CHAPTER 1

Introduction

Up to the present, nanoscience has been the most interesting and important technology in materials science. Recent efforts have been focused on not only the development of new synthesis routes for novel nanocrystals[1] but also the preparation of functional material with special morphology, and the morphology-controllable synthesis[2]. The effect of dimensionality and geometry on material properties has been extensively studied on the nanomaterials. The advantage of nanostructured materials provides high surface to volume ratio while maintaining some of the basic properties of the bulk material, including new exciting phenomena. These phenomena result in a variety of new physical and chemical properties that are not feasible for materials with bulk dimensionality. Since the discovery of carbon nanotubes with novel properties[3], many nanomaterials have been successfully fabricated in recent years because of their great potential for addressing some basic issues about dimensionality and space-confined effect as well as technological applications.

Metal oxide semiconductor (MOS) is the indisputable prerequisite for the development of various novel functional and smart materials because it has a widely various applications such as fuel cell electrodes[4], solar cells[5] and gas sensors[6], etc. Especially, Gas sensing properties were improved when reducing the grain size to nanoscale dimension because nanostructured materials have a high active surface sites and a large surface to volume ratio comparison with their bulk counterpart[7]. Another group of distinctly different semiconducting oxide nanostructure was reported. These oxides with different crystallographic structures are an exciting and potential new fields for nanotechnology[8]. These properties contribute to the potential of transition MOS as candidates for both theoretical studies and practical applications in micro/nanodevices.

Molybdenum oxide (MoO_3), a wide band gap n-type semiconductor, is a very attractive material for different technological applications, such as photochromic materials (change from colorless to blue by photonic absorption)[9,10], self-developing photography[9], conductive gas sensors[10], lubricants[11] and catalysts[12]. Orthorhombic α-MoO_3 was composed of MoO_6 octahedral corner-sharing chains, with edge sharing of two similar chains to form layer bounded by the weak van der Waals attraction[9]. There were different methods used to produce the oxide, which led to achieve products with different properties: evaporation of Mo foil by IR in 1 atm synthetic air to produce a uniformly semitransparent film on alumina substrate[10], directly oxidizing of Mo spiral coil in ambient atmosphere to produce film on a Si (001) substrate[13], a flash evaporation of molybdenum oxide powder on silica glass substrate and (111)-oriented silicon wafer in vacuum[14], precipitation[15] and hydrothermal method[16].

Cupric oxide (CuO), a p-type semiconductor, have also attracted attention as a functional materials for gas sensing application. This materials has various advantages[17]: non toxic, low production cost, numerous of the precursors. Thus, the effort has been made to study for preparation in the two decades. According to literature, CuO has been synthesized using various techniques. Direct oxidation[18], microwave hydrothermal without surfactant[19], precipitation–pyrolysis method[20] and alcothermal method[21] had been successfully produced with several obtained shapes.

Nowadays, air pollution problem is elevating as a global crisis. The systems with effective and inexpensive for detection and quantification of environmentally hazardous gases have been progressively studied. Gas sensors have been considered as promising alternative for environmental measurements because of the low cost, high sensitivity, fast response and direct electronic interface. However, their performances including accuracy, selectivity and reliability must be further improved to meet the requirements of standard air pollution measurement.

Ammonia (NH_3)[22], one of important environmentally hazardous gas, is a colorless gas with a characteristic pungent odor. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as precursors to foods and fertilizers. Ammonia, either directly or indirectly, is also a building block for the synthesis of many pharmaceuticals. It is also used in cleaning products. Despite its usefulness, ammonia is both caustic and hazardous to human especially when its concentration exceeds a value of 25 ppm.

According to previous reports, metal oxides nanostructures are interesting to be applied in technological invention because their properties can be supported in various applications and used at high temperature environment. So, metal oxides are one of the selected materials for industrial products that can be easily approach in daily life. Material scientists and engineers spend their effort to produce metal oxides nanostructures, which show its physical and chemical property better than their bulk counterparts due to their high ratio of surface/volume. A variety of synthetic methods had been studied for a few past decades. In the present, microwave plasma and direct current heating methods are satisfyingly presented as a low cost, rapid, simple and environment friendly for metal oxide synthesis. Gas sensor base on metal oxides semiconductor (MOS) is very attractive for toxic gas monitoring and controlling. MOS sensors show an excellent respond to gas and also stable in normal air. Thus, MOS sensors with different shapes, sizes, types of oxides and fabrications are widely studied through their efficiency, energy consumption and reversibility work.

Herein, some metal oxides were chosen to study their properties and synthesis by a lab-developed microwave plasma and a direct current heating methods. MoO_3 products are the goal of the microwave plasma synthesized technique. CuO was produced by direct current heating method. Crystalline morphology and optical characteristic of the existence products had examined by various techniques. Furthermore, as-synthesized CuO was also exposed to NH_3 gas in closed chamber for gas sensing performance by a lab-made gas sensing monitoring system.

1.1 Research Objectives

The objectives of this study were the following.

1.1.1 To study a possible formation mechanism of the metal oxide nanostructures by microwave plasma and direct current heating methods

1.1.2 To synthesize and characterize the properties of metal oxide nanostructures

1.1.3 To study the possibility of applying synthesized metal oxides for sensing applications

1.2 Usefulness of the Research

1.2.1 Understand the mechanism of processing technique both microwave plasma and direct current heating methods

1.2.2 Understand the relationship between characteristic of metal oxides nanostructures and preparation processes

1.2.3 Application of the synthesized substances as a gas sensor