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Nondiffusive thermal transport increases temperature rise in RRAM filaments KEITH REGNER, JONATHAN MALEN, Carnegie Mellon University — Resistive-switching memory (RRAM) offers benefits to nonvolatile memory systems due to scalability, fast switching, and easy fabrication. In RRAM, electrical stimulation switches the resistance of a metal-insulator-metal memory cell. A low-resistance state is achieved during the set process, when a conductive filament (CF) is formed by dielectric breakdown. During the reset process, disruption of the CF restores the device to a high-resistance state. Studies suggest that dissolution of the CF during the reset process occurs when the CF reaches a critical temperature due to Joule heating. Typically, the heat diffusion equation with bulk thermal properties is used to model the thermal processes both within the CF and the surrounding oxide. It is well known, however, that heat transport is nondiffusive when experimental length scales are comparable to energy carrier mean free paths (MFPs). We suggest that heat transport in RRAM is nondiffusive by determining the phonon MFP spectrum in TiO_2 (i.e., a promising material for RRAM) and showing that MFPs that contribute significantly to heat transport are comparable to the diameter of the CF. Thus, we approximate the CF as an infinitely long cylinder embedded in crystalline rutile TiO_2 and develop an approximate analytical solution to the BTE in the TiO_2. We find that the surface temperature of the CF predicted by the BTE is larger than that predicted by the heat diffusion equation. If the heat diffusion equation is used to model thermal transport in RRAM, a reduced effective TiO_2 thermal conductivity should be used.

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