ABSTRACT

Microporous Boron-Doped Diamond Architectures for Advanced Electrochemical Devices

R. Bogdanowicz

1Faculty of Electronics, Telecommunications and Informatics, Gdansk University of Technology, 11/12 G. Narutowicza Str, Gdansk, 80-233 Poland

This work discusses recent advances in the development of novel electrode materials for electrochemical devices. While gold and other noble metals are commonly used as electrode materials, microporous boron-doped diamond architectures and high surface area carbon nanowalls (B:CNW) have emerged as promising alternatives. These diamond-rich surfaces are grown by microwave plasma-assisted chemical vapor deposition (CVD). One approach to creating these novel carbon nanoarchitectures involves growing boron-doped vertically aligned graphene walls (BCNWs) on a boron-doped diamond (BDD) interfacial layer. This approach results in a maze-like morphology and a concurrence of different carbon hybridisations, leading to a higher current exchange density. Another approach involves producing a tangled fibrous polyacrylonitrile-based hierarchically-structured nanocomposite by wet-spinning, carbonizing, and decorating it with a carbon nanoarchitecture using microwave plasma-enhanced CVD. The synergistic action between surface etching and nanostructure formation significantly affects the porosity and electrochemical performance of the hierarchical fiber architecture. The incorporation of boron enhances the electrical and electrochemical properties of electrodes, and also influences their structure, changing them from maze-like to a heterogeneous distribution of nearly straight walls. These materials can be nanostructured to achieve microelectrodes with outstanding electrochemical properties such as high standard rate constant, low peak-to-peak separation value, and low surface resistivity. The work also discusses the applicability of BDD/B:CNW anodes for degrading organic pollutants. Persulfate was efficiently produced at the BDD electrode, while the ion-radical sulphate was the most important oxidant at the BDD/B:CNW anode. Additionally, laser-induced graphene (LIG)-boron doped diamond nanowall (BDNW) hybrid nanostructures have been developed for microsupercapacitors [1] with outstanding electrical characteristics and cyclic stability. Finally, diamondized titania nanocomposite supercapacitors deliver high power and

energy densities along with high capacitance retention rates, making them a promising alternative to current supercapacitors [2]. In conclusion, the development of novel electrode materials such as microporous boron-doped diamond architectures and high surface area carbon nanowalls have the potential to revolutionize fields such as energy storage and microelectronics, with outstanding electrochemical properties and applicability for degrading organic pollutants.

[1]. Bogdanowicz, R., Dettlaff, A., Skiba, F., Trzcinski, K., Szkoda, M., Sobaszek, M., Ficek, M., Dec, B., Macewicz, L., Wyrębski, K. and Pasciak, G., 2020. Enhanced charge storage mechanism and long-term cycling stability in diamondized titania nanocomposite supercapacitors operating in aqueous electrolytes. The Journal of Physical Chemistry C, 124(29), pp.15698-15712.
[2]. Deshmukh, S., Jakobczyk, P., Ficek, M., Ryl, J., Geng, D. and Bogdanowicz, R., 2022. Tuning the Laser-Induced Processing of 3D Porous Graphenic Nanostructures by Boron-Doped Diamond Particles for Flexible Microsupercapacitors. Advanced Functional Materials, 32(36), p.2206097.