

Carbon nanotubes for field emission display

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Introduction

Carbon nanotubes (CNTs), originally produced as by-products of fullerene synthesis, have remarkable mechanical, electronic, and magnetic properties that can be tailored in principle by varying diameters and chirality of CNTs and the number of concentric shells [1]. CNTs with extremely small diameters, hollowness, and chemical and mechanical strengths have provided a vast range of applications of nanotubes. In particular, there have been tremendous efforts in developing field emission displays (FEDs) using CNTs prepared by a suspension-filtering method [2], a CNTs/epoxy mixture [3], chemical vapor deposition for vertical alignment [4], and soot from arc-discharge [5]. Recently we have demonstrated large area carbon nanotube based field emission display [6, 7]. High brightness with low power consumption was achieved. In this presentation we will demonstrate characteristics of single wall (SWNT) and multi wall carbon nanotubes (MWNT) for field emission display.

Experiments

Fully sealed carbon nanotube panel was fabricated by squeeze and spray technology. SWNTs and MWNTs were used as field emitters (Fig. 1). The tubes were uniformly dispersed in organic binder. For the anode glass, the spacers of 200 μ m thickness were inserted. The phosphors of red, green, red were screen printed on

the ITO-patterned glass plate. Sealing of the glass plate was performed in an atmosphere of high purity Ar gas by means of glass frit. The display structure was evacuated down to the pressure level of 1×10^{-6} Torr. Field emission properties of nanotubes were characterized in high vacuum and in sealed panel.

Results

Many researchers have been reported on the field emission properties of CNTs. However, their emission uniformity did not confirmed by direct imaging experiment. The CNT cathode with high emissivity could not promise uniform emission sites (Fig. 2). For display applications, emission uniformity should be checked by phosphor screen. The emission uniformity depends on the distribution of CNTs, number of active tips, geometry of CNTs, and bias mode. Well-aligned CNTs cathode could be obtained by slurry squeezing technique and special surface treatment. The uniform emission image was successfully achieved on the large area CNTs cathode as shown in Fig. 2 (b).

Figure 4 shows a moving image of the CNT-FED with 240 x 580 lines that is matrix-addressable in a diode mode. A very uniform and stable emission image over the entire 9-inch panel was obtained. The brightness of 1800 cd/m² at 800 V or 4 V/ μ m (duty: 1/4, frequency: 15.7 kHz) was achieved on the green phosphor. Such high and uniform brightness

over a large area implies that the CNTs are well aligned, uniformly distributed with a high number density, and highly efficient in emitting electrons. The whole fabrication processes were fully scalable and reproducible. Field emission properties of MWNTs and SWNTs were compared (Fig. 3). Field enhancement factor of SWNTs was higher than that of the MWNTs.

References

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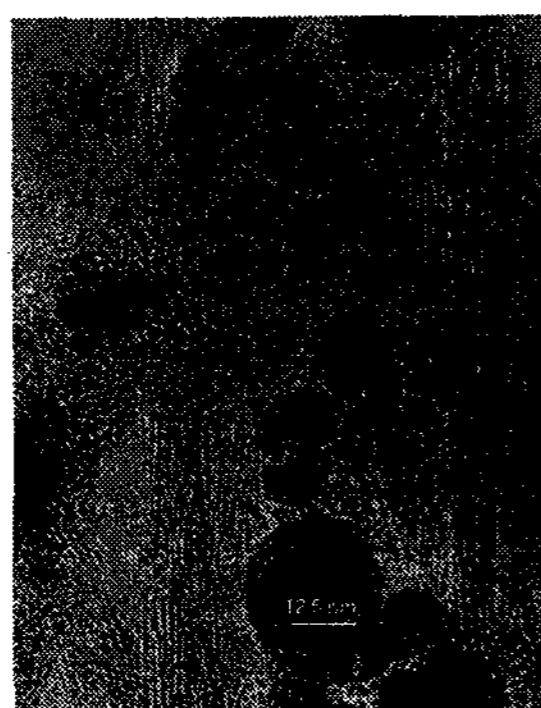
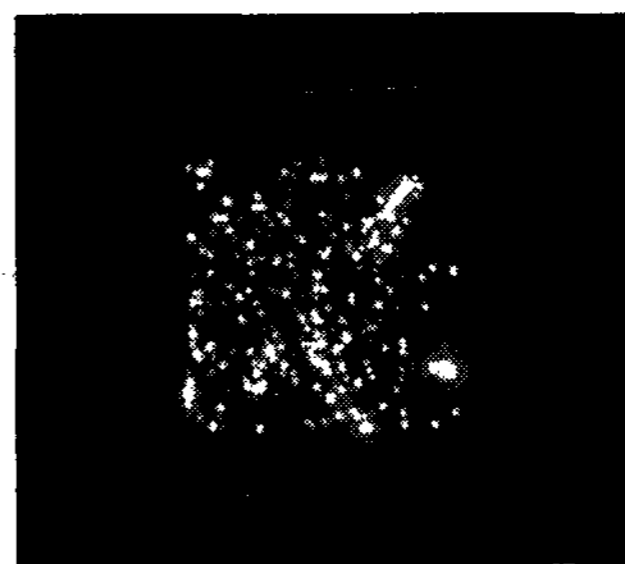
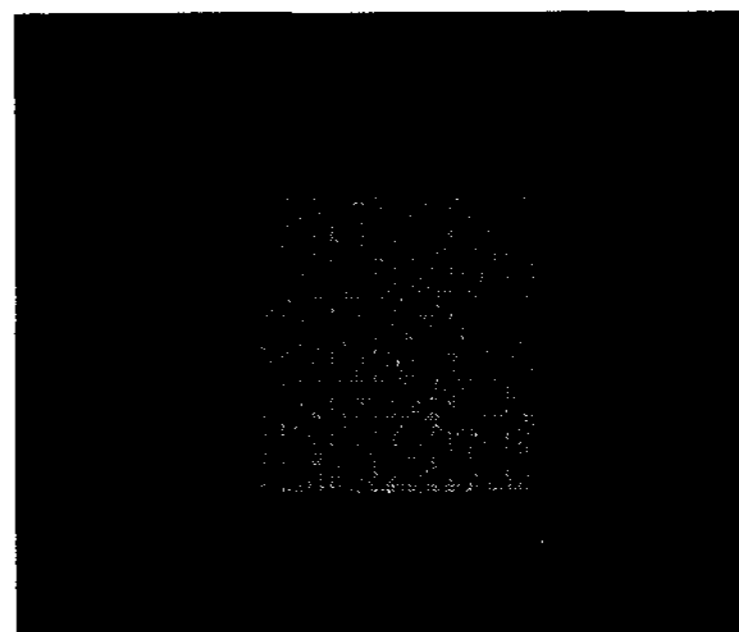


Figure 1. TEM image of SWNTs, in which SWNTs are formed as a rope type and carbonaceous particles are attached on the nanotubes.



(a)



(b)

Figure 2. (a) Emission image of as-fabricated 4.5 inch CNTs-FED (b) Uniform emission image of surface treated 4.5 inch CNT-FEDs.

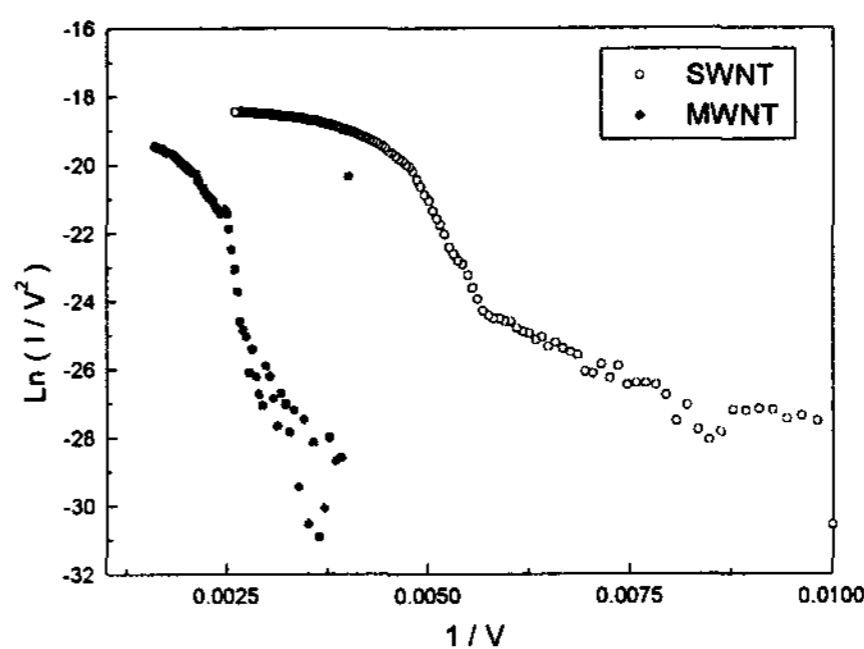


Figure 3. Fowler-Nordheim plot of SWNTs and MWNTs films.

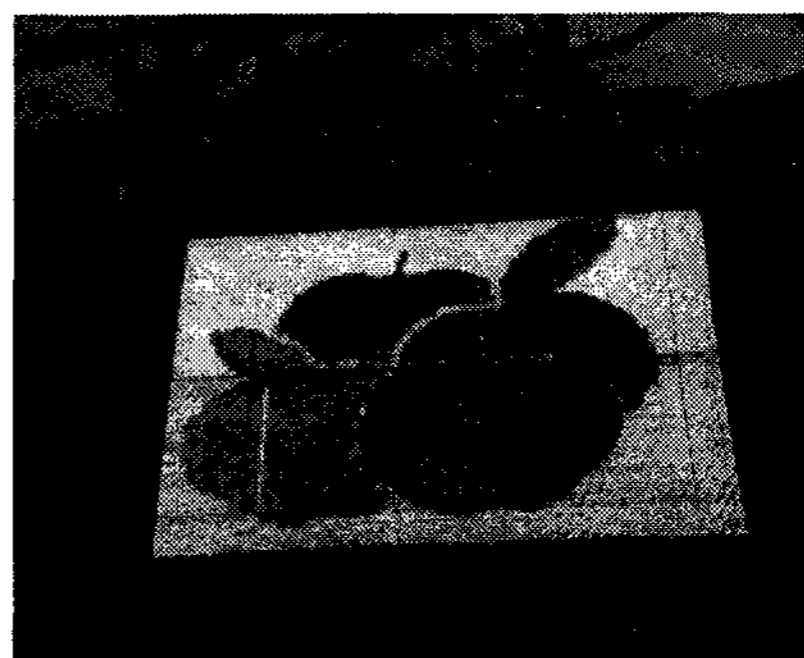


Figure 4. Emission image of a 9 inch CNT-FED.