Two-dimensionally Integrated Fluorescent Lamp for 40 inch LCD-TV Application

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Abstract

After showing 32 inch two-dimensionally integrated fluorescent lamp (TIFL) and its module at SID '04, 40 inch TIFL and its module of prototype have been developed at the first time. It is the biggest size in the world as well as has a backlight unit without BEF optical film. The luminance of TIFL is 14000 nit at 190 watt power consumption and its luminous efficacy is 51 lumen/watt. The use of TIFL simplifies backlight assembly process and removes high price optical sheets. As a result, LCD TV, used by TIFL, is rapidly going to expand its market share in the large size TV area.

Ten years ago, Back Light Unit(BLU) was a crucial key point for a evolution of LCD module. Needs of Note PC market that BLU had slim structure and low cost, leaded to various innovations of technology. Although the size of screen was larger, BLU structure has been an extension of the previous advance. Nowadays the TV market is the biggest application field for TFT LCD device and require new technological innovation again. The requirement of BLU for LCD TV is longer lifetime (> 50000 hours), brighter luminance (> 500 nit on LCD module) and lower cost.

The optical performance of LCD TV is excellent compared to other kinds of FPD (Flat Panel Display) [1]. Therefore the biggest and last issue for the LCD TV to be market leader in FPD market is to reduce the cost of LCD TV. The cost of LCD panel has been dramatically reduced by enlargement of the mother glass and simplification of the manufacturing process. However BLU cannot catch up the cost reduction of LCD panel because of inherent lamp array structure or optical component inside a LCD module. It is a big hurdle for LCD to enlarge its market share in TV application field.

TIFL and backlight unit were developed this year to reduce the cost of a LCD TV and demonstrated at SID '04 with a size of 32 inch and efficacy of 57 lm/W.[1]

Now we have developed the prototype of TIFL with a size of 40 inch and will report the characteristics of it in this paper. Until now many researchers have strived to make a large size flat light source. Table I shows various types for flat fluorescent lamp, which has been developed last years. Without spacers between upper and rear glass, the glass of lamp whether upper or rear, cannot be sustained because pressure difference between ambient atmosphere and

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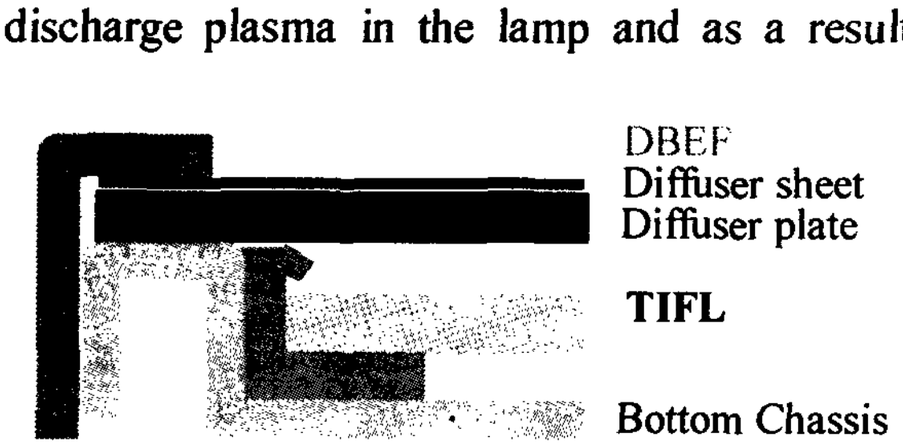
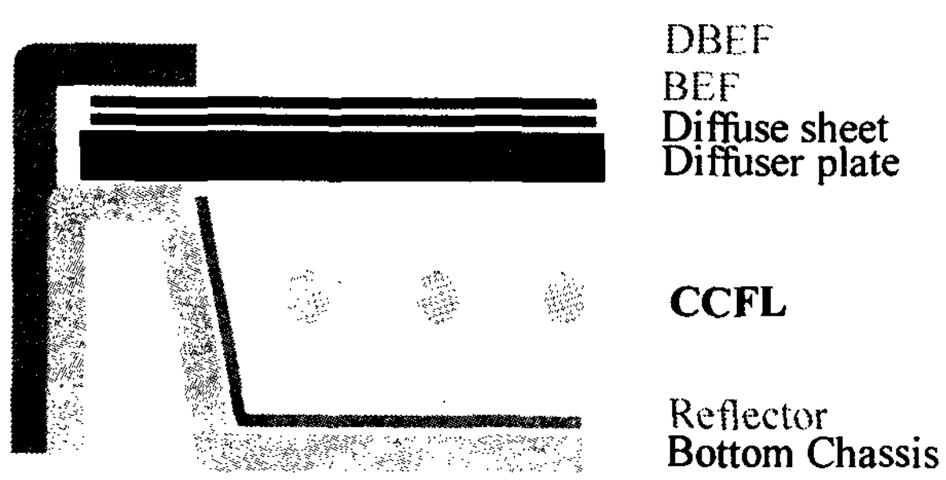
	S. Mikoshiba [2] (University of electro-communication)	*Thomas electronics [3]*	*M. Anandan[4]*	*OSRAM[5]*
Efficacy(lm/w)	50	40	16	29
Size (inch)	5.2 (108×75 mm^2)	11 (149×149 mm^2)	4	32 (690×410 mm^2)
Electrode	DBD(Dielectric Barrier Dischage)	Hot Cathode	Hollow cathode	DBD
Discharge space	No spacer	Serpentine	No spacer Multi channel discharge	Conical spacer

Table1. Comparison between various types of lamp

buffer gas inside the lamp stresses and breaks the glasses for a large size of flat fluorescent lamp. Therefore lamp structures of S. Mikoshiba and M. Anandan cannot be larger above 15 inch size. In addition, Anandan's flat fluorescencet lamp [4] is controlled by each ballast capacitor to have uniform discharge, which is generated from each metal electrode so that it cannot be appropriate structure for mass production scheme. A improved structure of Mikoshiba's for a large size which has lateral multi channel and electrode in parallel to it, is enlarged to 32 inch size recently, but uniform and electrically efficient discharge could not be achieved [6]. Flat fluorescent lamps of serpentine structure with only one pair of electrode at each end must be driven by very high voltage because of their long discharge cavity. The efficacy of the lamps is reduced by leakage current and low inverter efficiency. Thomas electronics [3] made the flat lamp with the serpentine structure with relatively low voltage utilizing the hot cathode. A lamp with hot cathode cannot be used in BLU of LCD for TV application because of their short life-time. The divided serpentine structure or its varieties can provide low driving voltage. [7, 8] But A contraction of current between divided spaces (channels) or "channeling" made non-uniform discharge plasma in the lamp and as a result, non-uniform brightness on the surface of the lamp.



(a) TIFL BLU structure



(b) CCFL BLU structure

Figure I. TIFL and CCFL backlight structure

40 inch backlight and LCD module	Specification	Remark
Peak lumi. Of LCD panel(nit)	500	
Color coordinates of White	0.28/0.29	
Luminance of backlight(nit)	14000	Without BEF film
Uniformit(%)	83	On backlight unit
Optical Efficacy(lm/W)	51	On diffser. Lambertian
Driving Voltage	< 1.7 kV	
Life Time(hrs)	Under test	> 50,000 hours expected

Table II. Specifications of the 40-inch backlight and the LCD module with TIFL

OSRAM made 32inch mercury-free flat fluorescent lamp [5] by arraying numerous small-area glow

discharges with conical spacer and using diffusing plates.

Its luminous efficacy is about 29 lumen/watt, much lower than that of a mercury lamp. Therefore, it requires high driving power consumption similar to PDP TV. TIFL, developed by Samsung, also has a multi-channel structure but does not show current

channeling phenomenon at all. We also have developed a backlight and an inverter unit to drive a TIFL. Figure 1 shows the concept of a TIFL backlight unit. Due to the high brightness of TIFL, we can eliminate a BEF optical film and do not need a reflecting sheet any more. TIFL has external electrodes coated at the end of both opposite sides and can be driven by a sinusoidal waveform inverter unit with a frequency of 50 kHz. . In the case of CCFL direct type backlight the same number of inverters as CCFL tubes is needed. Therefore, its assembly processes is not so easy because it requires many soldering and wiring processes. On the other hand, the assembly processes of TIFL backlight units become so simple and easy that it is possible to reduce down the assembly cost by automation.

Compared to TIFL with a size of 32 inch, 40 inch size TIFL has longer discharge cavity and more number of channels. As discharge length is longer with the same electrode, the positive column of discharge is longer with only small addition of power consumption and The lamp gains more electro-optical efficiency. But higher driving voltage and more leakage current through the cavity due to the longer discharge length and more number of channels, lowers the luminous efficacy. The two kinds of influence to efficacy of the lamp were compromised to a little lower efficacy 51 lm/W of 40 inch than 32 inch TIFL. However it is expected that the efficacy for this proto type of 40 inch TIFL be improved up to 60 lm/W soon.

TIFL can be larger to 56 inch in diagonal, the largest size of LCD TV panel, because of very simple

manufacturing process, multi-channel structure of backlight and parallel driving technique of these channels. Therefore, in the viewpoint of flat panel TV market the development of TIFL is a big step forward.

The luminance is 14000 nits at 190 watt power consumption on the backlight units without BEF optical film. Its luminous efficacy is about 51 lm/W. The color coordinates, x and y, are 0.28 and 0.29 on the backlight units, respectively. It corresponds to 500 nits on the LCD panel. The specifications of a backlight units and a LCD module with a TIFL lamp are shown in Table II. The optical efficiency is calculated by using the brightness on a diffuser sheet, based on the Lambertian distribution assumption.

In summary, we have developed a prototype of 40 inch TIFL, the largest size in the world, and its backlight units. The luminance of TIFL backlight is 14000 units at 190 watt power consumption without BEF optical film and its luminous efficacy is 51 lumens/watt. The usage of TIFL simplifies backlight assembly process significantly, can be driven by a sinusoidal inverter unit and removes expensive optical sheets. If TIFL is applied to LCD backlight units, it could cut down the cost in half relative to the current CCFL backlight unit. As the size LCD TV module increased, the benefits of TIFL in cost reduction become even large. As a result, LCD TV using TIFL is expected to expand its market share in the large size FPD area very rapidly..

References

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