Study of Plasma Process Induced Damages on Metal Oxides as Buffer Layer for Inverted Top Emission Organic Light Emitting Diodes

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Keywords : OLED, HIL, Metal Oxide, Damage, Hole-Only Device

Abstract

In the fabrication of inverted top emission organic light emitting diodes (ITOLEDs), the organic layers are damaged by high-energy plasma sputtering process for transparent top anode. In this study, the plasma process induced damages on metal oxide hole injection layers (HILs) including WO_3*,* MoO_3*, and* V_2O_5 *as buffer layer are examined. With the result of IV characteristic of hole-only devices, we propose that* MoO_3 *and* V_2O_5 *are stable materials against plasma sputtering process.*

1. Introduction

Recently, top emission OLEDs (TOLEDs) are very attractive for their large aperture ratio and high pixel resolution [1]. Especially, ITOLEDs have been actively investigated, because they would be more suitable than conventional normal staggered OLEDs for a-Si thin film transistors (TFTs) which have only n-type [2, 3].

To fabricate the ITOLEDs with high performance, it is needed to deposit the top anode of the transparent conducting oxide (TCO) such as indium tin oxide (ITO) and indium zinc oxide (IZO) by plasma sputtering process onto the organic layers. [4] During the plasma sputtering process, however, the organic layers could be easily attacked by energetic particles (ions and electrons) bombardment, heating, and UV radiation [5, 6]. In particular, the energy of charged particles bombardment is high enough to break most of the carbon-based bonds in organic layers [7]. Thus, the performance of ITOLEDs would be degraded.

To protect the organic layers from the energetic particles bombardment, therefore, ITOLEDs are needed HIL as buffer layer. Recently, many groups research WO_3, V_2O_5, and MoO_3 HILs as buffer layers in both normal structure bottom emission OLEDs (BOLEDs) and inverted structure bottom emission OLEDs (IBOLEDs). Especially, ITOLEDs using metal oxide HIL as buffer layer appear good electrical and optical performance.

In this paper, we examined the plasma process induced damages on various metal oxide HILs including WO_3, MoO_3, and V_2O_5. These damages were investigated by measuring the electrical properties of hole-only devices.

2. Experimental

The hole-only devices with glass substrate / anode (ITO 143 nm) / HIL (WO_3 or MoO_3 or V_2O_5 4 nm) / (Plasma Process) / HTL (N,N'-diphenyl-N,N'-bis (1,1'-biphenyl)-4,4'-diamine (NPB) 60 nm) / cathode (Al 100 nm) structure (Fig. 1) were fabricated. ITO-coated glass with sheet resistance of 11 Ω /square was cleaned with acetone and ethanol. The metal oxides were deposited on ITO by thermal evaporation. After the deposition of the metal oxide, the sample was transferred into the other chamber to exposure the Ar plasma with various RF power (30, 50, 80, 120, 190 W) onto the HIL. Also, the direct current (DC) self bias applied to the substrate. After that, NPB and Al were deposited in sequence.

The electrical characteristics of these devices were measured using a Keithley 236 source measure unit.

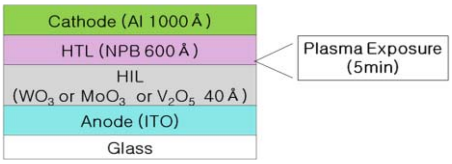

Fig. 1. The structure of hole-only devices

3. Results and discussion

Fig. 2 indicates the IV characteristics of the hole-only devices. As shown in Fig. 2. (a), the current density of WO_3 device is considerably decreased when increasing RF power from 30 W to 190W. It is considered that the energetic particle bombardment changes the morphology of WO_3 thin film. And it could affect the IV characteristics of the hole-only device.

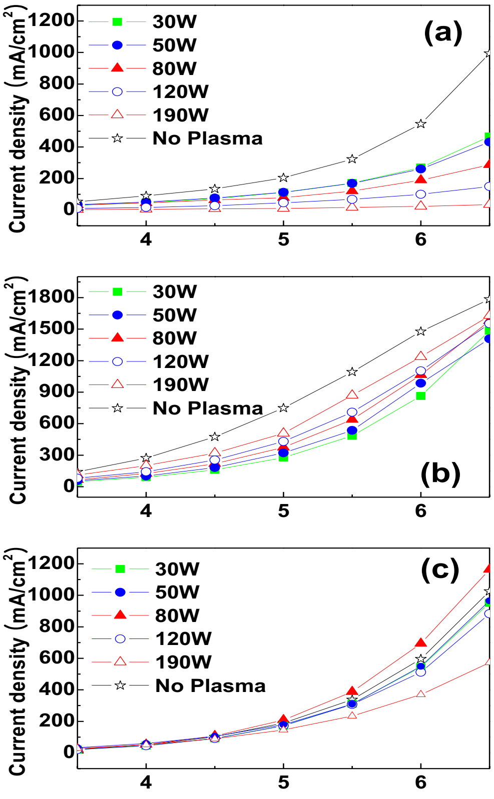

Fig. 2. IV characteristics of the hole-only devices with the HILs of (a) WO_3, (b) MoO_3, and (c) V_2O_5 after the plasma process with different conditions.

Fig. 2. (b) and (c) present the IV curves of MoO_3 and V_2O_5 devices. After plasma process, similarly to WO_3 device, the current density of most devices was less than that of no plasma devices. On the other hand, the variation of current density curves was much smaller than that of WO_3 device. In 6.5 V, while the current density of WO_3 device with the plasma process of RF power 190 W was decreased to 97% compared to no plasma device, the current density of MoO_3 device (RF power 50 W) was decreased to 21%, and V_2O_5 device (RF power 190 W) was decreased to 44%.

Above all, the MoO_3 devices had relatively higher current density values than other devices.

These results mean that the MoO_3 and V_2O_5 thin film could be more stable materials against the plasma process than WO_3 thin film. In particular, the MoO_3 devices after plasma process showed smallest variation of current density and highest current density values. It is expected that MoO_3 or V_2O_5 adapted ITOLEDs could appear better performances with less degradation than WO_3 adapted ITOLEDs and the further works will be performed.

4. Summary

The plasma process induced damages on metal oxide HILs including WO_3, MoO_3, and V_2O_5 were investigated by measuring the IV characteristics of the hole-only devices.

Based on the results, we propose the MoO_3 and V_2O_5 HILs as stable materials against the high-energy plasma process. From observing the good and stable electrical property of MoO_3 hole-only device, the ITOLEDs using MoO_3 as buffer layer could be expected to indicate the good optical and electrical characteristics with little degradations.

6. Acknowledgements

This research was supported by the MKE (The Ministry of Knowledge Economy), Korea, under the ITRC (Information Technology Research Center) support program supervised by the IITA (Institute for Information Technology Advancement) and a grant from the Information Display R&D center under the 21st Century Frontier R&D program

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