TOPICS

"OptDesigner": Optical Simulator of Organic Light-Emitting Diodes

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In recent years, organic light-emitting diodes (OLEDs) have received much attention as emitters for flat panel displays. OLEDs consist of stacked thin layers, each of which is as thin as the wavelength of visible light. Thus the external emission spectra, color, and luminance are affected by interference inside the device. These effects, however, can be calculated using optics of thin films and can be controlled by adjusting the thickness of each layer. Therefore, we have developed an optical simulation program of OLEDs, which we call "OptDesigner".

As shown in **Fig. 1**, OLEDs are modeled as a single-layer film of the emission layer (EML) on the substrate with upper and lower interfaces. The upper interface comprises the electron transportation layer (ETL) and the metal anode, and the lower interface comprises the hole transportation layer (HTL) and the indium tin oxide (ITO) cathode. The reflectance and transmittance of the two interfaces, which actually comprise multi-layers, are computed through recursive calculation of the Fresnel coefficient.[1] The interference of multiple beams reflected between the interfaces is calculated using an infinite series.[2] The thick substrate can be treated as an incoherent layer.

In order to validate the accuracy of the simulator, three conventional devices of different ITO thickness (A: 164 nm, B: 207 nm, C: 230 nm) were fabricated. Since the spectrum of device C at an observation angle of 0 degrees is used as the reference spectrum for the calculation, the relative change in the spectra with increasing observation angle and/or decreasing ITO thickness is of interest. The calculated and observed spectra of each device at the observation angles of 0 and 45 degrees are shown in **Fig. 2**. The shape of the shoulder peak around 575 nm, which is especially dependent on the ITO thickness, can be simulated well for both angles. **Figure 3**(a) indicates that the change in the chromaticity coordinate with increasing observation angle is also computable to a high degree of accuracy. The calculated and observed radiation patterns correspond precisely, as shown in Fig. 3(b).

"OptDesigner" has an easy-to-use graphical user interface as well as good accuracy. This simulator makes it possible to control the color and luminance of OLEDs efficiently. Moreover, this simulator is applicable to the design of microcavity OLEDs.[2]

References

1) Knittl, Z. : Optics of Thin Films, (1976), 47, John Wiley & Sons
2) Shiga, T., Fujikawa, H. and Taga, Y. : J. Appl. Phys., **93**-1(2003), 19

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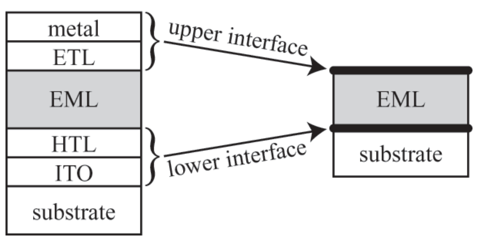

Fig. 1 Simulation model of OLEDs.

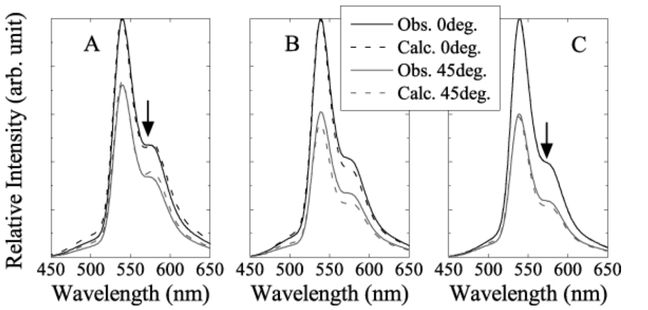

Fig. 2 Observed and calculated spectra of the devices A, B, and C. The arrow indicates the shoulder peak around 575nm.

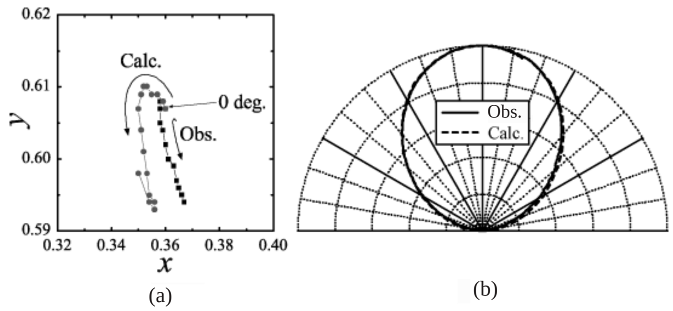

Fig. 3 (a) CIE1931 Chromaticity coordinate at every 5 degrees and (b) radiation pattern, observed and calculated in the device C.