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Title: Reliability and Operation for Vector Matrix Multiplication Neuromorphic Applications Using Ideal and Non-Ideal Conditions on 65nm HfOx ReRAM Devices

Abstract: Limitations related to the von Neumann bottleneck have resulted in a shift towards in-memory computing architectures including non-volatile memory (NVM) devices. Resistive Random-Access Memory (ReRAM) implemented with hafnium oxide (HfO2) is a strong candidate for such applications. The non-volatility of these devices and their amenability to compute in memory functionality makes them ideal for neuromorphic applications, deep learning, and mathematical accelerator circuits (e.g., Vector Matrix Multiplication - VMM). However, these devices suffer from stochastic switching variability that currently limits their usage and performance. To realize the full potential of these devices, performance and reliability analysis is required showcasing field of operation and device failure actuation given different operation parameters and environment. For my dissertation research, I will utilize reliability studies performed on 65 nm CMOS/ReRAM devices fabricated on a 300 mm wafer platform. To address the influence of switching compliance current, set/reset voltage, and pulse time on the variability of Low Resistance State (LRS) and High Resistance State (HRS), multiple parameters/conditions will be implemented, as well as the effect of temperature to mimic different use scenarios. The mechanisms of device drift, failure, and performance degradation under stress conditions will be studied to highlight operation vulnerability in array-based operations, such as for VMM related to image processing and recognition. Ongoing investigations are focused on ultra-short (<5ns) pulses to achieve more distinct resistance levels with lower variability and its effect on VMM Picture Similarity operations. VMM simulations will also be investigated to expand and compare to real device performance.