The proper functioning of the nervous system depends on many factors, both external ones and the changes based on genetics or related to the aging of the body. Some of the changes within the central nervous system (CNS) may occur as a result of neurodegenerative diseases. It is a group of congenital or acquired progressive diseases of the nervous system, in which the main pathological phenomenon is the loss of nerve cells. The most well-known neurodegenerative diseases include Alzheimer's disease, Parkinson's disease, amyotrophic lateral sclerosis (ALS) or multiple sclerosis. Many of these diseases develop for many years in an asymptomatic way and the effects become apparent only when a significant part of the nerve cells are damaged. To deal with these diseases, the most common is pharmacological treatment which is not always effective. In some cases especially the long-term treatment may have side effects, such as deepening of a given disease entity. One of the neurodegenerative diseases that affects several million people in the world is Parkinson's disease. In the treatment of this disease, pharmacological substances such as levodopa are most commonly used. However, a much more effective method of deep brain stimulation is the implantation of electrodes in a specific area of the brain. Deep brain stimulation (DBS) electrodes are also used for other conditions such as spontaneous tremor, dystonia or chronic pain. Materials for the production of electrodes are usually metals that, despite a number of advantages, have some significant drawbacks making the process of stimulation of certain areas of the brain ineffective. The disadvantages of the existing DBS electrodes include high stiffness which destroys delicate tissue structures, relatively large dimensions, lack of feedback concerning monitoring the electrical activity of the brain, high demand for electric current and possible bleeding in the brain. A significant problem in the case of electrodes for DBS is also a high probability of glial scar formation around the electrodes, which causes an increase in electrical resistance between the electrode and nerve tissue. This in turn results in the need for higher voltage and currents for nerve stimulation.

Given the above considerations, the aim of the project will be to develop a new material whose properties will meet the requirements set by the nervous system for electrode materials for CNS stimulation. The material proposed in the project is a carbon hybrid composite composed of carbon microfibers, pyrolytic carbon and carbon nanotubes. Thanks to the appropriate selection of carbon components, it will be possible to obtain a cylindrical composite material measuring from a few μm to a few millimeters in diameter. At the same time it will be endowed with a high surface to volume ratio to ensure a minimum electrode volume at which the electrical properties will be met. The electrode material must be characterized by high electrical conductivity, be biocompatible and at the same time durable in the biological environment. These materials do not corrode and are characterized by high biocompatibility. It is also possible to control the mechanical properties, and - in particular - the rigidity of these materials by selecting the appropriate carbon microfibers. In turn, the presence of carbon nanomaterials can effectively modify the surfaces of such materials, increasing their surface development important for the transport of electric charge. Also, the morphology of these nanostructures may improve the biomimetic character of the obtained systems. Similarity to tissue structures, e.g. neuritis will allow interaction and stimulation at the level of individual cells. In addition, we assume that carbon nanotubes will create a kind of "soft" coating on the surface of the electrode, causing the reduction of mechanical destruction of nerve structures. Surface modification of carbon nanotubes also widens the possibility of introducing additional substances with a confirmed stimulating effect on the growth or differentiation of nerve tissue cells.

The knowledge gained by the manager of this project will be used as part of previously conducted long-term research related to obtaining carbonaceous materials, such as carbon fibers and carbon nanomaterials. It will also expand the knowledge and experience connected with the impact of various types of carbon materials and in particular carbon nanoforms on cellular response and tissue.

The scope of research of the implemented project will concern such issues as the selection of appropriate raw materials, i.e. carbon fibers, the type of carbon gas sources, the type of carbon nanotubes and the appropriate conditions for the synthesis of carbon-carbon (C/C) composites by chemical vapor deposition (CVD). The conditions of CVD processes and electrophoretic deposition (EPD) of carbon nanomaterials on C/C composites in order to obtain carbon hybrid composites will also be optimized. The obtained samples will undergo structural, microstructural, physicochemical, electrical and mechanical tests. The assessment of electrochemical properties and biological evaluation will be important from the point of view of the application of the obtained samples. *In vitro* biological research will be carried out at the Institute of Pharmacology of the Polish Academy of Science using neurons and glial cells on a special system developed for the needs of the grant, allowing cells to be grown in contact with material subjected to simultaneous electrical stimulation. The research team will also include a neurosurgeon, deputy head of the Department of Neurosurgery from the T. Marciniak Lower Silesian Specialist Hospital – Center of Emergency Medicine in Wroclaw with extensive experience in the treatment of diseases of the central nervous system.