A Novel Method to Improve the CNT-FED Manufacturing

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Abstract: *We have fabricated a 25 mm x 25 mm CNT-Device with a space of less than 400 μm by printing technology. The sand-paper impression method was utilized to improve the CNT emission characters when the cathode surface was impressed by the sand-paper. According the experiment, a large size number of sand-paper could obtain a better field emission. The CNT emission could be seen in the vacuum chamber for this low cost and easy ways in CNT-FED manufacturing.*

Keywords: CNT-FED, sand-paper, field emission, carbon nanotube.

Introduction

Carbon nanotube was the first discovery by Iijima using arc plasma method in 1991 [1]. In 1995, the field emission from an isolated single MWNT was first reported by Rinzler et al. [2], and the field emission from a MWNT film was reported by de Heer et a. [3]. An excellent performance of carbon nanotube as field emitters was demonstrated at SID in 1998 for diode type flat panel with the screen printed nanotubes cathode [4].

It seems that they are two ways to forming CNT layer. One is a direct synthesis of CNTs into the cathode templates by using CVD technologies and the other is coating of as-grown CNTs in a form of slurry, solution, or paste by spin coating, spray, or printing, respectively. At present, CVD technologies to synthesize CNTs with uniform emission over a large area of glass substrates have not been well established [5]. Thus only the latter method is available for FED application because of its sizable and cost-effective. Moreover, a large size cathode could be easily manufactured with a very low cost by pasting the CNT and applying printing technique. However, the CNT has a cohesive characteristic in its nature and it has been very difficult to remove the mass in the paste. Since most of the CNTs lie down in carbon complex, they only show poor emission property.

The additional treatments have been proposed for the activation such as peeling, scratching, plasma bombardment, and laser irradiation in 2003 [6], but surface emission uniformity could not be obtained. In 2004, a simple stacking for obtaining uniform CNT electron emission distributions was proposed by Mitsubishi [7]. Advanced improvement was illustrated by Okuda et al. in SID'06 by heat-resisting CNT paste [8]. This heat-resist paste has been developed to obtain a uniform luminance compared to early methods. There are some effective ways being proposed for activation process in FED [9].

In this study, a possible fabricated method is proposed for low cost manufacturing in CNT-FED. A sand-paper impressing was used to improve the field emission properties on the cathode surface. The manufacturing method and the initial testing result would be described in this report.

CNT-Device Fabrication

The synthesized CNT powders were prepared to CNT slurry that contains organic binders, purified CNTs and some additives. As shown in Fig.1, the silver paste was first screen-printed with 25mm x 25 mm size on the glass substrate as an electrode. The slurry containing CNTs and binders was then screen-printed upon the silver layer, followed by oven baking at 550 ^{o}C in the nitrogen condition. The activation process of the test sample was further treated to improve CNT's emission by utilizing this novel method.

The anode plate was fabricated by coating the P22 phosphor on the ITO glass. Finally, the front plate of anode and the back plate of cathode were sealed around a gap of 400 micrometer. The emission phenomenon was observed in the vacuum chamber of 10^{-6} torr. Fig.1 shows the fabrication steps on the prepared CNT device.

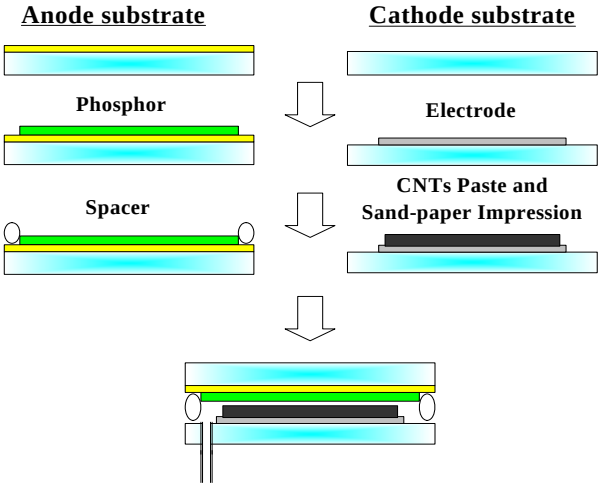


Figure 1 Fabrication steps of CNT device.

Activation process of sand-paper impression

The printing process is demonstrated to be low-cost and can be scaled to large area in high-volume manufacturing environments. A problem with the printing approaches is that they often require an activation process. Tape activation [10] [11] generally used, so the CNTs may be aligned vertically to the substrate.

In this study, we find that the sand-paper impression method is also an effective way to improve the filed

emission factors. The CNTs bundle buried in the paste could be protruded on the cathode surface after the impression process. The schematic drawing is illustrated in the Fig.2. The sand-paper is attached on the prepared cathode substrate, followed by the tape to fix the substrate and the sand-paper together. The sand-paper was pressed by the roller to get numbers of cavities on the CNT paste surface. This simple and easy process could obtain a CNT's filed emission.

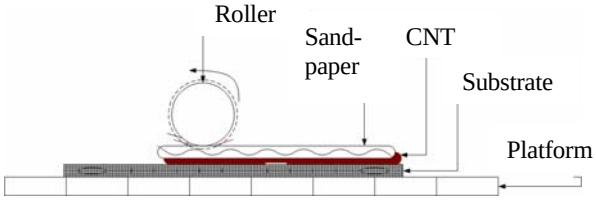
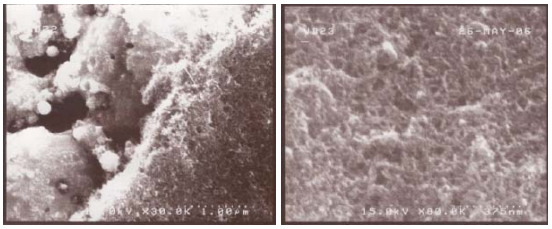


Figure 2 Sand-paper impression method

Experimental Result and Discussions

In the experiment, #320, #800, #1200, and # 2000 of the sand-paper were used to compare the different result. The #320 sand-paper could have a largest grind size and the #2000 has a smallest grind size in this test. Fig.3 shows the SEM image of the activation result after the sand-paper impression process. The cavities of the CNT cathode could be seen in Fig.3(a).



(a) 30,000 x (b) 80,000 x

Figure 3 SEM image of the CNT activation.

The initial result in the vacuum chamber could be obtained for various sand-paper #. As shown in Fig.4, the larger emission current would be acquired for #2000 of sand-paper. Thus, a smaller grind size may have a higher emission characters. Furthermore, it could be seen that the emission current with different anode voltage in Fig.5. The turn on voltage is around 580V, and the emission current is 3.5 mA at 1700V. This CNT-Device was installed into a vacuum chamber for lighting-on, shown in Fig.6. The lighted image could be seen in the Fig.7.

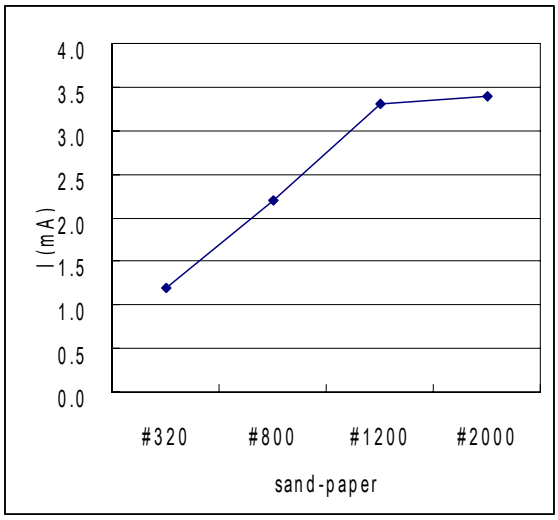


Figure 4 The emission current v.s. various sand-paper#.

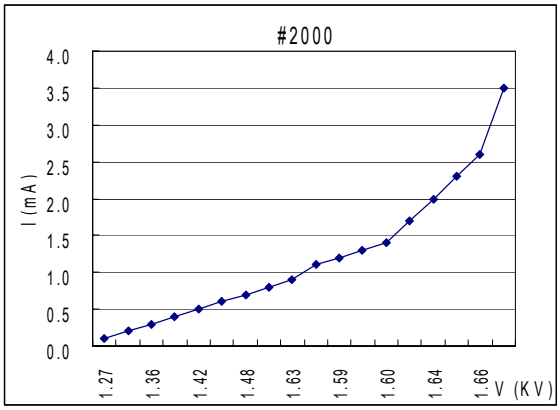


Figure5 The I-V curve of sand-paper #2000.

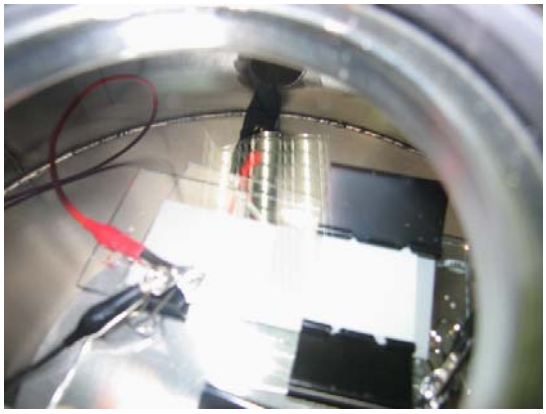


Figure 6 The CNT-Device in the vacuum chamber for lighting-on.

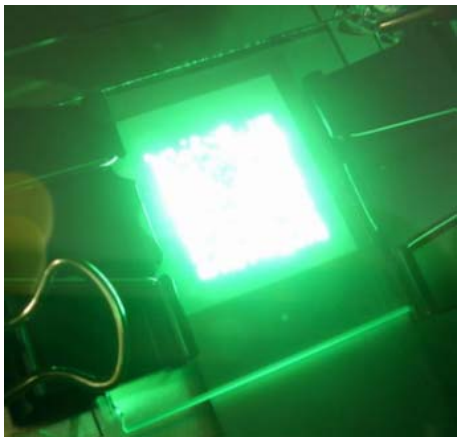


Figure 7 The lighted image on the CNT-Device

Conclusion

We have a successful approach to obtain the CNT emission by the sand-paper impression technology. The various grind size will have different emission current. From this experiment, #2000 sand-paper will have a better emission current compared to the others. The activation process is also could be done by this easy and low-cost method. In the future, there are some parameters must be optimized for a better emission properties.

References

1. S. Iijima, *Nature* 354, 56 (1991).
2. A.G. Rinzler et al., *Science* 29, 1550 (1995).
3. W.A. de Heer, A. Chatelain and D. Ugarte, *Science*, 270, 1179 (1995)
4. W. Uemura, Y. Saito et al., *SID*'98, 1052 (1998).
5. W.I. Milne, K.B.K. Teo, and M. Chhowalla, *SID*'02, 1120 (2002).
6. M. Takai, et al., *SID*'03, 794 (2003)
7. S. Nakata, S. Okuda et al., *SID*'04, 928 (2004)
8. S. Okuda et al., *SID*'06, 1852 (2006).
9. Richard Lee Fink, *US patent* 2006/0096950-A1.
10. Yu-Yang Chang, et al., *US patent* 2003/0092207-A1.
11. Daniel T. Colbert et al., *US patent* 2002/0109086-A1.