STUDIES ON THE IMPROVEMENT OF EFFICIENCY AND LIFETIME OF ORGANIC LIGHT EMITTING DEVICES

by

RAKHI GROVER

Instrument Design Development Centre

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CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON THE IMPROVEMENT OF EFFICIENCY AND LIFETIME OF ORGANIC LIGHT EMITTING DEVICES"** is being submitted by **Ms**. **RAKHI GROVER** to the **Instrument Design Development Center, Indian Institute of Technology Delhi** for the award of the degree of **DOCTOR OF PHILOSOPHY**. This thesis is a record of bona-fide work carried out by her under our guidance and supervision. In our opinion the thesis has reached the standards fulfilling the requirements for submission relating to the degree.

The results contained in this thesis have not been submitted to any other University/Institute for the award of any degree or diploma.

Prof. D. S. MEHTA
DEPARTMENT OF PHYSICS
INDIAN INSTITUTE OF TECHNOLOGY
DELHI

DR. M. N. KAMALASANAN
(RETD. CHIEF SCIENTIST)
CENTER FOR ORGANIC
ELECTRONICS, CSIR-NPL DELHI

Date:

Place:

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ABSTRACT

The rapid introduction of organic light-emitting diodes (OLEDs) in the field of solid state lighting, general illumination and display applications has led to enormous research interest and activities in this field. The thin, lightweight and flexible displays based on OLEDs are undoubtedly better than other competitive conventional devices. However, the efficiency and lifetime are two major concerns to be resolved for their reliable applications. The cost of production of these devices is also very high due to stringent techniques required for enhancing efficiency, lifetime and large area applicability.

This thesis presents the detailed studies on the improvement of efficiency and lifetime of organic light emitting devices. Chapter 1 gives an introduction to organic semiconductors and OLEDs. The working principle of OLEDs and current issues regarding efficiency and lifetime of OLEDs are discussed in detail.

Chapter 2 summarizes the materials involved in this study and the experimental techniques employed to study the electrical and optical properties of these materials and the fabricated OLEDs.

Chapter 3 describes the experimental results on the charge carrier injection and transport studies in organic semiconductors. This work is focused on the electron and hole transport materials i.e., 4, 7-diphenyl-1, 10-phenanthroline (BPhen) and 2, 7-bis [N, N-bis (4-methoxy-phenyl) amino]-9, 9-spirobifluorene (MeO-Spiro-TPD). Single charge carrier devices based on these materials have been fabricated. Mixing percentage of Tetracyano-quinodimethane (TCNQ) in BPhen was optimized and its effect on the morphology of thin films has been discussed. Effect of inserting thin films of 2, 3, 5, 6-tetrafluoro-7, 7, 8, 8-tetracyano-quinodimethane (F_4-TCNQ) on the hole injection from ITO to MeO-Spiro-TPD

has been discussed and the thickness of F_4-TCNQ has been optimized for efficient injection of holes from the anode.

In chapter 4, the application of optimized charge carrier injection and transport materials has been described for the improvement of efficiency of OLEDs.

Chapter 5 describes the enhancement in out coupling efficiency of OLEDs by making use of organic scattering layer which can be useful in terms of angle independent outcoupling, simplicity of fabrication and large area OLED applications.

Chapter 6 is concerned with the fabrication of hybrid organic-inorganic LEDs by using vacuum thermal deposition method. Different thicknesses of thermally evaporated Cadmium sulfide (CdS) and Cadmium telluride (CdTe) thin films were employed separately as the emissive layers. The devices exhibited significant luminance and efficiency values without using different deposition techniques for a single device which are usually required.

Chapter 7 deals with white electroluminescence from hybrid organic –inorganic LEDs based on thermally evaporated nanocrystals as the emissive layers. Spectral tunability has been demonstrated by adjusting the relative concentrations of CdS and CdTe nanocrystals in the emissive layer. White-light emission spectrum was achieved by introducing red-emitting DCM dye. The position and concentration of the dye was optimized to give high-quality white light.

Chapter 8 provides the detailed analysis of thin film encapsulation (TFE) technique for OLEDs using organic multilayer TFE structure. The optimized TFE, further coated with inorganic barrier films of Magnesium fluoride (MgF_2) deposited by normal and glancing angle deposition method, have been characterized and described in detail in this chapter. The encapsulation was found to be useful in terms of high moisture barrier, ease of fabrication as well as feasibility of deposition in the same chamber where OLEDs are fabricated without exposing the device to external environment.

Chapter 9 presents conclusions and scope for future work.

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