**Real time optical observation of multi-filament formation and electrode remodeling in Ag/SiO2/Au memristors**

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We report the direct optical observation of resistive switching mechanisms in Ag/SiO₂/Au memristive devices using in-situ microscopy during electrical characterization. Our findings reveal multiple critical current thresholds that separate standard memristive behaviour (volatile and non-volatile) to permanent electrode remodelling. Unlike conventional filamentary switching, which occurs at nanoscale dimensions[1,2], we demonstrate that increasing compliance currents from 0.5μA to 50mA triggers the formation of multiple micron-sized filamentary structures visible under standard optical microscopy. These structures appear precisely coincident with the high-to-low resistance state transitions. Differential interference contrast microscopy reveals both Ag extrusions and corresponding voids, confirming a substantial material redistribution process. AFM measurements verify these features as physical Ag protrusions extending from the electrode surface. Notably, the controlled formation of multiple parallel filaments and high current handling capability (up to 70mA) suggest applications beyond conventional memristors, including reconfigurable RF circuit elements, high-power switching, and plasmonic devices. The dependence of filament distribution on device geometry provides pathways for engineering application specific conduction patterns. This work bridges the gap between resistive switching mechanisms and microscale material transport phenomena with a rare direct visualization, enabling potential applications in optically accessible memory elements where states can be read both electrically and optically, advancing hybrid electro-optical computing architectures[3] and robust neuromorphic systems for high-power environments.

References:

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