# CHAPTER ONE

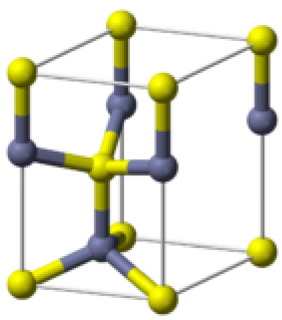
# INTRODUCTION

## 1.1 Introduction

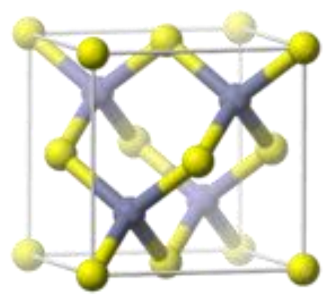
Carbon nanotubes have quickly become one of the most popular materials in nanoscience and nanotechnology. That returns to many favored proprieties which many other materials do not exhibit, such as small size, high strength, high electrical conductivity and good thermal conductivity. Accordingly, carbon nanotubes are used in many applications including field emission devices, flow sensors and gas storage [1]. One potential important application of CNTs is as gas sensor. Sensors are devices that detect or measure physical and chemical properties. Good sensors should be selective, high reliability, fast response, low cost, high volume production and sensitive at room temperature as well as at various temperatures. The common gases detectors are ammonia, carbon dioxide, carbon monoxide, hydrogen, zinc oxide and titanium oxide but some of these gases have operated only at high temperature such as zinc oxide, titanium, hydrogen and some other gases are difficult to react on the surface of MWCNT such as monoxide [2] to be a good sensor.

Multi-walled carbon nanotubes (MWCNTs) are of special interest for industry and will be the subject of this research. Structurally, MWCNTs consist of multiple layers of graphite superimposed to be rolled to form a tubular shape. There are some properties of MWCNTs are specifically interesting for the industry such as the electrical conductivity (as conductive as copper), their mechanical strength (up to15 to 20 times stronger than steel and 5 times lighter) and their thermal conductivity (same as that of diamond and more than five times that of copper). A combination of these impressive properties enables a whole new variety of useful and beneficial applications. Moreover, polymer nanocomposites are used to improve the interfacial adhesion between MWCNTs and polymer matrix by reducing agglomeration of MWCNTs and improvement in compatibility [3-5].

Gas sensors based on nanostructure oxide modified CNTs. Metal oxide gas sensors have been investigated extensively since decades ago owing to their advantages of high response to gases, fast response and recovery, low cost and small in size. However, they are usually operated at temperature range between 200 and 800˚C. Sensors based on metal oxides ($SnO_2$,$WO_3$ or $TiO_2$) modified CNTs can detect gases such as $NO_2$, CO, $NH_3$ and ethanol vapor at low operating temperature with improving sensing properties [6]. In this research, we will use ZnO besides the polymer to improve properties CNT. In material science, ZnO is often called II-VI semiconductor because Zinc and Oxygen belong to the $2^{nd}$ and $6^{th}$ groups of the periodic table, respectively. This semiconductor has several favorable properties, such as good transparency, high electron mobility, wide band gap, strong room temperature luminescence, etc. those properties are already used in emerging applications for transparent electrodes in liquid crystal displays and electronic applications of ZnO as thin film transistor. ZnO crystallize in three forms: hexagonal wurtzite, cubic zinc blend, and the rarely observed cubic rock salt. The wurtizite is most stable and thus most common at ambient conditions [7].



1. Wurtzite Structure.



2. Zinc Blend Structure.

Figure 1.1: Crystal structures of ZnO.

The common methods to fabricate nanocomposites are melt blending, solution casting and direct mixing. Several fundamental challenges must be overcome to enable applicable composites with carbon nanotubes. One significant challenge is to obtain uniform nanotubes dispersion within the polymer matrix. The second challenge is to understand the effect of gas vapor on carbon nanotubes composites. The third challenge is to create strong physical or chemical bonds between the nanotubes and the polymer matrix.

In this research, MWCNT/PEO, MWCNT/PVA, MWCNT/PVA/ZnO composites are fabricated by solution casting to produce composite films with good nanotubes dispersion. The method has been chosen because of its simplicity and ability to produce homogeneous dispersion of nanotubes that lasts for months. Methanol vapor sensor will be chosen due to the fact that it is a highly reactive; highly sensitive that can be operated at room temperature. The carbon nanotubes are very sensitive to their gas vapor where the electrical properties of CNT are changed when they exposed to gas molecules. These changes attributed to the charge transfer between the molecules and the nanotubes. The gas molecules act as an electrons (-) or holes (+). Accordingly, the sensors response to various gases by decreasing or increasing its conductivity based on the following chemical interaction:

$$\text{CNT} + \text{Gas} \longrightarrow \text{CNT}^{\delta_e} + \text{Gas}^{\delta_+} \text{ or } \text{CNT}^{\delta_+} + \text{Gas}^{\delta_e} \text{ [7].}$$

Where $\delta$ represents a number that indicates the charge transferred during the interaction. Moreover, the electrical responses of the composites under methanol vapor were studied as afunction of methanol concentrations. The methanol vapor concentration is not affecting the sensing properties of the composites significantly. Also, the sensitivities along with the responses were increased at CNT which modified by polymer and ZnO.

### 1.2 Research Objectives

The objectives of the research are:

(a) To fabricate and characterize composites of MWCNT/PEO, MWCNT/PVA and MWCNT/PVA/ZnO, with different MWCNT and ZnO loadings.

(b) To investigate the methanol sensing properties of these composites.

### 1.3 Thesis Outline

The introduction and objectives of the study are presented in chapter one. Chapter two gives a brief literature review about the properties of CNT and various methods to prepare carbon nanotubes composts.  CNT based alcohol sensor will be discussed along with different characterization techniques such as Fourier transform infra-red spectroscopy (FTIR) and x-ray diffraction (XRD).

Chapter three describes the method utilized to fabricate the MWCNT/PEO, MWCNT/PVA and MWCNT/PVA/ZnO composites and experimental setup for the gas sensing measurements. Results and discussions of MWCNT/PEO, MWCNT/PVA and MWCNT/PVA/ZnO composites are presented in chapter four, which included characterization of the crystalline structure for ZnO by x-ray diffraction and surface morphology by Fourier transform infra-red spectroscopy (FTIR) and scanning electron microscope (SEM). Finally the conclusions and suggestion of future work are presented in chapter five.

**References**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