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Efficiency Improvement of Top-emission Organic Light-emitting Diode by Using UV-ozone, Doped Emission Layer, and Hole-blocking Layer

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In this work we study the approaches to improve the performance of the top-emission light-emitting diode (TOLED) with a treated-Ag anode. As shown in Fig. 1, the work function of Ag increases under the UV-ozone exposure. The increased work function is attributed to the formation of silver oxide (AgO_x) on Ag film, in which the ionization potential is around 5.3 eV. However, the conductivity and reflectance of the treated-Ag film decrease with the increasing of the UV-ozone exposure time. To study the influence of UV-ozone exposure time on the TOLED property, a device architecture of Ag(200 nm)/m-MTDATA(30 nm)/NPB(20 nm)/Alq_3(45 nm)/BCP(2 nm)/Alq_3(3 nm)/LiF(1 nm)/Ag(20 nm) is proposed. Figure 2 shows the current density-voltage (J-V) characteristics of the present device with different exposure times. The turn-on voltage of the TOLED decreased from 9 to 5 V when the exposure time increases from 1 to 3 min. The improved turn-on voltage is attributed to the enhanced hole-injection ability, which is caused by the increased work function of the treated-Ag anode. To further improve the efficiency of the present TOLED design, a high quantum efficiency dopant of 1% C545T is added into the Alq_3 emission layer. An effective energy transfer between Alq_3 and C545T can be expected, owing to the observed overlapping spectra shown in the inset of Fig. 3. In addition, as can be seen from the energy-band diagram in the inset of Fig. 3, the energy barrier of the LUMO between the C545T and BPC layers is around 0.3 eV, which is lower than 0.5 eV between the Alq_3 and BCP layers. A lower energy barrier will enhance the emission of C545T, and thus improve the performance of the present TOLED. The highest current efficiency of the studied TOLED is 19.43 cd/A, which demonstrates nearly four-fold improvement as compared to 5. 19 cd/A in the same device without C545T doping.

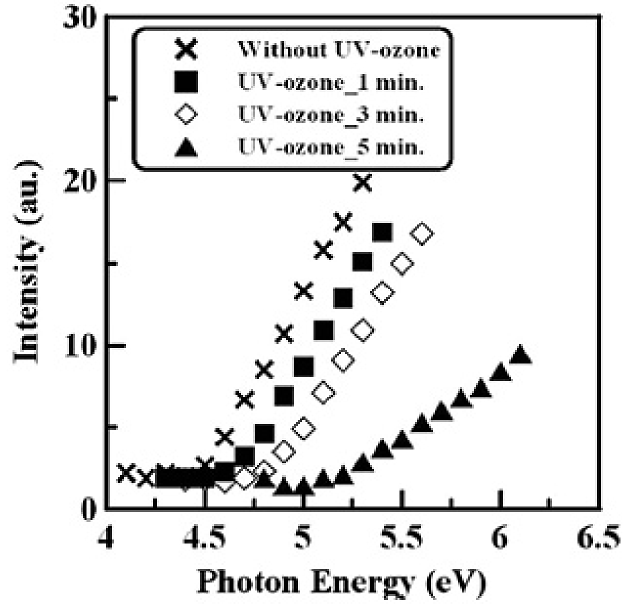

Fig.1 Photoelectron spectra of the UV-ozone-treated Ag anode under different exposure time

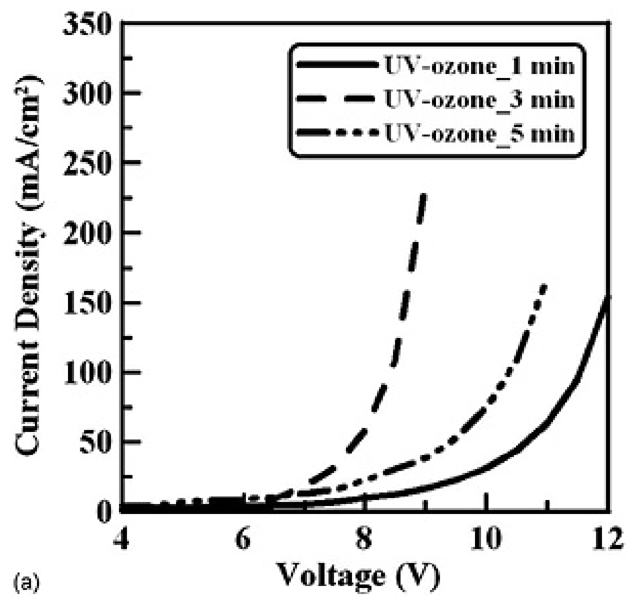

Fig. 2 The current density-voltage (*J*-*V*) characteristics of the studied TOLEDs under different UV-ozone exposure times for the Ag anode.

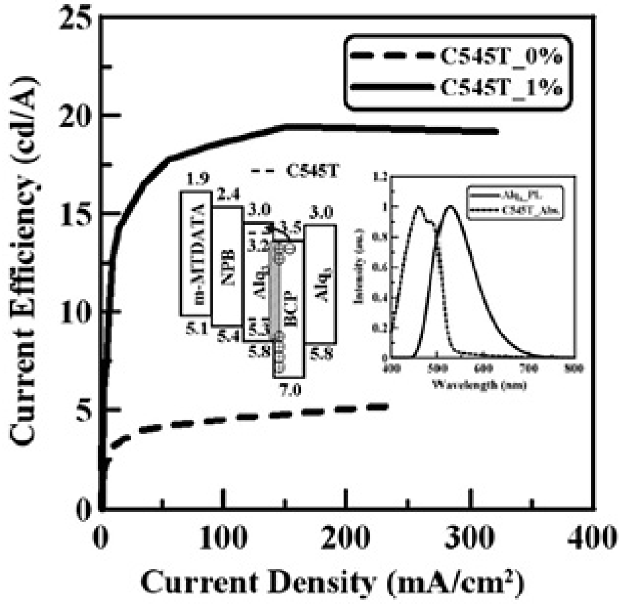

Fig. 3 Current efficiency-current density characteristics of the studied TOLEDs with/without the C545T doping. The insets are the energy-band diagram and the observed overlapping between the PL spectrum of Alq_3 and the absorption spectrum of C545T.