562c The Effect of Metal Gate Structure on the Gas Sensor's Electrical Characteristics

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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. Metal-insulator-semiconductor (MIS) type sensor with Pd alloy/AlN/Si structure shows high sensitivity and selectivity to hydrogen. This type of sensor works as a capacitor. In the depletion region of the capacitance-voltage (C-V) curve, the voltage shift at certain capacitance corresponds to the response to hydrogen. Since the composition and structure of the metal gate can greatly affect the operating parameters and the performance of the sensor, it is important to understand the relationship between the nature of metal gate and the electrical characteristics. The objective of this paper is to investigate the C-V characteristic as a function of metal gate composition (Pd, PdCr, PdCr/Pd, and Pd/PdCr) of the sensors. The insulator layer, AlN, was grown on top of n-Si with Plasma Source Molecular Beam Epitaxy (PSMBE), and different metal gates were deposited with magnetron sputtering. The composition of the gate was studied by X-ray Photoelectron Spectroscopy (XPS). The C-V curves were obtained with the AC signal from 100 Hz to 1 MHz. In the C-V curves of these four devices, it is interesting to note that the single layer metal gated (Pd/AlN/Si and PdCr/AlN/Si) and the double metal layer gated (Pd/PdCr/ AlN/Si and Pd/PdC/AlN/Si) devices fall into two distinct groups of the curves . Figure 1 shows the gate bias voltages of single layer gated and double layer gated devices measured at different frequency. This gate bias voltage corresponded to the middle point of depletion region in the C-V curves. The double layer gated samples showed a large shift, about ¨C6 V, as compared to the single layer gated device. In addition, there was a decrease in the measured capacitance for the double layer gated device. This suggested the existence of additional positive charge and capacitance in double layer gated device. Figure 2 shows the corrected conductance calculated based on the measured C-V and conductance-voltage (G-V) curves, with the series resistance effect removed. With the increase of AC frequency, the peak of the conductance gradually shifted to 0 V for single layer gated devices, and ¨C4 V for double layer gated devices. Finally, the interface state densities for single metal layer gate samples will be calculated and the possible relationship between these electrical characteristics and the performance of sensor will be discussed. Our results suggest that with a better understanding of the electrical characteristics of different sensors, somewhat modified structures could be designed to optimize operating conditions and sensor performance.

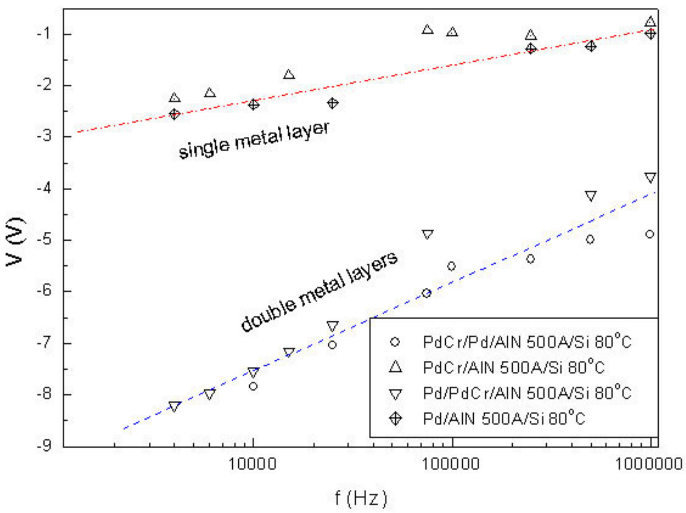

Figure 1. Gate bias voltages (middle points of depletion region) of single layer gated and double layer gated devices measured at different frequency. A large voltage shift for the double layer gated devices were observed as compared to the single layer gated devices.

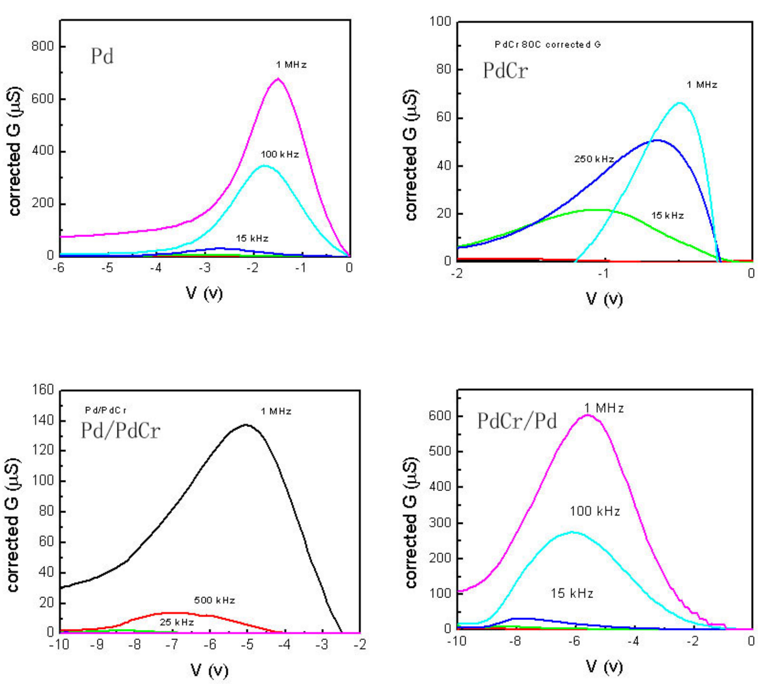

Figure 2. The corrected conductance as a function of gate bias for Pd, PdCr, Pd/PdCr, and PdCr/Pd samples. With the increase of AC frequency used in C-V/G-V measurement, the peak of the

conductance gradually shifted to 0 V for single layer gated devices and ¨C4 V for double layer gated devices.