MULTIFUNCTIONAL INTEGRATED FC ELECTRODE ON MACROPOROUS SILICON. DESIGN & TECHNOLOGY

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Introduction

Fuel cells (FC) on a basis of protonconducting membrane (polymer electrolyte membrane fuel cell - (PEMFC) possess a number of advantages to which it is necessary to attribute high power density and relative low rate power density to weight. Distinctive feature of fuel cells in comparison with traditional batteries is division into the energy transforms device (electrodes, catalysts, a membrane and other) and the device keeping or reserving energy (as a rule, capacity with hydrogenous fuel). This circumstance allows placing FC directly on the consuming electric power device. Connection to the device of a source with hydrogen fuel allows the user to receive necessary power supplies, without what or additional procedures Alongside with a number of other advantages polymer electrolyte membrane fuel cell are promising highly effective sources of power supplies as for the household and mobile equipment of wide application, and the equipment of special purpose. Nevertheless, till now it is not observed wide commercial application FC. The main reason is rather high cost of manufacture FC. Up to 60 % of cost thus, makes cost of usually used bipolar plate payments (electrodes) representing the graphite bases, in which channels for a supply of fuel - « an anodic electrode » and removal of products of reaction - a "cathodic" electrode (fig.1, a position 4) are generated [1].

One of perspective ways of depreciation FC is search of new materials, and also development of new technologies for creation of highly effective electrodes. In work the constructive - technological variant of FC electrodes created on technologies of silicon integrated circuits and macroporous silicon is considered. Such approach will allow creating both super tiny power supplies, and devices with the raised level of capacity.
The first is connected to opportunities modern nanotechnology, and the second with practically full exception of process of FC creation of the clamping contacts being one the main obstacles for maintenance of necessary reliability of such devices.

Results and discussion

In figure 1 the circuit of functional units traditional oxygen-hydrogen FC with « clamping contacts » is shown. Symmetrically on both sides of the polymer electrolyte membrane (PEM) (a position 1) the units included in anode and cathode electrodes are represented (positions 2-5, for simplicity units are numbered only on the one hand).

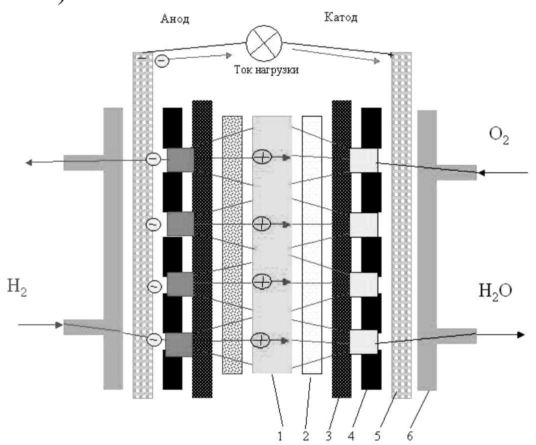

Fig. 1. The traditional scheme of PEMFC

On both sides of the PEM the supports also are located (a position 6). As the catalyst for electrochemical reactions to hydrogen and oxygen electrodes platinum serves (a position 2). Good results have been received at use as the carrier of "oven soot" Vulcan XC-72, [2]. The platinum contents in platinized soot changes approximately at a level 40. %. The area of a surface on this carrier reaches up to 100 m^2/g while for disperse platinum without the carrier it is usual no more than 15 m^2/g. Gas diffusion layer (a position 3) consist of a porous hydrophobic carbon layer and formed a catalyst active layer. Diffusion layer formed by carbon particles (soot) and polytetrafluoroethylene approximately 35wt% loaded on the carbon cloth. Porosity of diffusion layer consist approximately 60%. High porosity is especially important at use as an oxidizer of oxygen from air. Bipolar plates (a position 4) represent graphite plates with mechanically made channels for supply of fuel and oxidizer, and also removal of reaction products (water).

Volume resistance of a graphite plate is about 17 mOm cm [1], therefore from an underside is formed metal contact (a position 5). However the most important is minimization of electric contact of a bipolar plate with gas diffusion layer. It is achieved with the help of clamping contact, which is created, as a rule, with the help of connection by bolts. Thus contact resistance 30 mOm cm^2 is reached at pressure of compression not less than 120 N/ cm^2 [1].

In the present work structurally technological variant of a solid-state fuel cell element completely excluding clamping contacts (fig. 2) is offered. The technological scheme of manufacturing of " silicon workpiece " such element is in detail considered in [3]. It represents a combination of methods of modern planar technology and methods of structurization developed by the author to the help of macroporous silicon. The design of a cell of a FC provides presence of all functional elements represented on fig. 1. These elements are spatially allocated in volume silicon structures (fig. 2). Besides on a surface at the bottom of the gas diffusion channel 4 the Pd film is located. It allows applying as fuel not only pure hydrogen, but also hydrogen containing mixes.

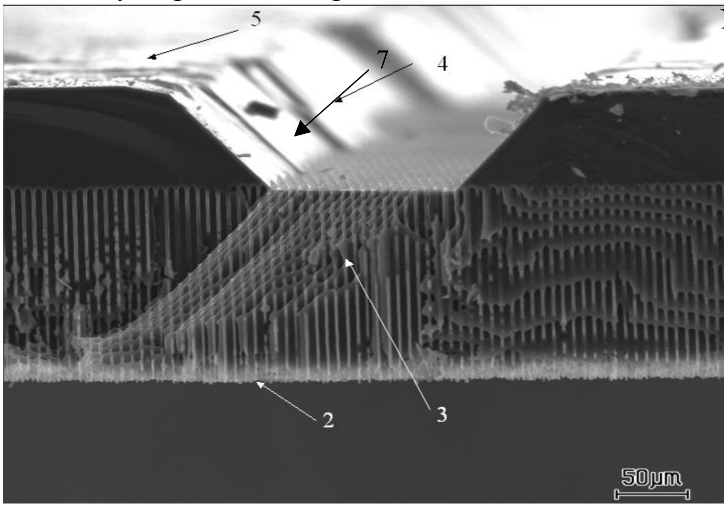

Fig. 2. Cross-section view of integrated FC electrode on the basis of monocrystal macroporous silicon.

As a base of protonconducting membrane polyvinyl alcohol (PVS) and phenolsulfonic acid (PSA) was synthesized [4]. Membrane is rendered on a surface of a catalytic layer and dries up at room temperature.

As shown in [4], at ratio PVS:PSA=4:1 the membrane surpasses widely used in PEMFC membranes on the "Nafion" basis. Besides experimental data testify that the solution can successfully be used as a connecting element for pasting the anode and the cathode at FC assembly.

References

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