

Investigation of Pd content in C–Pd films for hydrogen sensor applications

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Abstract Nanocomposite carbonaceous-palladium (Nc-C-Pd) films were synthesized by physical vapor deposition method (PVD). Scanning electron microscopy studies showed that they were composed of carbonaceous matrix containing Pd nanograins. Nc-C-Pd films were also characterized by thermogravimetric analysis, X-ray powder diffraction, and Fourier transform infrared (FTIR) spectral analysis. The content of Pd in films synthesized at different PVD conditions was determined based on TG measurements. Technological parameters of PVD process affected C/Pd ratio. FTIR spectra exhibited characteristic absorption bands for the precursors of carbonaceous-palladium samples (fullerene C₆₀ and palladium acetate). The influence of hydrogen on electrical properties of the films was tested by measuring their resistance in the presence of hydrogen (1% H₂/N₂).

Keywords Carbonaceous-palladium films · Physical vapor deposition · Thermogravimetric analysis

Introduction

In the near future, hydrogen as an energy carrier could replace fossil fuels. In contrast to traditional fuels hydrogen burns to water and does not pollute the environment. Enormous financial resources in the European Union have been allocated to the specialized Programs associated with hydrogen technology (CUTE, HYPOGEN, HYCOM) [1–3].

Recently, hydrogen has been used in many industry branches connected with, e.g., hydrogenation process,

chemical compounds production (NH₃, HCl, CH₃COOH), cryogenic cooling, metallurgy, and welding process and also in rocket engines [4]. Thus, continuous monitoring of the atmosphere composition near the hydrogen emission sources is necessary to preserve the industrial safety and protect human life. Sensors for monitoring and detection of dangerous gases could eliminate risk of explosion. These devices should be characterized by high sensitivity, fast response, and short regeneration time. Moreover, they should be cheap and simple in operation.

Currently available H₂ sensors have a response time of several seconds at 2% hydrogen content in atmosphere and have limitations and drawbacks depending on their constructions (e.g., semiconductor sensors show lack of selectivity, dependence of selectivity and sensitivity on temperature, and sensitivity change with the time) [5, 6]. Therefore, there is a need to develop a new kind of detectors that could measure the content of hydrogen and hydrogen compounds together.

An important factor for the detection sensitivity is well-developed surface area of active layers because it decides on the rate of a gas adsorption/desorption process. On the other hand, in case of hydrogen sensors, palladium is often applied as a component of the active layers because of its strongly reactivity toward hydrogen [7–9]. It is known that Pd creates palladium hydride PdH_x as a result of H₂ adsorption and next its absorption [10, 11]. The small activation barrier of the surface adsorption and the exothermal reaction of the inner absorption for palladium are together responsible for the palladium hydride formation. Some properties of PdH_x are different than pure Pd (e.g., conductance) [12] what allows to register the hydrogen presence in environment. It is worth noticing that Pd content as well as Pd nanograins size affects the sensitivity of sensor's active layers.

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