Different Behaviour Seen in Flexible Titanium Dioxide Sol-Gel Memristors Dependent on the Choice of Electrode Materials

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Motivation

The archetypal (Strukov) memristor was made via atomic deposition of TiO2 between platinum electrodes [1]. The report of flexible solution-processed titanium dioxide memristor [2] was greeted with interest as it made it easier to fabricate working memristors. This device consisted of a spun-on sol-gel layer between two aluminium electrodes.

Despite several examples in the ReRAM literature of aluminium oxide playing an essential role in resistance switching [3], even when it was just via aluminium electrodes [4,5,6,7], reference [2] did not report a detailed test comparing aluminium electrodes to noble metal electrodes and instead simply stated that the switching was not attributable to the aluminium electrodes as the memristors still switched with noble metal (Au, Pt) contacts.

We have undertaken a study to elucidate the effect of changing the electrode metal on TiO2 sol-gel memristors, prepared as in [2], to discover possible methods to control device characteristics.

We found that Au – TiO2 – Au memristors did still switch, but in a fundamentally different way. These devices switched in a fuse-like manner, but did not switch back the way that Al – TiO2 – Al devices did (as reported in both [2] and right). The low resistance state, LRS, and first high resistance state, HRS, currents were ohmic and separated by 5 orders of magnitude, making these devices useful for WORM (Write-Once Read Many (times)) memory. There was also a second low resistance separated by an order of magnitude.

As all the resistance states in these devices piecewise linear rather than non-linear circuit elements, these devices are best described as resistance switching memory, RSIM, rather than memristors.

Au – TiO2 – Au sol-gel ‘memristors’

Al – TiO2 – Al sol-gel memristors

Some Al – TiO2 – Al memristors had high current triangular memristor profiles that resembled those reported in [2]. The LRS was ohmic and in the mA range and never reached the 10A range which the LRS of the Au – TiO2 – Al memristor did (in a comparison of virgin runs of the device between ±3V). These devices had a non-linear HRS in the same range as the curved bipolar switching below.

We also found non-linear memristor I-V curves in these devices which resembled both Chua’s memristor theory [8] and also ReRAM bipolar resistance switching. Devices with this mode of operation were higher resistance, (most in the 10^6 to 10^8 range over the voltage range tested) and very reproducible. Those with triangular memristor profiles were less reproducible, they had the same behaviour, but the switching voltage was not constant.

Conclusion

• The aluminium electrodes are an essential part of the operation of the TiO2 sol-gel memristor