New Light Fiber BLU System for Large LCD Display

Man Young Chung[1] and Tong Soo Park[2]
[1]Taesan LCD Company
30 Jije Dong, Pyong Taek, Korea
[2]Department of Physics
Kyungpook National University
Sangyok Dong, Taegu, Korea

Abstract: A new PLF-BLU (Plastic Light Fiber-Back Light Unit) using side glowing light fiber rods array for the 42" LCD TV display has been evelopedd. The light fibers were 14mm in diameter and 50cm long pure transparent acrylic rods of 1.49 refractive index. Fine scratces were made on the flat side of rod. Extremely bright incandscent light from lamp fed into the fiber is scattered at scratches then emerges through the surface of rod. A typical PLF-BLU system consists of 24 PLFs produced side glow of brightness of 4,500cd/m^2 to 6,500cd/m^2. New PLF-BLU is proved to be a BLU of rigid, bright, no heat generation, and low power consumption, hence a prospective BLU system for very and/or ultra large size TVs. A new LED-PLF-BLU system considered to be a revolutionry to break-through of the BLU technologies has also been developed, and is decribed briefly.

1. Introduction

LCD(Liquuid Crystal Display), VFD(Vacuum Fluorescent Display), ELD(Electroluminscent Display), OrgECD(Organic Electric Crystal Display), FED(Field Emitter Display), and PDP(Plasma Display Panel) technologies for the FPD (Flat Panel Display) have rapidly been developed for various display systems start with hand phone, note book computer monitor up to large size TVs. Basically the FPD requires those factors as thin, light, bright, high efficient, high resolution, fast response, long life, low power consumption, etc. Currently PDP's are dominent in the market of large-screen TVs while LCD chases them aggressively. Authors developed a novel large area LCD backlight system using side glowing light fiber for TV's, possibly larger than 42" that would break through the technical difficulties in current LCD systems.

2. Very Large FPD Systems

2.1 PDP, LCD Systems

Existing PDPs for very large size screen TVs of 40" and 60" have unlikely match the LCD or IEL display's performance level or their cost structure because of the aspects in brightness, pixel elements and power consumption due to their complex barrierrib structure and other factors. Henceforth, it is prospected that LCD system will dominate the market of 40" TVs by 2005 and 60" TVs by 2010 for its higher pixel elements, lower power consumption, and low cost. See Table 1.

Year		2001	2005	2010-2015
PDP	Size	60 Inch	60 Inch	80 Inch
	P.E.	1 M	2 M	4 M
	C.P.	300 W	150 W	100 W
TFT-LCD	Size	28 Inch	40 Inch	60 Inch
	P.E.	2 M	3 M	4 M
	C.P.	77 W	85 W	100 W
Org.ELD	Size	13 Inch	15 Inch	20 Inch
	P.E.	0.48 M	1.2 M	2 M

Table 1. Prospect of very Large FPD System

2.2 A Prospect of the TV Market

The annual sales amount of PDP, LC and CRT display system TVs is shown in the Fig. 1. The conventional CRT system which is bulk, heavy and high power consumption will keep the high sales positiion in the TV market until 2010 for the merit of low cost. As the figure shows that although both LCD and PDP started in the same year of 2001 it is noteworthy that the sales of LCD increase rapidly competing CRT and largely suppressing PDP by year of 2005 and there-after.

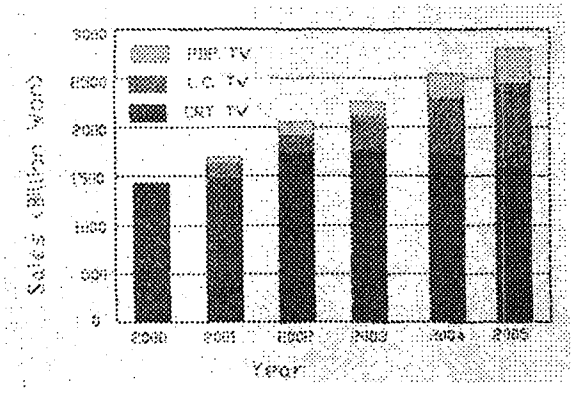


Fig. 1. Comparison of the Sales Amount of PDP, LCD, and CRT TVs

3. Plastic Light Fiber(PLF) as a Strong Light Source for BLU

Since LCD is not an emissive device, TFT-LCD needs a back light unit(BLU) as a light source to illuminate the display. Most widely used BLU consists of cold cathode fluorescent lamp, power supply, and a light distribution technique to evenly distribute the light to the display assembly. In case of small area display such as note book computer monitor, a single lamp mounted on the edge-side of panel is enough to get sufficient illumination. For the large size LCD a rib-array of tens of long lamps are necessary. Never-the-less, such a fluorescent lamp sytem will not be met the essential requirements as a commercial BLU. Eventually long fluorescent lamps need higher glow discharge voltage, and brake hazard. In order to get 450cd/m^2 brightness at the surface of LCD the BLU must supply the excitation light of more than 4,500cd/m^2 Our new array system PLF BLU is able to supply very bright light of 4,500cd/m^2 to 6,500cd/m^2 brightness. The plastic light fibers used were 14mm in diameter and 50cm long straight round rod of pure MMA. The index of refration of fiber is 1.49 and the transmission loss is less than 3%/m at red light.. One side of rod is flattened about 5mm wide along the rod, then scratched. Both ends of rod were carefully mirror polished. The incident end of rod leaves as transparent while a terminal end is closed with a high reflective mirror. Incandescent white light from a metal halide (halogen) lamp fed onto the light fiber scatters at the scratches then intensive glow emerges through the surface of transparent rod. A schematic side glow ray tracing diagram at the cross section of the rod is shown in Fig. 2.

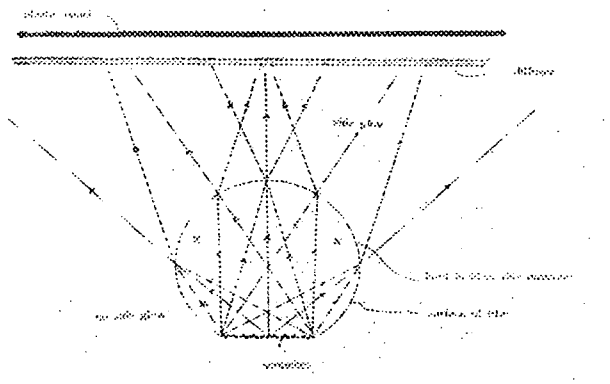


Fig. 2. Schematic Diagram of scattered ray tracing: rays scattered at the scratches emerge to the air after refraction at the surface of fiber. The unscattered rays travel along the axis of the fiber. For the rays of incident angle greater than 43 defree which is the critical angle reflect internally at the interface hence do not emerge. Index of refraction for the air and the fiber is 1 and 1.49 respectively.

Since the index of refraction of the fiber (n=1.49) is greater than that of an air (n=1) the upward side glow is very bright while all scattered light beyond the critical angle is internally reflected hence no side glow is observed in the vicinity of scratched bottom side. The geometry and population of scratches are designed such a way that the side glow to be evenly bright all along the light fiber. (See Fig. 3).

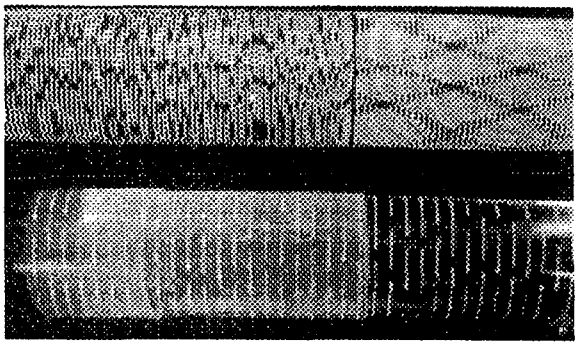


Fig. 3. Typical Patterns of Scratches on PLF.

It was found that the brightness of side glow can be enhanced to nearly 20% to 30% by painting the scratched side with a special white paint, and placing a waved reflector underneath of the fiber array. An array type PLF- BLU with metal halide light sources is shown in Fig. 4. The BLU is composed of 24 POFs aligned in parallel spcing 35mm acrossed the flat panel at vertical direction., and the plastic film light diffusers. Four sets of E/L generators of metal halide incandescent lamps are installed separately. Each generator contains one focused halogen lamp which supplies white light to 6 rods through 6 light feeding fibers (12mm in diameter) connected to the ends of six rods. All light feeding fibers are mirror shiny polished at the ends and divided into four sets. Each head of the fiber set containing 6 fibers bundled together to form a single cylindrical-like solid light rod, is placed close to the port of each lamp which is nearly the focal point of the lamp. Absolutely no heat and or uv light were detected no the entire panel.

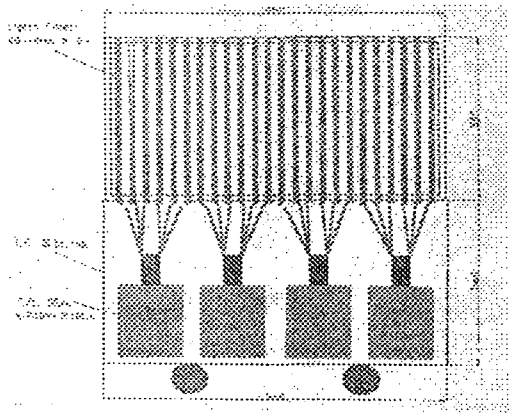
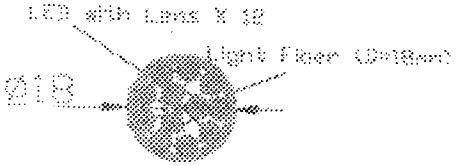


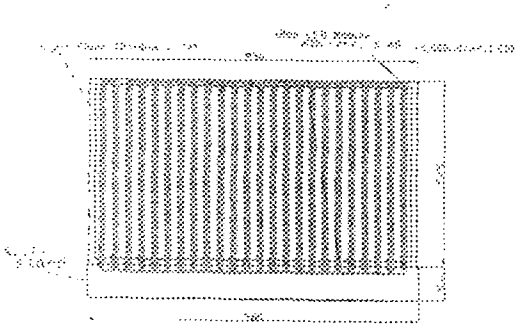
Fig. 4. PLF-BLU System with Metal Halide Light Sources.

4. Built-in LED-PLF-BLU System

A Built-in LED-PLF-BLU system was conceived and has been developed as a revolutionary PLF-BLU. As the light sources, thewhite light LED modules with lens were used. An LED module was built in both ends of each PLF of 18 ㎜ in diameter. One LED module contains 12 white light LEDs arrayed in series. Bright beams emitted at both LED modules propagate through the fiber in oposite direction each other superpose then enhance the brightness.
LEDs are operated simply by either battery set and/ or common dc line power supply of 4.5 volts and 20㎃. They are quite alternative. More details will be described in eleswhere. Fig. 5 is the diagrams of (a) a LED Module, and (b) typical built-in PLF-BLU system for 42″ HDTV.



(a)



(b)

Fig. 5 (a) 12 white light LEDs with lens are circularly arrayed in series and built in a circular light fiber of 18㎜ in diameter. The life of a LED module is expected to be more than 5 years (b) An LED-PLF-BLU for 42″ HDTV. This typical Unit consists of 24 PL Fibers of 18㎜ in diameter and 50 ㎝ long aligned verically. 48 LED Modules for 24 fibers aer used in this Unit. This system is adequately operted with the power of 27volts and 0.9㎃ supplied by battery and/or dc power supply.

The following advantages of Buil-in LED-PLF-BLU are prospected: (1) separate bulky light sources are unneccessary, hence be simple, light and compact (2) low cast (3) no heat (4) operated by battery or dc power supply (5) portable (6) low power consumption (7) very long life more than 5 years, etc. At present stage, very bright white light LEDs are essential elements to innovate the technology. Fortunately, the mass production of very bright white light LEDs, about 4 time of today is expected.

5. Conclusion

It was concluded that our PLF-BLU system to be a unique alternative solution to develop very large size LCDs in the future world TV markets. It was also prospected that the built in LED-PLF-BLU system will take a revolutional role in break through the future very large size LCD technologies.

6. Reference

(1) Pending Korea Patent (2001.09)
(2) Pending Korea Patent (2002.06)
(3) Semiconductor Monthly (2002.06)