OLEDs), organic field effect transistor (OFET) and organic photovoltanic cells (OPV).

The different types of organic photovoltanic materials are small molecules, polymers, etc. Some of the small molecules are phthalocyanines, fullerene, Tris (8 hydroxyquinolinato)aluminium(Alq_3) and so on. Alq_3 is an excellent electron transporting material. Metal quinolates are most standard organic small molecules for the organic electronic devices [1].These molecules should have the ability to transport electrons efficiently. Earlier studies havesuggested that charge transfer [2,3] effects at Alq_3/metal interface, as well as interface states [2,4] and possibly metal induced gap states [2,4] play an important role in charge injection and device performance. Alq_3 having a high internal quantum yield and a stable electrical conductivity is a state-of-the-art green emission and an electron transporting material in an organic solar cell. Thin films of the aromatic diamine molecule N,N'-diphenylbis(3-methylphenyl)-biphenyl-4,4'-diamine (also named N,N'-bis(3-methylphenyl)-N,N'-bis(phenyl)-benzidine,
abbreviated by TPD or more precisely by 3-methyl-TPD is widely used as a hole transport layer (HTL). TPD is a laser active material and also works as thin film laser material [5]. TPD is well known as a typical hole transport layer with the hole mobility ~10^{-3} cm^2/Vs[6].

Moreover, there are still challenges to improve the performance and efficiency of organic electronics. As the performance of the devices depends critically on the interface region between the different layers, it is important to get a fundamental understanding of the physical processes between the metal electrode and the organic layer. In this paper, we have prepared Alq_3/TPD multilayer thin film using physical vapor deposition technique and characterized using XRD (Shimadzu XRD-600), FTIR (IRPrestige-21) , UV-Visible spectroscopy(Jasco V-670 Spectrophotometer) and Photoluminescence spectroscopy (Horiba Jobin Yuon Fluorg).

II. EXPERIMENT

The preparation of multilayer thin film was carried out using Physical vapor deposition (PVD) technique. The samples were prepared by keeping the chamber pressure at kept at 10^{-5}torr. Alq_3 and TPD purchased from 'Aldrich chemicals' were placed on separate molybdenum boats. Alq_3 was evaporated by passing a current from 58 to 62 A and the deposition rate was from 1 to 3 Å/s. TPD having lesser melting point was evaporated by passing a current from 44 to 46 A and the deposition rate was from 1 to 3 Å/s .Alternate layers of Alq_3/TPD were deposited on unheated substrates by heating successively the two sources containing Alq_3 and TPD. The multilayer Alq_3 /TPD film has five layers with Alq_3 as a top and bottom layer. The thickness of Alq_3 and TPD is 50 nm and the total thickness of the film is 250 nm.

III. RESULTS AND DISCUSSIONS

A. Structural studies

XRD pattern recorded for the Alq_3/TPD multilayer thin film is shown in figure1. It is clear from the pattern that there is no prominent diffraction peak, which means Alq_3 is amorphous in nature as reported in earlier studies. As the thicknessof the film is less and the top layers are very thin (50nm), the observed film is not showing crystalline behavior.

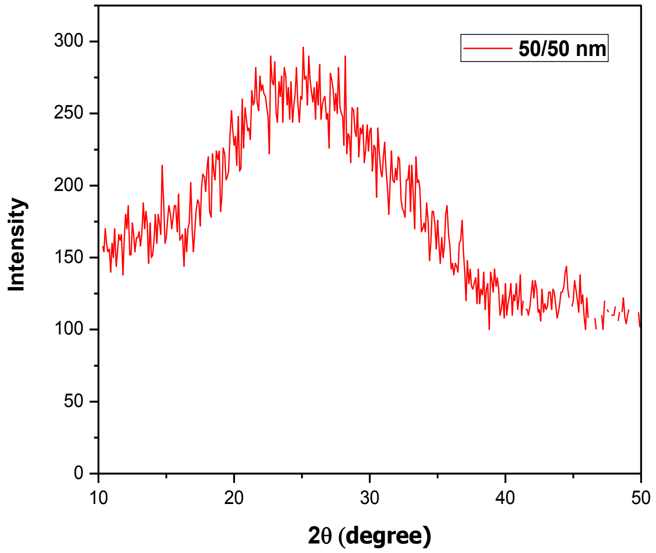

Fig 1 XRD pattern of Alq_3/TPD multilayer thin film.

FTIR analysis was taken for the prepared Alq_3/TPD multilayer thin film in order to study the structural behavior of the films (figure 2).The spectrum was recorded in the wavenumber range 500 to 3500 cm^{-1}.

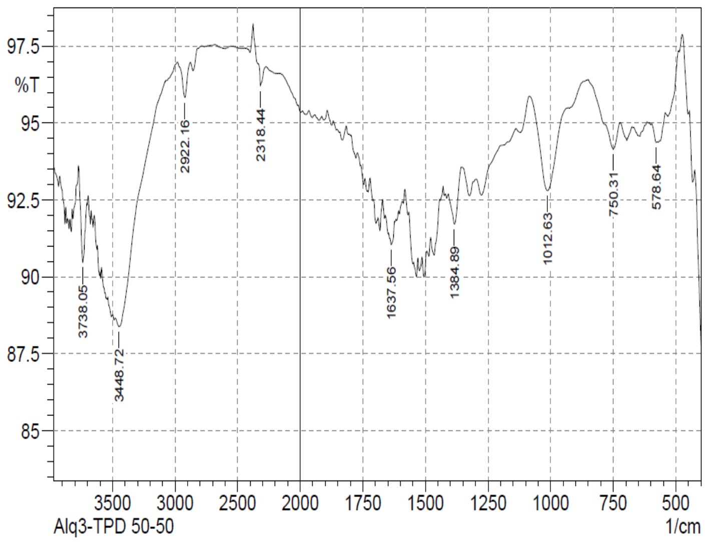

Fig 2 FTIR spectrum of Alq_3/TPD film

The FTIR absorption spectrum of Alq_3/TPDdisplays all the characteristic absorbance of the quinolone and the Al ions with ligands. For example characteristic bands centered at 600-800 cm^{-1}comes from vibration of quinoline and the band at 400-600cm^{-1} can be attributed to stretching vibration of Al ions with ligands. The intense band of C-O at 1012.6cm^{-1} and the weaker band at 1384.8$cm^{-1}$is almost same as the reported results from the literature (Royal Society of Chemistry 2011).

B. Optical studies

The transmission spectrumwas taken for prepared the Alq_3/TPD multilayer thin film which is shown in figure 3

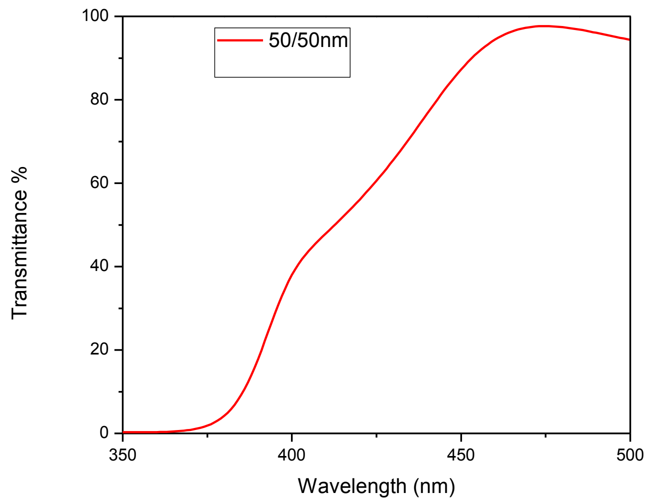

Fig 3 Transmission spectrum of the multilayer Alq_3/TPD films

From the transmission spectrum, it is observed that the film is 95% transparent in the visible region and has two energy bands, one corresponding to Alq_3(3.24 eV)and the other corresponding to TPD(2.72 eV). The band gap energy along the fundamental absorption region is determined by the following equation:

$$\alpha = \frac{1}{d}\ln\frac{1}{T} \text{ --------(1)}$$

where d is the thickness of the sample, T is the transmittance and α is the absorption coefficient.

The calculated values in the absorption region are used to find the energy band gap using the equation :

$$\alpha E = A\left(E - E_g\right)^{1/2} \text{ ---------(2)}$$

where A is a constant.

The value of E_g is determined by drawing a graph between $(\alpha E)^2$ and E. Typical plots of $(\alpha E)^2$ versus E are shown in Figure 4. The extrapolation of the straight line portion to the energy axis gives the value of energy band gap, E_g.

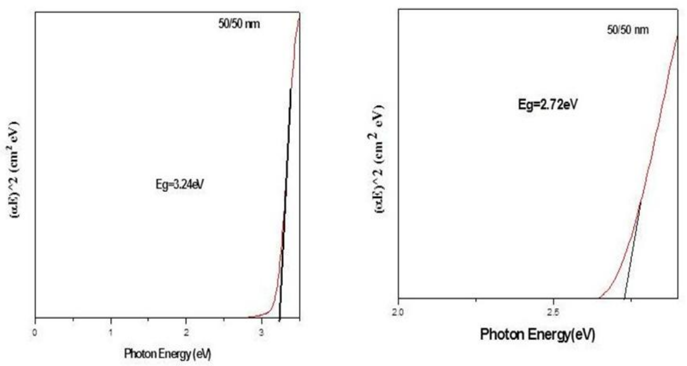

Fig 4 Graph showing the plot of (αE)^2 versus E

The PL spectrum was taken in the wavelength range of 400 to 550 nm for the Alq_3/TPD multilayer thin film which is shown in figure 5.

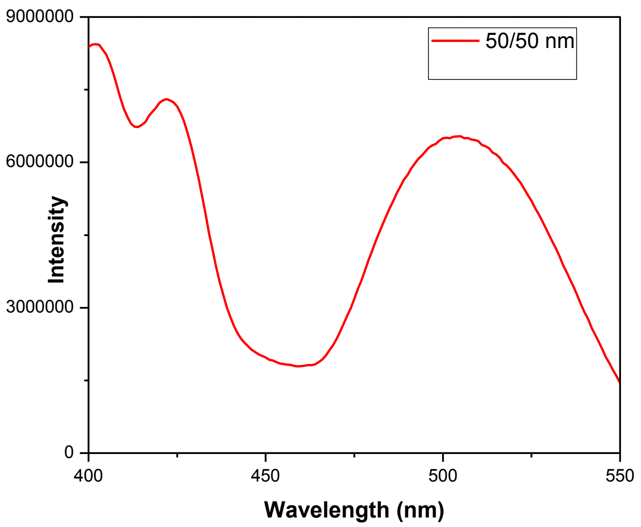

Fig 5 PL spectrum of the Alq_3/TPD multilayer thin film.

The PL emission spectrum was taken for the excitation wavelength λ=350 nm. The emission peak is in green the region centered at 504 nm.The emission band centered at 504 nm is in the green region which aroused from the Alq_3 light emitting organic material. The emission band centered at 420 nm is ascribed to the TPD material. Thus, the light emitting behavior of the Alq_3/TPD multilayer film is examined using PL studies.

IV. CONCLUSION

Alq_3/TPD multilayer thin film was successfully deposited using physical vapor deposition technique. XRD results show that the film is amorphous in nature. FTIR confirms the presence of vibration of quinoline and the stretching vibration of Al ions with ligands. The optical studies reveal that the films are highly transparent in the visible region. The energy band gap of the film was determined using optical transmittance and was found to be 3.24eV(Alq_3) and 2.72eV(TPD).The characteristic emission peak of Alq_3 and TPD films examined using PL studies was absorbed at 504 nm and 420 nm respectively. As, the film is exhibiting good photoluminescence behavior the film is suitable for optoelectronic application.

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