EFFECT OF MICRO-GAP ELECTRODE IN NITROGEN DIOXIDE SENSOR USING TUNGSTEN OXIDE THIN FILM

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We have found that the WO_3 thick film sensor equipped with Au comb-type microelectrodes (line width : 5 µm, distance between lines : 5 µm) showed extremely high sensitivity to dilute NO_2 [1-3]. It is considered that the usage of the disk-shaped WO_3 particles and the Au comb-type microelectrodes was responsible for high sensitivity to dilute NO_2. In this study, the effect of microelectrode on NO_2 sensing properties was elucidated as described below.

The micro-gap electrode with various gap sizes (0.2-1.6 µm) and various line width (10-50 µm) were fabricated by means of MEMS techniques (photolithography and FIB techniques). The WO_3 thin film was deposited on the micro-gap electrode by using suspension dropping method to be micro-gap-sensor as schematically drawn in Fig. 1. The sensing properties to dilute NO_2 of WO_3 thin film microsensors were measured in the range of 0.01-3 ppm at 200 ℃ and the effects of micro-gap size and line width on dilute NO_2 sensing properties were investigated. The sensitivity (S) was defined as Rg/Ra.

At first, the effect of micro-gap size on NO_2 sensing properties was evaluated. Figure 2 shows the sensitivities to dilute NO_2 of WO_3 thin film microsensor at 200 ℃ as a function of gap size. In this case, we used the micro-gap with line width of 10-15 µm. The sensitivity to dilute NO_2 was almost unchanged for the gap size larger than 0.85 µm. However, the sensitivity tended to increase with decreasing gap size less than 0.85 µm. The highest sensitivity (S=47 to 0.5 ppm NO_2, S=8 to 0.1 ppm NO_2) was obtained for the microsensor with gap size of 0.33 µm. When the gap size decreases, the number of WO_3 particles included in the gap decreases. If WO_3 particles are linearly lined in the gap, it is assumed that the sensor resistance is the sum of resistance at interface between Au electrode and WO_3 particle, and WO_3 grain boundary resistances. When the gap size and thus the number of WO_3 particles decrease, the contribution of resistance between Au electrode and WO_3 particle to total sensor resistance increases. If the resistance change upon exposure to NO_2 at interface between Au electrode and WO_3 particle is much larger than that at WO_3 grain boundary, the NO_2 sensitivity increases with decreasing gap size.

From the results of gap size effect, it is considered that the higher sensitivity is expected when the contribution of Au electrode-WO_3 particle boundary becomes larger. Thus, the effect of line width was evaluated because large line width brought about a lot of Au-WO_3 boundaries. Figure 3 compared the gap size effect for micro-gap sensors with line width of 10 µm and 50 µm. In a whole range of gap size, the sensitivities were higher for the sensor with 50 µm width than 10 µm width although the plots were scattered a little.

Consequently, the sensitivity was found to increase with decreasing gap size as well as with increasing line width.

References

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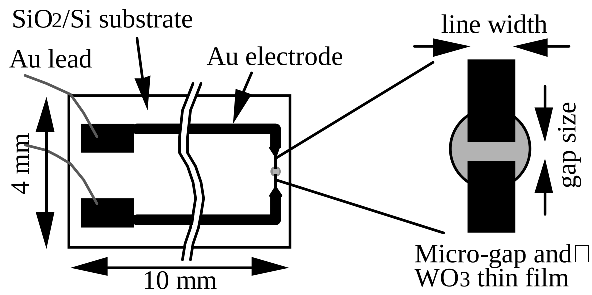

Fig. 1 Schematic drawing of WO_3 thin film microsensor equipped with micro-gap.

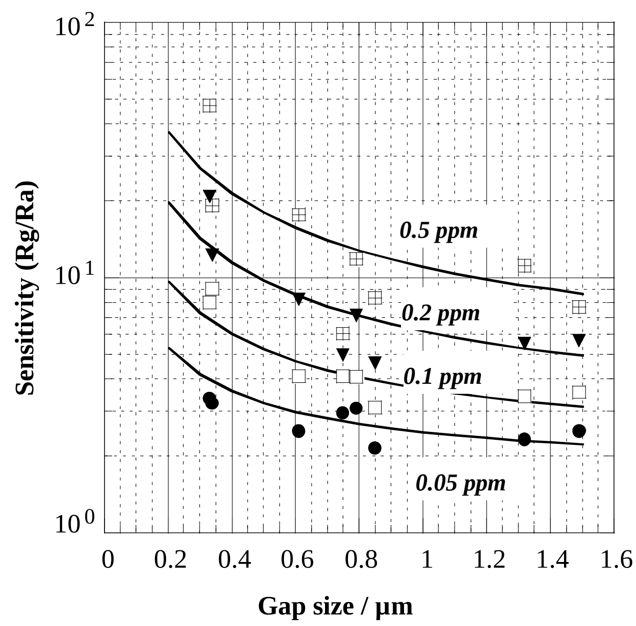

Fig. 2 Sensitivities to dilute NO_2 of WO_3 thin film microsensors as a function of gap size (operating temperature : 200 ℃).

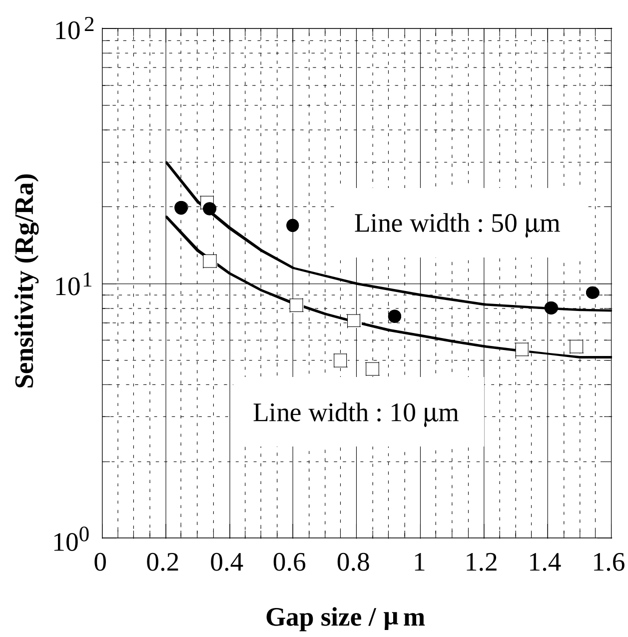

Fig. 3 Sensitivities to 0.2 ppm NO_2 of WO_3 this film microsensors with line width of 10 µm and 50 µm as a function of gap size.