

CHAPTER I

INTRODUCTION

1.1 Background and motivation

Since the discovery of carbon nanotubes (CNTs) (Iijima, 1991), the CNTs have attracted considerable attention owing to their unique electrical and extraordinary mechanical properties as well as optical and thermal properties (Saito, Dresselhaus and Dresselhaus, 1998). From many researches of nanoelectronic devices, the CNTs have been widely adopted as field emitters due to their special properties such as high aspect ratio, low work function and good electrical conductivity. To improve field emission properties of the CNTs, the CNT growth is synthesized with metal oxides to improve the field emission properties (Yu et al., 2002). Metal oxides enhance the emission sites and reduce the work function, resulting in lower turn-on voltages in comparison with pristine CNTs. Among variety of metal oxides, zinc oxide (ZnO), which is a semi-conducting material with a large exciton binding energy of 60 meV, is a promising candidate material for field emission improvement (Özgür et al., 2005) due to its wide band gap (3.3 eV) and small electron affinity (2.1 eV). In the past researches, ZnO nanostructures grown with CNTs could reduce the threshold electric field because ZnO has smaller electron affinity than the CNT, and the ZnO/CNT junction is similar to a ZnO/metal junction allowing electrons to be easily emitted into a vacuum (Yu et al, 2006).

Recently, several researchers reported synthesis methods of the ZnO/CNT composites (Chen et al., 2006; Wu et al., 2007). These methods are related to wet chemical process of various chemicals operated under low temperature which seems to be complicated and might cause contamination of synthesized products. From the limitations of these previous works, another simple synthesis method of the composites such a facile single-step synthesis which expected to decrease contamination was motivated. In this work, the ZnO/CNT composites were synthesized using gas phase reaction within single-step process. Glycerol, known as by-product of bio-diesel production, was used as carbon source, while ferrocene was used as iron catalyst for the formation of the carbon nanoparticles, especially

MWCNTs using chemical vapor deposition (CVD) method. Zn powder was employed as Zn source for the formation of ZnO nanoparticles using oxidation method. The carbon nanoparticle synthesis process was simultaneously taken place with ZnO nanoparticles synthesis process within the same of reactor system, leading to partial formation of their composites. Various parameters including nitrogen flow rate, oxygen flow rate, synthesizing temperature and glycerol to ferrocene molar ratio significantly affected on the formation of the composites. Therefore, isolated synthesis of carbon nanoparticles and ZnO particles was previously studied for controlling various parameters, leading to the formation of the ZnO/MWCNT composites under designated condition from the previous studies.

1.2 Objective of research

The objective of this research was to synthesize the ZnO/CNT composites by gas phase reaction. Pure zinc and oxygen were employed as sources for fabrication of ZnO nanoparticles while glycerol and ferrocene were used as carbon and iron sources for fabrication carbon nanoparticles. The research was preliminary investigated from study of isolated synthesis of carbon nanoparticles and ZnO particles for controlling various parameters which affected on the formation of the composite. The ZnO/MWCNT composites were sequentially synthesized under the designated condition.

1.3 Scope of research

1.3.1 Synthesize SWCNTs using laser ablation under atmospheric pressure by controlling laser intensity and temperature.

1.3.2 Synthesize carbon nanoparticles using CVD of glycerol and ferrocene by varying nitrogen flow rate, synthesizing temperature and glycerol to ferrocene molar ratio.

1.3.3 Synthesize ZnO nanoparticles by oxidation of zinc under various conditions of nitrogen flow rate, synthesizing temperature and oxygen flow rate.

1.3.4 Synthesize ZnO/MWCNT composites by gas phase reaction under designated condition.

1.3.5 Characterize the synthesized nanoparticles by following instruments:

- Scanning Electron Microscope (SEM)
- Transmission Electron Microscope (TEM)
- Raman Spectroscope
- Scanning Mobility Particle Sizer (SMPS)
- X-Ray Diffraction (XRD)
- UV-Visible Spectrophotometer (UV-Vis)
- Fourier Transform Infrared Spectrophotometer (FT-IR)

1.4 Procedure of the research

1.4.1 Survey and review related literatures

1.4.2 Synthesize SWCNTs by laser ablation

1.4.3 Synthesize carbon nanoparticles by CVD of glycerol and ferrocene

1.4.4 Synthesize ZnO by oxidation of Zn

1.4.5 Perform preliminary experiments to find out suitable condition for the synthesis of the ZnO/MWCNT composites by gas phase reaction

1.4.6 Analyze and conclude the experimental results

1.4.7 Prepare a manuscript for journal publication and dissertation

1.5 Obtained benefits

1.5.1 Obtain fundamental knowledge related to carbon nanoparticles, ZnO nanoparticles and their composites.

1.5.2 Obtain advanced knowledge related to synthesis methods and formation mechanisms of carbon nanoparticles, ZnO nanoparticles and their composites