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The Structure Design of a Passive Matrix (PM) color Organic Light-Emitting Device

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1. Introduction

The rapid progress made in the organic light emitting devices (OLEDs) during these last few years, has seem to compete with liquid crystal display (LCD) for plane display market in near future. To realize full-color display, many means have been done. One is using separate, side-by-side (or S×S) red (R), green (G), and blue (B) OLEDs to make a full-color display. [1] Others have suggested using an array of white OLEDs [2] backed by S×S R, G, and B color filters deposited and patterned prior to OLED growth. Variable angle incidence Spectroscopic Ellipsometer (VASE®) is a non-destructive optical technique used to characterize thin films. Many people use it make scientific research. [3-6] In our work, we use VASE® characterize several materials for organic light emitting devices: ITO, NPB, CuPc and PEDOT. We think that CuPc is not a good buffer layer to a color OLED. We use PEDOT replace CuPc as a buffer layer. And we use the soft Wvase32®* to analyze the effect of absorption and interference effect on the external quantum efficiency (η_e) in a PM color OLED by using side-by-side red(R), green (G), blue (B) OLEDs. And the best structures parameters of three subpixels to realizing PM color display are obtained.

2. Structure

A pixel of PM color OLED is shown in Fig.1. It consists of three subpixels (R, G, B). The peak wavelength of R, G, B is at 600nm, 520nm, and 450nm respectively.

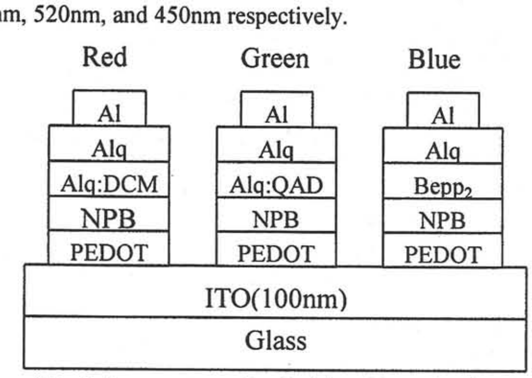

Fig. 1.the structure of a pixel in a PM color display

The light that emitting from the luminescent layer must pass thought NPB, PEDOT, ITO and glass substrate. Then we analyze the light intensity transmission of the multilayered system [NPB/PEDOT/ITO/glass] at difference wavelength.

3. Measurement and discussion

First, the optical constants of ITO, CuPc, NPB, PEDOT and glass substrate are measured by the VASE® technique (show in Fig.2). The spectral range is from 300nm to 1000nm.

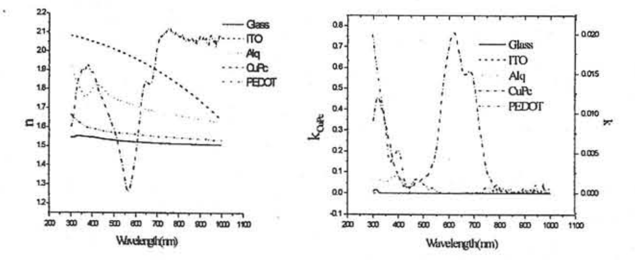

Fig.2. ITO, NPB, CuPc, PEDOT and glass optical constants obtained from analysis of VASE data

From the Fig.2 we can know that extinction coefficient (k) of CuPc exhibits three peak maximum at 320m, 615nm and 676nm. It shows that using CuPc as a buffer layer in red-OLED is not appropriate.

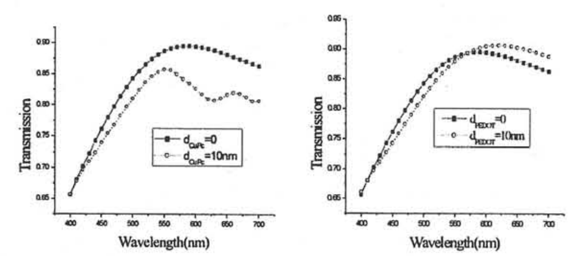

Fig.3. The transmission of the multilayered system (A:NPB(50nm)/CuPc/ITO(100nm)/glass,B:NPB(50nm)/PEDOT/ ITO (100nm)/glass, angle of incidence is 90^0)

It also can be testified from the light intensity transmission of the multilayered system [NPB(50nm)/buffer layer/ITO/(100nm)/ glass] as show in Fig.3 (A).

We can see that the transmission of system A has not big change from 400nm-550nm for the system has CuPc or not. But it has a remarkable decrease from 550nm-700nm, especially at 630nm. We use PEDOT replace CuPc as buffer layer in color display. From Fig.2 and Fig.3 (B), we can know that PEDOT was better than CuPc as a buffer layer.

It is important to obtain the same transmission for difference color light in a color display. Now consider the pixel as shown in Fig.1, the thickness of NPB, PEDOT and ITO is 50nm, 10nm and 100nm respectively. In our work, we suppose that: (1) the light rays striking the Al-Alq_3 interface all reflect by the Al surface; (2)

the refractive index of luminescent layer is as much as that of Alq_3. So the light all reflect by the Al surface will not occur internal reflection would if the light rays strike the luminescent layer-Alq_3 interface. Then we obtain that $T_{\lambda=450nm}$=74.278%, $T_{\lambda=520nm}$=84.774%, $T_{\lambda=600nm}$=90.512%. It shows that the light intensity transmission of blue light is less than that of green (about 10%) and that of red (about 16%).

In our work, we think that the absorption and interference effect cannot be neglected because it will influence the light intensity transmission. Fig.4 shows the transmission of the system [NPB(50nm)/PEDOT (10nm)/ITO/(100nm)/glass]. From it we can know that the absorption and interference effect cannot be neglected.

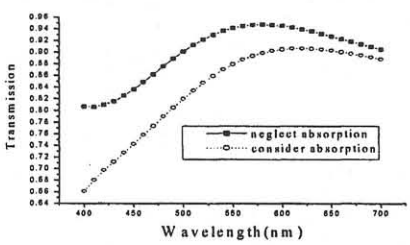

Fig.4.the transmission of the multilayered system [NPB(50nm)/PEDOT (10nm)/ITO/(100nm)/glass]

Based on the view that the absorption and interference effect cannot be neglected, we try to optimize the structure of the color display. Firstly, the thickness of ITO must be confirmed. The thickness of ITO cannot too thick take account of the electrical performance of the device. Then we let the thickness of ITO change from 100nm to 200nm. And we can obtain the transmission of the system [NPB(50nm)/PEDOT(10nm)/ITO/glass] as shown in Fig.5. We let the thickness of ITO is 160nm in order to obtain the greater transmission for blue subpixel in a color display (Because $T_{\lambda=450nm}$ is the least of that of three-color).

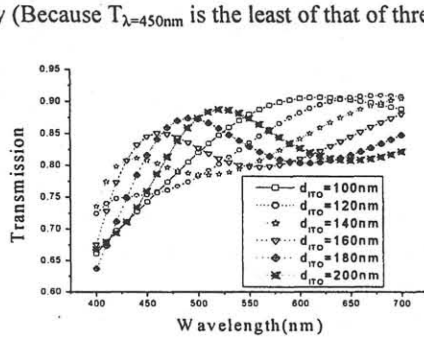

Fig.5 the transmission of the system [NPB(50nm)/PEDOT(10nm)/ITO/glass](the thickness of ITO changes from100nm-200nm.)

Then we change the thickness of PEDOT and NPB. Because the thickness of PEDOT is very thin, it will not have remarkable effect on the transmission of the system when the thickness changes from 5nm to 15nm. Then in our work, the thickness of PEDOT is 10nm.

Finally we must confirm the thickness of NPB in difference color pixel. Fig.6 shows the transmission of the system [NPB/PEDOT(10nm)/ITO(160nm)/glass] when the thickness of NPB changes from 40nm-80nm.

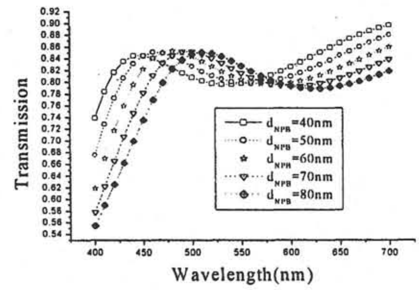

Fig. 6the transmission of the system [NPB/PEDOT(10nm)/ITO/(160nm)/glass](the thickness of NPB changes from 40nm-80nm.)

Now we can obtain the transmission of difference color pixel from Fig.6: When d_{NPB}=40nm, $T_{\lambda=450nm}$=84.564%, d_{NPB}=70nm, $T_{\lambda=520nm}$=84.12% and d_{NPB}=40nm, $T_{\lambda=600nm}$=82.666%.

4. Conclusion

In summary, we have been demonstrated the optical constants of ITO, CuPc, NPB and PEDOT with VASE® technique and used the software Wvase® analyze the effect of the absorption and interference effect on the transmission in OLEDs. We used PEDOT replace CuPc as a buffer layer. Finally we obtained the best structure parameters of a color device: R: Al/Alq/Alq:DCM/NPB(40nm)/PEDOT(10nm)/ITO(160nm)/glass, G: Al/Alq/Alq:QAD/NPB(70nm)/PEDOT(10nm)/ITO(160nm)/glass, B: Al/Alq/$Bepp_2$/NPB(40nm)/PEDOT(10nm)/ITO(160nm)/glass, and obtain the same transmission approximately: $T_{\lambda=450nm}$=84.564%, $T_{\lambda=520nm}$=84.12%, $T_{\lambda=600nm}$=82.66%.

5. Acknowledge

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