New generation of hydrogen sensors

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Hydrogen sensors are important for many industrial areas (e.g. production of chemical compounds, automotive transport, new energy sources) to detect or to measure concentration of the gas in real conditions. Typical requirements of these sensors are as follows: high sensitivity, fast response, high selectivity, long life-time, operational safety, and low power consumption. It is well known, that typical hydrogen sensors usually use expensive, pure palladium. Therefore, researches still looking for novel materials with adequate properties.

Nanostructured materials are very promising for a gas sensing because they have developed adsorption surface, low density and weight. We have found that carbon – palladium nanostructures are good materials in hydrogen sensor application. These materials are in a form of film composed of carbon matrix (with an amorphous or graphite-like form) and nanograins of palladium placed within this matrix [2]. Such film is resisted on corrosion and exhibits high mechanical strength and thermal resistance and low density due to the presence of different size pores.

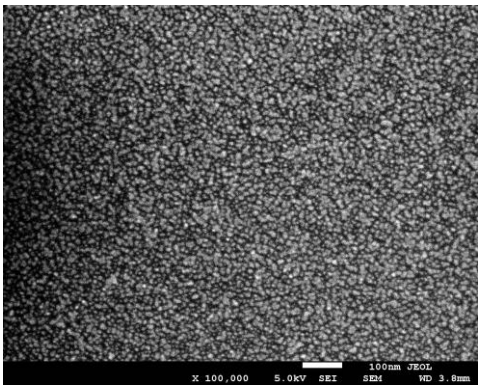

Fig.1 SEM image of C-Pd film composed of carbon matrix with embedded Pd nanograins (bright objects).

Carbonaceous films containing Pd nanograins can be applied as active layers in proposed gas sensor applications [3]. In Fig. 1 SEM image of C-Pd film prepared by PVD method and used as active layer C-Pd is shown.
Our film could be prepared by two methods: (1) physical (PVD) and (2) two steps physical/chemical deposition methods (PVD/CVD). Details of technological processes are described in [4]. First type of film prepared by physical vapor deposition (PVD) process could be composed of fullerite, amorphous carbon and/or nanographite grains with palladium nano-grains. In the second method PVD films are modified with CVD process. Due to CVD modification nanoporous carbon matrix could be form as well as Pd grains with size of few tens to few hundred nm. Both types of films were studied by SEM, TEM, TGA, Raman and FTIR Spectroscopy and electrical characterization (measurement of resistivity versus composition of gaseous

hydrocarbons mixture) [5-8]. Typical PVD film response for hydrogen introduction into atmosphere is presented in Fig.2.

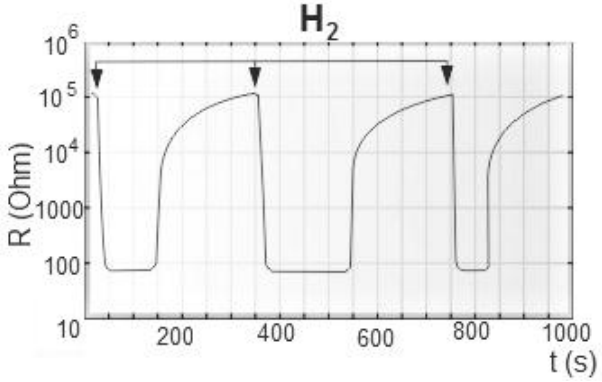

Fig.2. Resistivity changes of PVD film due to introduction of hydrogen to atmosphere

New generation of hydrogen sensor was elaborated in project deteH [8]. This project is implemented by the scientific and industrial consortium and is concentrated on the following tasks:

- developing active layer technology of sensor
- preparation of suitable substrates for the deposition of the active layer
- development of technology for applying electrodes on the sensor active layer
- development of electronic control system for sensor signal acquisition and measurement temperature compensation resistance layer instability.

Proposed by us new generation of H_2 detector has high sensitivity, fast response and recovery based upon the unique properties of nanostructured C-Pd layers.

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References

1.) M. Kozłowski, R. Diduszko,K. Olszewska, H.Wronka, E. Czerwosz, Vacuum 82, 956 (2008).
2.) E. Czerwosz, E. Kowalska, H. Wronka, J. Radomska, Patent Notification 2008 nr P384 591
3.) E. Czerwosz, R. Diduszko, P.Dłużewski P, J.Keczkowska, M.Suchańska, Vacuum ;82:372 (2008)
4.) E. Czerwosz, P. Dłużewski, J. Kęczkowska., M. Kozłowski, M. Suchańska, H. Wronka, Materials Science-Poland 26, 119 (2008)
5.) E. Czerwosz, M. Kozłowski, P. Dłużewski, J.Kęczkowska, M. Suchańska, In **Nanostructured Materials for Advanced Technological Applications**, Springer Science + Business Media B.V. 2009 227-230 2009
6.) E. Czerwosz, E. Kowalska, R. Belka, J.Kęczkowska, M. Suchańska, H. Wronka, J. Radomska, M.Płaza, U. Schmidt, Proceedings of SPIE 7502, 750223-1 (2009)
7.) R.Belka, M.Suchańska, E.Czerwosz, A. Chiasera, M.Ferrari , Procedding of SPIE, 8070, 807019-1 (2011)
8.) www.deteh.eu