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Graphene Structures for Applications in Fuel Cells and Supercapacitors

Abstract
The proposed paper is synthesizing the results obtained in the implementation of the MULTISCALE Project (Scientific Research Activities on the Development of Advanced Materials by Integrating Nano-structured Materials and Multiscale and Multiphysics Optimization Dedicated to Advanced Energy Systems, ID P_40_279, code MySMIS 105531), by a research group from the Institute for Nanotechnologies and Alternative Energy Sources at "Ovidius" University of Constanta.

The aim of the research activities is to analyze the possibilities to develop robust solutions of advanced materials for energy systems based on the integration of nanostructures and appropriate multiscale and multiphysics optimization [1].

The graphene flakes there were obtained by aqueous arc discharge process. The selected graphene production process has the following features: (1) Low energy power consumption process to exfoliate graphene from graphite rather than to evaporate carbon molecules. (2) Water used as a dielectric medium uses a coolant to maintain the temperature during the process. (3) Controllable graphene layers and the number of oxygen-related functional groups. (4) A seamless process for morphological transition of graphene from 2D to three-dimensional (3D) construction [2].

Figure 1: Testing facility for the electrochemical performances of the obtained samples.

There were carried out several tests with various compositions of electrodes and solutions. The synthesized carbon materials have been investigated using electronic microscopy and spectrometric analyses. The results

were evaluated in respect to the composition of the electrodes, solution composition and the arc discharge parameters that have been used in the experiments.

Using the testing facilities presented in figure 1, selected samples of graphene flakes have been tested for the possibility of being used as catalyst supports in electrochemical applications and porous electrodes for supercapacitors.

The fuel cells are complex systems with an elaborated architecture as system of systems, emerging behavior in the sense that lower hierarchy structures are determining the behavior at higher hierarchies and in some cases might be considered as adaptive by adjusting the response function according to the values of some output parameters. The complexity is also at the level of coupled processes as electrochemical reactions, mass, heat and charge transport phenomena, irreversible physical and chemical degradation processes and control and automation processes.

Supercapacitors, also called supercapacitors, store electro- chemical energy by accumulating the charge from electric double layer, which is caused by electrostatic attraction. The capacity of supercapacitor is proportional to the electrode surface, i.e., the electrochemically active surface.

There were prepared catalyst layers that have been integrated in Membrane Electrode Assemblies – MEAs and layers for porous nanostructured carbon materials that have been tested for their performances.

In the presentation there will be included results obtained on the testing of sample MEAs and porous films.

References

[1] E. Mamut, at all, *Graphene Structures Engineered for Selective Absorption/Desorption and Permeability Applications*, 7th European Conference in Graphene and 2D Materials GRAPHENE 2017, Barcelona Spain.

[2] S. Kim, *Novel Graphene Production: An Aqueous Arc Discharge Process*, 2015, PhD Thesis, University of California, San Diego, USA