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Effect of Panel Size on the Xe Gas Discharging Lamp with Double-T Shape Electrodes

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In this paper, the electrical characteristics of Xenon gas discharging areal fluorescent lamp and the effect of improving of discharging efficiency at 55 inch diagonal size with a newly designed electrode shape named "double-T" are investigated. The investigation was based on a "T shape" electrode, which is well known in plasma discharging. The extending effect of the effective length of an electrode by a "double-T" electrode, which was applied to Xenon gas discharging areal lamp works well at 55 inches. This effect was induced to the plasma discharging of luminance of about 11,000 cd/m^2 at 1.1 kVrms driving signal. If the areal fluorescent lamp is divided into several blocks and applied dimming driving scheme each blocks, it can be applied to an eco-friendly backlight source due to the mercury-free and cost merit with a better contrast ratio in TFT-LCD area.

Keywords Back light unit; gas discharging; plasma discharging; TFT-LCD; xenon

Introduction

Even though recently, LEDs have been the basic light source for back lighting of TFT-LCD at mobile phone, laptop computer and TV application, due to LED's characteristics of the spot light which is emitted from a few hundreds of μm square size chip or mm^2 diameter size of package, required complex optical parts to convert spot lighting into areal in order to use it as a TFT-LCD backlight source, whether aligned along the side edge or under TFT-LCD panel. Moreover, in large size applications such as a television or public information display areas, overall deviation of luminance and color coordinate remain due to the disparity of device-to-device compensation even if LEDs increase capacity and lowers cost.

In considering Rohs, Xenon gas discharging areal lamps that use VUV(vacuum ultraviolet) as exciting energy of phosphor instead of UV radiated by mercury, have an advantage in optical simplicity as a backlight source. These can be fabricated from a single areal lamp or assembled several unit areal lamps as the areal lamp module with the advantage of mercury free applicable to eco-friendly area even they should have more improved the efficiency of luminance. Xenon gas discharging areal lamps can be divided four kinds by a lamp structure of discharging cell or driving scheme. These four kinds are 1) face discharging 2) surface discharging 3) inverted surface and 4) dual surface [1–3] discharging as shown in Fig. 1.

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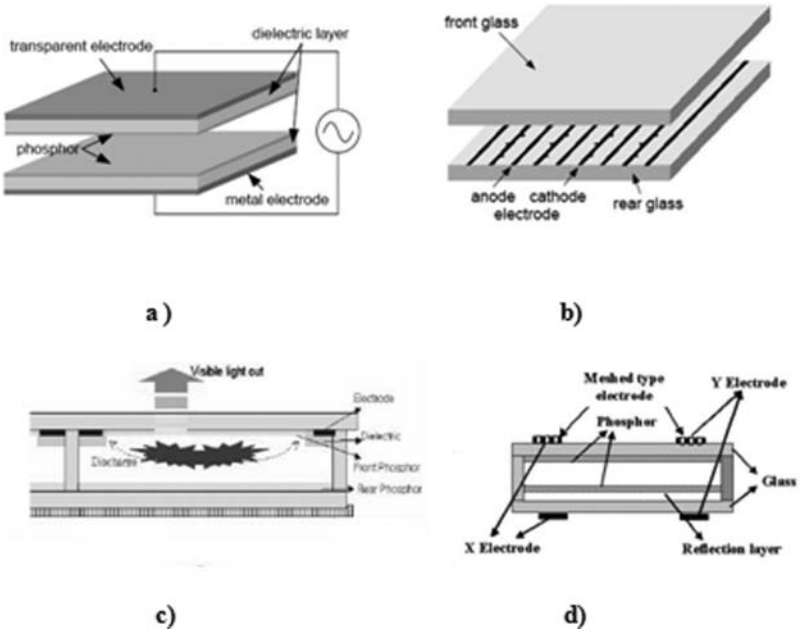

Figure 1. Types of Xenon gas discharging areal lamp, a) face discharging, b) surface discharging, c) inverted surface, d) dual surface discharging.

The first stage of Xenon discharging areal lamp showed insufficient performance of about 5,000 cd/m^2 of luminance and 20∼30 lm/w of efficiency at 2.8kV driving conditions as backlighting source. That is until a recent improvement of about 6,000∼7,000 cd/m^2 of luminance at 1 kV or 10,000∼18,000 cd/m^2 of luminance and 30∼40 lm/w of efficiency at 2.8 kV. This improvement was accomplished by optimizing the design in phosphors

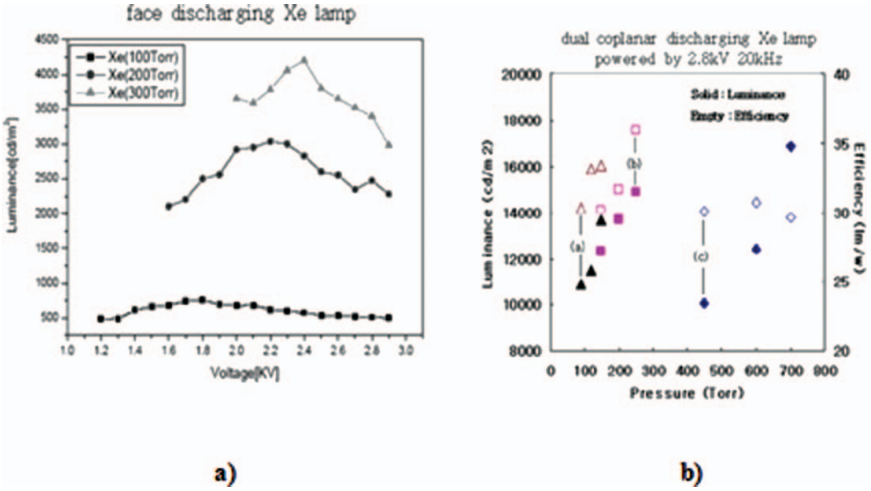

Figure 2. Electrical characteristics of Xenon gas discharging areal lamp, a) first stage of, b) recent date.

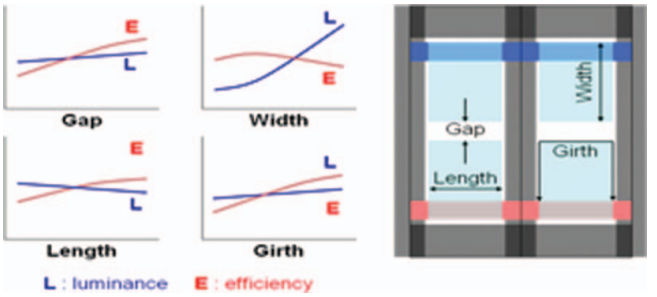

Figure 3. Characteristics of Xenon gas discharging areal lamp according to patterns of electrode.

quantum efficiency, structures of discharging cell, patterns of electrode, and by the driving scheme as shown in Fig. 2. However further improvement in the efficiency of Xenon gas discharging as back light source of TFT-LCD is recommended.

Optimizing the Design

Most of the technologies used in improving ac plasma panel can be applied to Xenon gas discharging areal lamp. However, the mixing rate of Xenon gas at a highest possible rate to ensure high luminance must be considered. In addition to this, an effective design shape of the T-shape electrode, which was designed by the 'Pioneer Company' and that induces a strong electric filed in the discharging cell, should be contemplated. All of the above effectively decrease the current at the electrode while sustained the same luminance of visible light by increasing the effective girth of electrodes. In electrode design, the dominant factor is the girth for improving the luminance and efficiency, as shown in Fig. 3. Further improvement, for this paper a newly designed electrode shape named "double-T" electrode applied, which was added at the auxiliary electrode behind of discharging electrode. This electrode modified form of the T-shape, as shown in Figure 4, which extends more the girth of [3,4]. It was also found to improve the efficiency in comparison experiments between T-shape and double-T shape by tested with 7 inch and 27 inch diagonal size. Moreover, in 55 inch diagonal size.

Experimental & Measurements

We fabricated 55 inch diagonal size Xenon gas areal lamp, which consists of frit glass sealant, upper and lower soda-lime glass which is coated and baked at 130°C alumina

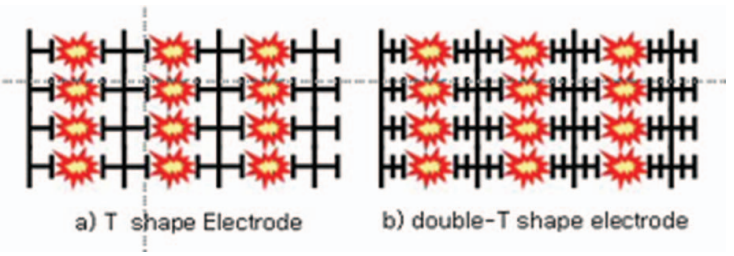

Figure 4. Shape of electrode, a) T shape electrode, b) double-T shape electrode.

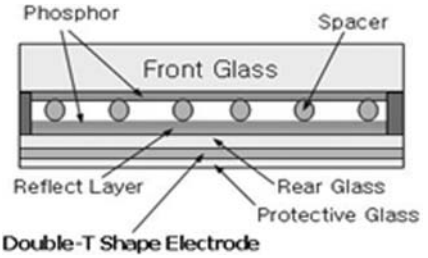

Figure 5. Structure of surface discharging Xenon gas areal lamp.

layer, 10 μm for protection, spray coated and fired at 620°C phosphor layer with mixture paste of $BaMgAl_{10}O_{17}$:Eu, $ZnSiO_4$:Mn, Y_2O_3:Eu, 20 μm which were treated SiO_2 for enhancing the color index as shown in Figure 6 and made vacuous about $10^{-6} \sim 10^{-7}$ for evaporating the contaminations inside of lamp after that filled with Xenon gas about to 120∼200 torr and formed the double-T shape of electrode by three times of screen printing process with silver paste(thickness:1 mm) followed by baking and firing as shown in Fig. 7 [5].

These results were measured and compared with the results from a previous experimental that used the same methods and equipment. The equipment used in both experiment were a photometer (YOKOGAWA 3298), which measured luminance; a voltech, PM 3000A

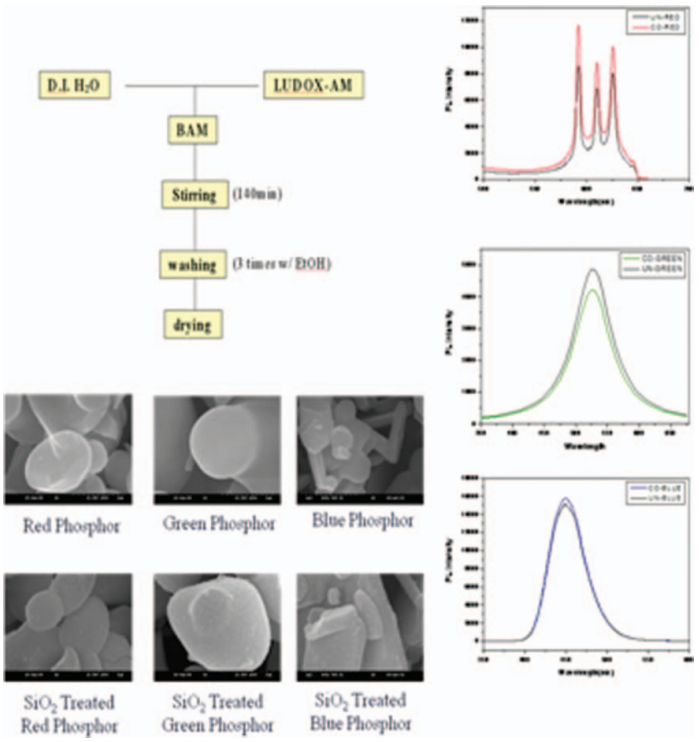

Figure 6. Phosphor Treating.

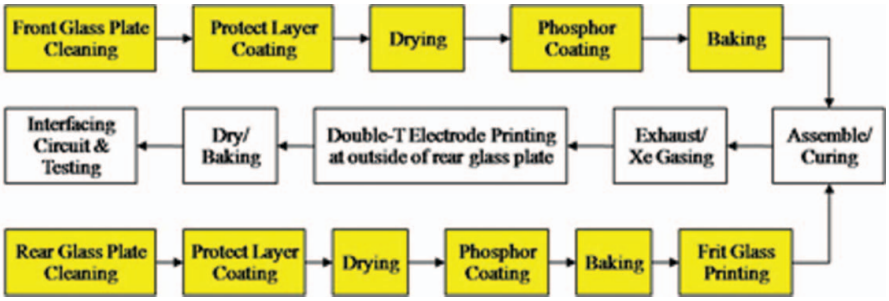

Figure 7. Process flow of Xenon gas discharging areal lamp.

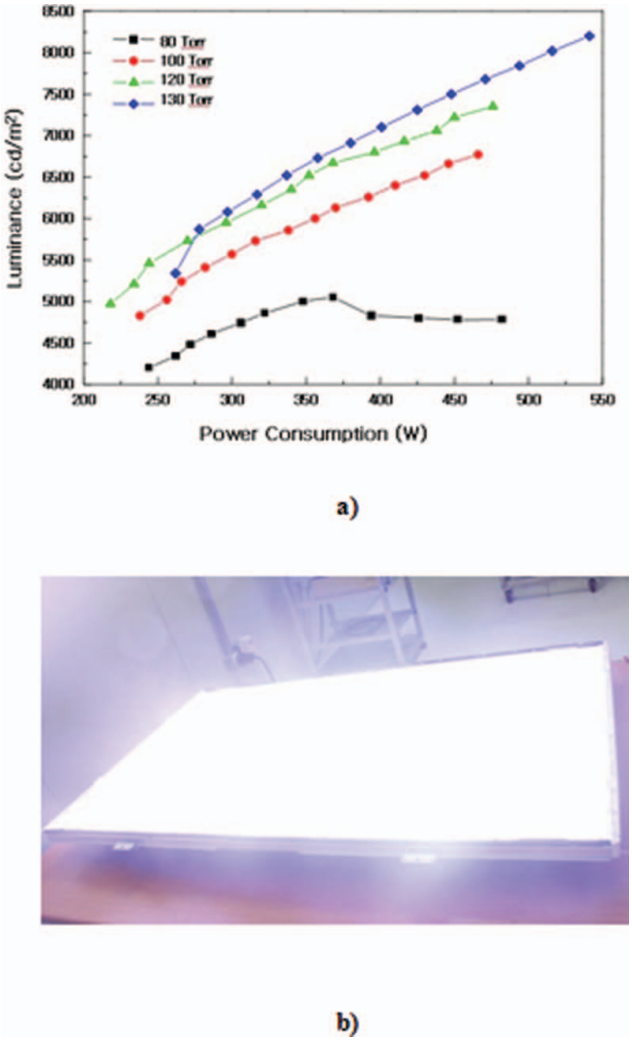

Figure 8. Luminance of a 55 inch Xenon gas areal lamp, applied the "double-T" electrode, a) according to the pressure of filled gas, b) discharging image of.

that measured power consumption; and Lecroy, waverunner 44xi that measured driving signal waveform inducing electric field at 55 inch diagonal size Xenon gas discharging areal lamp. A 29 kHz (duty 24%) synthesized square wave signal by high power signal generator, applied to the electrodes induced the lamp.

Results and Discussion

Former experiments with 27 inch diagonal size of Xenon gas discharging area lamp, confirmed the improvement of luminance by 35∼38% with double-T shape electrode and achieved over 10,000 cd/m^2 luminance at 1.1 kV square wave [6].

In this work, 55 inch diagonal size achieved about 7,520 cd/m^2 luminance at a 1.1 kV square wave signal with double-T electrode and Xenon gas discharging areal lamp.

Consequently, the results of the study confirmed the improved effects of a comparatively large size, 55 inch diagonal size Xenon gas discharging areal lamp and ensured these do not diminish as sizes increase. These results were achieved by applying the double-T shape electrode which extended the girth of electrode as shown in Fig. 8.

By extending the girth of the electrodes, the capacitance of the discharging unit cell, which consists of extended pair of electrodes and an inert gas called, Xenon, as a dielectric substance, has been increased. Increasing the capacitance of discharging cell resulted in improving the charging rate and density of electrons or ions, which is contributes to the discharging of plasma. These phenomena have improved the efficiency of Xenon gas plasma discharge.

Conclusions

In this paper, the luminance characteristics of Xenon gas discharging areal lamp with an applied "double-T" shape electrode on the outside of rear glass plate was compared with a conventional Xenon gas discharging area lamp and the scaling effect was confirmed.

Xenon gas discharging areal lamps are just as eco-friendly light source as LEDs, but have the additional benefits of simplified optical parts for areal conversion of light and free of hazardous substances in their device and fabrication process. Additionally, they are cost effective and have other advantages in their electrical characteristics like plasma display panel response time, color reproducibility, dimming controls.

Furthermore, if the local dimming control to Xenon gas single areal lamps, which could be separated blocks of electrode patterns or a lamp module assembled with several unit areal lamp are applied, the commercialization of Xenon gas discharging lamps could be expected through the additional improvements in efficiency and contrast ratio in TFT-LCD images.

Acknowledgments

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