Formation of Black Matrix Pattern by using Black Photoresist

Yoon Lae Cho, Tae Yong Kim, Jin Mog Kim, Jeong Mok Song, Nam Je Koh
LG.Philips Displays
184,Gongdan,Gumi-City, Gyungsang Buk-do
730-030, Korea
E-mail: sselmo@lgphilips-displays.com
Phone:+82-54-460-3316

Abstract

Generally, the Black Matrix of CRT is formed by the application of photoresist and black material separately. We have developed the simple process for black matrix of CRT. We used the black photoresist, It made it possible that the formation of Black Matrix by application of the light exposure and development only once.

Introduction

Black Matrix of Conventional CRT

The Black Matrix plays an important part in the performance of CRT. It reduces the reflection of the ambient light on the screen of CRT and provides for the better contrast. Matrix patterns are formed by application of photoresist resin and black material separately. The most of CRT makers forms the Black Matrix by using this "Lift off" process. The successive process stages for Black Matrix are washing, photoresist application, photoresist drying, shadow mask insertion, exposure, shadow mask removal, developing(removal of non-adhering photoresist), black material application, drying, etching (breaking open the photo resist pattern), developing(spraying away the graphite residue). This process is too complex. But there were no way to form the Black Matrix of CRT except this "Lift Off" process. Because, In light exposure, we had to use the shadow mask as a masking device.

Exposure of FLATRON

LG.Philips Displays had successfully developed a perfect flat color display tube(FLATRON). FLATRON has the flat inner surface, and this flat surface enable to adapt the glass photo master in exposure process of Black Matrix. In making the Black Matrix of FLATRON, instead of using the shadow mask as a masking device, the glass photo-master can be used. The Black Matrix patterns on the glass masters are optically placed the same locations of the light through the shadow mask. Moreover, the flat surface made it possible to apply screen printing process to fabricate phosphor pattern of CRT.

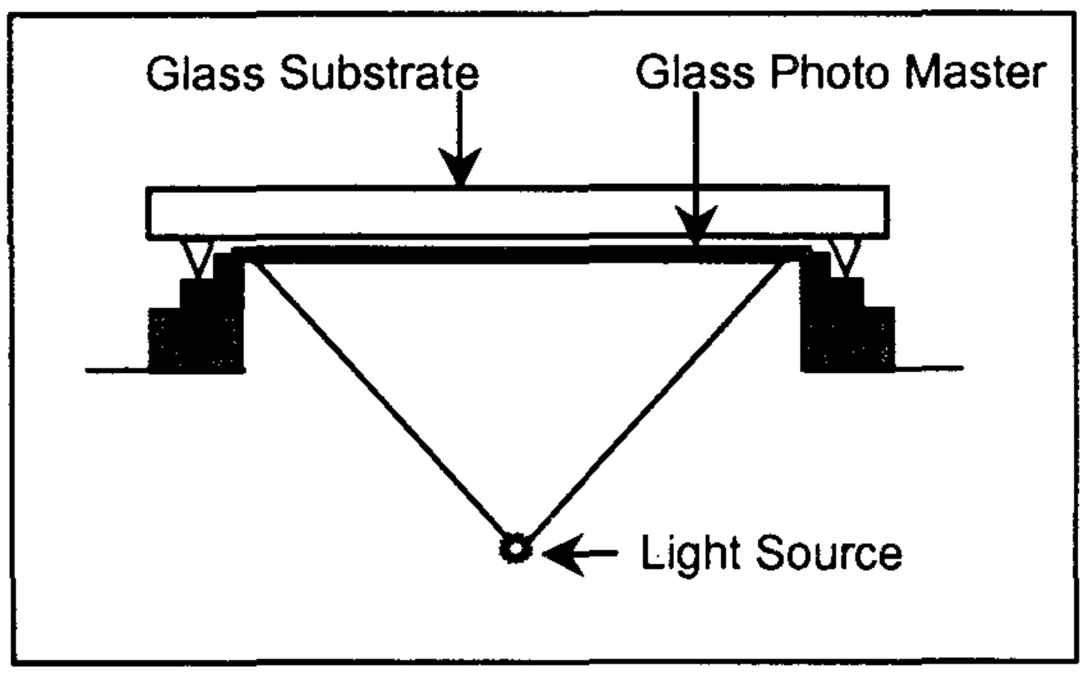


Figure1. Exposure of FLATRON

The beginning of the studying screen printing of phosphor, we noticed the overflow of printed phosphor paste. The overflow of paste was caused by the thin Black Matrix. We had come to understand that the conventional Black matrix couldn't control the overflow of paste. In order to control the fluidity of printed paste, the thicker Black Matrix was required in screen printing process.

Experimental

Preparation of Black Photoresist

In the last several years, LCDs have developed the Black photoresist to get the high optical density, high resistance and to protect the environment.

At first, we applied the black photoresist of LCDs to CRTs process. Though the formation of the black matrix pattern was success, but the pattern was pyrolyzed after 450℃ of baking. In order to apply to the CRT, the Black Photoresist has good heat resistance against high temperature of CRT process. And we tried to seek another black material for the black photoresist.

Black Pigment	feature	Heat Resistance	Conductivity After bake
Graphite	Used in CRTs	Excellent	O
Carbon Black	Used in LCDs	X	X
Metal Oxide Pigment	Hard to treat	O	X
Inorganic Black Pigment	Hard to disperse	O	X

Table1. Comparison of each black pigment

The heat resistance of the black material was evaluated by measuring the residue after baking at 450℃ for 30 minutes. The graphite had the best heat and chemical resistance among the black pigments. And it had a good conductivity after baking. So the graphite was selected as black pigment .

In this study, it was necessary to make the mixture of fine dispersed graphites with photoresist. The adopted dispersion method and technical condition were studied with LG Chemical Research Institutes. Graphite was finely dispersed in solvent , and then mixed with alkaline soluble and UV-curable resin and photoinitiators. The obtained mixture was used as black photoresist. The general composition of black photoresist is shown in the Table 2.

Processing Step

The black photoresist was coated on a glass substrate which had been cleaned. The coating method was spin coating. It was baked to 70℃. Then UV light was exposed on the coated film through a photomask. The major wavelength was 365nm.Next the coated film was developed with an alkaline based developing agent. And it was showered by pure water. Finally, the pattern was baked again to increase chemical durability. All of process were performed in conventional CRT process. It means that the application of black photoresist to CRT process is very easy.

Composition	**Function**	**Major factors**
Black pigment	Light shielding	-Blackness -Heat resistance
Binder polymer	Film formation	-Thermal Stability -Developability -Mechanical stabiliy
Multi functional Monomor	Cross linker	
Photoinitiator	Photo radical generator	Light sensitivity
Photosensitizer	Energy transfer	
Solvent	Solvation,Coatin g,Processibility	-Boiling point -Surface tension -Vapor presssure -Toxicity
Additives	Adjusting various process	Leveling,Adhesion, Dissolution,Curing, Thermal polymerization inhibitor

Table 2. General composition of Black photoresist

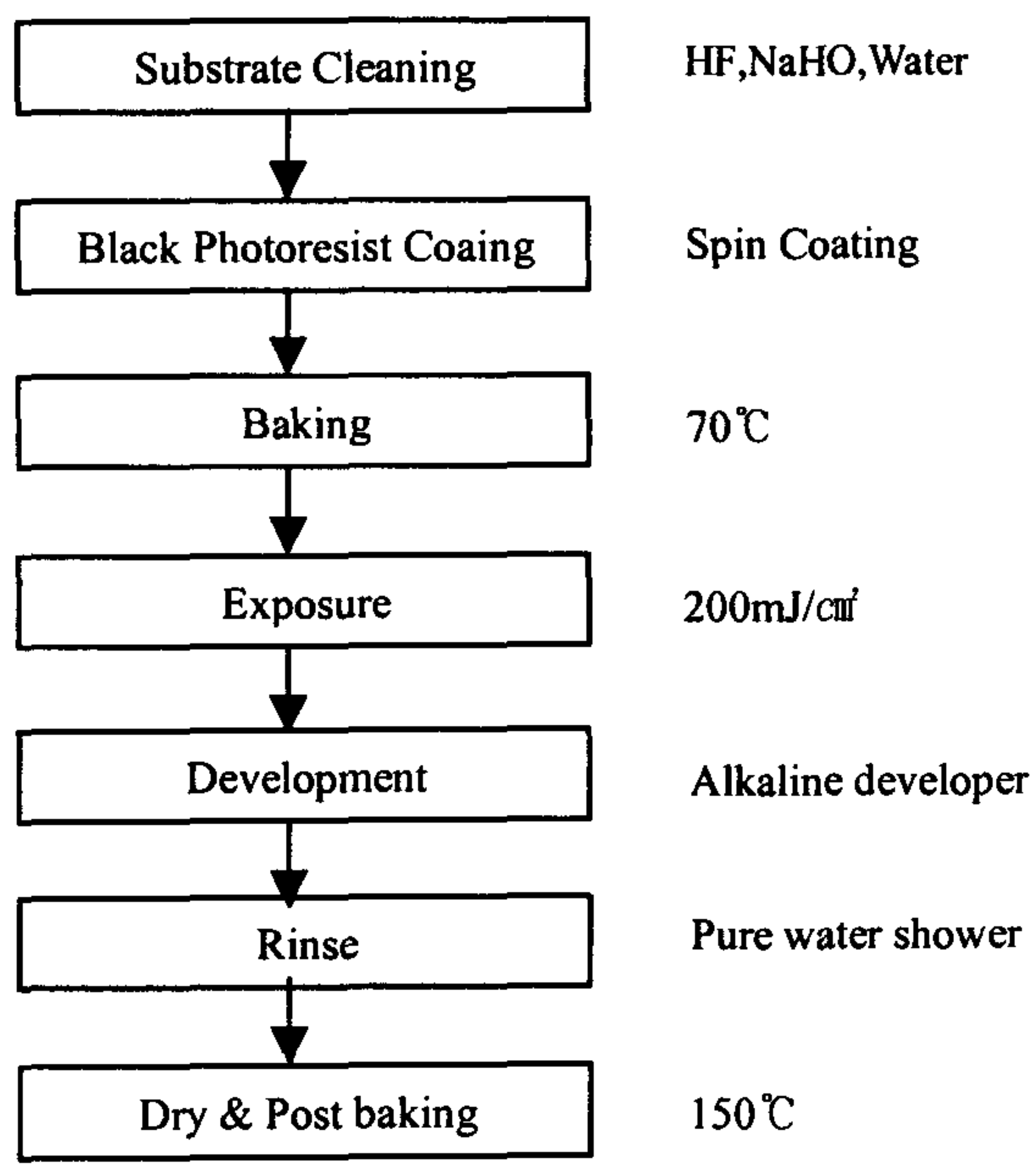


Figure2.General process condition of Black photoresist

Results and Discussion

Thickness

The thickness of conventional black matrix is 0.5㎛ and below. In conventional black matrix process, the thickness was very hard to control. The thickness of black matrix was influenced by the thickness of conventional Photoresist resin. In order to improve the screen quality in screen printing process, The thickness of black matrix is 4㎛ or more. The control of spin time and spin rpm enables to control the thickness of black matrix. The spin time, spin rpm and thickness of black photoresist are shown in Figure3. In general , the relation between film thickness and rpm of spin coat is express like below.

$d \sim 1 / w^{1/2}$ where d: thickness

w: spin speed

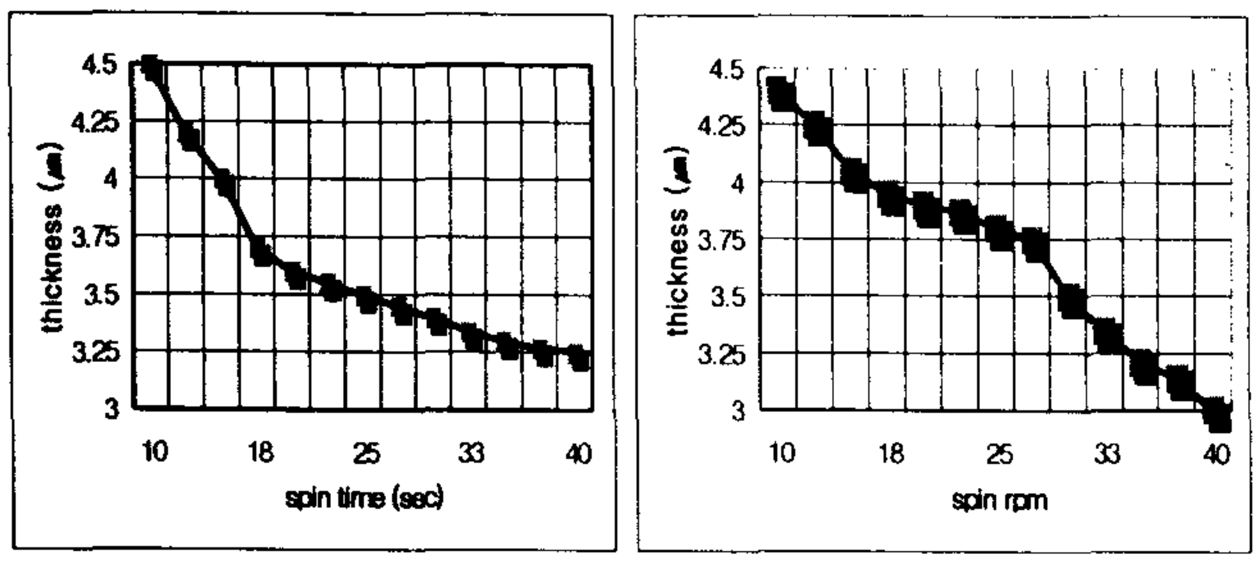


Figure 3. Thickness dependence of spin control

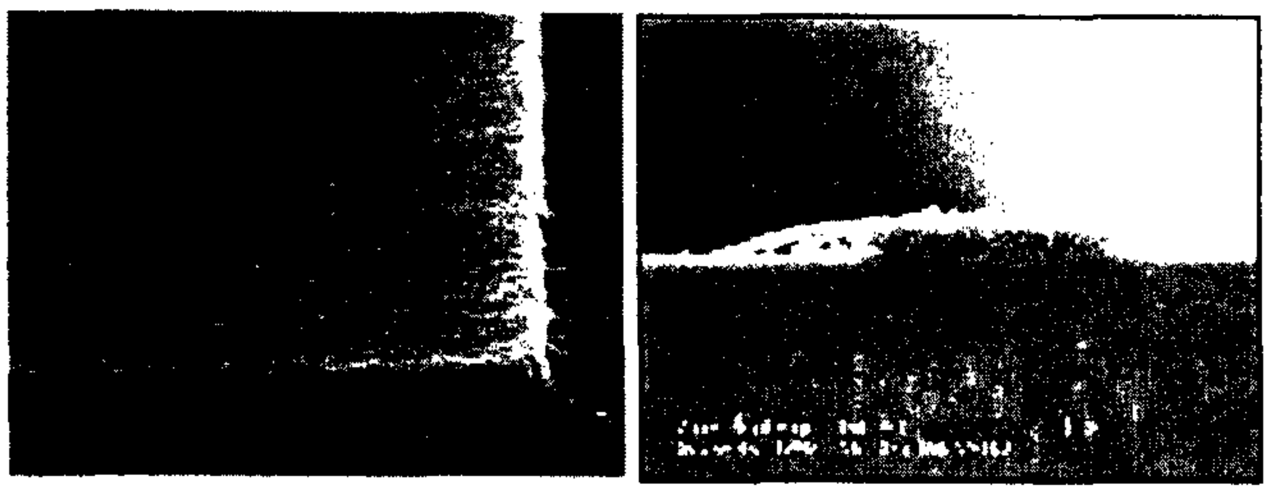
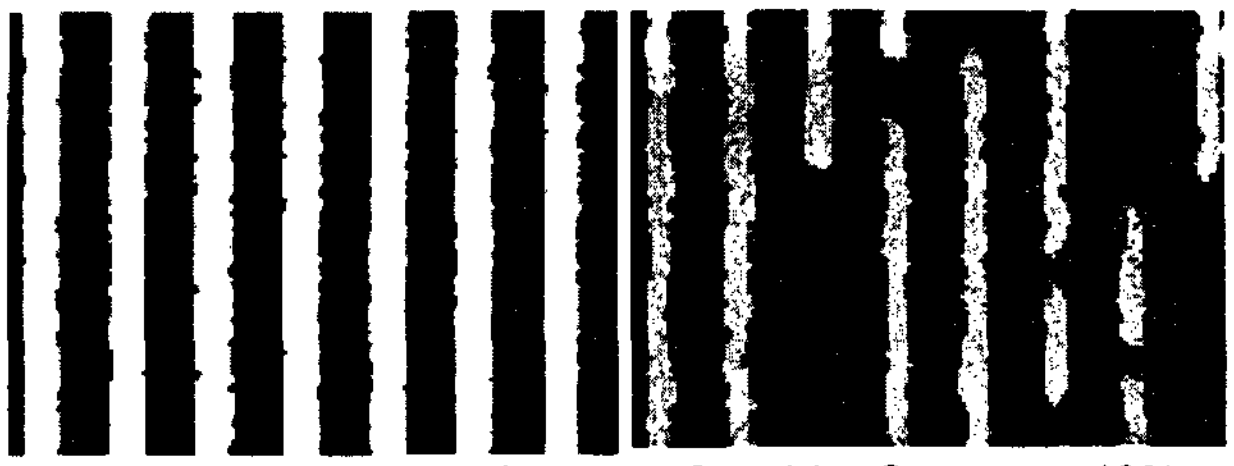


Figure 4. SEM photograph of a black matrix Pattern

Blackness and Edge sharpness

After baking at 450℃ for 30 min, the blackness of black matrix is went down.

To improve the blackness of black matrix after baking, several trials were performed. The best method to get the blackness after baking was the increase the graphite contents in black photoresist. But there was marginal contents of graphite in black photoresist. The black matrix pattern made by high graphite concentration in Black photoresist showed very poor edge sharpness (See Figure 5). In the case of 30% or more graphite contents in black photoresist, the formation of the normal black matrix pattern was impossible.



Graphite Contents: 30% Graphite Contents: 40%

Figure 5. Edge sharpness and Graphite contents

We measured the relations between the blackness and graphite contents in black photoresist. The L* value indicates the blackness of object in L*a*b* color system. The smaller value it has, the blackness of object is increased. In normal CRT, the L*value of black matrix is 10.

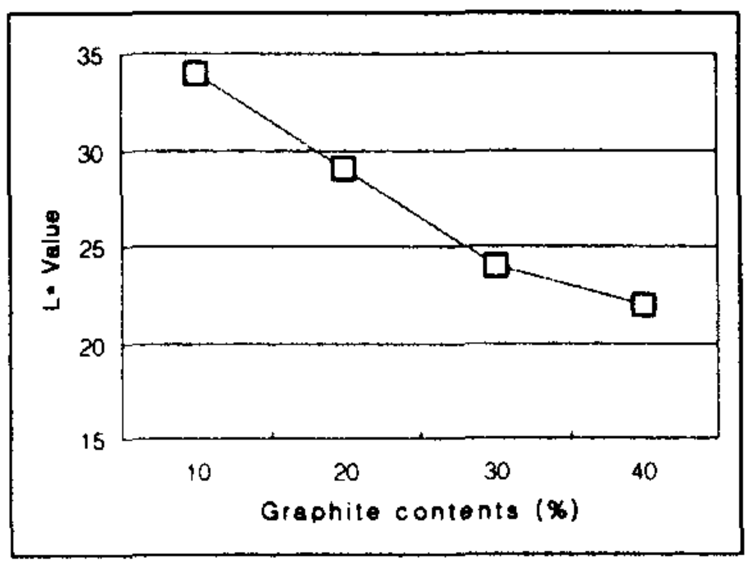
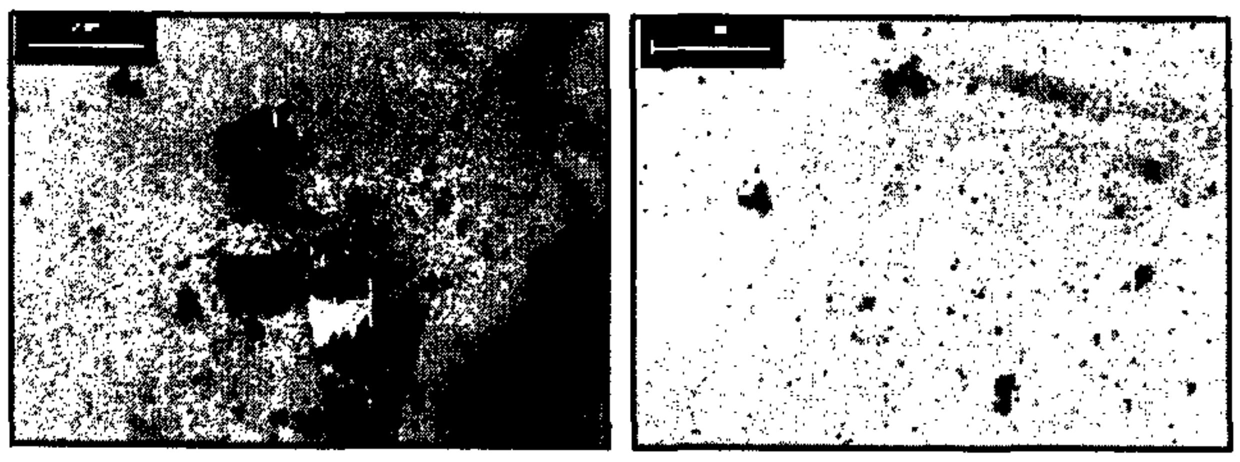


Figure 6. L*value and graphite contents

The formation of black matrix was impossible with the 30% or more of graphite contents, so we could not get the sufficient blackness

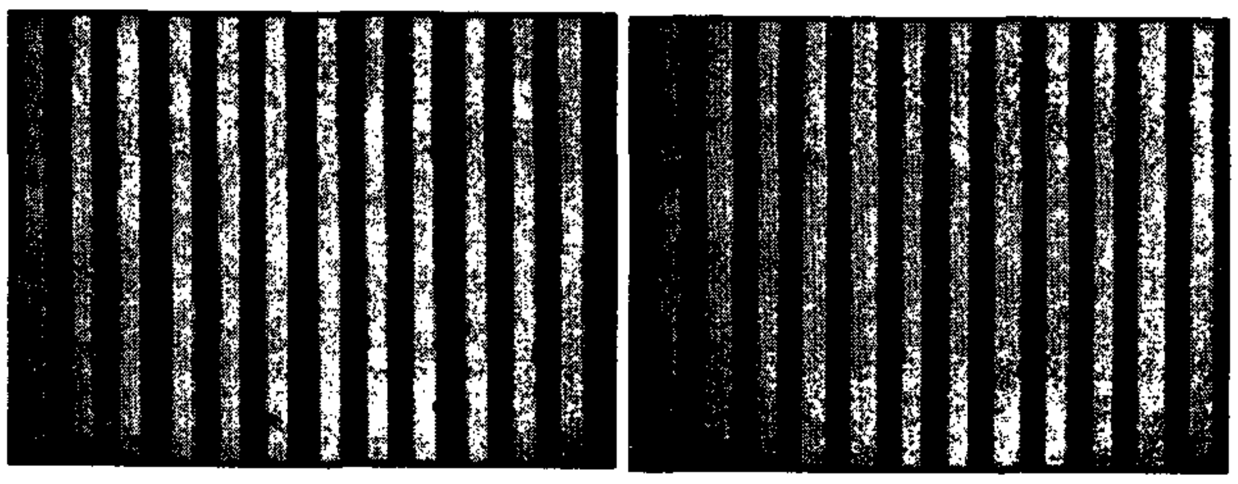
In order to get the blackness (10 or less of L*value) we tried the control of graphite size. The small size of graphite reduces the reflection of the ambient light. In the mixing operation of black photoresist, the milling operation is needed. We became to know that the milling time has an influence on the particle size. After 5 hours of milling operation, the particle size of graphite(D_{50}) showed the decrease of 80 percent compared with that of 1hour's milled graphite.(See Figure 7)And the small size of graphite made it possible the formation of black matrix with good edge sharpness and better blackness(L*value=14).



1 hour milling 5 hours milling

Figure 7. Change of graphite size and milling time

Moreover, the edge sharpness of black matrix made by black photoresist is superior to the that of normal size.



Normal Flatron Black photoresist

Figure 8. The black matrix pattern of normal black matrix and black matrix of black photoresist

Conclusions

We developed a black photoresist for CRT. In order to apply the black photoresist to the CRT, we selected graphite as a black material for black photoresist. And we developed the 4μm of thick black matrix to improve the screen quality in screen printing process. The edge sharpness and blackness can be controlled by optimizing the milling time and graphite contents.

We become to have the important screen process of flat display device.

Acknowledgements

We would like to thank J.H Kim, D.C Choi and J,E Yoon in LG Chemical Research Park. for helpful discussion and development of Black photoresist.

References

[1] L.F.Bacchetti, .L.Alemy,M.E.Perkins,C.R.Szmanda,R. L.Brainard,IDW'96,333 (1996)

[2] T.Itoi, Y.Demachi ,S.Ito and M.Tani, IDW'00 (2000)

[3] Takanori Kudo, Yuki Nanjo, Yuko Nozaki,Hidemasa Yamaguchi and Georg Pawlowski, IDW '96(1996)

[4] W.S.DeForest,1975,"Photoresis-Materials and processes", McGRAW-HILL book,pp25-42