CNT Emitter Coated with Titanium Oxide Nanoparticles for FED Application

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Abstract

Carbon nanotubes (CNTs) have used as an electron field emitter of the field emission display (FED) due to their characteristics of high-electron emission, rapid response and low power consumption. However, to commercialize the FED with CNT emitter, some fundamental problems regarding life time and emission efficiency have to be solved. In this study, we investigated the TiO_2 coated CNT as a field emitter. TiO_2 nanoparticles can coated on CNT surface by chemical solution method. TiO_2 nanoparticles had uniform size with the average size of about 2.4 nm to 3.1 nm. Field emission performance of CNT coated with TiO_2 nanoparticles was evaluated and discussed.

1. Introduction

Recently, there are many efforts to develop the field emission display (FED) using the carbon nanotube (CNT) as an emitter. The properties of CNT, such as a high aspect ratio, sharp tip, excellent chemical and mechanical properties, are favorable for field emitter [1-5]. However, there are still problems to be solved in order to make a practical CNT-FED. One of the key issues is to improve the emitter performance, especially the life time. Nanoparticle coating on CNT results in increasing the emission site, concentrating of electric field at nanoparticle, decreasing the work function of CNT, increasing the electrical conductivity and decreasing the turn on voltage and consequently improving the life time.

2. Experimental

TiO_2 nanoparticles were coated on CNT surface by chemical solution method. Heterogeneous nucleation of TiO_2 nanoparticles occurs on CNT surface. Then TiO_2 nuclei grow to form nanoparticles which coated on CNT surface. Particles size distribution could be controlled by optimizing the synthetic parameter, such as solid content, concentration of solution, rinsing and heat treatments condition. The properties of CNT coated with TiO_2 nanoparticles were characterized by TEM, EDS, XRD, XPS and TGA&DTA analysis. Field emitting performance of CNT coated with TiO_2 nanoparticles were tested.

3. Results and discussion

Titanium salts produced nuclei of titanium oxide on CNT surface by heterogeneous nucleation. After nucleation the growth of TiO_2 particle leading to CNT surface coating with nanoparticles. The size of TiO_2 nanoparticle has the range between 2 and 4 nm (average size of 2.68 nm) and size distribution shows narrow. The TEM image and size distribution are presented in Fig. 1. XRD pattern of the TiO_2 nanoparticle coated on CNT was shown in Fig. 2. Peaks were matched with the anatase phase TiO_2 (JCPD #21-1272) but the crystallinity was slightly low. Coating quantity of TiO_2 on CNT was about 46 wt% determined by TG-DTA analysis. Weight loss at around 400 ℃ due to the decomposition of CNT.

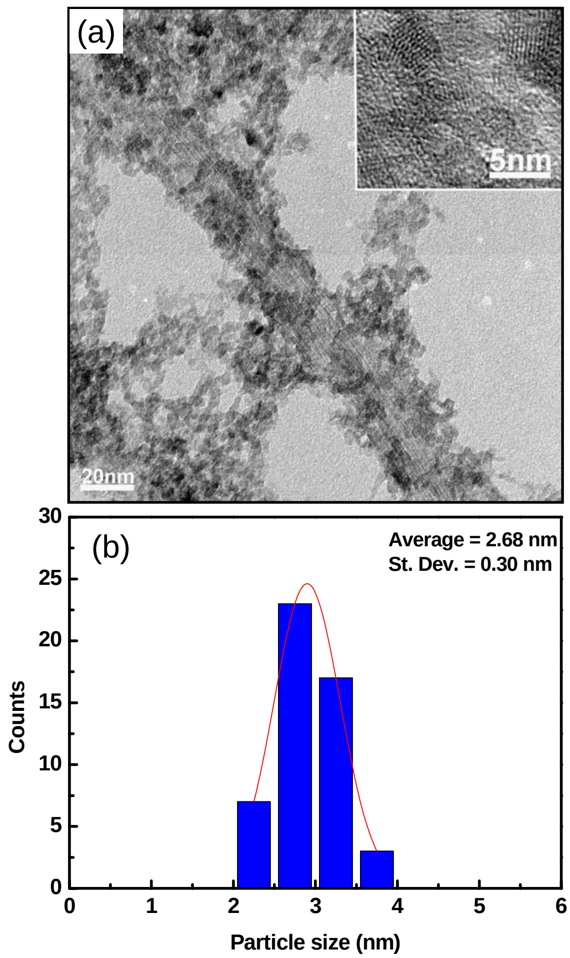

Fig. 1. TEM image (a) and size distribution (b) of TiO_2 coated CNT.

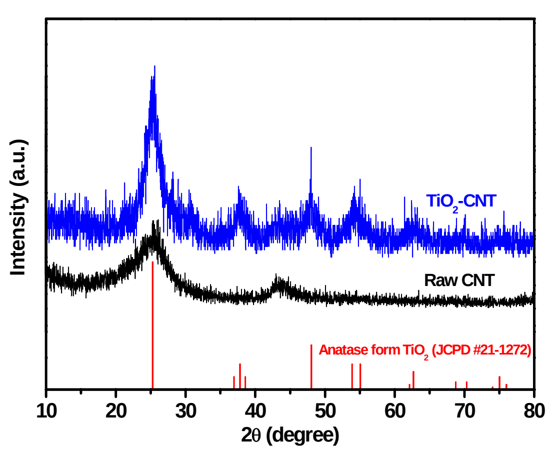

Fig. 2. XRD pattern of TiO_2 coated on CNT.

In order to improve the crystallinity of amorphous TiO_2 nanoparticles, they were heat treated at 700, 1000, and 1300 ℃ for 2 h in hydrogen atmosphere. After the heat treatment, The size of TiO_2 nanoparticle was increased from 6.9 nm to 28.4 nm. This was due to grain growth by heat treatment. XRD pattern of the TiO_2 nanoparticle coated CNT after heat treatment was shown in Fig. 3. TiO_2 at 700 and 1000 ℃ shows a mixed crystal phase of the anatase (JCPD #21-1272) and rutile (JCPD #83-2242) phases. TiO_2 at 1300 ℃ shows the phase transition to pure rutile phase. As a result, Heat treatment at high temperature in hydrogen atmosphere improved the crystallinity of TiO_2.

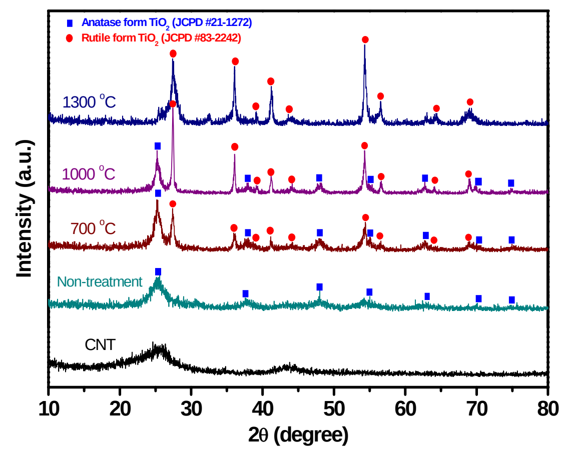

Fig. 3. XRD patterns of CNT coated with TiO_2 nanoparticle heat treatment in H_2 atmosphere.

Field emission characteristics of the TiO_2 nanoparticle coated CNT. Raw CNT shows the turn-on voltage of 3 V/㎛and current density of 53.1 ㎂/㎠ at 6 V/㎛. CNT coated with TiO_2 nanoparticle shows the decrease of turn-on voltage to 1.6 – 1.7 V/㎛ and increase current density to 120.7 – 133.7 ㎂/㎠at 6 V/㎛. However, there is no difference between different temperatures of heat treatment in field emission performance.

4. Summary

TiO_2 nanoparticles could be coated on CNT surface by chemical solution method. The size of nanoparticles ranged between 2 and 4 nm and size distribution showed narrow. Amorphous nanoparticle could be transferred to crystalline phase through heat treatment in hydrogen atmosphere. TiO_2 nanoparticle coating on CNT surface could improve the field emission performance. Turn-on voltage was decreased and current density was increased comparing to raw

CNT, which expected to improve the life time of CNT emitter in FED application.

5. Acknowledgements

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6. References

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