CHAPTER 5

Conclusions

Synthesized metal oxides including MoO_3 and CuO were determined their crystalline structures, morphologies and optical properties following to the procedure in previous chapter. CuO, a p-type metal oxide semiconductor, was exposed to NH_3 reducing gas under the controlled concentration in a lab-made closed chamber. All experiments are summarized as follows.

Orthorhombic α-MoO_3 was successfully produced by a 900 W microwave plasma process for 40, 50 and 60 min. The product processed for 60 min was α-MoO_3 microplates with good accordance with optical study of the previous report. Three main Raman peaks were detected at 666, 813 and 990 cm^{-1}. Raman analyzing value is in agreement with the report of T. Siciliano [87]. FTIR vibration modes showed peaks at 621, 874, and 993 cm^{-1} that are similar to the report of G.S. Zakharova [89]. PL spectra had emitting wavelength in range of 430–440 nm of indigo emission. Emission wavelength is very close to J. Song's report. According to result of characterization, as-synthesized MoO_3 microstructure is a pure phase that is a promising material for different applications.

CuO synthesized by 50A and 3.6 V DC electrical heating method has been successfully synthesized, and was characterized its crystalline structure, morphology, optical properties and gas sensing performance. Monoclinic CuO particles with about 450 nm in diameter showed 3.95eV energy gap. The PL emission peak is observed at 402 nm wavelength in violet region. The XPS spectrum indicates the Cu(II) oxidation state with the formation of CuO. Gas sensing performance exhibits 21.9% sensitivity to 1055 ppm NH_3 rich at 250 ^oC working temperature. Gas sensitivity values are similar to previous report at the same gas-air mixture concentration (see in discussion chapter), but this research shows a higher working temperature although irregular particles with a diameter of few hundred nm were fabricated to be a film with porosity. Nanowires fabricated film, nanowires with size of 80 nm in diameter and a few μm in length, has a low electrical resistance (5.5×10^{-6} Ω) in air at room temperature. Irregular particles distributed film cannot measure its resistance at room temperature. Thus, thermal activation used to enhance resistance of film was reduced. However, the as-synthesized CuO can be used as an efficient sensor to ammonia due to its promising advantage for large-scale production with low cost and benign to the environment.

Microwave plasma and direct current heating methods can be applied as efficient synthesizing techniques for metal oxide production. These techniques have an advantage comparing with others due to their low cost, simple, rapid and no waste product. In contrast, two techniques are still limited by size and shape controllable and substance for use as precursors. Microwave plasma method is appropriate to a starting materials with loss tangent value of more than 0.1. If loss tangent value less than 0.1, materials will not able to absorb microwave energy in order to transform into thermal energy. Although, plasma in vacuum chamber irradiates energy to surface of materials but plasma heating has lower influence than microwave-material interaction. Disadvantage of direct current heating method was developed for use in the research room at SCB 2611 room, Department of Physics and Materials Science, Faculty of Science, Chiang Mai University, for metal oxide synthesis. The equipment was designed to operate in normal air surrounding. Thus, production of materials is limited-metal sulfide, metal nitride and others should be used in higher vacuum condition. One important factor of precursor selection is electrical resistance (0.1Ω for Cu powder at initial step before heating). Metal powder is preferable for use as starting materials. In case of materials with high resistance, power supply must apply high electrical energy for current flowing through the materials to heat the materials by Joule's phenomena. Some case of materials production, stainless steel electrode could be melted due to high temperature developed inside and to contaminate with the as-synthesized products. In addition, pressing the powder to form as dense platelets can reduce the resistivity as well.