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Avalanche Breakdown in Microscale VO_2 Structures

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In voltage-swept current-voltage (I-V) characterization of small scale VO_2 devices, an ostensibly electric field-induced metal-insulator transition (MIT) has indeed been widely reported.[1-3] The mechanism of triggering the metal-insulator transition (MIT) by an external electric field in small scale VO2 structures has been attributed to excess carrier injection, rather than Joule heating. This is in part due to the fact that the delay time for MIT to be induced by Joule heating seems much longer than what is observed.[4] However, modeling the resistivity as a function of temperature, explicitly considering phase coexistence of metallic and insulating states near the
MIT, and considering thermal dissipation in realistic structures, we demonstrate that Joule heating can exhibit a self-accelerating, avalanche-like behavior, in which the time scale for thermally-driven breakdown can be in the nanosecond regime. This model matches experimental results quite well. Over-threshold voltages, temperature, and size effects on switching delay time and threshold voltage are discussed.

References

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