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Spike-timing-dependent plasticity of polyaniline-based memristive element

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Abstract

A phenomenological model of the polyaniline (PANI) based memristive element's conductivity evolution during the application of varying voltages is presented in this work. The model is based on the experimental data on the conductance versus time dependencies for a set of applied voltages. The model could be used for simulation of complex artificial neural networks (ANNs) based on PANI memristive elements. We have experimentally shown that organic PANI-based memristive element could be trained by the biologically inspired spike-timing-dependent plasticity mechanism. The results obtained by the simulation using the developed model are in a good agreement with the experimental data. It allows considering the usage of the organic memristive element as a synaptic element in a hardware realization of spiking ANNs capable of non-supervised learning.

Keywords: memristor; resistive switching; spike-timing-dependent plasticity; artificial neural networks; polyaniline

1. Introduction

In natural neural systems, neurons communicate with each other with action potential pulses – spikes [1]. In comparison with it, conventional (formal) ANNs have, at the most, biologically implausible principles of work, such as a stationary activation function, pure mathematical weight update algorithms, non-dynamical functioning (clock by clock and layer by layer). Moreover, the pulsed neural networks implemented in hardware have significantly reduced power consumption [2]. Therefore, the development of spiking neuromorphic hardware circuits, which explicitly mimic neural spikes, is of high interest. In the simplest spiking neuromorphic networks, each neuron is represented as a leaky-integrate-and-fire unit, which integrates