Chapter VII

Conclusions

A systematic approach had been carried out to fabricate and develop SnO_2 thin film gas sensors by sol-gel technique. The study included the construction of a flow injected type gas measuring system for evaluating gas sensing performance of SnO_2 gas sensors, the development of a new gas measuring circuit, the chemical synthesis of tin alkoxide sol, the fabrication of thin film gas sensor and the characterization of gas sensors. The results of some fundamental experiments are summarized and given below.

A circuit analysis including the non-linear electrical behavior of gas sensor showed that the conventional gas measuring circuit is not suitable for evaluating gas sensing performance of a gas sensor. In this circuit, the important parameters, i.e. sensitivity and recovery time, depends on the external circuit components such as resistance and voltage source. This inhibits a quantitative comparison of various gas sensors by this circuit. Some fundamental experiments were carried out to confirmed our analysis. In order to overcome these problems occurring in the conventional circuit, a novel measuring circuit was desired by using the voltage to current converter. The circuit analysis and experimental results showed that this new circuit can provide a constant sensitivity and recovery time. Moreover, under the condition that the voltage source of all gas sensors are identical, the gas sensing performances from various gas sensors can be compared quantitatively.

The sol of tin alkoxide had been successfully synthesized by the sodium method. This method involves the reaction steps of tin tetrachloride with sodium ethoxide. It was found that the careful control of moisture is one of the most important parameter in this synthesis. The final product of these reaction was a pale yellowish solution. This sol could be deposited as a thin film on various substrate such as glass

and Si by using spin coating technique or dipping technique. The SnO_2 films prepared from this sol by spin coating technique could be linearly controlled by the successive coating. The thickness of one coating layer was about 350 Å. The ellipsometry results indicated that SnO_2 films have refractive index about 1.75. The SnO_2 gas sensors were fabricated by coating two Ti/Pt electrodes on the surface of SnO_2 thin films.

The gas sensing performance of various gas sensors had been tested on the flow injection system. The analysis of the change of sensitivity with sample concentration were done by using the power law model. The power law provided some important parameters which can be used to compare the sensing performance quantitatively. The results of the experiments showed that the unmodified SnO_2 gas sensors prepared from the rigorously controlled sol gave the best results in both alcohol and ammonia detection. The ranging of alcohol and ammonia detection were 0.08 - 10 and 0.05 - 10 % by volume. The optimum operating temperature for alcohol and ammonia were 250 and 350 °C respectively. Moreover, the SnO_2 gas sensor fabricated from this sol also gave the fastest recovery time. The sensitivity to alcohol of SnO_2 could be enhanced by adding the small amount of $FeCl_3$.