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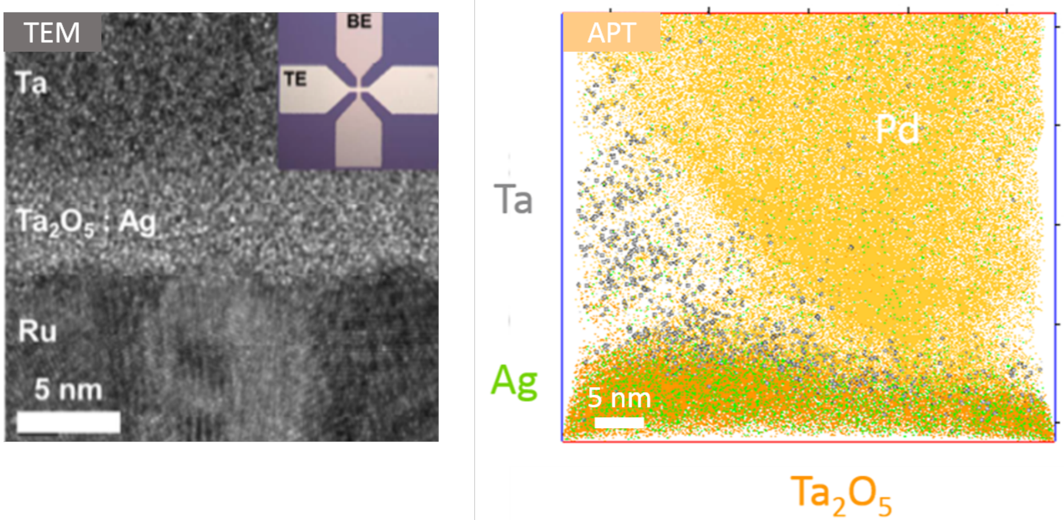
Truly Electroforming-Free and Low-Energy Memristors with Preconditioned Conductive Tunneling Paths.

Yoon, J. H., Zhang, J., Ren X., Wang Z., Wu H., Li Z., Barnell M., Wu Q., Lauhon, L. J., Xia Q., Yang J.J.



Caption: *The left panel shows cross-sectional high resolution TEM image of a memristor device with a top view image inset. The right shows an APT reconstruction (50x45 nm^2) of a specimen targeting the edge of a memristor crossbar device, with yellow dots for Pd, gray dots for Ta, orange dots for Ta_2O_5 and green dots for Ag. Pd was deposited to protect Ta from oxidation.*

Scientific Achievement

APT analysis was performed on novel electroforming-free and low-energy memristor devices with a Ta/Ta_2O_5:Ag/Ru stacked structure to evaluate the concentration and distribution of Ag atoms in the Ag doped Ta_2O_5 active layer. The interface between the top electrode and Ag doped Ta_2O_5 layer was successfully analyzed, determining the concentration of Ag in the Ta_2O_5 layer to be ~ 8%, and revealing that Ag atoms are uniformly distributed in regions close to the top electrode in the OFF state. These observations support that the novel memristor devices are switched through conductive tunneling paths instead of the continuous traditional conductive filaments.

Significance

A truly electroforming-free device with both low switching current and voltage was proposed and experimentally demonstrated for the first time. APT analysis contributed to establishing the novel switching mechanism involving conductive tunneling paths instead of continuous conductive filaments.

The low operating current and voltage make the memristors highly compatible with two-terminal selectors, creating an avenue to engineer memristors for high-density and low-energy applications. Substoichiometric transition metal dichalcogenides have been shown to support both vacancy motion and metal cation motion in support of memristive switching.

Citation

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