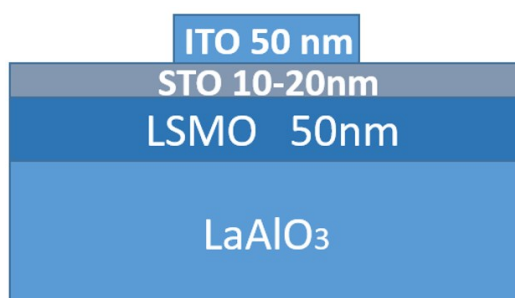
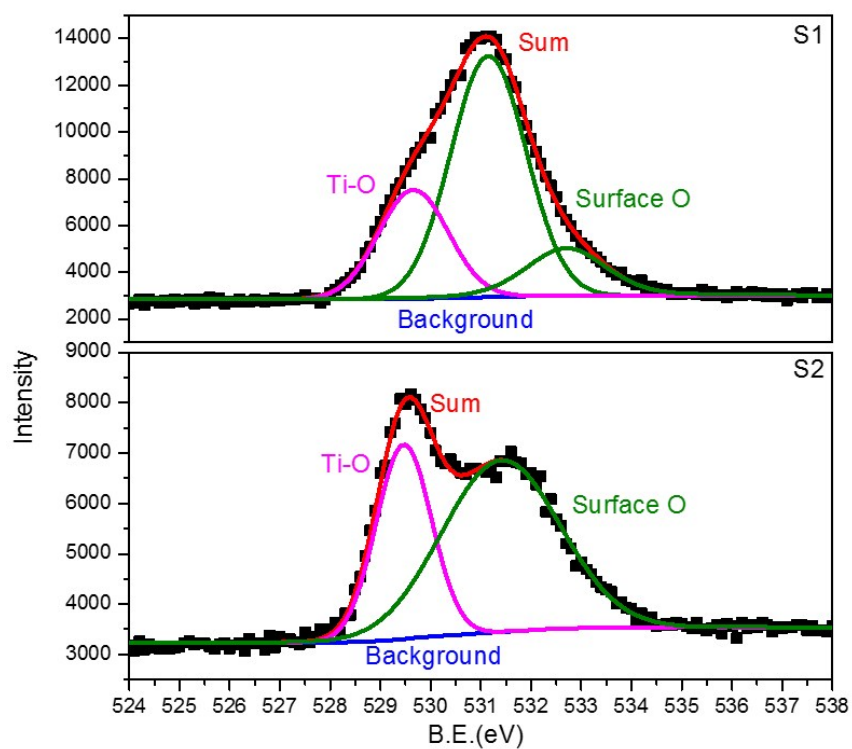


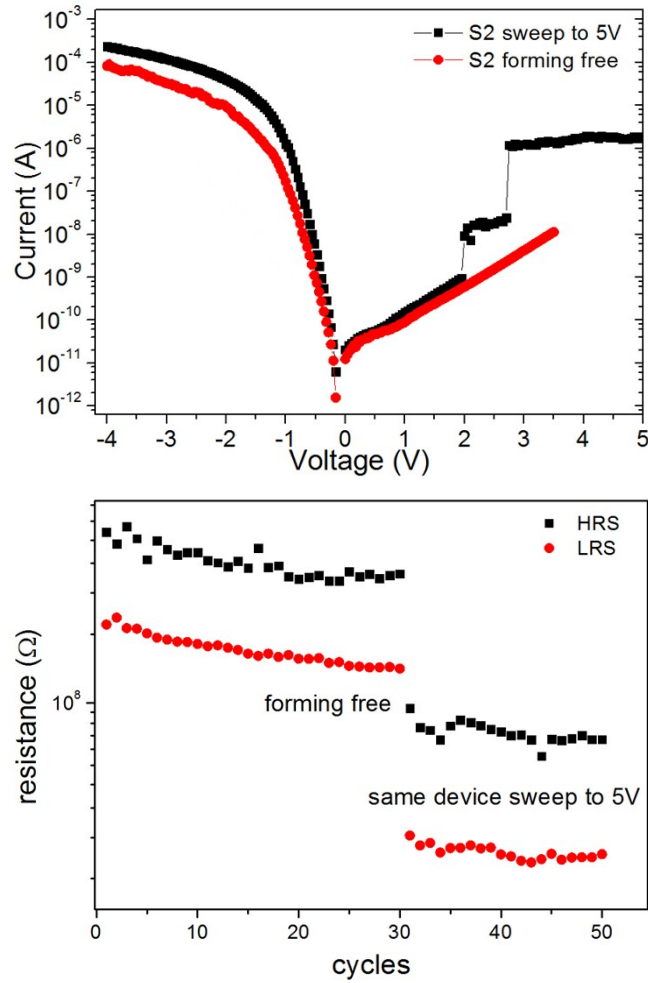
Supplementary information



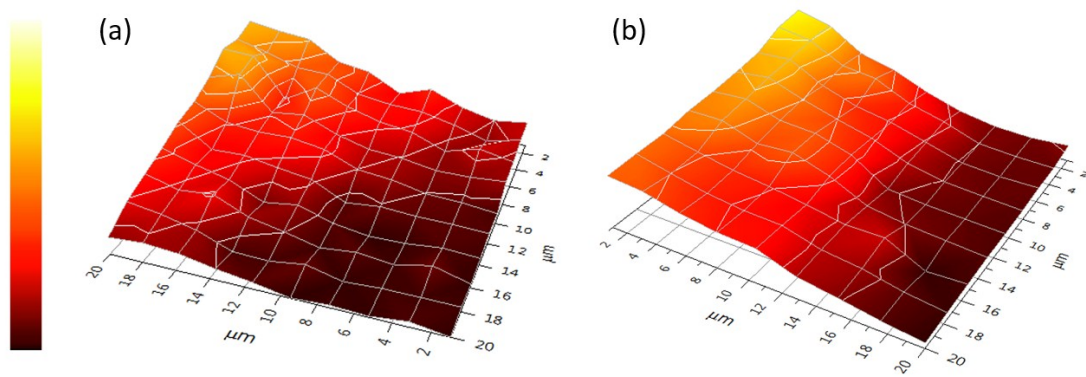
S. 1. Schematic showing the lateral structure of the STO based RS device, where ITO act as the transparent TE and LSMO (Lanthanum strontium manganite) is the BE.



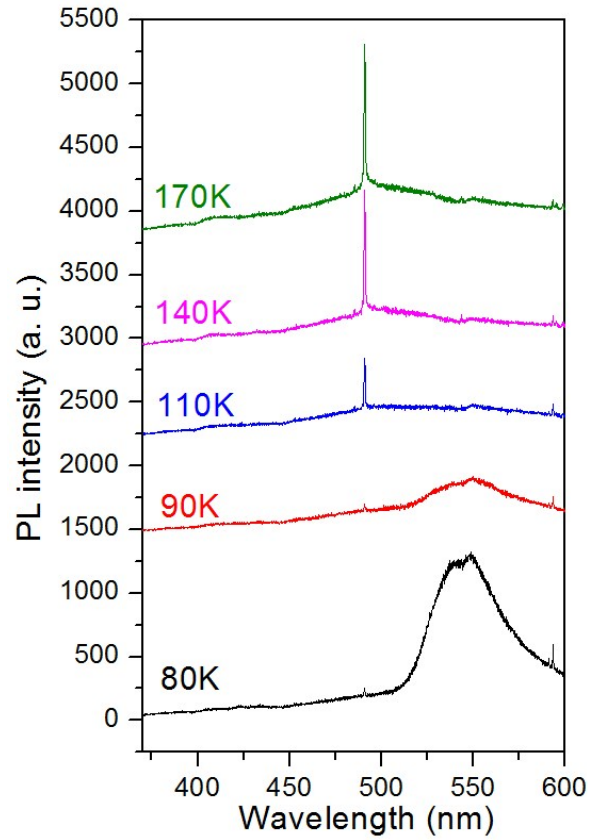
S. 2. Energy spectra of O1s for sample S1 and S2



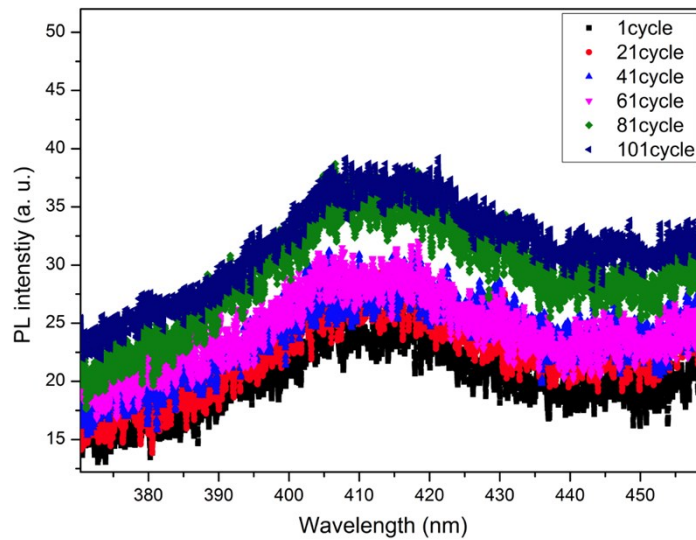
S. 3. (top figure) Device S2 before and after sweeping to 5V, the two steps under positive bias indicate weak filaments are formed while the current on the negative bias is also slightly increased after forming. (below figure) The resistance value of S2 for cycling endurance before and after sweeping to 5V, after the formation of weak filament, the resistance of the both HRS and LRS has decreased.



S. 4. PL mapping of device S2 (a) before and (b) after extend the sweeping range to 5V



S. 5. PL spectra of as-grown STO thin film of device S1 from 80K to 170K. Notice that the quenching of green luminescence band and the emerging of the sharp emission (490 nm) from 110K.



S. 6 PL spectra of oxygen vacancy emission at the filament region for different endurance cycles