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Selective gas sensing using WO_3 nanoparticles and zeolites hybrid structure for human cutaneous gas sensors

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Abstract

Improvement of gas sensors using WO_3 nanoparticles is acquired by integrating a zeolite layer into gas sensors. It could be fundamental base of hybrid sensors using multiple gas sensors with different zeolites represent improved selectivity.

1. Introduction

Metal oxide semiconductor nanoparticle based gas sensors are widely used for health care gas sensors, detecting the respiratory and cutaneous gases from human body and it makes disease screening possible. Especially, WO_3 gas sensors shows remarkable sensing qualities comparable to SnO_2 with high signals to ammonia, hydrogen sulfide, and acetone. It is the reason why WO_3 is the only two metal oxide semiconductor based gas sensors in commercial application. [1-3]

Despite of its common applications, there is a problem of gas selectivity on WO_3 gas sensors that not only target gases but also many kinds of gases are reacted with WO_3 nanoparticles. Considering that porous zeolites show the various gas absorption characteristics by different pore sizes. [4] By applying porous zeolites have different pore sizes on the gas sensors, it is expected to get high selectivity by adsorbing targeted gases onto zeolites. In addition that, combination with many kinds of gas sensors which have different gas sensitivity shows much better performance of sensors by signal analysis of each sensor.

In this study, two different types of zeolites onto WO_3 gas sensors are fabricated and get the better selectivity for low pressure of acetone gas from human skin surface. At the end of this experiments, fabrication of WO_3 nanoparticle based gas sensors are insensitive to the other gases except acetone is expected and it would be suitable health-care application for personal diet progress examination.

2. Experiment

To fabricate the gas sensors, commercial WO_3 nanoparticles with a particle diameter of 7.3 nm were prepared. A metal mask made of stainless steel (thickness 0.1 mm) was prepared, a metal mask was brought into tight contact with an sapphire substrate (10 mm × 10 mm). And then a comb-shaped Cr and Pt electrode films were formed with a thickness of 1.5 nm and 38.5 nm by a sputtering apparatus, respectively. A solution in which 100 mg of WO_3 nanoparticles prepared in 10 mL of de-ionized water was dispersed was prepared and 5 μL of the prepared solution was dropped on the comb electrode and vacuum drying in a desiccator was performed for about 30 minutes to obtain a WO_3 nanoparticle film in comb shape was deposited on the electrode. After the solution process, annealing was performed in an electric furnace at 100℃ for 1 hour and 400℃ for 1 hour in an air atmosphere. For the gas compressing device part, two different types of zeolites are prepared which have 4 nm (A4) and 7.4 nm (390HUA) pore size respectively. The structure of fabricated device is shown in Fig. 1.

3. Results and discussion

Measurement conditions are mainly depends on zeolites temperature. Before heating up, acetone and ammonia gases are injected separately and wait until the gas is adsorbed onto the zeolite sufficiently. Each gas concentration is controlled by 0, 50, 100, and 150 ppb. By heating the hybrid WO_3 gas sensors, sensing part and gas compressing part are simultaneously activated. As the result, 390HUA hybrid gas sensors response to acetone with improved sensitivity at 50 ppb concentration while sensitivity of ammonia is decreased. The grain boundary resistance (R_{gb}) is extracted from measured impedance graph of hybrid WO_3 gas sensors using 390HUA. (Fig. 2) As shown in Fig. 4, change of R_{gb} of hybrid gas sensors means reaction with acetone gas is more sensitive compared with ammonia gas. This result is considered that hybrid gas sensors using 390HUA have much higher selectivity to acetone gas than ammonia.

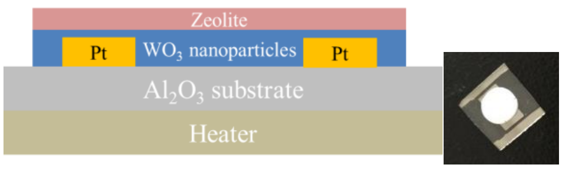

Fig. 1 Cross-sectional view of hybrid WO_3 nanoparticle based gas sensors and fabricated device.

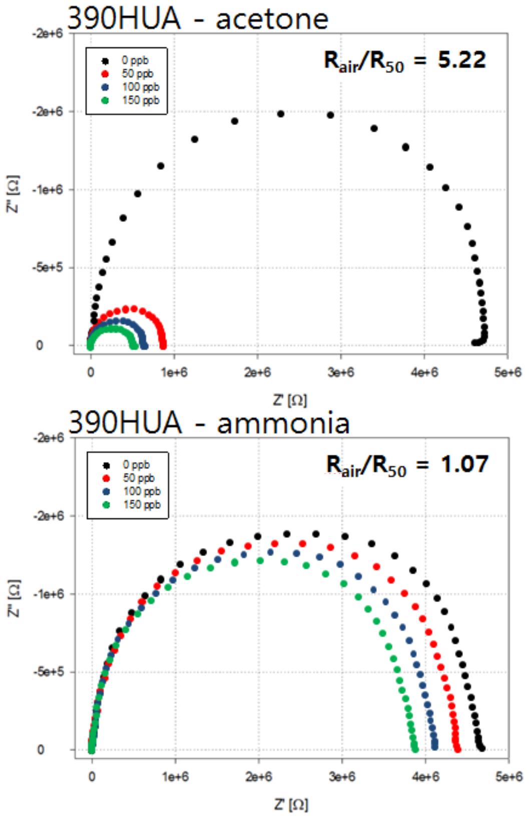

Fig. 2 Response of hybrid WO_3 nanoparticle based gas sensors with 390HUA zeolite to 2 different gases.

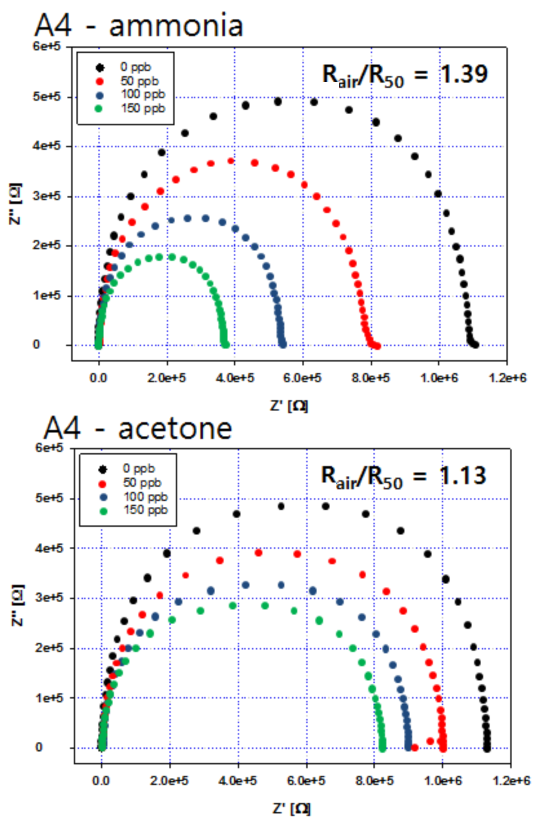

Fig. 3 Response of hybrid WO_3 nanoparticle based gas sensors with A4 zeolite to 2 different gasses.

On the other hand, in Fig. 5, A4 hybrid gas sensors show improved ammonia sensitivity while become insensitive to acetone. (Fig. 3) From the results, it is realized that hybrid gas sensors can have high selectivity to specific gas intentionally by using various porous zeolites.

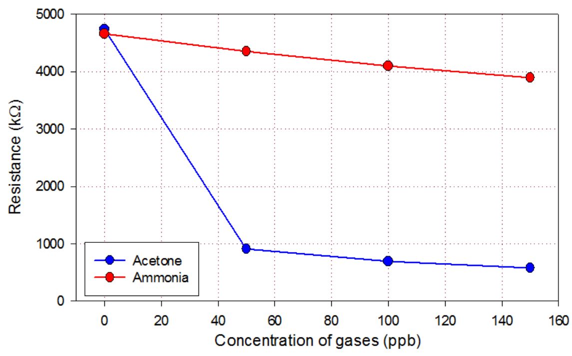

Fig. 4 Grain boundary resistance of hybrid gas sensors using 390HUA

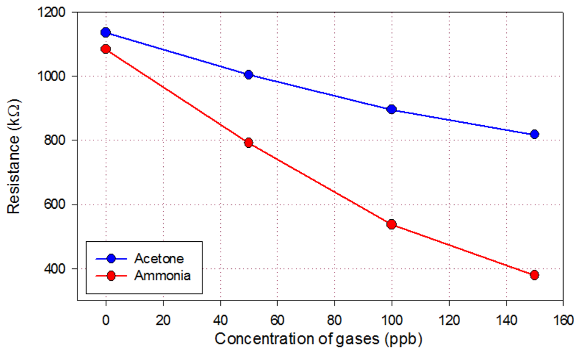

Fig. 5 Grain boundary resistance of hybrid gas sensors using A4

3. Conclusions

Zeolites hybrid gas sensors using WO_3 nanoparticles are fabricated. Hybrid gas sensors with various zeolites shows improved response signal to target gas are identified. Nevertheless, there's some room for improvement this hybrid gas sensors by integrating two gas sensors which have different sensitivity to each targeted gas. By analyzing gas signal of each gas sensors, we expected it would be gained much higher selectivity at the same condition.

Acknowledgements

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References

[1] A. Staerz *et al.*, Sens. and Actuators B, 237(2016), 54
[2] L. Valentini *et al.*, Thin Solid Films, 436 (2003), 95
[3] T. Toyooka *et al*, J. Breath Res., 036005(2013)
[4] Y. Yamada et al, Anal. Chem., 7588(2015), 87