

สมบัติการตรวจจับไอเอทานอลของก๊าซเซนเซอร์ดีบุกออกไซด์ผสมโมลิบดีนัมออกไซด์ที่เจือด้วยทอง
Ethanol sensing properties of Au-doped SnO₂-MoO₃ Gas Sensors

มีชัย เทพนุรัตน์, สุภาพ ชูพันธ์, บัณฑิตา คอนกาวิน, นววรรณ ทองมี, ผ่องศรี มังกรทอง, และ นิกร
มังกรทอง

Meechai Tapnurat, Supab Choopun, Buntita Donkawin, Navavan Thongmee, Pongsri
Mangkorntong, and Nikorn Mangkorntong
Department of Physics, Faculty of Science, Chiang Mai University, Chiang Mai 50200,
Thailand.
e-mail address : jamephy@yahoo.com.

บทคัดย่อ: ดีบุกออกไซด์(SnO₂) เป็นสารกึ่งตัวนำที่สำคัญต่อการนำมาใช้เป็นก๊าซเซนเซอร์ได้ โดยใช้หลักการเปลี่ยนแปลงของสภาพต้านทานไฟฟ้า ก๊าซเซนเซอร์เตรียมขึ้นได้โดยผสมผงดีบุกออกไซด์และผงโมลิบดีนัมในอัตราส่วน 80:20 โดยน้ำหนัก และเจือด้วยผงทองคำ ขึ้นรูปเป็นท่อทรงกระบอก จากนั้นเผาที่อุณหภูมิ 600 องศาเซลเซียส 6 ชั่วโมง ลักษณะเฉพาะของก๊าซเซนเซอร์สังเกตได้จากการเปลี่ยนแปลงของค่าความต้านทานไฟฟ้าในอากาศและในเอทานอลของก๊าซเซนเซอร์ที่อุณหภูมิ 150-250 °C พบว่าสภาพต้านทานไฟฟ้าของก๊าซเซนเซอร์ภายใต้บรรยากาศไอเอทานอล มีค่าต่ำกว่าสภาพต้านทานไฟฟ้าในอากาศ และการลดลงของสภาพต้านทานไฟฟ้าขึ้นอยู่กับอุณหภูมิทำงาน สภาพต้านทานไฟฟ้าที่เปลี่ยนแปลงสูงสุดที่อุณหภูมิ 250 °C นอกจากนี้ยังพบว่าสภาพไวต่อการตอบสนองสูงสุดที่ค่า 31ในก๊าซเซนเซอร์ที่เจือด้วยทองอัตราส่วน 60% โดยน้ำหนัก และเวลาในการตอบสนองน้อยสุดที่ค่า 8 วินาทีในก๊าซเซนเซอร์ที่เจือด้วยทองอัตราส่วน 10% โดยน้ำหนัก

Abstract: Tin oxide (SnO₂) is a dominating semiconductor material for gas sensor operating on the basic of resistivity change. The gas sensors was prepared by mixing SnO₂ and MoO₃ powders with the ratio of 80:20 by weight and then, mixing with Au powder, pressing into cylindrical tube and then sintering at 600 °C for 6 h. The characteristics of sensor were observed from the changing of resistance in air and in ethanol ambient with ethanol concentration of 1000 ppm and at work temperature of 150-250 °C. It was found that the sensor resistivity under the ethanol atmosphere is lower than the resistivity in air and the decrease of resistivity depends on the operating temperature. The largest resistivity change was observed at a temperature of 250 °C. Moreover, the maximum sensitivity of 31 has been observed in 60 %-Au: SnO₂-MoO₃ sensor and the minimum response time of 8 sec has been observed in 10 %-Au: SnO₂-MoO₃ sensor.

Introduction: Tin oxide (SnO₂) is a dominating semiconductor material for gas sensor operating on the basic of conductivity change. It is known that doping SnO₂ with metal such as platinum, and palladium can significantly increase the sensitivity of SnO₂ based gas sensor toward inorganic vapor and toxic gas [1-5]. It is also believed that gold would give similar result as platinum. Thus, it is our interest to study gold as a dopant in tin oxide. In this work, we report on the gas sensing properties of Au-doped SnO₂-MoO₃ (Au: SnO₂-MoO₃) gas sensors toward ethanol vapor.

Methodology: The gas sensors was prepared by first mixing SnO₂ and MoO₃ powders with the ratio of 80:20 by weight and then, mixing with 10 wt%, 30 wt%, 50 wt%, 60 wt% and 70 wt% of Au powder. The mixture was grounded and pressed into a cylindrical tube with inner diameter of 1.12 mm, wall thickness of 0.19 mm and length of 3 mm. The tube was sintered in air at 600 °C for 6 h. After sintering, the tube sample was painted with silver paint and connected with copper wires to form the electrodes. The gas sensor was tested in cylindrical gas flow chamber. The characteristics of sensor were observed from the changing of resistance in air and in ethanol ambient with ethanol concentration of 1000 ppm and at work temperature of 150-250 °C. The response and recovery as a function of time was monitored and recorded via interfaced personal computer.

Results, Discussion and Conclusion: The response and recovery curves of Au: SnO₂-MoO₃ gas sensor at operating temperatures of 150 °C, 200°C and 250 °C under an ethanol vapor concentration of 1000 ppm are shown in Figure 1. It is seen that the sensor resistivity under the ethanol atmosphere is lower than the resistivity in air and the decrease of resistivity depends on the operating temperature. The resistivity of the sensor decreases as the operating temperature increases. The largest resistivity change was observed at a temperature of 250 °C. The response and recovery curves of Au: SnO₂-MoO₃ gas sensor with 10 wt%, 30 wt%, 50 wt%, 60 wt% and 70 wt% Au under ethanol vapor concentration of 1000 ppm at an operating temperature of 250 °C are shown in Figure 2.

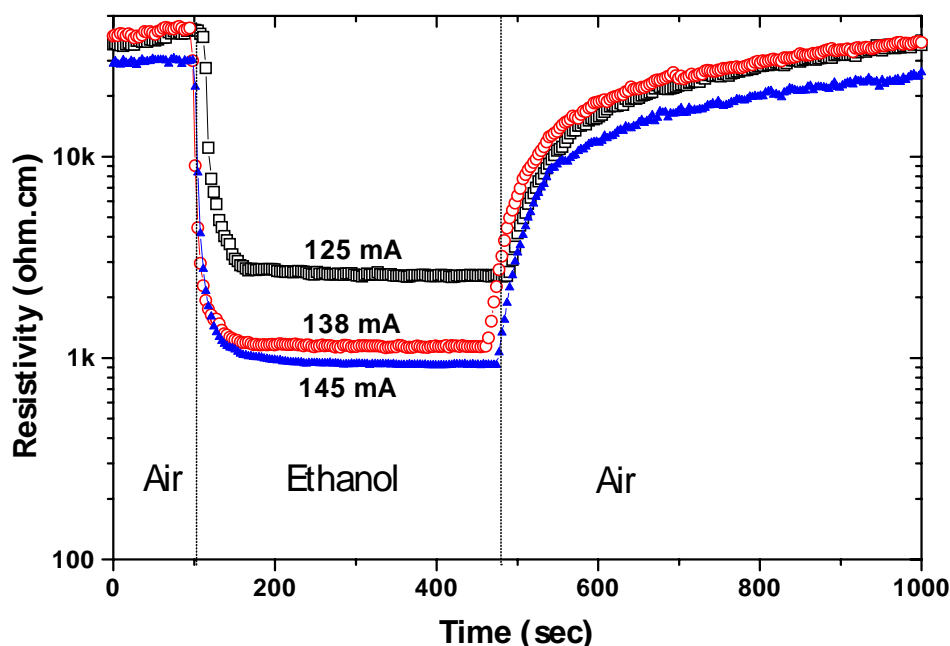


Figure 1. Response and recovery characteristics of 60 wt% Au:SnO₂-MoO₃ gas sensor under ethanol vapor concentration of 1000 ppm at operating temperature of 150 °C, 200 °C and 250 °C.

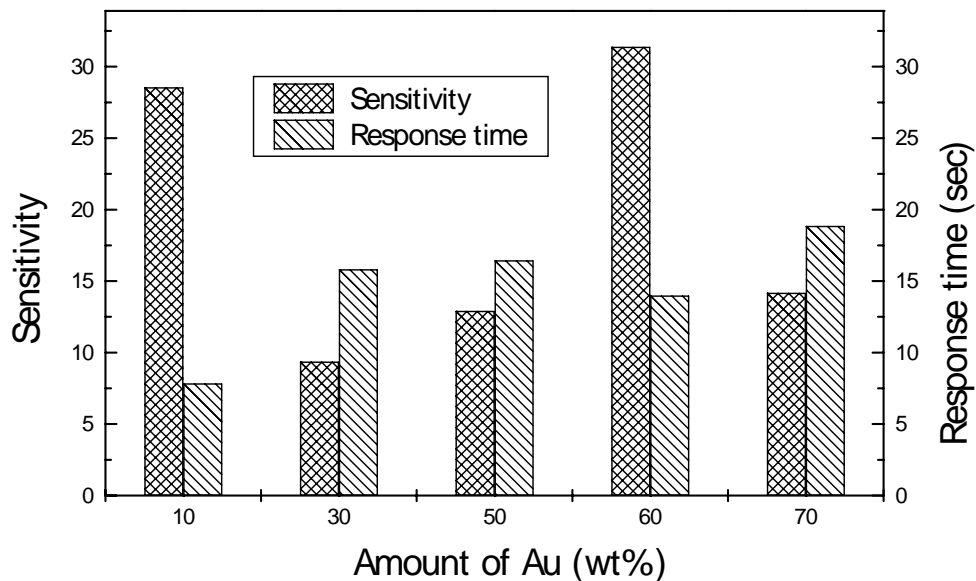


Figure 2. Sensitivity and response time (τ_{90}) of ($\text{SnO}_2\text{-MoO}_3$) with 10 wt%, 30 wt%, 50 wt%, 60 wt% and 70 wt% Au gas sensors at operating temperatures 250°C under ethanol vapor concentration of 1000 ppm.

Typical parameters used to determine the quality of a gas sensor are sensitivity and response time.

The sensitivity; S of the sensor is defined as R_a/R_o where R_a is the electrical resistivity of the sensor in air and R_o is its resistivity in ethanol vapor. The response time (τ_{90}) is defined at the time required for the sample resistance variation to reach 90% of equilibrium value following a step increase in the concentration of the testing gas. The sensitivity and response time of Au: $\text{SnO}_2\text{-MoO}_3$ gas sensor is shown in Figure 2. At operating temperatures 250°C under ethanol vapor concentration of 1000 ppm, the maximum sensitivity has been observed in 60 wt%-Au: $\text{SnO}_2\text{-MoO}_3$ sensor and the minimum response time has been observed in 10 wt%-Au: $\text{SnO}_2\text{-MoO}_3$ sensor. Different amount of Au doing would cause the changes in microstructures such as grain size and morphology of the materials of the materials the effect of microstructures sensitivity and response time of the samples is under intense investigation.

In conclusion, the sensor resistivity under the ethanol atmosphere is lower than the resistivity in air and the decrease of resistivity depends on the operating temperature. The largest resistivity change was observed at a temperature of 250°C . Moreover, the maximum sensitivity of 31 has been observed in 60 wt%-Au: $\text{SnO}_2\text{-MoO}_3$ sensor and the minimum response time of 8 sec has been observed in 10 wt%-Au: $\text{SnO}_2\text{-MoO}_3$ sensor.

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Keywords: ethanol sensing property, SnO₂, MoO₃, gas sensor.