SENSOR SYSTEMS BASED ON NANOCARBON MATERIALS

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Introduction

Nanocarbon materials are promising supports for Pt metals based electrocatalysts used in the development of electrode materials for ammetric sensors, fuel cells, and supercapacitors.

The task to be solved in this work is the study of hydrogen activation on Pd and Pt catalysts immobilized on the surface of oriented moieties of multi-walled carbon nanotubes (MWNT).

Results and Discussion

We suggested to use carbon nanomaterials (CNM) prepared by pyrolysis of hydrocarbons in the presence of a Fe-containing catalyst applied to a TiN/Ti support. The study of electrodes by scanning electron microscopy (SEM) showed it to be covered by densely packed vertically oriented MWNT of 0.1-0.2 μm diameter (Fig.1). Additionally, a layer of chaotically arranged nanofibers forms on the electrode surface.

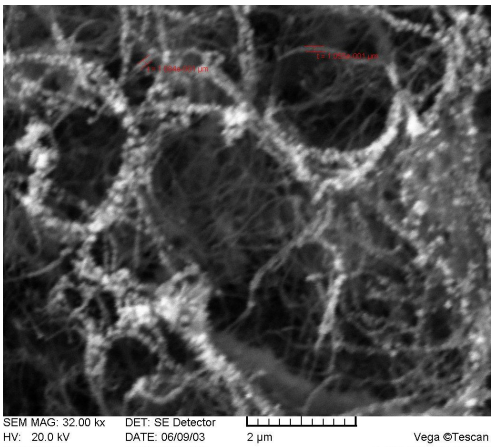

Fig.1. A transverse chip of the sample. From the bottom there are TiN and MWNT moiety layers above which there is a thin layer composed of nanofibers.

The electrode was impregnated with $PdCl_2$ dissolved in 1M H_2SO_4, washed and reduced by hydrogen. According to the SEM data, Pd is attached mainly to nanofibers (Fig.2). Catalytic activity in hydrogen sensors was tested in a cell with solid electrolytes: (i) H_3PO_4- polyvinyl alcohol [1] and (ii) fluorine- conducting electrolyte [2]. Experimental results were compared with the data for electrodes based on palladinized polyaniline (PAn) [1] (Fig.3).

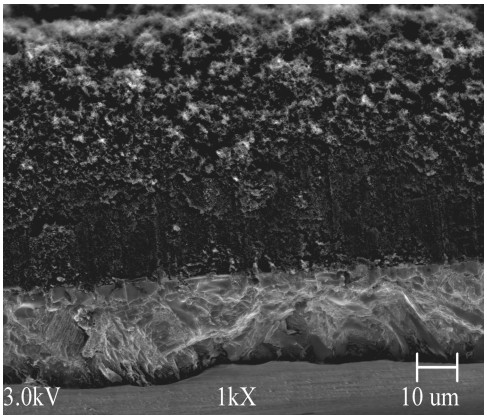

Fig.2. The view of the sample from the above. Amorphous Pd clusters cover the nanofibers surface.

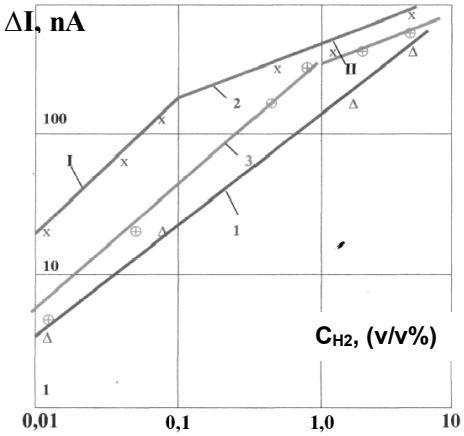

Fig.3. Hydrogen sensor with fluorine-conducting $Pb–Sn/Pb_{0,9}$ $Al_{0,05}$ $Ti_{0,05}$ $F_{2,1}$ electrolyte/indicator electrode:
1 (Δ) – Pd – MWNT, air+ H_2;
2 (x) – Pd –MWNT, N_2 + H_2;
3 (⊕) – Pd – PAn, N_2 + H_2

The electrodes show a linear equilibrium dependency of current on hydrogen concentration. It should be noted that the performance of Pd – MWNT systems is an order of magnitude higher than that of a Pd – PAn system. This difference seems to be reasonable since Pd clusters are immobilized in the latter system in a polymer matrix that results in diffusion limitation. In a Pd –MWNT system catalytic centers are more accessible.

The bends of the curve at 0.1% of H_2 in nitrogen seem to be due to Pd saturation by hydrogen, while for the mixture with air a linear portion of the curve is up to 1% as a result of partial oxidation of hydrogen by oxygen.

Conclusion

1. New sensor systems based on Pd clusters immobilized on carbon nanofiber surface have been developed. Carbon nanofibers form a felt-like network, which covers densely packed oriented MWNT moieties.
2. A hydrogen sensor structure has been suggested, which involves solid electrolyte with fluorine ion conductivity. A current-forming reaction is hydrogen fluorination. Sensitivity of such a sensor weakly depends on humidity that is of principle importance for measurements used in cryogenic engineering.

The work was supported by RFBR (N03-03-32692).

References

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