Advanced Color Filter for TFT-LCD

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Abstract

A new manufacturing method using laser transfer technology was developed for a color filter of TFT-LCD. This method can make red, green and blue color layer at the same time without several baking processes. Simple process, no residue, good edge profile, and so on are merits of this process. The same performances (such as color characteristics, reliability, hardness and so on) of current color filter were achieved with this process.

Introduction

There are several color filter manufacturing methods such as dying method, pigment dispersed photolithography method, printing method and electro-deposition method [1-4]. Among these methods, the pigment dispersed photolithography method is commonly used in a mass production because this method have satisfied the more stringent requirements such as fine resolution, uniformity and high stability for heat, light, and chemicals. However, the manufacturing process is too long and complicated

Recently, LCD manufacturers are developing the large size and high-resolution TFT-LCD devices for the purpose of monitor, TV, and portable high information display. They are doing intensive R&D activity to increase screen sizes, improve image quality, and reduce costs. The color filter, which is the most important parts of LCD also, has trends to be large sizes, high resolution, high color purity, and lower price [5].

Under the current situation, new color filter manufacturing methods such as bubble jet printing, ink jet printing, and laser printing have been proposed to provide simple making process [6-8]. By laser printing method which is proposed several companies, a color filter layer is formed by transferring from film to substrate using a light sources such as laser or flash lamp. Among of these new methods, we investigated and developed laser transfer method.

Manufacturing Method

Laser transfer method is a dry process by using a donor film including supporting layer, light absorbing layer, and transfer layer with laser scanning system. Principle of this method is a kind of laser to heat converting technology. In Figure 1, our process of making a color filter and a structure of donor film is described in detail. A black matrix layer is coated on a glass substrate and then a black matrix pattern is formed through a photolithography process. A donor film for the first color is placed on that substrate and then laser is irradiated through donor film. A light absorbing layer in donor film absorbs almost light energy and then emits heat. Due to the emitted heat, a first color layer formed in donor film is transferred to the black matrix substrate. The second and third color layers are transferred in the same manner. Then, the resultant is cured at 220 °C.

In this process, a new laser scanning method was designed in order to provide very uniform energy to donor film. As shown in Figure 2, a continuous wave (CW) laser beam having different size with respect to X and Y directions was designed. The scanning field was designed about 640mm and the beam size was 30x300μm. This beam can scan X and Y directions at the same time to generate uniform energy on color filter pattern. In this scanning technique, there are several energy control factors such as scan speed of X and Y directions, scanning shape, and laser power. By controlling these factors, very uniform stripe pattern of color layers could be obtained. The width variation of color layer with this scan method is under ± 1.5μm in all scan field.

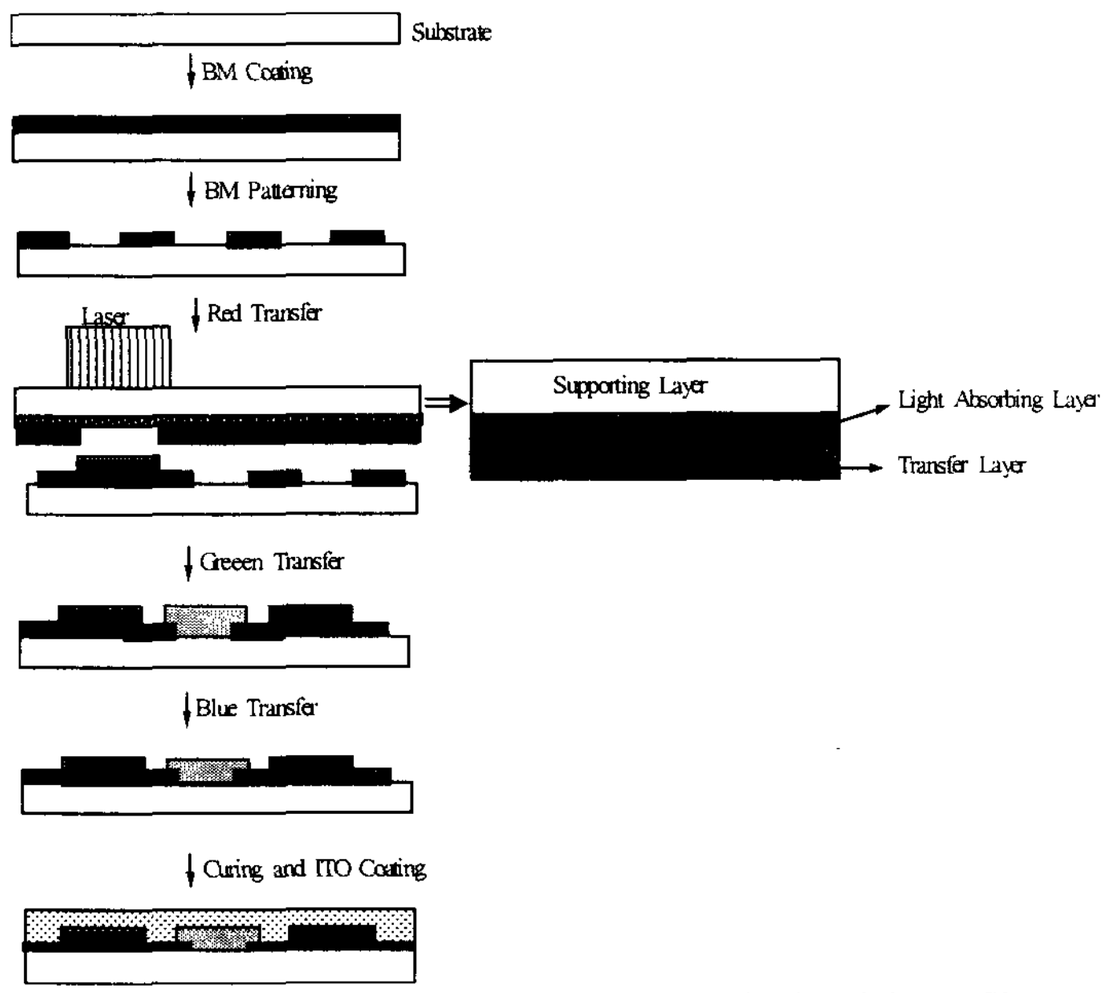


Figure 1. A new color filter manufacturing method and donor film structure.

As described above, laser transfer method for making a color filter is very simple and can make color layer at the same time without several baking processes. The process steps for making a color filter is about one third compared with conventional ones.

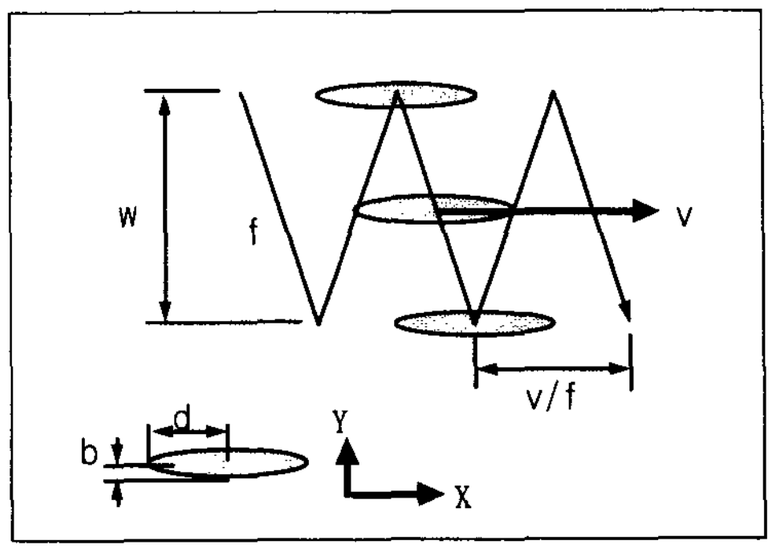


Figure 2. Laser beam scanning method for a color filter.

Results and Discussion

The 15-inch color filters for note PC were fabricated with our laser transfer method. Several properties such as thickness,

hardness, adhesion, flatness, color characteristics, edge profile of color layer, residue, surface roughness, and so on were investigated with these color filters.

The color layer had about 1.3μm thickness and flatness among the three color layers was under 1000Å as shown in Table 1. The adhesion and pencil hardness of each of the color filter layers after curing process were measured according to ASTM D3359-93, X-cut tape test and JIS K5400 test. The result was about 5A for adhesion and 4~5H for pencil hardness, which means that laser transferred color layers has very good adhesion between color layer and black matrix layer and has a strong film strength to satisfy the process of TFT-LCDs.

Color	Ave. Thickness	Flatness
Red	1.22㎛	R-G: 470Å
Green	1.25㎛	G-B: 260Å
Blue	1.27㎛	B-R: 610Å

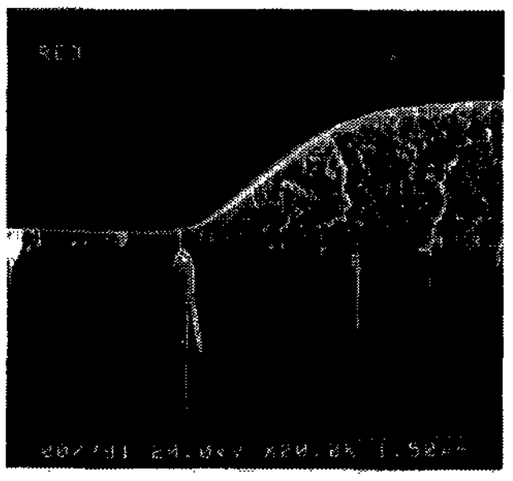
Table 1. Color layer thickness and flatness

The reliability of laser transferred color filters and color coordinates was summarized in Table 2. The color characteristics and all reliability results were very similar to that of conventional color filters.

Test Items	Test Conditions	Results
Color Coordinates	1931 CIE	R: x 0.591, y 0.344, Y22.6 G: x 0.313, y 0.541, Y62.1 B: x 0.139, y 0.168, Y20.5
Heat Durability	230℃, 2H	ΔEab<3
High Temp.	80℃, 500H	ΔEab<3
Thermal Shocking	-30/80℃,30min,20Cycles	〃
Low Temp.	-30℃ 500H	〃
Light Durability	Xe, 500H	R,B:ΔEab<3 G:ΔEab≒4.0
High Temp & High Humidity	40℃, 95%, 240H	ΔEab<3
Chemical Durability	γ-Butyrolactone, NMP, IPA, TMAH, 70℃ Water, etc.	〃

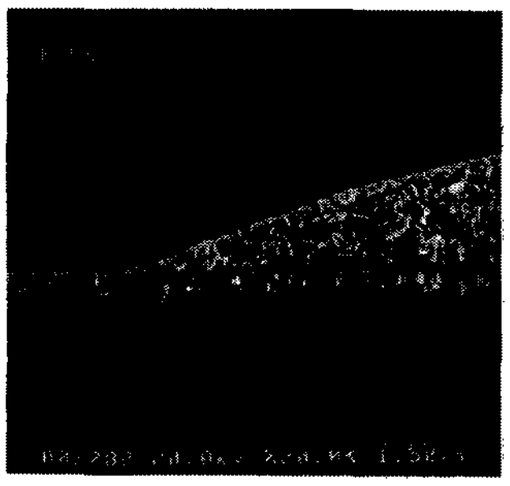
Table 2. Reliability and color coordinate of laser transferred color filter.

Some of merits of this process were that laser transferred color filter has a good edge profile, no residue on the surface of black matrix substrate, and a good surface roughness. Figure 3 shows SEM pictures of laser transferred color filters. In general, the surface on color layer made by a conventional method has some surface roughness because of three times of developing and curing process. In addition to that, the color layer residue in conventional process is always remained on the surface of black matrix substrate. In laser process, due to dry process and one step curing process, a good surface roughness of color layer was obtained and no residue color filters also was obtained.

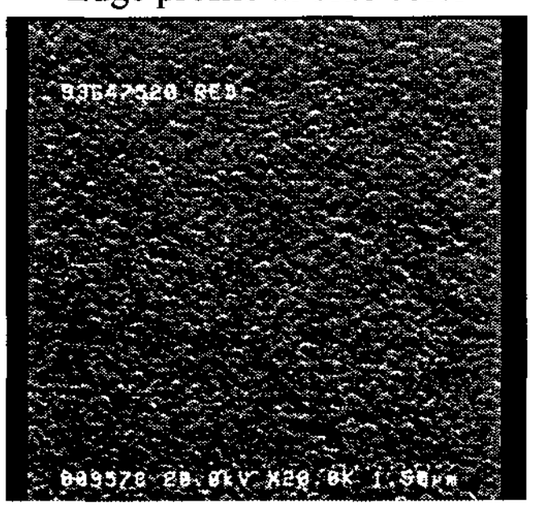


<Edge profile in red color>

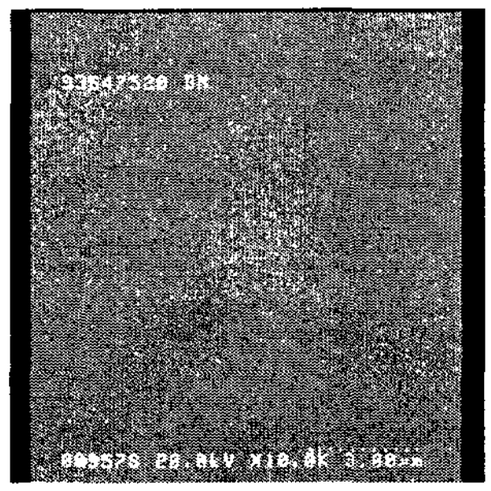
< Edge profile in green color >



<Edge profile in blue color>



<Surface roughness of red color>



<Residue on black matrix>

Figure 3. SEM pictures of laser transferred color filters.

Conclusion

A new manufacturing method using laser transfer technology was developed for a color filter of TFT-LCD. A new laser scanning method in this process was applied for a color filter. The width variation of color pattern was obtained under ± 1.5μm level in all scan field with this process. This laser transfer process can make color filter layer very easily without several baking processes. Simple process and, no residue, a good edge profile are merits of this method. The same performances such as color characteristics, reliability, adhesion, hardness, and so on of current color filter were achieved with laser transfer method.

References

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