PLASMA MODIFICATION OF NANODIAMOND PARTICLES

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[ENGINEERING OF BIOMATERIALS 138 (2016) 123]

Introduction

This paper concerns the modification of diamond powders (DPP – *diamond powders particles*) in order to achieve the specific physical and chemical properties that would be beneficial for various applications in biomedical engineering. That was the reason why the innovative MW PACVD rotary reactor chamber (MW PACVD – *Microwave Plasma Activated Chemical Vapour Deposition*) was designed and constructed. The material modified in the reactor chamber was tested for potential applications.

Materials and Methods

Currently, there is a great interest in the development of the diamond powder particles (DPP) modification methods, thanks to which they gain new properties [1]. Diamond powders are modified by chemical, mechanical and plasma methods [1,2]. The MW PACVD is one of the methods used for the modification of the DPP. The technology of modifying the DPP by the MW PACVD method, by the use of the rotary reactor chamber, may be much more advantageous in comparison to commonly used methods that use the static reactors. It allows to carry out the modification process in a continuous and cyclic way (through the repeated rotation of the reactor chamber) at the level not reachable for the classical methods. At the same time, it will lower the costs, increase the efficiency and allow for the control of the level of DPP modification.

This paper concerns the basic research that were carried out in the field of the material engineering, more specifically in the technologies of plasma modifications of diamond powders. During the implementation was carried a careful analysis of the physical and chemical processes that occur during the process of DPP modification (first of all, the influence of the rotation of the reactor chamber on the level of the DPP modification). The research carried out are mainly design realizations and experimental studies. These are the original research works conducted in the field of obtaining and modification of the DPP, which make an invaluable contribution to the development of this discipline and, in particular, to the development of plasma methods.

Results and Discussion

The initial concept involved the use of the vacuum chamber (FIG. 1.) equipped with a quartz window (1), the inlet of the reactive gases (6), and the vacuum pump connector. The chamber was supposed to be water cooled and was to be equipped with the system of elements allowing the free rotation of the inner drum (3) e.g. with the use of the stepper motor (7). The basis of the construction would be the typical ECR chamber (electro cyclone), due to that in the construction were predicted such elements as: electromagnets (2) – introducing the excited plasma creative gases (plasma) in the spiral movement directed towards the narrowing of the chamber and the nozzle of reactive gases (6). The quartz window was to be equipped in the main axis of rotation. During the rotation of the drum, the material subjected to the modification is to be located, repeatedly and cyclically, in the area of microwave plasma. The chamber, in contrast to the presented drawing, will have the horizontal orientation.

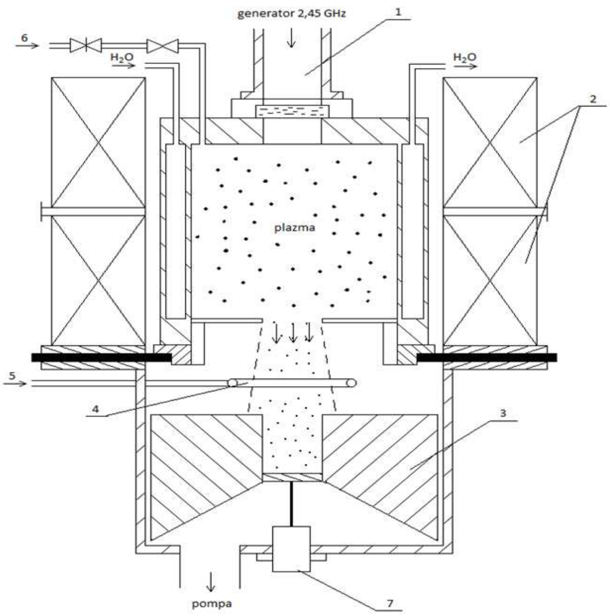

FIG. 1. The concept of MW reactor chamber.

Biological test was carried out by in vivo method on cells of the human blond haemoglobin for all three types of nanodiamond. The images of the optical microscope indicate the following:

• The result of contact of human haemoglobin with not modified nanodiamond powder, in ten minutes is the occurrence of the schistocytosis (decomposition) of erythrocytes.

• The result of contact of human haemoglobin with modified nanodiamond powder, in ten minutes' time no changes are observed.

The analysis of diamond nanopowders using Raman spectroscopy show unnoticeable differences within the analyzed spectrum. It signifies that despite the modification by the MW PACVD + R method, the structure of nanodiamond was fully preserved (no increase in the content of σsp^2 diamond phase providing for overlapping potential partial graphitization of the substrate).

The analysis of diamond nanopowders using FTIR method show small differences in the peaks located on the wavenumber 1419 cm^{-1}, 1636 cm^{-1} and 3424 cm^{-1}, which cause spectacular differences in the biological properties of the modified diamond nanopowders.

Despite the unnoticeable differences in the results of the Raman and small differences characterizing diamond nanopowders by FTIR method, in the biological tests carried out by in vivo method on the human haemoglobin, the results are evident and clearly indicate high biocompatibility of the modified carbon material.

Conclusions

The new knowledge, about the impact of the innovative design of the MW PACVD reactor chamber on the plasma processes occurring in its inside, was acquired during the subsequent experiments with its use.

Acknowledgments

The project is financially supported by the National Science Centre No. UMO-2011 /03/N/ST8/06184.

References

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