Fabrication, Characterization, and Modeling of an RRAM-Based Synapse for Neuromorphic Applications

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Neuromorphic computing requires the use of electronic circuits which work analogous to the human brain. Teaching machines to recognize patterns as effortlessly as humans do, can potentially make a large difference in our lives in areas such as disease diagnosis and cybersecurity. Resistive switching devices, or RRAM devices, are excellent candidates for use as electronic synapses in pattern recognition applications because of their low energies, small sizes, and their ability to have multiple resistance states. The purpose of this project was to fabricate a working resistive switching device, characterize it, mathematically model it, and finally simulate it in a neuromorphic application. A Pt/HfO_2/TiN resistive switching device was successfully fabricated and device characterization was completed using Transmission Electron Microscopy and Energy-Dispersive X-ray Spectroscopy to obtain morphological and compositional information. Electrical characterization results showed that the device was analog in nature and capable of neuromorphic behavior. Mathematical models were used to capture the device physics and determine fitting parameters based on experimental data. All modeling and simulation work was completed using MATLAB. To demonstrate pattern recognition, simulations were performed using handwritten digits from the MNIST database as well as the student researcher’s handwritten digits. Recognition accuracies as high as 93.5% were achieved in the testing phase, in which the number of output neurons was varied. The results of this novel proof of concept research indicate an impactful technology which can be used in crucial areas required to improve our everyday lives.

Awards Won:

Third Award of $1,000