ENHANCEMENT OF FIELD ELECTRON EMISSION PROPERTIES OF CARBON NANOTUBES/ZINC OXIDE NANOCOMPOSITES USING SINGLE AND MULTI-STEP METHODS

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ABSTRACT

This study aimed to enhance the field electron emission (FEE) properties of carbon nanotubes (CNTs) synthesized from waste cooking palm oil combined with zinc oxide (ZnO) to produce CNTs/ZnO nanocomposites. The methods used in this study were single and multi-step depositions. The single-step deposition method was done by directly mixing the CNTs and ZnO precursors and they were synthesized using thermal chemical vapor deposition (TCVD) method for 30 minutes. Meanwhile, the multi-step deposition process was carried out by combining TCVD and sol-gel immersion methods to fabricate CNTs/ZnO nanocomposites. There were three different ZnO nanostructures namely nanorods, nanoflowers and nanorods-nanoflakes which were composited with CNTs via multi-step deposition process. The obtained samples were analyzed using electron microscopy, energy dispersive X-ray, micro-Raman spectroscopy, X-ray diffraction spectroscopy, photoluminescence spectroscopy and four-point probe current-voltage measurement. The field emission properties of the samples were also studied using FEE measurement. The findings showed that the turn-on and threshold fields of CNTs/ZnO nanocomposites decreased as compared to pristine CNTs. Other than that, different nanostructures of ZnO contributed to the FEE performance of CNTs/ZnO nanocomposites. The best FEE properties were given by the growth of CNTs on ZnO nanoflowers, which has the lowest turn-on field of 0.8 V/μm at current density of 1 $\mu A/cm^2$ and a high field enhancement factor of 9417. Larger emission site density and lower screening effect in this sample were believed to affect the FEE performance. As a conclusion, the fabrication of CNTs/ZnO nanocomposites have successfully enhanced the FEE properties of CNTs. Implication of this study is that it provide a new insight on advancing the synthesis of CNTs/ZnO nanocomposites for electron emission devices.

PENINGKATAN SIFAT PEMANCARAN ELEKTRON MEDAN BAGI NANOKOMPOSIT NANOTIUB KARBON/ZINK OKSIDA MENGGUNAKAN KAEDAH TUNGGAL DAN BERPERINGKAT

ABSTRAK

Kajian ini bertujuan meningkatkan sifat pemancaran elektron medan (PEM) nanotiub karbon (NTK) yang disintesis menggunakan minyak masak terpakai dengan menggabungkan zink oksida (ZnO) bagi menghasilkan nanokomposit NTK/ZnO. Kaedah yang digunakan bagi kajian ini adalah pemendapan tunggal dan berperingkat. Kaedah pemendapan tunggal telah dilakukan dengan mencampurkan secara langsung prekursor NTK dan ZnO kemudian disintesis menggunakan kaedah pemendapan wap kimia terma (PWKT) selama 30 minit. Sementara itu, proses pemendapan berperingkat dilakukan dengan menggabungkan kaedah PWKT dan rendaman sol-gel untuk fabrikasi nanokomposit NTK/ZnO. Terdapat tiga struktur nano ZnO yang berbeza iaitu nanorod, nanobunga dan nanorod-nanoemping yang telah dikompositkan dengan NTK melalui proses pemendapan berperingkat. Sampel yang dihasilkan dianalisis menggunakan mikroskop elektron, analisis penyerakan tenaga sinar-X, spektroskopi mikro-Raman, spektroskopi pembelauan sinar-X, spektroskopi kefotopendarcahayaan dan pengukuran prob empat titik arus-voltan. Sifat pemancaran medan daripada sampel juga telah dikaji melalui pengukuran PEM. Dapatan kajian menunjukkan bahawa nilai bagi medan permulaan dan medan ambang nanokomposit NTK/ZnO menurun berbanding dengan NTK tulen. Selain itu, struktur nano ZnO yang berbeza menyumbang kepada prestasi PEM nanokomposit NTK/ZnO. Sifat PEM yang terbaik diberikan oleh pertumbuhan NTK di atas ZnO nanobunga yang mempunyai medan permulaan terendah iaitu 0.8 V/µm pada ketumpatan arus 1 $\mu A/cm^2$ dan faktor peningkatan medan yang tinggi iaitu 9417. Kesimpulannya, fabrikasi nanokomposit NTK/ZnO telah berjaya meningkatkan sifat PEM NTK. Implikasi kajian adalah ianya memberi gambaran baharu bagi pengembangan sintesis nanokomposit NTK/ZnO sebagai peranti pemancar elektron.

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θ	-	The angle between the incident rays and the surface of the crystal
χ	-	Electron Affinity
φ	-	Work Function
µm	-	Micrometer
AlZnO	-	Aluminum-Doped Zinc Oxide
Ar	-	Argon
at%	-	Atomic Percentage
cm	-	Centimeter
CNTs	-	Carbon Nanotubes
CVD	-	Chemical vapor Deposition
D	-	Defect Peak
EDX	-	Energy-Dispersive X-Ray
FEE	-	Field Electron Emission
FESEM	-	Field Emission Scanning Electron Microscopy
F-N	-	Fowler-Nordheim
G	-	Crystalline Graphite Peaks
G’	-	Second-Order Raman Peaks
HMT	-	Hexamethylenetetramine
I_D/I_G	-	The Integrated Intensity ratio of the D and G Peaks
I-V	-	Current-Voltage
J-E	-	Current Emission-Electric Field
MgZnO	-	Magnesium Zinc Oxide

mm	-	Millimeter
MWCNTs	-	Multi-Walled Carbon Nanotubes
nm	-	Nanometer
O_i	-	Oxygen Interstitial
PL	-	Photoluminescence
S cm^{-1}	-	Siemen per centimeter
SiO_2	-	Silicon Dioxide
SWCNTs	-	Single-Walled Carbon Nanotubes
TPa	-	Terapascal
V_O	-	Oxygen Vacancy
V_{Zn}	-	Zinc Vacancy
wt%	-	Weight Percentage
XRD	-	X-Ray Diffraction Spectroscopy
ZnO	-	Zinc Oxide
β	-	Field Enhancement Factor

CHAPTER 1

INTRODUCTION

1.1 Introduction

"There's plenty of room at the bottom" was brilliant idea that has been presented by Feynman in 1959, which opened up the possibility to work and manipulate materials at nanometer scale. The possibility to manipulate and modify a nanomaterial as well as to produce large surface area without changing its dimension makes these studies beneficial for further application devices. The word "nanotechnology" is introduced for the first time by Taniguchi (Taniguchi, 1974). Since then, numerous studies and investigations, both on nanomaterial and nanotechnology, have been extensively explored (Drexler & Minsky, 1990; Gohel, Chin, Zhu, Sow, & Wee, 2005). To date, the application of nanotechnology has been applied in large areas such as electronic (Liu & Guo, 2012), energy production (Y. Zhang et al., 2009), aerospace component (Cabrera & Miranda, 2014) and medicine (Sui, Zhang, Sheng, Huang, & She, 2013).