613e Reverse Response Transient in a Pd Alloy/Aln/N-Si Hydrogen Sensor

Linfeng Zhang, Erik F. McCullen, Lajos Rimai, Ratna Naik, Gregory W. Auner, and K.Y. Simon Ng

Hydrogen attracts more and more attention as a variable clean fuel and thus there are extensive research activities in hydrogen storage, generation, and fuel cells. Since hydrogen is explosive when its concentration in air is more than 4 vol %, sensitive, selective, and stable sensors are needed to measure hydrogen concentration. In our previous research, metal-insulator-semiconductor (MIS) type sensor with Pd/AlN/n-Si structure showed reverse response transient to hydrogen at high temperature and high hydrogen concentration. The transient would affect the stability of the sensor and make calibration difficult. The objective of this paper is to understand the nature of this response transient phenomenon. To this end, sensor with Pd0.95Ni0.05/AlN/n-Si structure was prepared to make the metal gate more stable, thus allow reverse response transient studies with a wider range of hydrogen concentration. The Pd-Ni alloy film was deposited through magnetron sputtering and the AlN layer was grown on top of n-Si through Plasma Source Molecular Beam Epitaxy (PSMBE). The composition of the gate was studied by X-ray Photoelectron Spectroscopy (XPS). This type of sensor works as a capacitor. Thus, the voltage shifts at a constant capacitance correspond to the response to hydrogen. For the low hydrogen concentration (1000 ppm), there was no reverse response transient observed at 80 oC (Figure 1a). However, there were turn on/off reverse response transients at 120 oC (Figure 1b). When hydrogen concentration was 5 %, the sensor only showed turn-on reverse response transient at 80 and 120 oC, and the initial voltage shift decreased with the turn-on/off cycles. After several cycles, the reverse response transients gradually disappeared and the stable value was quite close to the response to 0.1 % hydrogen. It should be noted the time constants for turn on reverse response transients to 0.1 % and 5 % hydrogen at 120 oC are both around 300 seconds, suggesting that both transients are due to the same process. Furthermore, for a period of 1,000 seconds, the turn-on reverse response transient is 0.161 V in the response to 5 % hydrogen at 80 oC, which is equal to 38% of the maximum response; while the reverse response transient is 0.172 V at 120 oC, which is equal to 61% of the maximum response. Thus, the rate of the turn-on reverse response transient is slow at a low temperature. Our results suggest that in order to minimize response transient, a low operating temperature should be used. The mechanism of the response transient will be discussed in terms of the metal gate compositions, hydrogen concentration, and temperature.

Figure 1 Cyclic testing of 0.1 % hydrogen on the sample of Pd0.95Ni0.05/AlN/n-Si(111) at 80 oC (a) and 120 oC (b), there is no reverse response transient at 80 oC, but there are obvious turn-on/off reverse response transients at 120 oC