Computational Analysis of Complex Amorphization/Crystallization Dynamics in Large Phase Change Memory Devices

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Phase change memory devices become practical for non-volatile storage at small dimensions due to reduced power and predictable device operation. In larger scale cells, devices can be locally melted due to filament formation and liquid filaments can be retained in parts of the cell for a long time even if most or all of the cells are initially amorphized during long fall-times. The complex amorphization and crystallization dynamics make these large cells more unpredictable and enable their applications as physically unclonable functions (PUF) [1,2].

Computational analysis of the complex amorphization-crystallization dynamics in phase change memory devices with large geometries is important to understand the evolution of phase distributions and temperature profiles during programming of these devices. In this work, we conduct electrothermal finite element simulations of reset operation on a large $Ge_2Sb_2Te_5$ (GST) cell using the framework we have developed in COMSOL multiphysics [3]-[9] and analyze the complex dynamics of amorphization, nucleation and growth during electrical stress. We input voltage waveforms measured from electrical characterization of on-oxide GST line cells with bottom metal contact pads and Si_3N_4 capping. A 2D polycrystalline model of the experimentally measured cells (~360 nm wide, ~400 nm long and ~50 nm thick) is constructed in the simulations. Access devices are modeled using the spice models. The simulations capture some of the interplay between changes in the device resistance due to heating and phase changes and current fluctuations.

References:

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