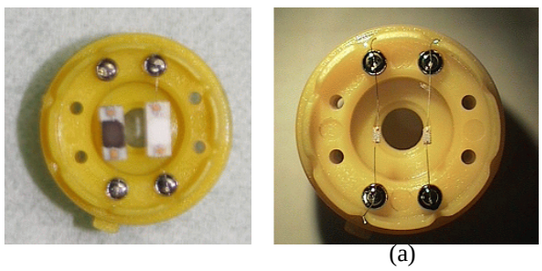
Improved hydrogen sensing characteristics of flat type micro catalytic hydrogen gas sensor of smaller size

Chi-Hwan Han, Sang-Do Han
Korea Institute of Energy Research,
71-2, Jangdong, Yuseong, Daejeon 305-343,
Republic of Korea

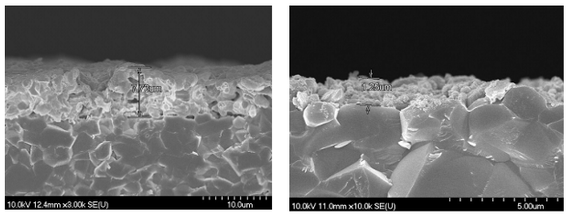
Hydrogen is a promising and potential fuel for cars, buses, and other vehicles and can be converted into electricity in fuel cells. It is already being used in medicine and space exploration as well as in the production of industrial chemicals and food products. In order to successfully implement a renewable hydrogen economy, the safe production, storage, transport, handling and use of hydrogen is imperative. Like all fuels, hydrogen has inherent hazards and must be handled carefully. The principal hazard presented by hydrogen systems is the uncontrolled combustion of accidentally released hydrogen. It is very important to note from the flammability studies that the hydrogen concentration in air exceeding 4% is flammable and explosive. Being odorless and highly inflammable gas it is necessary to detect its leakage. Therefore, today a wide range of investigations are being carried out for the development of reliable hydrogen sensors. One of the simplest forms for H_2 monitoring is the use of catalytic combustion sensors. Catalytic type gas sensors have been developed by many research groups. Combustible gas mixtures do not burn until they reach an ignition temperature. However, in the presence of certain chemical media, the gas can ignite and burn at lower temperature. This phenomenon is known as catalytic combustion. A gas molecule oxidizes on the catalyzed surface of the sensor at a much lower temperature than its normal ignition temperature. Every conductive material has its own coefficient of temperature resistance (C_t). Platinum which has large C_t in comparison with other metals is a good candidate for the catalytic combustible sensor because it can detect flammable gases by measuring change in resistance of the heater metal with temperature. The catalytic surface is generally prepared by sintering noble metal particles (Pt, Pd) on a high surface area material like γ-Al_2O_3. However, there are still certain limitations associated with the catalytic sensors to be addressed. These sensors show low sensitivity due to the adsorption of hydrogen in small amounts.

Since the sensitivity of the sensor device is essentially governed by the amount of hydrogen adsorbed, the improvement of gas sensitivity can be achieved by using small size sensor device which can operate at lower temperatures with small power consumption. In this paper, we report an improvement of the sensitivity by decreasing the size of the sensor. The working temperature, response time and recovery time of the present small size sensor (b) has been compared with a large size sensor (a).



(a) (b)

Fig. 1. Photos of fabricated sensor (a) and sensor (b).



(a) (b)

Fig. 2. SEM images of the formed Pt heater of sensor (a) and sensor (b). Dimensions are in μm.

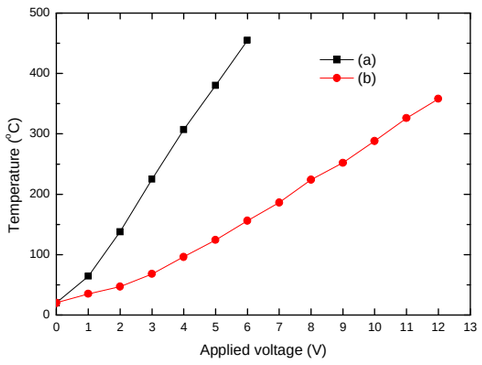


Fig. 3. Variation of sensor structure temperature vs. heater voltage for sensors (a) and (b).

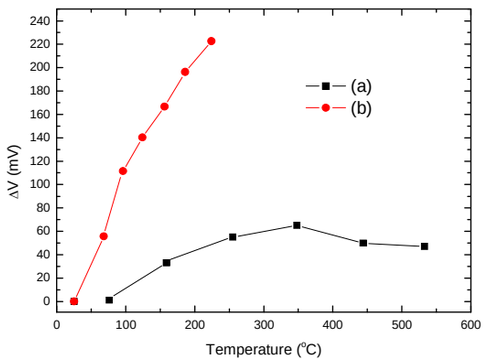


Fig. 4. Response of the sensors (a) large size and (b) small size to 1% hydrogen in air.

Fabrication and performance measurements of small and large size flat type micro hydrogen sensors have been presented. The response of these devices to the hydrogen gas was studied with respect to their size. It was observed that small size sensor can work at lower temperatures and this sensor array has been found to be more sensitive. The improved response of the small size sensor at lower working temperatures seems to be triggered by the better adsorption of hydrogen due to an increase in the surface to volume ratio which facilitates the oxidation of hydrogen by the catalysts. Hence, the present flat type micro-hydrogen small size sensor with enhanced sensitivity is fast-responding, selective, stable, and reliable and an economic candidate for detection of hydrogen.

[1] J.G. Firth, A. Jones, T.A. Jones, Principle of the detection of flammable atmospheres by catalytic devices, *Combust. Flame* **21**(1973) 303–311.
[2] C-H. Han, D-W. Hong, I-J. Kim, J. Gwak , S-D Han, K. C. Singh, Synthesis of Pd or Pt/titanate nanotube and its application to catalytic type hydrogen gas sensor, *Sens. Actuators B* **128** (2007) 320–325.