CHAPTER 1

Introduction

1.1 Principles, theory, rationale and/or hypotheses

Metal-oxide semiconductors such as TiO_2[1,2], ZnO[3,4], WO_3[5], SnO_2[6,7], and In_2O_3[8] have been reported as attentive materials due to their extraordinary properties[9]. Many works have been reported on their applications such as dye-synthesized solar cell and photocatalytic. In addition, these materials also show the great potential applications for environmental monitoring as gas sensor. Gas sensor is a device which uses to detect injurious gases such as ethanol[1,10,11,12], methanol[13], ammonia[6,14], carbon monoxide[15], acetone[16], and etc. Owing to the sensor consisted of metal-oxide semiconductors, the electrical conductivity of the sensor varies with the presence of gas surrounding. Some examples of gas sensors based on metal-oxide semiconductors are shown in Figure 1.1

Figure 1.1: Gas sensor devices based on metal-oxide semiconductors (RKI instruments, inc.)

Metal-oxide semiconductors were firstly applied in gas sensor since 1960s by Taguchi in Japan[17]. The gas sensor was made based on SnO_2 thick films which was used to warn leaking of gases.

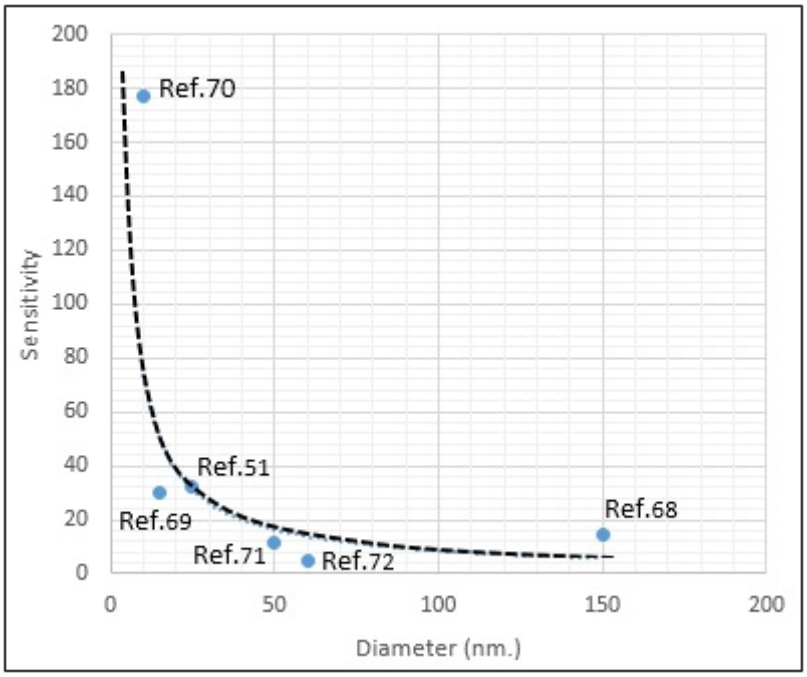

Figure 1.2: Illustration tendency of sensitivity relative with diameter

Though the gas sensors based on SnO_2 have been vasty studied. Limitation of SnO_2 sensors revealed as low selectivity, low sensitivity in ppb level, and long response and recovery time. Among metal-oxide semiconductors, ZnO is the most promising one which has delightful properties to be good sensor device. Q. Wan et al. reported that the causes of low sensitivity were due to the limitation of surface to volume ratio which presents the carrier concentration[5]. Therefore, nanostructure forms have shown a higher surface-to-volume ratio compared to thin film and microstructure. Due to enormous surface area, nanostructures can absorb more gas molecules which directly relate to sensitivity of the sensor. Now, many techniques have been developed in order to synthesize the nanostructures in order to achieve high surface area. Figure 1.2 shows tendency of sensitivity by ethanol concentration of 100 ppm relative with diameter of ZnO.

Many techniques have been used to prepare gas sensor materials. Pulse laser deposition (PLD) was used to prepare good materials for ethanol and acetone sensor based on SnO_2 nanoparticle[23]. R. C. Pawar et al. made cacti-like ZnO nanorod by aqueous solution method and cacti-like ZnO nanorod sensor showed a high sensitivity with testing by NO_2[24].

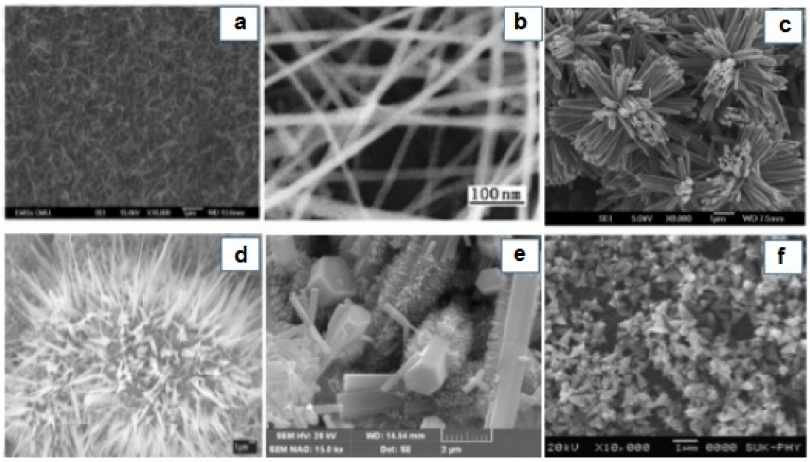

Figure 1.3: Illustration of ZnO nanostructures (a) aligned ZnO nanowires[54], (b) ZnO nanowires[51], (c) flower-like ZnO nanorod[43], (d) wire-like ZnO[33], (e) cacti-like ZnO nanorod[36], and (f) ZnO nanorod[73]

C. Wongchoosuk et al applied thermal oxidation technique to produce VOCs sensor based on Au-doped one-dimensional ZnO nanostructures which showed highly sensing properties[25]. L. Liu et al. prepared high quality flower-like ZnO nanorods using the precipitation method. The ZnO nanorads had high sensitivity under ethanol vapor[12].

Chemical vapor deposition (CVD) is the most popular technique used to prepare metal-oxide nanostructures[28]. The simple growth step starts with the metal ions agglomerate with oxygen ions to form metal-oxide ions and deposit on substrate. K. Palawong et al synthesized aligned ZnO nanowires by CVD under various acetone flow rates at growth temperature of 500°C[26]. They got aligned ZnO nanowires with diameter of 45 nm. This technique yields higher nanostructure quality as compared to the other techniques. Moreover, CVD has benefits on low production cost, easily capable and high crystal quality.

In this work, the CVD technique has been used to prepare vertically aligned ZnO-nanowires on coated glass slide substrate in presence of acetone vapor as the oxygen source. There are two interesting factors which will be consicered consisting of growth temperature and acetone flow rate. The obtained vertically aligned ZnO-nanowires were then characterized for crystal structure by X-ray diffractometry and structural morphology by scanning electron microscope.

1.2 Motivation

As mentioned above, metal-oxide semiconductors with nanostructures play an interesting materials for gas sensor technology. Recently, ZnO has been widely investigated for gas sensing applications and fabricated for ethanol sensors. Additionally, its sensing properties with nano-scale detector have already been investigated and exhibited improvement of sensitivity. However, the gas sensing properties of ZnO nanostructures synthesized by chemical vapor deposition in condition of normal pressure and acetone ambient have rarely been reported, especially vertically aligned ZnO nanowires. Thus, for the complete understanding of vertically aligned ZnO nanowires sensor, it is interesting to synthesize and characterize vertically aligned ZnO nanowires with the purpose of ethanol gas sensor applications

1.3 Research objectives and usefulness

1.3.1 Research Objectives

The objectives of this study are

1. to synthesize and characterize vertically aligned ZnO nanowires by chemical vapor deposition technique under acetone atmosphere.

2. to investigate gas sensing properties of sensor based on the vertically aligned ZnO nanowires toward ethanol vapor.

1.3.2 Usefulness

1. The work will provide understanding of preparation of vertically aligned ZnO nanowires by chemical vapor deposition technique under acetone atmosphere.

2. The gas sensing properties based on the obyaned vertically aligned ZnO nanowtres can be viewed due to nanostructure effect.