



Synthetic Metals

Volume 158, Issues 21–24, December 2008, Pages 810–814

Organic light-emitting diodes based on new n-doped electron transport layer

J.W. Ma ^a  , Wei Xu ^a, X.Y. Jiang ^a, Z.L. Zhang ^{a b}[Show more](#)  Share  Cite<https://doi.org/10.1016/j.synthmet.2008.05.009> [Get rights and content](#) 

Abstract

Organic light-emitting diodes with 8-hydroxy-quinolinato lithium doped 4'7-diphenyl-1, 10-phenanthroline as electron transport layer (ETL), and etrafluro-tetracyano-quinodimethane doped 4,4',4''-tris(3-methylphenylphenylamono) triphenylamine as hole transport layer (HTL) are demonstrated. The conductivity of carrier transport layers with different doping concentration is examined by hole-only and electron-only devices. Compared with the referenced device (without doping), the current efficiency and power efficiency of the p-i-n device are enhanced by approximately 51% and 89%, respectively. This improvement is attributed to the improved conductivity of the transport layers and the efficient charge balance in the emission zone.

Introduction

Since the discovery of organic light-emitting devices (OLEDs), there has been a considerable interest in developing OLEDs with high efficiency for display applications [1]. In order to lower driving voltage and enhance power efficiency, it is critical to enhance the carrier injection from the electrode to the transporting layer and to increase the transport conductivity [2], [3]. The hole injection can be improved by increasing the work function of ITO with different surface treatments such as O₂ plasma or UV–ozone treatment of ITO surface [4]. It can also be enhanced by introducing hole injection layer (HIL), such as copper phthalocyanine (CuPc) [5], starburst polyamines [6], polymeric PEDT:PSS [7] and 4,4',4''-tris(*N*-(2-naphthyl)-*N*-phenylamino)triphenylamine (2-TNATA) between the ITO/hole transport layer (HTL) interface.

Recently, the p-doping of HTL has drawn a lot of attentions because of its ability to enhance hole injection and lower driving voltages in OLEDs. The p-doping HTL is typically made by co-evaporating the hole transporting materials with a strong electron acceptor like tetrafluoro-tetracyano-quinodimethane (F₄-TCNQ) [8], or oxidants like SbCl₅ [9], FeCl₃ [10] and iodine [11]. p-Doping can also achieve ohmic conductivity to reduce driving voltage of device and the proper control of doping levels can also lead to efficient carrier injection by tunnelling [12].

However, organic molecules are known to be poor in electron injection and transport compared with that of hole. Many attempts have been made to improve the electron injection and transport, including using low work function metals [1], [13], [14], [15] as cathode, or inserting a thin interlayer between cathode and electron transporting layer [16], [17], [18], [19], [20] to enhance electron injection. Great efforts have been made to enhance the electron conductivity [21], [22], [23], [24]. Kido and Matsumoto [22] reported the improved electron transport by doping Li into tris(8-hydroxyquinoline) aluminum (Alq₃). Fong et al. [21] also demonstrated that the device performance was enhanced significantly by doping 4'7-diphenyl-1, 10-phenanthroline (Bphen) into Alq₃ as a cohost electron transport layer (c-ETL). However, few studies have been reported about using lithium quinolinato complex such as 8-hydroxy-quinolinato lithium (Liq) as an electron injection layer [25], and no work has yet been reported about using Liq-doped BPhen as electron transport layer (ETL).

In this paper, we have demonstrated a device with an new n-doping (33 wt.% Liq:BPhen) layer as ETL and p-type (*m*-MTDATA:xwt.% F₄-TCNQ) layer as HTL. Here, 33 wt.% Liq is chosen due to the fact that the device with the doping ratio of

33wt.% Liq demonstrates the best current density vs voltage (J - V) curve among all the electron only devices. Using this method, we obtained a significant improvement in the device performance as compared with the referenced device.

Access through your organization

Check access to the full text by signing in through your organization.

Access through **your organization**

Section snippets

Experiments

The structure of the complete devices fabricated in this work is as follows:

ITO/*m*-MTDATA: x wt.% F₄-TCNQ (40nm)/NPB (10nm)/Alq₃ (20nm)/ BPhen: y wt.% Liq (50nm)/LiF (1 nm)/ Al (130nm).

Device A (referenced device): $x=0, y=0$; *Device B:* $x=0, y=33$; *Device C:* $x=0.3, y=33$; *Device D:* $x=2, y=33$; *Device E:* $x=4, y=33$.

In the devices, 4,4',4''-tris(3-methylphenylphenylamono) triphenylamine (*m*-MTDATA): x wt.% etrafluro-tetracyano-quinodimethane (F₄-TCNQ)and Bphen: y wt.% Liq are used as p-doping HTL and n-doping

Results and discussion

Fig. 2 and 3 show the J - V , current efficiency vs current density and power efficiencies vs current density characteristics of the complete devices, respectively. Shown are results for *Device B, C, D, E* with different weight ratios of F₄-TCNQ (0wt.%,

0.3wt.%, 2wt.%, 4wt.%) to *m*-MTDATA and Liq (33wt.%) to Bphen, compared to a referenced *Device A* with an undoped *m*-MTDATA HIL and Bphen ETL. In Fig. 2, one can see that already slight doping HIL (0.3wt.% F₄-TCNQ) strikingly decreases the driving

Conclusion

A good carrier balance is considered to be one of the most important factors in getting an excellent performance in OLEDs. In this paper, the p-i-n devices with a novel n-doping (33wt.% Liq:BPhen) layer as ETL and a p-doped (0wt.%, 0.3wt.%, 2wt.% and 4wt.% F₄-TCNQ:*m*-MTDATA) layer as HTL is fabricated. We have demonstrated the high current efficiency of 5.90cd/A, power efficiency of 4.51 lm/W, and a driving voltage of 4.10V at a current density of 20mA/cm² in Alq₃ based p-i-n OLEDs. The *J-V*

Acknowledgement

The authors acknowledge the financial support given by The National Natural Science Foundation of China (90201034, 60477014, 60577041), 973 project no. (2002CB613400).

[Recommended articles](#)

References (30)

X. Zheng *et al.*
Thin Solid Films (2005)

C.W. Tang *et al.*
Appl. Phys. Lett. (1987)

J. Huang *et al.*

Appl. Phys. Lett. (2002)

J.S. Kim *et al.*

J. Appl. Phys. (1998)

M.G. Mason *et al.*

J. Appl. Phys. (1999)

S.A. VanSlyke *et al.*

Appl. Phys. Lett. (1996)

Y. Yang *et al.*

Appl. Phys. Lett. (1994)

T. Grandlund *et al.*

J. Appl. Phys. (2001)

J. Blochwitz *et al.*

Appl. Phys. Lett. (1998)

C. Ganzorig, M. Fujihira, Improved drive voltages of organic electroluminescent devices with an efficient p-type...



View more references

Cited by (12)

[Room-temperature interface state analysis of Au/Poly\(4-vinyl phenol\)/p-Si structure](#)

2009, Synthetic Metals

[Show abstract](#) ✓

[Improved Thermal Stability and Operational Lifetime of Blue Fluorescent Organic Light-Emitting Diodes by Using a Mixed-Electron Transporting Layer ↗](#)

2022, ACS Materials Letters

[A Series of Lithium Pyridyl Phenolate Complexes with a Pendant Pyridyl Group for Electron-Injection Layers in Organic Light-Emitting Devices ↗](#)

2017, ACS Applied Materials and Interfaces

[Effect of doping of 8-hydroxyquinolinatolithium on electron transport in tris\(8-hydroxyquinolato\)aluminum ↗](#)

2011, Journal of Applied Physics

[Spectroelectrochemical and photovoltaic characterization of a solution-processable n-and-p type dopable pyrrole-bearing conjugated polymer ↗](#)

2010, Macromolecular Chemistry and Physics

[One polymer for all: Benzotriazole containing donor-acceptor type polymer as a multi-purpose material ↗](#)

2009, Chemical Communications



[View all citing articles on Scopus ↗](#)

[View full text](#)

Copyright © 2008 Elsevier B.V. All rights reserved.



All content on this site: Copyright © 2024 Elsevier B.V., its licensors, and contributors. All rights are reserved, including those for text and data mining, AI training, and similar technologies. For all open access content, the Creative Commons licensing terms apply.

