

Carbon Nanotube FEDs for Low Power Character Displays

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Abstract

High-luminance CNT-FED character-displays using simple line-rib-structure was performed. One display-panel had 48x480-dots and the sub-pixel pitch was 1mm. Another panel had 32x256-color-pixels, and the sub-pixel size was 0.6mmx1.8mm. The power consumption was less than 10W at character-displaying module. It should be useful for public display even under emergent no-power condition.

1. Introduction and Objective

Carbon nanotubes (CNTs) were discovered in 1991 and were accepted as an emitter material because of their high-aspect ratio.[1] But industrial-scale fabrication processes and imaging performance had not been reported on display applications of CNTs. Since 1997, we have been developing the process technology to use CNTs as an electrode that can be applied to the industrial products. The experimental FEDs have been manufactured with the CNT emitters, and the CNT emitter showed an excellent field-emission property because of a high chemical stability and a high mechanical strength of the CNT emitter. [2-4] The greatest benefit of a display using CNT technology is high luminance performance with low power consumption. So, we intend to develop a CNT-FED for half-meter-sized character displays, which will be used for message displays with color. One of applications of CNT-FED character displays is message display in vending machine, as shown in Figure 1. In Japan, vending machines were set up in anywhere, indoor and outdoor. As they could be connected by ubiquitous communication technology, the information board in vending machine is highly expected to display important message to evacuate

from the disaster area under emergent condition. Usually at the emergency, the electric power should be downed to prevent the fire. So, the display should be battery-driven. Figure 2 and 3 show luminance characteristics and power consumption of CNT-FED compared with other-character-displays. In this work, we investigated a middle size color character display with a high luminance at low power consumption. The size was required to fit the vending machine, and the size could not be realized by LED.

This feature will also significantly contribute to energy conservation when applied to ubiquitous displays. In addition, the high-definition capability of a CNT display can provide good visibility when installed in outdoor locations, enabling public use. The development and practical application of this new technology is highly expected to benefit an advanced information society.



Figure 1 A vending machine image with a CNT-FED character display.

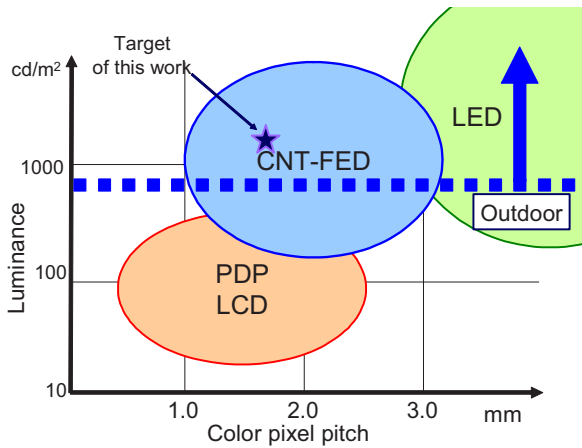


Figure 2 Luminance characteristics of CNT-FED compared with other character-displays.

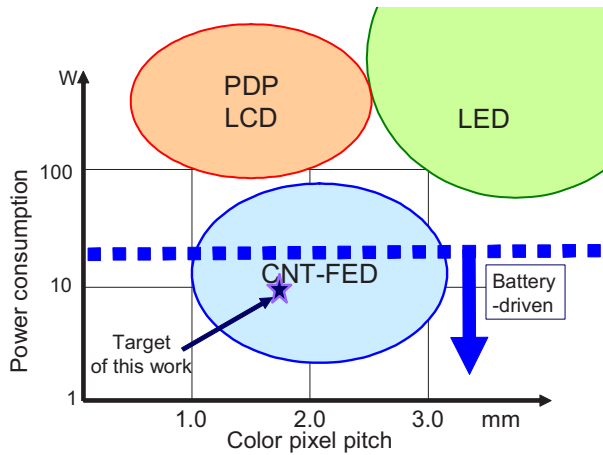


Figure 3 Power consumption of CNT-FED compared with other character-displays.

2. Results and discussion

Since 2003, we have been developing one half-meter-size color character-display. The phosphor line was 1mm-pitch, and the panel had 48x480-dots. For color display, the color pixel size was 3mm x 3mm. And the panel had 16x160 color pixels. In SID'07, we presented a prototype device as shown in Figure 6 which displayed 10-Japanese characters. [5]

Another, we developed a high-luminance 1.8mm-pitch CNT-FED for a color-character-display, which had 32x256-color-pixels. The sub-pixel size was 0.6mm x 1.8mm, which displayed Japanese characters of 32 small or 8 large characters. [6]

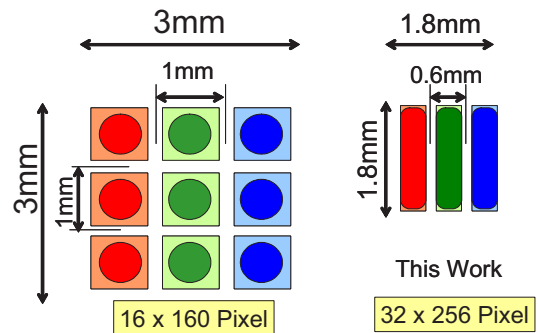


Figure 4 Difference of each pixel, 3mm pixel-pitch and 1.8mm pixel-pitch (this work).

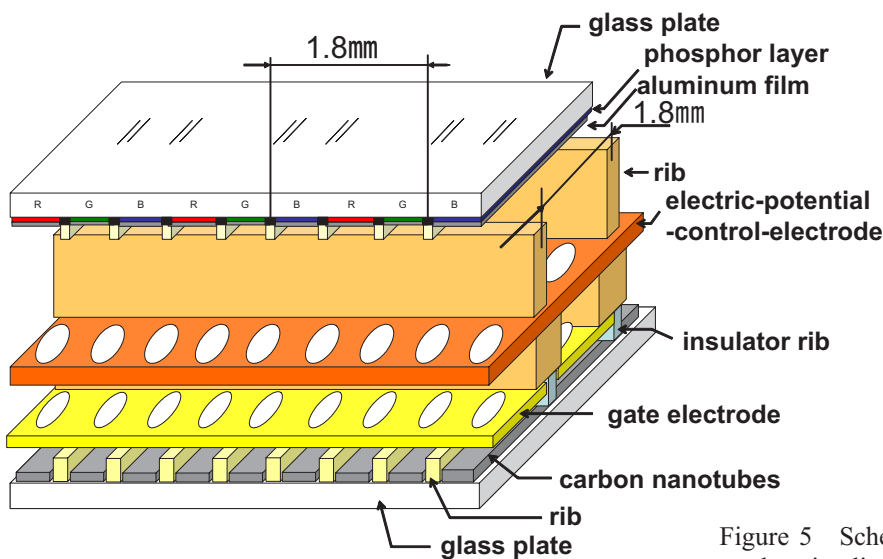


Figure 5 Schematic structure of this work using line rib spacer.



Figure 6 (a)



Figure 8 (a)



Figure 6 (b)



Figure 8 (b)

Figure6 (a) A photograph of the panels.
 The display area was 480mmx48mm.
 Upper device is a prototype device. The outer size was 580mmx112mm.
 Lower device is an industrial model. The outer size was 508mm x 76mm.
 (b) A photograph of a battery driven demo display.

Figure8 (a) A photograph of the panel.
 The outer size was 85.6mm x 488.8mm and the display area was 57.6mm x 460.8mm.
 (b) A photograph of a displayed color character pattern.
 The color pixel size was 1.8mm x 1.8mm.

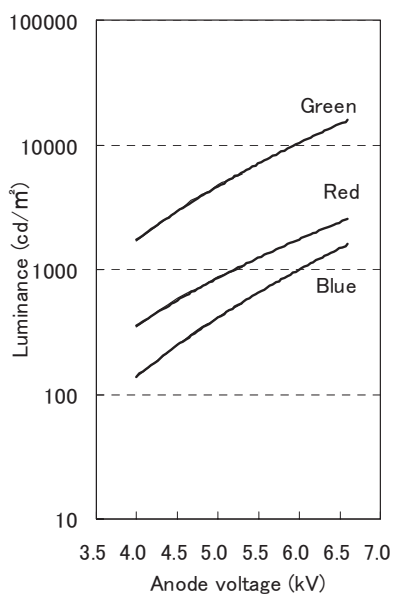


Figure 7 Luminance for green, red, blue dots as a function of anode voltage.(Duty factor 1/16)

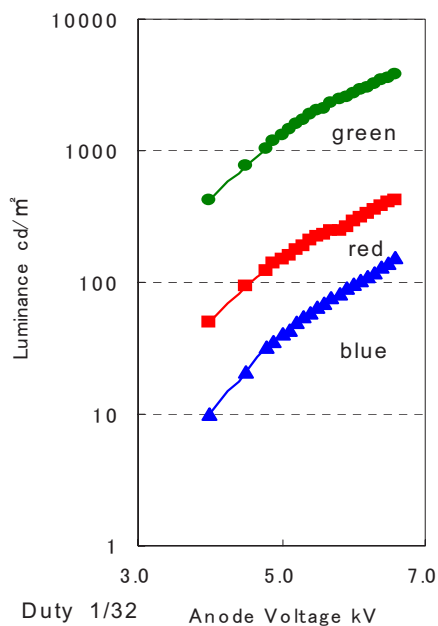


Figure 9 Luminance for green, red, blue dots as a function of anode voltage.(Duty factor 1/32)

Figure 8 shows the photograph of the panels. The luminance of green-color dot was ca.10,000cd/m² under 1/16 duty cycle driving at 6.0kV anode voltage. And the green-luminance of another panel was ca. 4,000 cd/m² under 1/32 duty cycle driving at a 6-kV anode voltage under an adjusted anode current density of ca.600 μ Ap-p/cm².

The devices and the display characteristics were tested in various condition under -40 $^{\circ}$ C~+85 $^{\circ}$ C. The vibration, mechanical and thermal shock, heat cycle testes were conducted. Additionally, 1000 hours agings were examined under 85 $^{\circ}$ C,85%RH and -40 $^{\circ}$ C. The results showed that the device was suitable for ubiquitous display in any where. Table 1 shows the characteristics of CNT-FED compared with LED.

4. Acknowledgements

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5. References

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Table 1 Characteristics of the CNT-FED compared with LEDs

Character display	CNT-FED	RGB-LED	RG-LED
Pixel-pitch	1.8mm	6.0mm	2.5mm
Multi color	○	○	▲
Luminance	ca.1,000 cd/m ²	ca.1,500cd/m ²	ca.1,000cd/m ²
Viewing angle	170 degree	120 degree	90 degree
Power consumption per character (white)	ca.0.3W (ca.0.6W)	ca.6W (ca.15.0W)	ca.3.2W (ca.8.0W)
Operating temperature	-40~+85 $^{\circ}$ C	-20~+60 $^{\circ}$ C	-10~+60 $^{\circ}$ C
Weight per character	ca.35g	ca.100g	ca.100g
Life time	ca.50,000 hours (expected)	50,000 hours	50,000 hours