ALL SOLID STATE ROOM TEMPERATURE HYDROGEN SENSOR

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Metal/Insulator/Semiconductor (MIS) structures have been used for gas sensors especially for hydrogen. The $Pd/SiO_2/Si$ based sensor [1] was used for hydrogen detection at room temperature but the behavior was rather poor. Therefore, normally the sensor is used at temperatures near to 150°C.

In this paper we describe the application of a $Pt/LaF_3/Si_3N_4/SiO_2/Si$ field effect structure for the detection of hydrogen at room temperature. The additional LaF_3-layer was shown to improve the characteristics of field-effect gas sensors for hydrogen monitoring. The sensors were prepared by thermal evaporation of LaF_3 (Merk) on the surface of n-type silicon covered with SiO_2 and Si_3N_4[2]. A Platinum gate electrode was deposited by DC sputtering of a Pt target in argon atmosphere at a pressure of 6 Pa. A shadow mask was used for patterning of the gate electrode. The electrical parameters of the MIS capacitors (CV-curves and hydrogen response) were measured using computer driven RCL-meter HP 4284A.

The additional layer of lanthanum trifluoride in contact to Pt significantly increases the signal and decreases the response time of hydrogen field effect gas sensors working at room temperature compared to traditional MIS structure hydrogen sensors with Pd gate. In contrast to the Pd/Insulator-MIS sensors the presence of the Pt/LaF_3 interface leads to a Nernstian character of the sensor response. The sensitivity of the sensor is equal to 27 mV per decade of hydrogen concentration. The limit of detection was found to be 10 ppm. A typical hydrogen response curve is presented in Fig. 1.

The response time to increasing hydrogen concentration was shown to be of about 110 seconds and is independent of concentration (Fig.2). After storage, this response time becomes longer. However, a method of the stabilization of the long-term behavior of the sensor, which consists in periodic heating ("activation") of the sensor at 350^0C, followed by room temperature measurement of H_2 concentration, was successfully demonstrated. The thermal treatment can be done simply and fast by using the gate metal as a resistive heater. This way a stable long time behavior can be achieved.

The response mechanism to hydrogen of our sensor using a lanthanum trifluoride/Pt interface was shown to be different from that of the MIS type sensors. It involves probably a step of the interaction of hydrogen with oxygen adsorbed on the Pt/LaF_3 interface, and therefore is connected to the mechanism of oxygen sensitivity of "activated" MIS sensors with LaF_3 layer[3]. This conclusion is a result of the comparison of sensor behavior in air and in argon atmosphere. A thin layer of lanthanum fluoride containing different oxygen species results in a reversible electrode LaF_3/Pt for electrochemical reactions involving oxygen and hydrogen. The number of applications were hydrogen has to be detected at constant oxygen concentration (e.g. in air) is rather large and therefore, a lack of selectivity is not a problem for the sensor described in this paper.

The new hydrogen sensor exhibits much improved room temperature behavior. Therefore, power consumption for portable devices can be very much reduced.

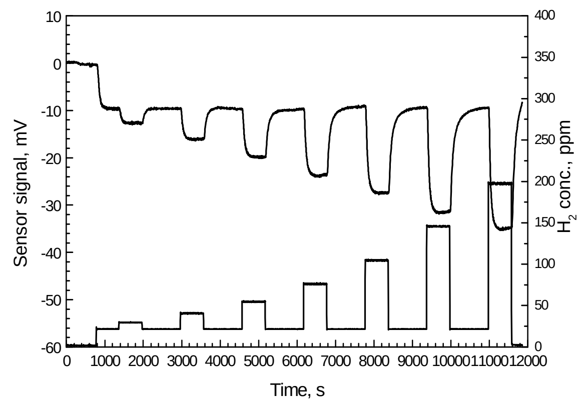

Fig. 1. Response of a reactivated sensor (solid line and left scale) to different concentrations of hydrogen (right scale) in synthetic air. Room temperature measurements, 33% RH. 1 min reactivation at 350^0C.

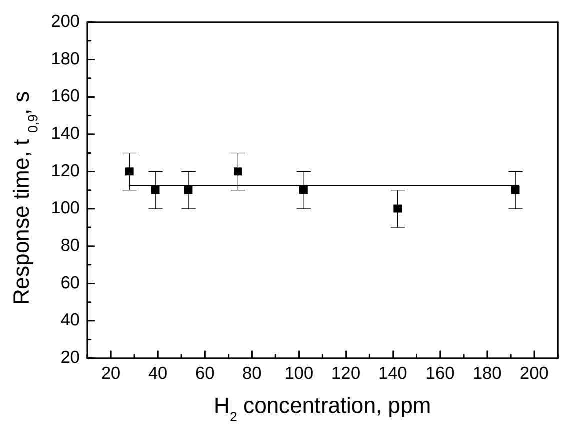

Fig. 2. Response time of a reactivated sensor as a function of H_2 concentration in air. Room temperature measurements, 33% RH. 1 min reactivation at 350^0C.

References

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