Description for the general public

The aim of the project is to examine the influence of structural properties of composite materials in form of three-dimensional structures of carbon with a high degree of graphitization and the catalyst layer of Pt and Pt – Ru obtained on its surface by pulsed laser deposition (PLD), on their electrochemical properties.

In proposed composites the three-dimensional graphene encapsulates with MgO core will play the role of the carbon support for the catalyst layers. Carbon support enables both better dispersion of the catalytically active nanoparticles, as well as provides better electrical contact and affects the electrochemical and chemical stability of the catalytic material. The high dispersion of catalytically active nanoparticles significantly increases the utilization factor of the catalyst designated as electrode reactions rate based on the amount of catalyst used and can reduce the quantity of noble metal used. However, due to the carbon support long-term operation at high temperature, moisture, low pH, high concentration of oxygen, the presence of a metallic catalyst and a high potential, a carbon support undergoes degradation (corrosion). Degradation of the support weakens attachment to it's the surface of catalyst particles, leading to their disconnection, migration and agglomeration. A direct consequence of these processes is reduction of the electrochemically active surface and decrease of electrode reactions performance. Recent research in the field of fuel cells demonstrate the superiority of carbon materials with a high degree of graphitization over the supports with a large proportion of amorphous carbon. Attractiveness of materials with a high degree of graphitization mainly results from their excellent electrical and mechanical properties and specific interaction with the catalyst. These materials also have several times greater corrosion resistance in relation to amorphous carbon. In the group of intensively studied materials are primarily single-walled and multi-walled carbon nanotubes and two-dimensional graphene nanostructures. We expect that received by us three-dimensional graphene encapsulants may have the advantages of the above-mentioned structures and at the same time a low production cost. The application of the proposed material as a carbon support can contribute to solve the following problems occurring when reducing the amount of catalytic material used:

- large decrease in electrode reactions speed versus time,
- degradation (corrosion) of the carbon support and migration of the catalyst,
- reduction the transport of reactants through the carbon support layer used in the performed membrane-electrode assembly (MEA),
- carbon monoxide poisoning of the catalyst.

The tested carbon support can be used in the construction of polymer electrolyte fuel cells (PEMFC). These PEMFC fuel cells are considered promising source of clean energy for a possible broad application to supply everyday devices. However, the cost of their production in relation to working time is still too high, which limits their use. It is estimated that in the case of standard fuel cell with polymer electrolyte, the cost of catalyst is about 50% of the fuel cells cost. To accelerate breakthroughs in PEMFCs great effort have been devoted by a number of research groups world-wide in order to decrease the Pt loading at a level of lower than 150 $\mu g\ cm^{-2}$.

Reduction the cost of PEMFC and prolongation of their work time can be achieved through the use of new cheaper materials or refining materials currently used.

Improving PEMFC structure is possible inter alia by the use of carbon support with a high degree of graphitization enhancing cell stability, reducing catalyst poisoning by carbon monoxide and ensuring greater use of catalyst. The results of the proposed research can contribute to the development of knowledge of new carbon materials for potential use as support for metal catalysts. In the future, this may lead to the improvement of the relation between cost and working time of cell and technological and industrial progress of fuel cells.

Justification of undertaken research problem is that there is still a discrepancy between current capabilities of fuel cell technology, and the needs of practical hydrogen energy, which would be competitive in relation to the present, based mainly on coal and crude. Cost of producing cells for commercial applications remains to high for such systems were in widespread use. We still need to take extensive research into more advanced materials and construction solutions that would contribute to the technological and industrial advancement of fuel cells. The described material in this field has a high potential by virtue of its spatial structure and high degree of the structure graphitization. Implementing the described research project we want to contribute to the development of new carbon supports bringing Polish achievements closer to the world results.