IGZO Synaptic Transistors using Ionic Gel-based Electric Double Layer Operation for Low voltage Driving

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Neuromorphic computing, which mimics the behavior of biological neurons and synapses is a method that dramatically solves the problem of the traditional von Neumann structure by performing information processing and data storage simultaneously. Transportation of neurotransmitter from pre-synaptic neurons to post-synaptic neurons induce excited post-synaptic potential, and this process of excitatory post-synaptic potential is the key factor in conducting memory function and data processing simultaneously. Here we propose a coplanar structure having an ionic gated electric double layer transistor (EDLT) with indium gallium zinc oxide (IGZO) for low voltage driving and its synaptic behavior based on modulated channel conductivity induced by an electric double layer (EDL) [1]. The EDL is formed at the interface between IGZO and ionic gel dielectric, and we confirmed that the operation voltage was below 1 V due to the formation of large capacitance (~2μF) [2]. We studied the physical phenomenon at the interface between the IGZO channel and the ionic gel where EDL was formed by the oxygen vacancy of the channel and the ion contents of the ionic gel. This interface is a crucial point for the synaptic behavior owing to the variations of conductance of the interface with the ion movements. The ionic gated EDLT achieves subthreshold swing of 0.1/dec, on/off ratio of 10^5, and 10^3 range of excitatory post-synaptic current (EPSC). We successfully demonstrated that the gate bias applied in the form of a pulse and source/drain bias linearly controls the conductance of the channel and shows potentiation, depression, and memory characteristics, revealing its potential to be industrialized in next-generation neuromorphic computing.

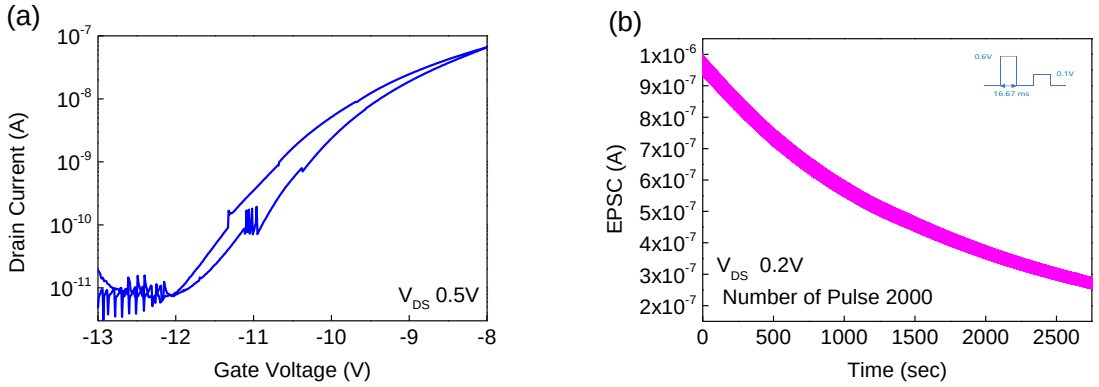

Figure 1. (a) I-V transfer characteristics of ionic gated EDLT, (b) Excitatory post-synaptic current as a function of time for an applied voltage pulse

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