Transparent carbon nanotube field emission devices for field emission display and lamp

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Abstract

A simple new method to fabricate transparent carbon nanotube field emission devices was developed. The highly graphitized single wall carbon nanotubes were attached on Sn/ITO glass by arc discharge method. Post heat treatments below the deformation temperature of soda-lime glass guaranteed a good mechanical adhesion and electrical contact of the nanotubes. The Sn layer was oxidized below 400℃ and became transparent. As increasing the oxidation temperatures, the emission properties became stable and life time of emitter has been increased.

1. Objectives and Background

The carbon nanotubes have been researched to apply the field emission devices due to its high aspect ratio and electrical conductivity [1, 2]. There are some restrictions in emission stability and reproducibility [3]. We will introduce a simple new method to fabricate transparent carbon nanotube field emission devices which have high current density at low electric field and emission stability.

2. Results

Fabrication processes of the transparent carbon nanotube field emission devices are a preparation of electrode metal layer, a synthesizing of SWNTs, a heat treatment process, and oxidation process. The Sn layer was deposited on the ITO glass by magnetron DC sputter. The thickness of Sn layer was fixed at 100 nm. The SWNTs were attached on the Sn layer by in situ arc discharge methods. The heat treatment processes were performed at 450℃ and 1 atmospheric pressure of nitrogen gas to increase the adhesion between the SWNTs and Sn metal particle. After heat treatment process they were oxidized at air ambient pressure. The oxidation temperatures were varied from the 300℃ to the 400 ℃.

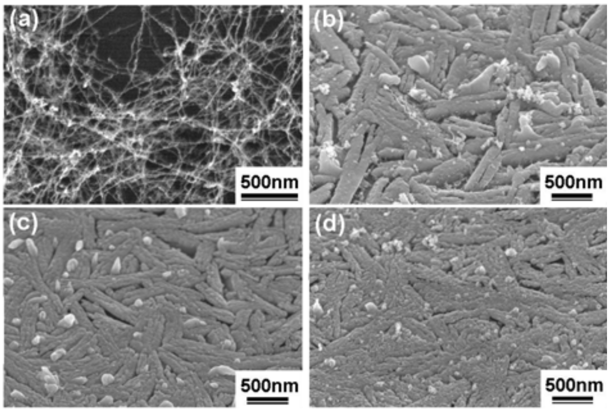

Fig. 1 The SEM images of (a) as-deposited SWNTs on the Sn/ITO glass, (b) Sn layer after heat treatment, (c) SnOx layer after oxidation process at 300℃, and (d) SnOx layer after oxidation process at 400℃.

The fig. 1 (a) is the SEM image of as-deposited SWNTs on the Sn layer. The SWNTs and Sn metal have been agglomerated and formed Sn and SWNTs composites during the heat treatment process because melting temperature of Sn metal is about 232℃. This reason will cause the other problem in the emission stability because the emitters have been heated during field emission. Dean et al discussed about the increasing of carbon nanotubes temperature during the field emission [4]. Oxidation process was performed to increase the melting temperature of Sn metal. The fig. 1 (c) and (d) are the SEM images of SnOx layer after oxidation processes. There aren't serious morphological changes in the Sn layer after oxidation processes. But the transparency of the Sn layer have been increased as increasing the oxidation temperatures

The fig. 2 is the field emission results of samples, which are a Sn and carbon nanotube composites after heat treatment process and two SnOx and carbon nanotube composites after oxidation processes. Their current densities were about 1 mA/cm^2 at 2.5 V/mm. The aging properties were also characterized. As increasing the oxidation temperatures, the emission stability has been improved. The minimum reduction rate of current density was shown in the sample which was oxidized at 400℃.

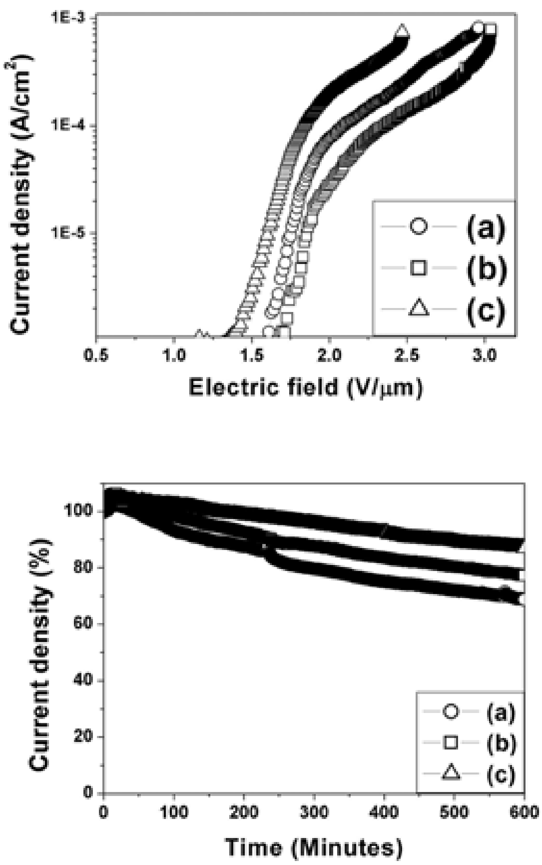

Fig. 2. The field emission properties of (a) heat treated SWNTs and Sn composites, (b) oxidized SWNTs and SnOx composites at 300℃, and (c) oxidized at 400℃.

As increasing the oxidation temperatures, the SnOx layer became transparent. Fig. 3 is emission images of the oxidized SnOx and SWNTs composites at 400℃. Fig. 3 (a) is the image from anode part and (b) is the image from cathode part.

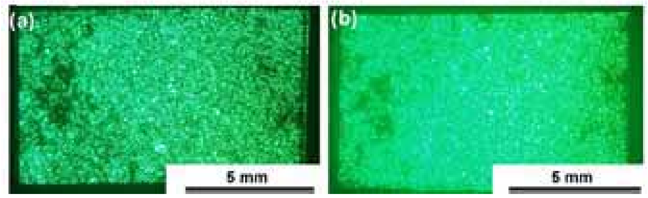

Fig. 3 (a) is the image from anode part. (b) is the image from cathode part.

3. Impact

SWNTs were agglomerated with Sn metal layer by heat treatment process guaranteed a good mechanical adhesion and electrical contact of the nanotubes. The field emission property was stabilized by oxidation process. The Sn metal layer became transparent. The transparent carbon nanotube field emission cathode is thought to be applied to the field emission devices and field emission lamp.

4. Acknowledgements

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5. References

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