Supporting Information

Conductive filament distribution in nano-scale electrochemical metallization cells

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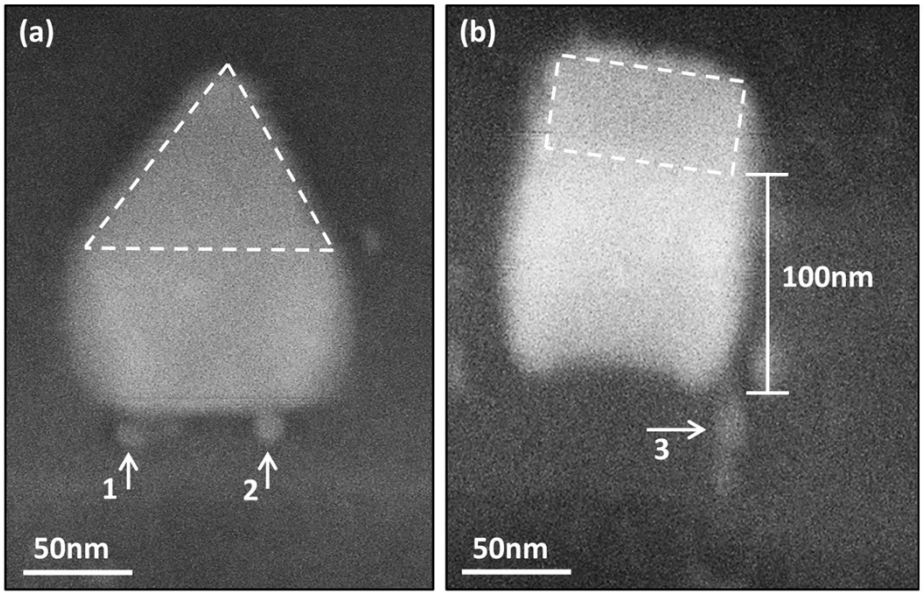

FIG. S1: Cross-sectional SEM images of filaments below AgNCs on p-Si/20 nm TiO_2 after electroforming. (a) and (b) show representative cross-sectional SEM images at the locations of AgNC after FIB milling (stage tilt-angle 36°) with white dashed lines indicating the remaining AgNC top facets. White arrows 1, 2, and 3 indicate conductive material agglomeration below AgNC edges. These round bright features are assigned to contracted Ag CFs, characteristic of threshold switching behavior.

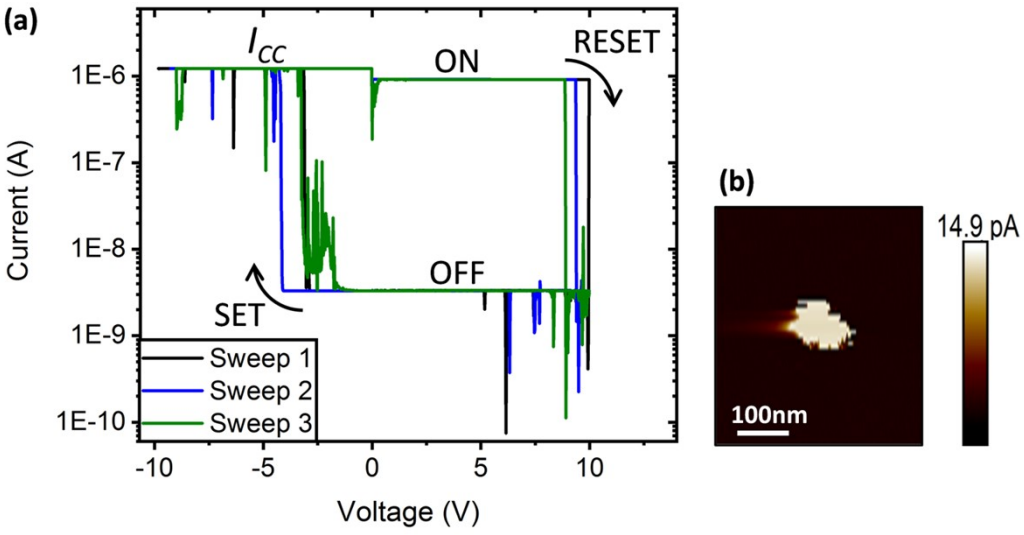

FIG. S2: (a) First three DC-IV sweeps of a single AgNC on 5 nm Al_2O_3 revealing non-volatile bipolar memristive switching. (b) Typical current map at the previous position of a AgNC on 5 nm Al_2O_3, after electroforming and delamination, revealing a single dense current spot, with no clear fine-structure observed.

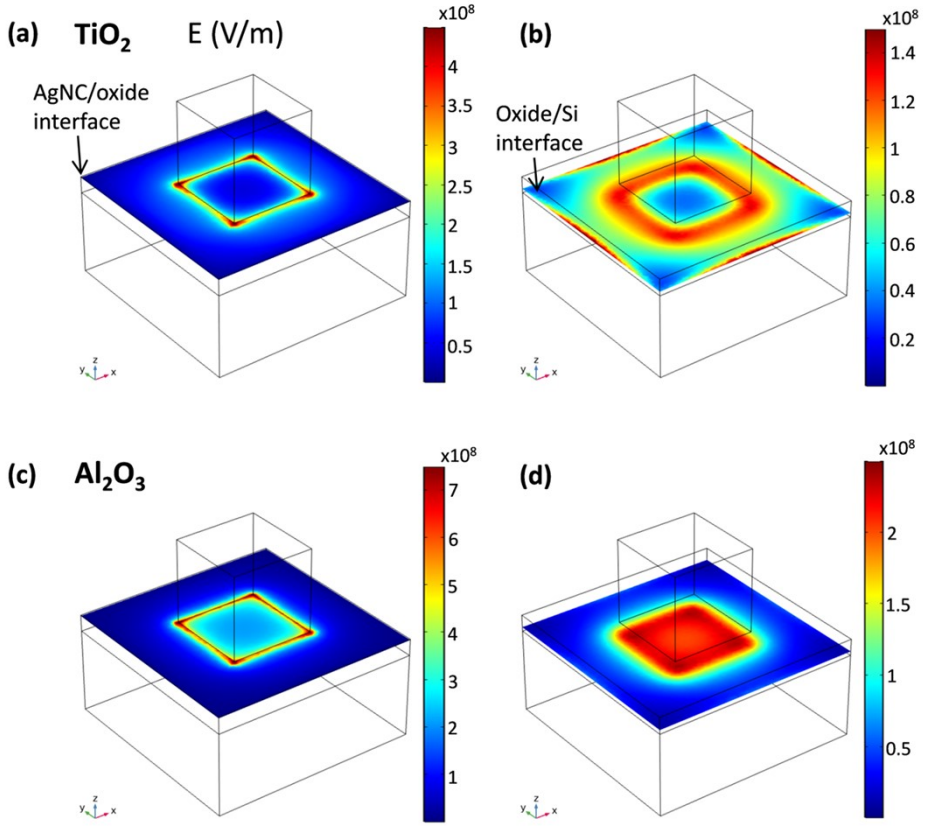

FIG. S3: Finite element simulations (*Comsol Multiphysics*) of the electric field distribution (a) at the AgNC/TiO_2-interface, (b) the TiO_2/Si-interface, (c) the AgNC/Al_2O_3-interface, and (d) the Al_2O_3/Si-interface. An electrical potential of 10 V was applied to the Si, whereas the AgNC was fixed at zero (ground) potential. As apparent from the color scales, inhomogeneity of the electric field inside the oxide arising from the AgNC geometry is more pronounced in the case of TiO_2. Parameters of the simulation: oxide thickness = 20 nm, $\varepsilon_{TiO2} = 80$, [1] $\varepsilon_{Al2O3} = 11$. [2] We note that, high dielectric permittivity values for TiO_2, have been reported over a wide range, depending on substrate, deposition method and crystal structure. We here selected one mid-value within this range, for illustrating the qualitative difference originating from the disparate dielectric constants of both oxides.

References

[1] J. Robertson, "High dielectric constant oxides," *EPJ Applied Physics,* Review vol. 28, no. 3, pp. 265-291, 2004, doi: 10.1051/epjap:2004206.

[2] A. I. Kingon, J. P. Maria, and S. K. Streiffer, "Alternative dielectrics to silicon dioxide for memory and logic devices," *Nature,* Article vol. 406, no. 6799, pp. 1032-1038, 2000, doi: 10.1038/35023243.