

Abstract

It has been recently shown that resistive switching (RS) can be utilized in a Pt/TiO₂/Pt hydrogen gas sensor with a capacitor-like arrangement to create a device called “gasistor”. Such devices can register a drop of the hydrogen gas concentration in the surrounding atmosphere under a pre-set threshold value and store this information as a change of the resistance state of the device. However, the sensitivity of the sensor to low ($< \sim 1000$ ppm) H₂ concentrations is limited due to its very high baseline resistance ($> 10^{11} \Omega$, above the measurement limit of most measurement setups). At the same time, it has been shown that after the electroforming process, the “gasistor” device is sensitive to the H₂ gas only if the resistance of the sensory part is comparable to (or lower than) the resistance of the resistive-switching cell in the high-resistance state (typically $< 10^7 \Omega$).

The focus of this work is to examine the two parts of the gasistor (the sensor and the memristor) and to demonstrate the possibilities of enhancing it in terms of stability and sensitivity. This was achieved by implementing large-scale nanoporous top Pt electrodes, which preserve the advantages of the previously used very narrow ($< \sim 200$ nm) top Pt electrodes, but at the same time allow to significantly decrease the baseline resistance of the device. The decrease of the baseline resistance also leads to decrease of the sensing limit. The nanoporous top Pt electrodes were prepared by depositing PtO_x layer by reactive magnetron sputtering and subsequent annealing. To fine-tune the fabrication method, PtO_x layers of different thicknesses and annealed at several temperatures ranging from 645 to 690 °C were analyzed by atomic force microscopy and subjected to gas sensing measurements. We also investigated the possibility of preparing analogous devices with separate gas sensor and memristor cells, which would allow for more flexibility in optimization and interconnection.

In the first part of the thesis, fundamental properties of titanium dioxide as a hydrogen sensing material and a medium for resistive switching are summed up. Subsequently, the gas sensing mechanisms of metal-oxide semiconductor gas sensors, resistive switching phenomena and basic functionality of memristors are described. Finally, the working principle of the device utilizing both above-mentioned phenomena - the gasistor is explained. In the second part, experimental methods used for the fabrication and analysis of prepared samples are outlined. The last part of the thesis is devoted to the presentation of results, which are discussed and summarized.

Keywords: nanoporous electrode, hydrogen gas sensor, memristor, gasistor.