# Recent Trends in Optical Materials of Backlight for LCD Display

Hyun-Soo Dong,*[1] O-Yong Jeong,[2]

[1]Vice president, Display Materials Division, Samsung Cheil Industries Inc., Uiwang-si, Gyeonggi-do, Korea
hansdong@samsung.com
[2]Senior Manager, Display Materials Division, Samsung Cheil Industries Inc., Uiwang-si, Gyeonggi-do, Korea
oyong.jeong@samsung.com

## Introduction

The use of liquid crystal displays (LCDs) has been constantly increasing, driven by information technology products such as LCD–TV, laptop computer, wireless portable phones. Because liquid crystals do not emit lights, a backlight source is necessary in order to process viewable images on a LCD. A backlight unit (BLU) of LCD consists of a light source and optical materials for transmission, reflection, and diffusion of incident lights. Many Companies have been making a large amount of effort to obtain a BLU which has good optical properties, which are high luminance, good luminance uniformity, and a wide viewing angle [1–6], and also it requires an optimized structure such as thin and lightweight.

TFT-LCD BLU has been remarkably developed for a recent few years as TFT-LCD market is increased. Recently new BLU technologies and components are developed as more aggressively than before since TFT-LCD panel requires higher quality and resolution. As shown at figure 1, current TFT-LCD system closely combined with BLU as a light source and BLU of LCD-TV is nearly forty percent of whole TFT-LCD panel in its cost. Even developing other light source such as flat light or LED, BLU with cold fluorescent lamp(CCFL) has been widely used.

Recent displays such as LCD, PDP have been developed mainly in Asia countries such as Japan, Korea and Taiwan etc. Especially Samsung Electronics and LG Philips LCD of Korea are major LCD panel makers and the major optical materials of LCD BLU and panel for Samsung Electronics have been supplied by Samsung Cheil Industries. In this presentation introduction to main components of LCD BLU will be investigated details. Also characteristics and applications of optical polymers such as PMMA, PET, PC, PS, COC etc. for LCD display will be included and finally recent trends in optical materials for LCD BLU will be shown briefly.

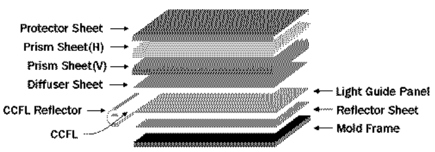


**Figure 1.** BLU Configuration of LCD monitor

## Basic structure of BLU

BLU structure is divided with edge type and direct type according to the arranged position of light source. Laptop computers such Note-PC, Monitor have been adapted the edge type and direct type has been applied for LCD TV which lamps attached at backside is directly lightning forward to the diffusing plate. The edge type BLU which two or four lamps are positioned at both or one side of Light Guide Plate(LGP) could be spilt two kinds again, that is, flat and wedge type. The former is consist with two or four lamps at both side of flat LGP, the later use one lamp on one side of inclined LGP. In the case of LCD TV, the diffusing plate is usually used instead of LGP, which is set in laptop computers. Figure 2. Basic structure of BLU according to light position: a) wedge, b) side or flat, and c) direct type

Usually BLU is composed of lamp, optical sheet, mold frame, inverter, housing and function of each components is as following. Currently almost of lamps is adapted to CCFL, which the charged particles inside glass tube impact and excites phosphor materials. The brightness of lamp itself is about 30,000 ~ 40,000 nits with its own characteristic color.

LGP is a wave guide, which consists of polymethylmethacrylate (PMMA). Linear light source of one dimension is conversed to two dimensional area light type. Due to the wave guide character LGP needs the scatter sites so as to forward the scattered light to the front side of BLU and enter into TFT-LCD panel. Conventional scatter site is dot patterns by screen printing. The brightness and/or uniformity of light were controlled by changing the dot size and the distance between two dots. Since screen printing has several drawbacks, print-less methods such as injection molding, laser engraving, hot embossing etc. are actively developing by many BLU-related companies.

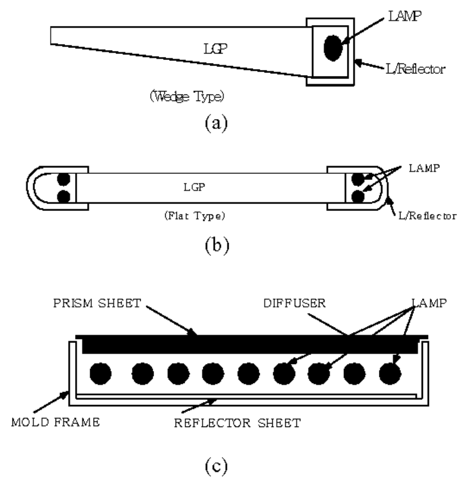


**Figure 2.** Basic structure of BLU according to light position: a) wedge, b) side or flat, and c) direct type

Generally, the BLU may be classified into two categories in terms of the location of the light sources inside the module, i.e. edge lighting and direct lighting. To achieve good brightness uniformity and high luminance, the direct lit BLU is comprised of several kinds of optical materials, such as a reflective film, diffusing plate, diffusing sheet, brightness enhancement film (BEF), and reflective polarizer film, as shown in Fig. 1. Each optical material has special function in a BLU.

For example, the reflective film which is located at the bottom of the BLU reflects the lights coming from the light sources toward the BLU top to minimize light loss. High reflective materials like silver, titanium and some other polymer materials are coated on the metal substrates. The function of the diffusing plate and diffusing film is to obtain uniform brightness by spreading the lights.

Light through LGP or diffusing plate towards LCD panels. To avoid its shadow, diffusing film is used(Fig 3). On both side of base polymer film coating layers are covered with fine grains of 1~10micron diameter as light scattering center. Figure 4 reveals the function and structure of diffusion film.

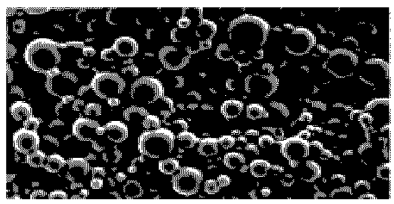

**Figure 3.** SEM of diffuser sheet

The light scattered through the diffusion film is need to be focused forward into the front side of LCD panel again in order to enhance the viewing angle. For this purpose, early two prism films (vertical and horizontal), specially called brightness enhanced film (BEF) are positioned upper the diffusion film. Viewing angle is related with cutoff angle of prism and the distance between pitches. The BEF, also called 'prism film,' collects the uniformly diffused lights, and reflective polarizing film reflects light in a perpendicular polarization, therefore enhances the LCD panel's brightness. However, the luminance uniformity of the direct type BLU may still need to be improved. The reason comes from the significant difference in luminance between the spaces of CCFLs, so that how to obtain high brightness and uniform luminance has been a big issue in a BLU design.

## Materials and Manufacturing of optical sheet

Commercially available polymers have been applied to optical base materials for LCD BLU. PMMA has been an optical polymer because of its good light transmission and haze. Generally, PMMA has been used as a good LGP and diffusing plate, and also as diffusing beads coated on a polyethylene terephthalate (PET) film which diffuse the introduced or reflected light from light source or reflective film. However, PMMA has low thermal stability and low mechanical properties due to high moisture absorption by containing hydrophilic group, a carbonyl group. In a direct-lit backlight, a PMMA diffusing plate, which was hygroscopically expanded, was easily bended into LCD panel, so that the plate pushed the LCD panel and the panel could be seriously damaged. In addition to PMMA, PET several other polymers such as polycarbonate(PC), polystyrene(PS), cyclic olefin copolymer(COC) are used as optical sheets.

For micro imprinting of special optical pattern in a temperature assisted embossing process a number of thermoplastic polymers is commercially available. Main properties with impact on the imprint process are the glass transition temperature Tg of the respective polymer and its mean molecular weight as well as the molecular weight distribution. The longer the polymer chains, the higher the imprint temperature has to be chosen above Tg in order to maintain a dedicated viscosity suitable for replication of the stamp pattern into the polymer layer, resulting in an increased processing time due to long heating and cooling cycles.

Wedge type LGP was usually produced by injection molding and extrusion method was used to make flat type LGP. After extrusion back layer of flat type LGP was printed by silk screening of ink paste to diffuse light which was entered from side lamp. To replicate the special optical patterns on the surface of LGP, hot embossing or roll to sheet UV embossing methods could be used commercially as shown in figure 5.

## Recent trends in optical sheet for BLU performance

Recently to combine the function of each optical sheet is the main issue in the BLU technology. One of the most realized items may be prism LGP which was applied function of prism sheet to LGP. But it was very difficult to eliminate prism sheet (BEF) in the BLU component because of the lower luminance performance of prism LGP. But recently it was firstly commercialized in Samsung Cheil Industries to produce dot-prism LGP which is able to eliminate BEF for LCD monitor as shown in figure 4. This LGP has been adapted to BLU of Samsung Electronics in the end of 2005.

In the case of note-PC, BEF was replaced by inverse prism sheet which was patented by Mitsubishi Rayon(MRC). For LCD TV prism sheet was changed by three sheet of diffusing sheet in the low cost products. The main issue in the LCD monitor or TV will be cost firstly including optical performance.

## Conclusions

LCD display market has been enlarged heavily within only several years and expected to increase steady in the future. Also the cost was downed rapidly. To meet the need of market such as high performance and low cost, incessant breakthrough in BLU technology is needed. In addition companies of sheet or BLU are trying to move to china. Also it is necessary to combine or integrate optical engineering, chemistry, chemical /polymer engineering, mechanical and material engineering to make some suitable sheet or BLU in LCD display.

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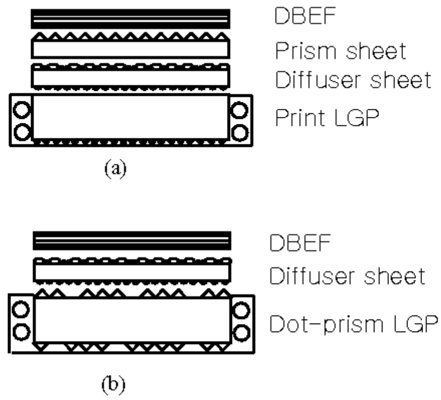


**Figure 4.** BLU configuration of (a) general BLU and (b) Cheil's BLU

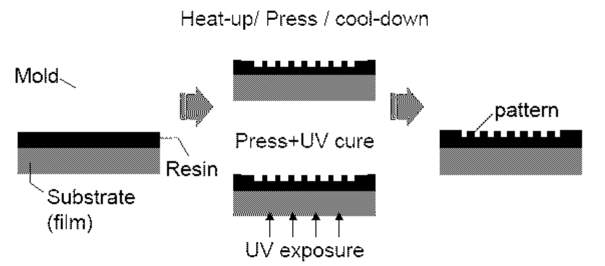


**Figure 5.** Micro imprinting process of optical pattern by UV embossing