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Responses' time Parameters of Hydrogen Sensors based on MISFET with Pd(Ag)-Ta_2O_5-SiO_2-Si structure

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Abstract:
The influence of the hydrogen concentration and electric modes of measuring circuit on times' parameters of responses of hydrogen sensors based on metal-insulator-semiconductor field-effect transistor (MISFET) with structure Pd(Ag)-Ta_2O_5-SiO_2-Si have been experimentally studied. MISFET sensing element has been fabricated by means of conventional MOS-technology on single silicon chip together with (*p*–*n*)-junction temperature sensor and heater-resistor.There were measured the responses of MISFETs for different hydrogen concentrations and drain currents. MISFET hydrogen sensors has been investigated by modelling. The sensor conversion function, hydrogen sensitivity, errors and power consumption have been studied. The studies have shown how the responses' times parameters (response and relaxation times) depend on hydrogen concentrations and the measuring circuit's electric modes. The models of MISFET's responses for different hydrogen concentrations are presented in this work.

Key words: hydrogen sensors, MISFET, responses, time parameters, model

Introduction

The hydrogen sensors based on the metal-insulator-semiconductor field-effect transistor (MISFETs) have been studied by many investigators [1–5]. The studies have shown that the conversion characteristics (the sensor output signals *V* as function of the hydrogen concentration *C*) depend on MISFET's technological parameters, chip temperature, electric modes and external factors (other gases, irradiation).

This work deals with the hydrogen sensors sensing elements based on MISFET with structure Pd(Ag)-Ta_2O_5-SiO_2-Si. The times' parameters of hydrogen responses have been researched at different concentrations of H_2.

Experimental and Results

MISFET hydrogen sensing elements has been fabricated by means of conventional n-MOS-technology on single silicon chip together with (*p*–*n*)-junction temperature sensor and heater-resistor. The integrated sensor's cell is showed in Fig.1. The gas chamber and computerized measuring system were used for experiments. The chip temperature 130^0C is supported by means of temperature-stabilization circuitry with feedback loop using on-chip thermo-sensor and heater.

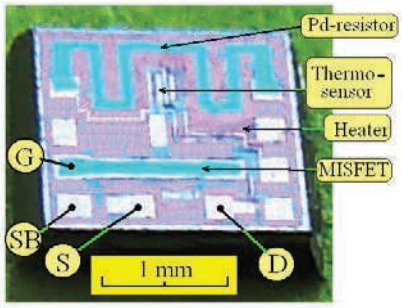

Fig. 1.The chip's photo: (S,G,D,SB are outputs of source, gate, drain, substrate respectively).

The parameters of typical hydrogen response are illustrated in Fig.2: an initial voltage V_0, amplitude of response ΔV_C, residual value of response δV_0, response τ_1 and relaxation τ_2 times). There were measured the responses of 5 MISFET samples for hydrogen concentrations (0.02; 0.05; 0.1; 0.2; 0.8) % vol. at different drain currents I_D (0.1; 0.5) mA and the const

source-drain voltage V_D = 0.2 V. The views of responses depend on hydrogen concentration and hydrogen exposition time τ (see examples in Fig.3). Generally, 8 time's stages of response can be considered (Fig. 4). The average values of responses' times parameters τ_1 and τ_2 are determined at $0.9\Delta V_C$ and presented in Table 1. To describe the results there was developed the general model of V vs. t (Fig. 5).

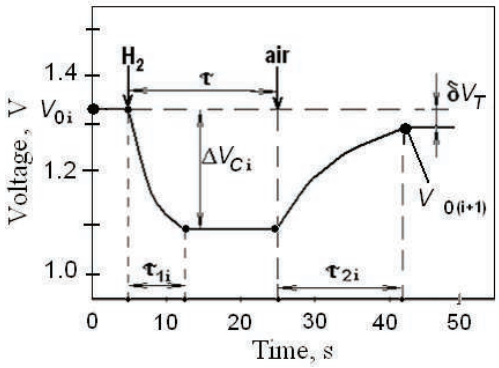

Fig.2.Parameters of typical response for hydrogen concentration 0.05 % vol.

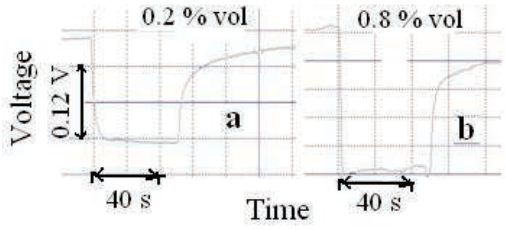

Fig.3. Examples of hydrogen responses.

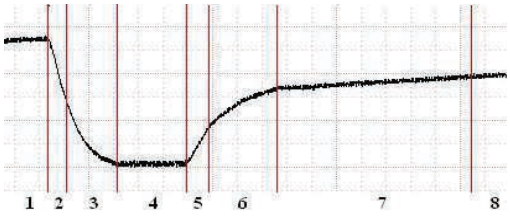

Fig.4. The time's stages of hydrogen responses.

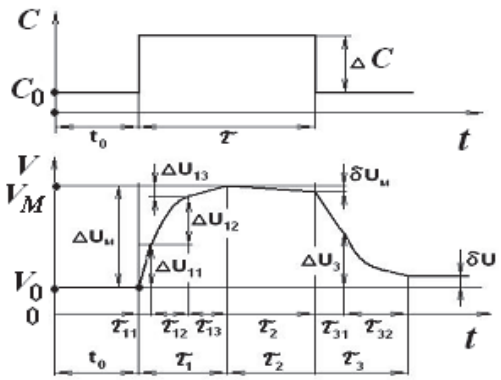

Fig.5. The general model of hydrogen responses.

The parameters of this model were calculated for different hydrogen concentrations using experimental data, and will be presented in paper.

Tab. 1: The average values of responses' times parameters (dispersion is less than 12 %)

C, % vol.	I_D = 0.1 mA		I_D = 0.5 mA	
	τ_1, s	τ_2, s	τ_1, s	τ_2, s
0.02	13	25	10	30
0.05	10	15	10	30
0.1	8	12	6	35
0.2	7	10	6	35
0.8	7	10	6	35

Conclusions

Responses' times parameters depend on hydrogen concentrations and the circuit's electric modes just a little. If hydrogen concentration increases, that responses' times τ_1 and τ_2 decrease. Responses' time τ_1 decreases and time τ_2 increases, if drain currents I_D is rising. Developed model can be used to forecast the performance characteristics of gas-analytic devices and hydrogen sensors based on MISFETs.

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