Slot Die Coating for Multilayer Organic Light-Emitting Diodes

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As a flat-panel light source, organic light-emitting devices (OLEDs) draw much attention due to their superior features such as large-area surface emission, flexibility, transparency, etc [1]. To improve the cost competitiveness of OLED lighting panels, it is desired to fabricate them using solution process. Slot-die coating is the promising fabrication scheme for large-area OLED lighting panels because it provides large and uniform films and the simultaneous coating of multiple layers of different solutions [2]. It involves many process variables such as coating speed, flow rate, coating gap, surface tension, viscosity, plate and drying temperatures, etc.

We investigate three technical issues related with large-area slot-die coating for OLED lightings. One issue is the flow down problem of an aqueous polymer solution, which occurs at the perimeter of an insulator bank. This problem has been solved by adding a wetting agent into the polymer solution. Another issue is that other than polymers, no chain entanglement occurs in dilute solution for small molecules. Since only the packing density is changed, pinhole-like surface appears in solution-processed small-molecule films. The other issue is the dissolution problem that occurs between two stacked layers with different solvents during slot-die coating. By optimizing the slot-die coating process, we have suppressed those phenomena to a great extent. To demonstrate it, we have fabricated large-area green phosphorescent OLED devices, the layer structure of which is presented in Fig. 1(a). For the hole injection layer (HIL), we used aqueous PEDOT:PSS solution (Clevios AI 4083). For the hole transport layer (HTL), we have coated the small-molecule KHT-001 solution (Duksan Neolux Co., Ltd.), which is dissolved into a solvent at 1.5 wt%. The other layers are deposited under vacuum. With the optimized coating process, we have fabricated the bilayer (HIL/HTL) films. Shown in Fig. 1(b) is the image of light emission from OLED with the slot die-coated bilayer film. As evident in Fig. 1(c), a clear HIL/HTL interface is observed, verifying that a serious dissolution problem of the HIL by the solvent of the second layer does not appear. The bilayer films show the average roughness value as low as 0.4nm ~ 0.6nm and the peak-to-peak roughness value as low as 6nm ~ 12nm. Fig. 1(d) shows the power efficiency measured as a function of luminance. It is demonstrated that OLEDs with slot-die coated multiple layers show almost the same device performance as a reference OLED device with the spin-coated HIL and vacuum-evaporated HTL. The OLED device with the slot die-coated bilayer film exhibits the power efficiency of 27.2lm/W at the luminance of 1,000nit, which is even higher than that (25.5lm/W) of the reference device.

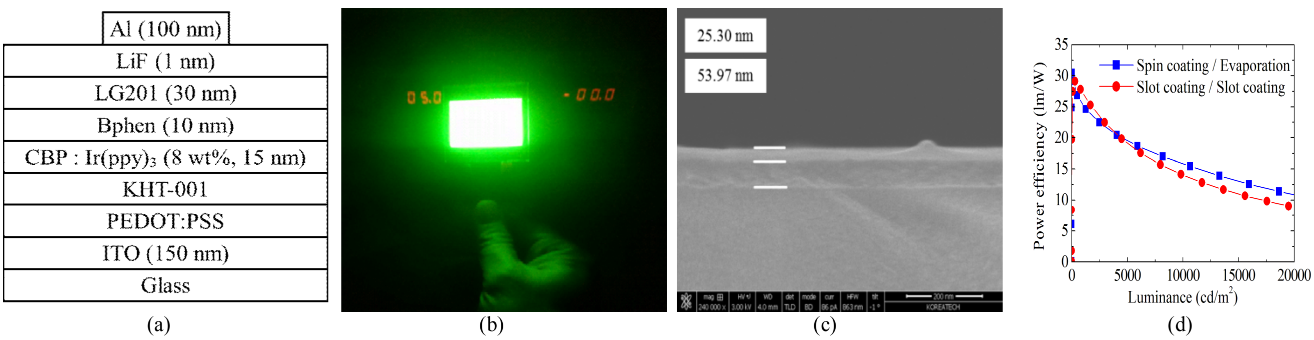

Fig. 1. (a) Layer structure of green phosphorescent OLED device, (b) image of light emission from large-area (43mm × 29mm) OLED panels, (c) measured SEM image showing the thickness of the bilayer HIL/HTL film, and (d) measured power efficiency versus luminance for different OLED devices.

References

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2. Lin, C. F., Wong, D. S., Liu, T. and Wu, P., *Adv. Polymer Technol.*, vol. 29, p. 31 (2010).