The characteristics of dye containing PMMA films for the PDP filter

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Abstract
Optical filters consisting of dye containing Polymethyl methacrylate(PMMA) thick films have been fabricated by a tape casting method. Their optical properties have been investigated as functions of dye contents in films and the film thickness. The absorbance coefficient in 588nm and 830nm could be calculated from the results.

1. Objectives and Background

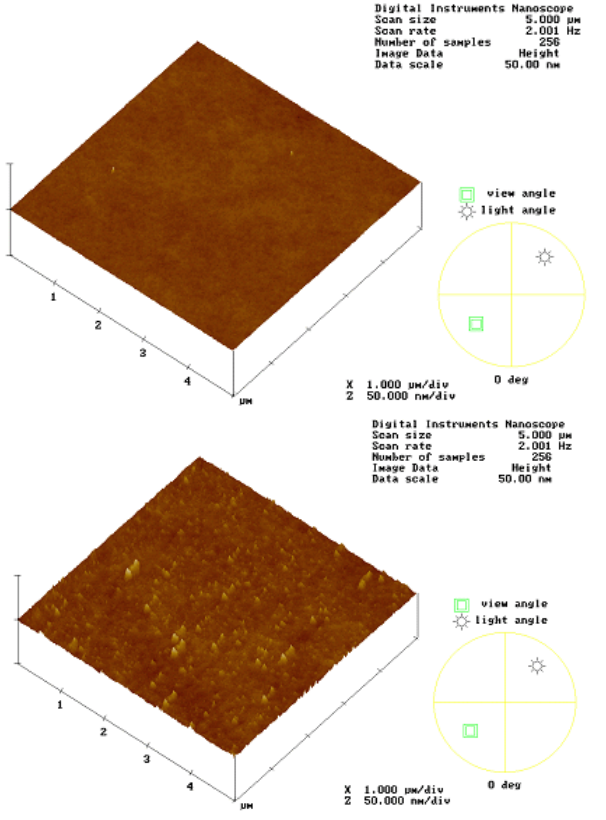
The Flat Panel Display predominates over the display industry. All sorts of FPD are made of pixels, that is Red, Green, Blue cells. The purer are red, green and blue cells, the higher is color reproducibility. The phosphors of most FPD don't emit pure color, and thence the color reproducibility of FPD is usually low in comparison with that of NTSC. PDP known as one of the most promising technologies for large-area flat panel displays emits visible lights from the gas discharge itself and phosphor. The visible light around 585nm emitted from PDP causes an impure color purity. So we need to filter the unnecessary lights. PDP also emits a strong near-infrared light(NIR) which sometimes causes malfunctions of devices working in the range of 850~900nm. So it needs screening NIR emitted from Xe gas in panels.

In this work, we fabricated optical filters by a tape casting both for improving the color purity and for blocking NIR, and investigated the properties of optical filter, containing several organic dyes. The filters were made by PMMA which dye A is contained in. Dye A absorbs the lights around 588nm. To screen the NIR, dye B and dye C were chosen. These kinds of dyes were chosen to absorb the light around 830nm. Finally, we investigated optical properties of our filters as functions of dye contents in films and the film thickness.

To fabricate the optical filters, in the first place, measured dye is dissolved in Methylene Chloride(CH_2Cl_2). After dissolving dye completely, PMMA was put into the solution. The solution was then stirred gently for about 2 hours. After stirring, the solution became a paste. At the end the paste was molded into a film by the tape casting method. An absorbance coefficient of the film can be determined from the absorbance data at several wavelengths. In this work, we calculated absorbance coefficient of dye A in 588nm and absorbance coefficient of dye B in 830nm.

2. Results

[Figure 1] shows the surface morphologies obtained from AFM. The roughness(rms) was measured below 1nm.



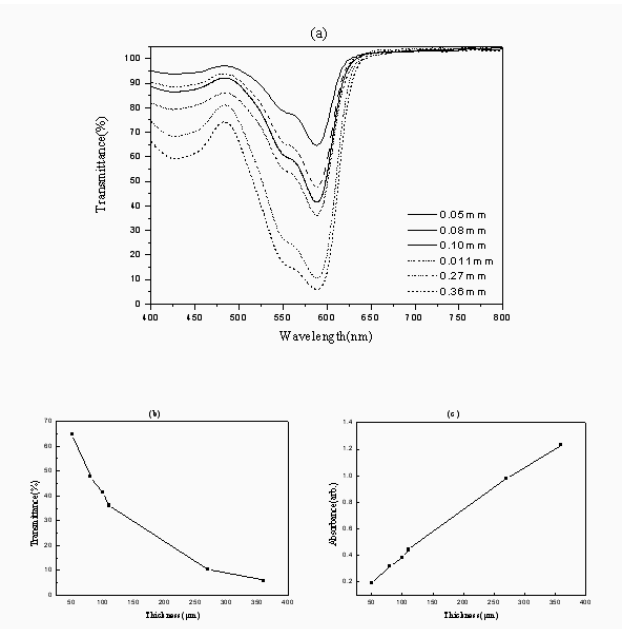
[Figure 1] AFM picture of PMMA filter containing dyes.

(The upper picture: The front surface,
The lower picture: The rear surface)

Optical characteristics are shown in [Figure2~4]. The absorbance A or optical density for materials follows the Beer-Lambert law. The law is given by

$$A=\log10(I_0/I)= \varepsilon(\lambda)cl, \quad (1)$$

where $\varepsilon(\lambda)$ is a function of wavelength and the molar absorption coefficient or molar absorptivity, c is the concentration of the absorbing components in material, and l is thickness of the absorbing material.



[Figure 2] The optical characteristics of PMMA filter containing dye A with a different thickness and about 300 ppm concentration.

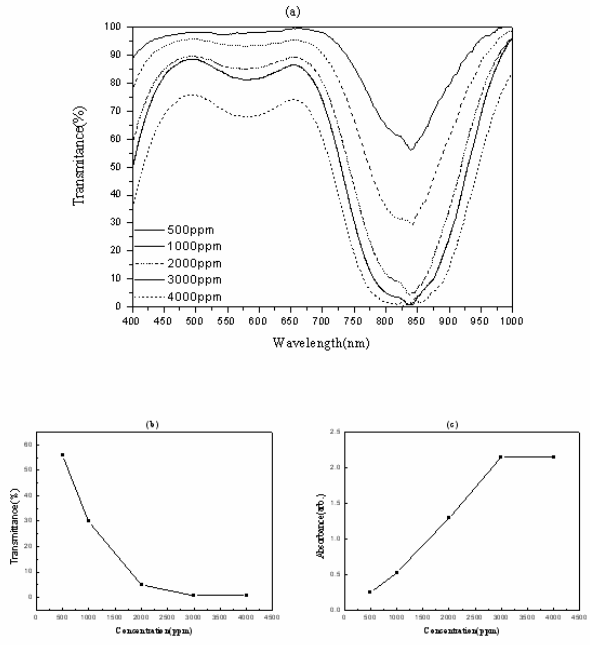
(a) Transmittance spectra.

(b) The transmittance change

(c) The absorbance change

[Table 1] The absorptivity of optical filter containing Dye A at 588nm.

Thickness L(cm)	Absorbance A	Concentration C(ppm)	Absorptivity ($ppm^{-1}cm^{-1}$)
0.005	0.18984	300	0.126560
0.008	0.32212	300	0.134217
0.010	0.38403	300	0.128010
0.011	0.44287	300	0.134203
0.027	0.97677	300	0.120588
0.036	1.22841	300	0.113741
The average absorptivity			0.124623



[Figure 3] The optical characteristics of PMMA filter containing dye A with a different concentration and same 0.013cm thickness.

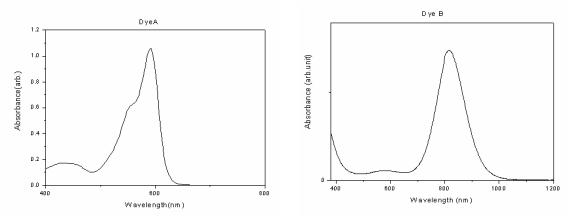
(a) Transmittance spectra.

(b) The transmittance change

(c) The absorbance change

[Table 2] The absorptivity of optical filter containing Dye B at 830nm.

Thickness l(cm)	Absorbance A	Concentration c (ppm)	Absorptivity ε ($ppm^{-1}cm^{-1}$)
0.013	0.25194	500	0.038760
0.013	0.52536	1000	0.040412
0.013	1.29585	2000	0.049840
0.013	2.14691	3000	0.055049
0.013	2.14997	4000	0.041346
The average absorptivity			0.045081



(a) (b)

[Figure 4] The absorbance spectrum of (a) Dye A and (b) Dye B.

The thicker is the thickness of a filter, the higher is an absorbance linearly and the lower is a transmittance logarithmically. The denser is the concentration of dye in a PMMA filter, also the higher is an absorbance linearly and the lower is a transmittance logarithmically. [Table 1] and [Table 2] show the absorptivity of samples of [Figure2], [Figure 3] respectively. The optical filters made with dye A or dye B for absorbing light of 588nm and 830nm reveal special absorbance characteristics, respectively. The results are in good agreement with the Beer-Lambert law.

3. Conclusion

From the experiment, it was found that the properties of organic dye containing filters obey the Beer-Lambert law. It is important to know the properties of organic dyes, related to the thickness of film and the concentrations of dyes in film with respect that it gives us a fabrication process with ease. In this sense, the Beer-Lambert Beer law allows us to make PMMA filter containing organic dyes simply, based on the function of the thickness of filter, the concentration of dye in the optical filter. The fabrication process introduced in this work yields an easy way to obtain the optical filters for PDP.

4. References

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