Non-volatile redox memory for brain inspired computing

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The end to Moore's law is driving interest in developing novel memory and logic devices with dramatically improved energy efficiency. Electrochemical systems can improve efficiency and imbue novel functionality through ion-induced transformations that are inaccessible to traditional semiconductor devices. Here, I will discuss two electrochemical systems that are combined to execute neuromorphic computing: one based upon proton insertion/extraction and redox reaction in a polymer matrix for synaptic weight storage[1, 2], and a second based upon ion migration and diffusion for synapse addressability and retention[3]. The first device is a synaptic transistor based upon PEDOT:PSS (Fig. 1 green, blue, orange) that is programmed via protonation/de-protonation of the channel. Addressable programming of the polymer synapse is mediated by current injection through a Ag-based diffusive electrochemical-metallization cell (d-EMC) (Fig. 1, purple). Combined these systems comprise a non-volatile redox memory (NVRM) with unique advantages over other memory proposed for neuromorphic computing (i.e. phase change cells and filament forming metal oxides). For example, NVRM is capable of operating at voltages <500mV with currents <10nA. Due to low circuit parasitics and linear and symmetric programmability (Fig. 2), NVRM is capable of efficient online learning with fully-parallel inference and weight update operations. A path towards realizing a fully flexible and biocompatible neuromorphic array will be discussed.

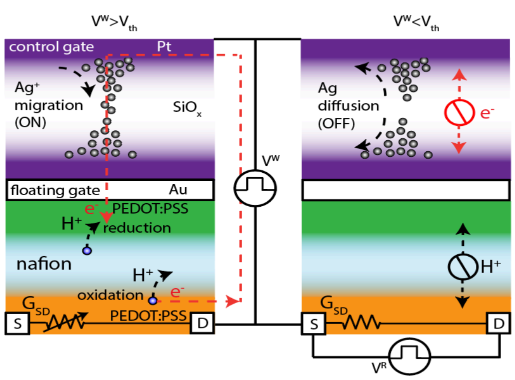

Fig. 1 NVRM consisting of an d-EMC and a polymer redox transistor.

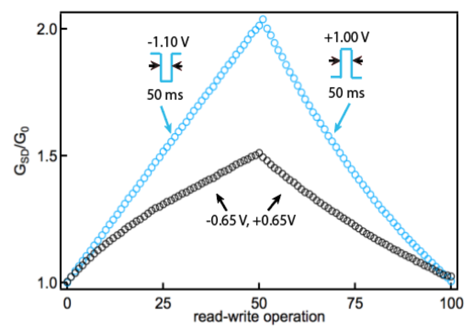

Fig. 2 Linear and symmetric programming of NVRM cell at 1V (blue) and 0.65V (black).

[1] E. J. Fuller, *et al*., Advanced Materials, 2017
[2] Y. van de Burgt, et al., Nature Materials, 2017
[3] Midya, et al., Advanced Materials, 2017

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