DESCRIPTION FOR THE GENERAL PUBLIC

(State the objective of the project, describe the research to be carried out, and present reasons for choosing the research topic - max. 1 standard type-written page)

The scope of the project is related with neuromorphic computing systems and the analysis of the basic phenomena which support their operations. The neuromorphic systems are a new class of computer systems whose architecture and operation mimic the human brain. Despite the advantages of traditional computer systems the human brain still has no match in solving such tasks as image or face recognition. At the same time it is incredibly efficient and operates using a fraction of the energy of the traditional computers. Nowadays developing information society is based on continuous analyses of increasing quantities of data and searching for the connection between them. For such application the neuromorphic systems seem to be a prominent solution. Currently, despite the fact that software neuron networks are gaining in popularity, there are no hardware solutions which can efficiently mimic the human brain. For operation of such architecture the key element are synapses – connections whose properties are adapted during learning processes. The recent investigations have shown that the promising systems for construction of efficient artificial synapses are metal oxide memristors. Memristors have the unique ability of learning and hold their electrical resistance state. It is then possible to use a memristor as an adjustable connection (synapse) between neurons. This should allow for analysis and learning from data processes. However, before this will be possible it is necessary to investigate which fundamental processes and phenomena are responsible for the synaptic properties of memristor. The research undertaken within this project will answer such questions and will be the basis for neuromorphic systems, where the single synapses will have nanometer dimensions. The aim of this project is to find the basic physical processes which allow for the formation of artificial synapses based on titanium dioxide – TiO_2. During the project such synapses will be generated with stimulated self-organization of material and their properties will be complementarily analyzed. The undertaken research will describe the fundamental processes which allow to obtain synapses with nanoscale dimensions and at the same time to preserve their ability to operate. The focus will be put on the fundamental processes responsible for such operations. The aims of the project will be achieved by a variety of experimental investigations supplemented by theoretical simulation. The synapses will be examined at the nanoscale with the use of local conductivity atomic force microscopy, scanning tunneling spectroscopy measurements and Kelvin probe force microscopy. Then nano-synapses will be stimulated (learning) and characterized by applying appropriate voltage pulses via conducting tip of atomic force microscopy. The modifications occurring in memristors will be assessed and analyzed in terms of correct synapses operations. It will be confirmed if nano-structures generated in TiO_2 possess all the properties necessary to act as a connection in neuromorphic systems. The important part of the project will be to describe the crystallographic and electronic structures of artificial synapses. This will allow for developing a model of synapses operation and in consequence allow to evaluate their maximal capability. In the wider perspective the research undertaken within the project will allow to design and build artificial synapses based on the knowledge of their functioning, and thus in an optimal way.