HIGH SENSITIVITY MICRO-NO_2-SENSOR USING WO_3 THICK FILM AND ITS APPLICATION TO ENVIRONMENTAL MONITORING

T. Takagi, A Hayashi, J. Tamaki, and Y. Yamamoto
Department of Applied Chemistry, Faculty of Science and Engineering, Ritsumeikan University, Kusatsu-shi, Shiga 525-8577, Japan

It is well known that WO_3 is excellent sensing material for NO_x detection [1]. Recently, we have found WO_3 thick film sensor equipped with Au comb-type microelectrode showed extremely high sensitivity to dilute NO_2 [2-4]. The high sensitivity was contributed to the disk-shaped WO_3 particles deposited on microelectrode. In this study, The WO_3 thick film sensor fabricated by using H_2WO_4 suspension showed outstandingly high sensitivity to dilute NO_2 (0.01-2 ppm). Thus, this sensor was subjected to environmental monitoring as described below.

H_2WO_4 and WO_3 were prepared in wet process. The suspension containing WO_3 or H_2WO_4 was dropped on Au comb-type microelectrode (line width : 5 μm, distance between lines : 5 μm), dried, and calcined at 400 ℃ to be WO_3 film sensors. Sensors (A) and (B) were fabricated by using WO_3 suspension and had thin and thick WO_3 film, respectively. Sensor (C) was fabricated from H_2WO_4 suspension and had WO_3 thick film. The NO_2 sensing properties were measured in the range of 0.01-2 ppm at 200 ℃. The sensitivity was defined as Rg/Ra.

The surface morphologies of WO_3 film sensors (A-C) were investigated by means of SEM. As shown in Fig 1, the WO_3 thick film sensor (B) consisted of dense packing of disk-shaped WO_3 particles (300 nm in diameter, 20 nm in thickness). For sensors (A) and (C), the deposition of disk-shaped WO_3 particles was also observed in SEM images. The WO_3 film for sensor (A) was very thin, while the surface morphologies of sensor (C) was very similar to that of sensor (B). Figure 2 shows the sensitivities to dilute NO_2 of WO_3 film sensors (A-C) at 200 ℃ as a function of NO_2 concentration. The WO_3 thin film sensor (A) exhibited relatively low sensitivity to dilute NO_2. However, the sensitivities to 0.02-0.05 ppm NO_2 were much improved when the thickness of WO_3 film was increased (sensor B and C). The film thickness is considered to be more optimized for sensor (C) than sensor (B), resulting in the high sensitivity of sensor (C). The WO_3 thick film sensor (C) showed extremely high sensitibity of 17-73 to 0.02-0.05 ppm NO_2 at 200 ℃, suggesting the possivility of environmental NO_2 monitoring using WO_3 sensor (C). Figure 3 depicts the results of environmental monitoring test in the laboratory atmosphere using WO_3 sensor (C) and the chemiluminescence-type NO_x analyzer. It is seen that the sensor resistance well corresponds to the variation of NO_2 concentration measured by NO_x analyzer in the very low concentration range of 5-25 ppb.

Consequently, it was found that the WO_3 thick film sensor (C) showed extremely high sensitivity to dilute NO_2 of ppb-level and that the environmental monitoring was possible using WO_3 thick film sensor (C).

References

[1] M. Akiyama, J. Tamaki, N. Miura, N. Yamazoe, Chem. Lett, **1991**, 1611-1614 (1991).
[2] J. Tamaki, A. Hayashi, Y. Yamamoto, Sensors and Actuators B, **95**, 111-115 (2003).
[3] J. Tamaki, A. Hayashi, Y. Yamamoto, M. Matsuoka, Digest of Technical Papers of Transducers' 03, **1**, 524-527 (2003).
[4] J. Tamaki, A. Hayashi, Y. Yamamoto, J. Ceram. Soc. Jpn., **112**, S546-S549 (2004).

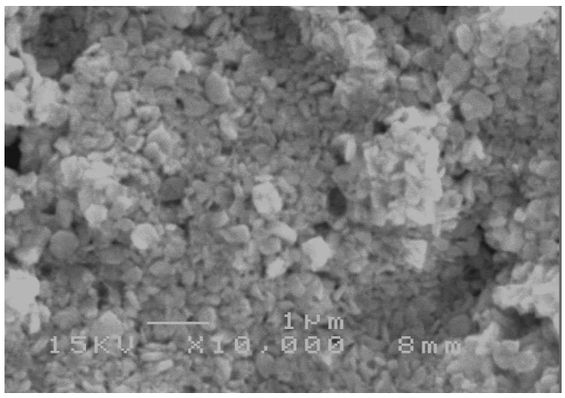

Fig.1 Surface SEM image of WO_3 thick film sensor (B).

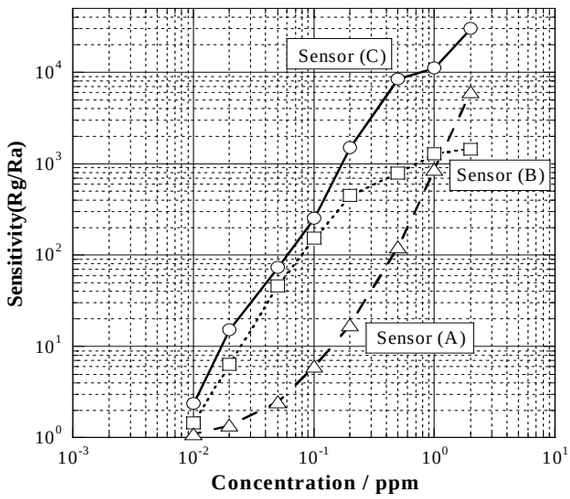

Fig. 2 Sensitivities to dilute NO_2 of WO_3 film sensors (A-C) as function of NO_2 concentration at 200 ℃

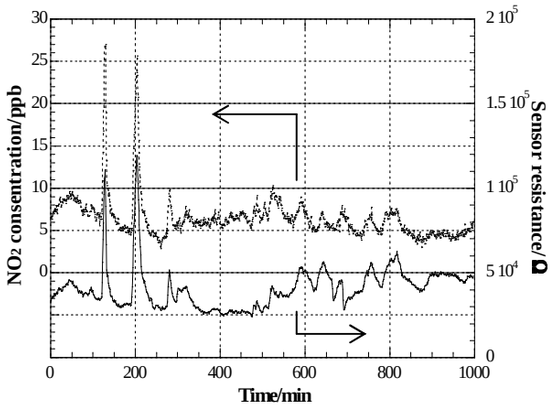

Fig. 3 Environmental monitoring test in laboratory using WO_3 thick film sensor (C) at 200 ℃
The gas cooking strove was used for boiling water at 120 and 190 min.