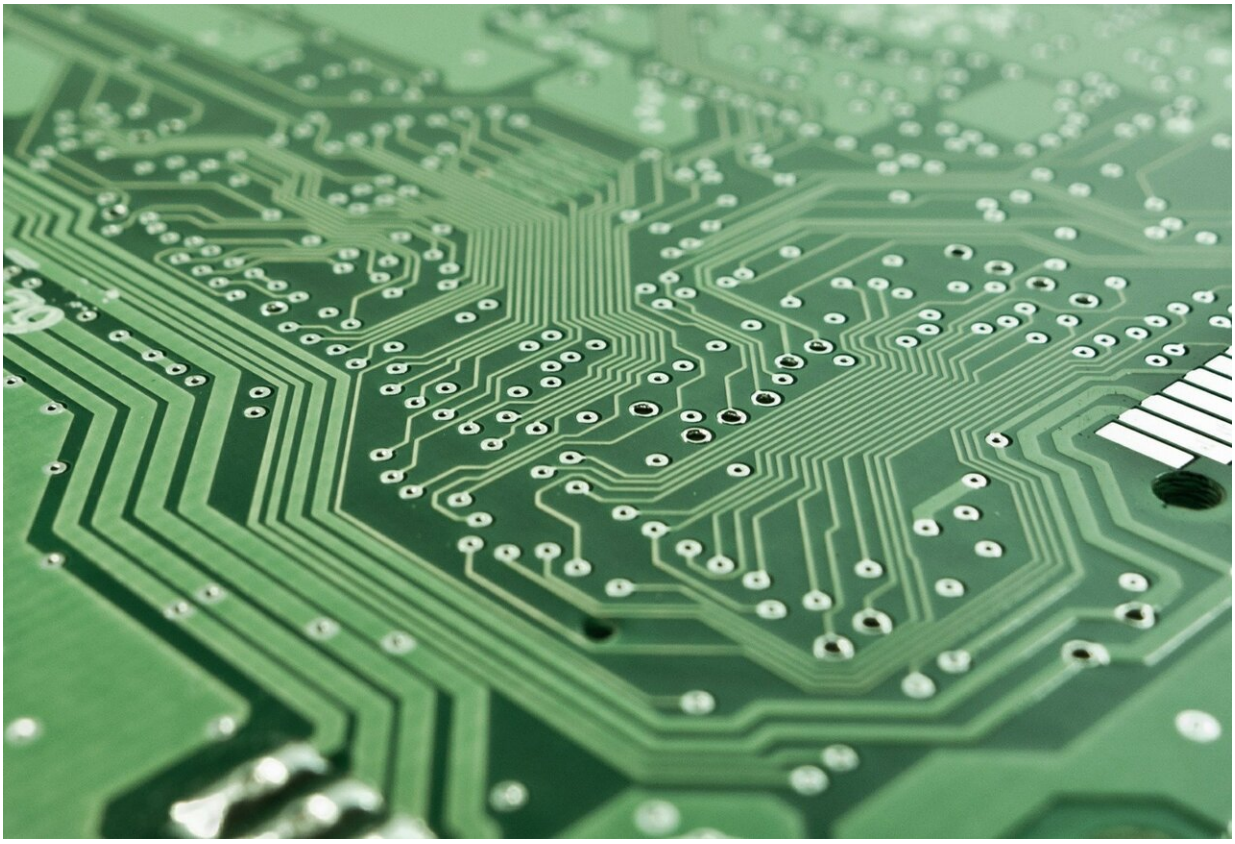
Researchers solve decades-old problem of how to uniformly switch memristors

September 29 2020



Credit: CC0 Public Domain

Lack of uniformity is possibly the biggest challenge in today's technology of memristor devices as it gives rise to problems like inconsistency, stochastic variability, and instability of the memory state.

A uniform switching mechanism in memristors is something researchers have been looking at in the last several decades.

Now, an international team, led by the scientists from the National University of Singapore (NUS), has developed a solution to address this long-standing problem in the field of organic and molecular electronics.

This work was published in the journal *Advanced Materials* on 6 September 2020.

Professor T. Venkatesan, who led this project, said, "We are working on an organic material system that is possibly one of the most efficient platforms for realizing artificial intelligence and brain-inspired computing. My former graduate student Dr. Sreetosh Goswami, who is now a postdoctoral researcher at the NUS Department of Physics, is the key architect of this work. While working on our previous studies on molecular memristors that were published in *Nature Materials* and *Nature Nanotechnology*, he discovered that the conductance switching is amazingly uniform."

"A molecular switching mechanism should ideally be uniform. The fact that no one ever observed a uniform switching puts the credibility of organic memristors into question. What it says is that either the existing measurements are problematic, or the mechanism is non-molecular," explained Dr. Sreetosh.

In this paper, the team resolved the problem by demonstrating a homogeneous molecular switching with less than 7 nanometre spatial resolution. This work also provided guidance on how such measurements should be performed, and how ideal molecular switching should look like.

Dr. Sreetosh added, "I thank Professor Venkatesan for sending me to

France to collaborate with HORIBA on the tunneling enhanced Raman Spectroscopy measurements. These measurements enabled characterisation at molecular levels, and what we showed here is a small part of the data we have acquired. Much more exciting results are on the way."

The material systems used in this study is the brainchild of Professor Sreebrata Goswami, who is from the Indian Association for the Cultivation of Science, Kolkata. Professor Sreebrata shared, "The correlation we have observed between micro and nano-scale measurements in this study is just amazing. It shows the homogeneity and scalability of a molecular mechanism in a device. Through nano-Raman spectroscopy, we were able to monitor the individual bonds in a molecule as a function of voltage. Such deterministic understanding of molecular mechanism charts routes to design new molecular systems, and we are currently in progress of doing so."

"While usual memristors show switching energy in the order of pico joule, these devices promise switches with energy dissipation in the range of atto joules. This is a huge advantage offered by the material system," elaborated Associate Professor Ariando. He is a co-author of the paper, and also the lead Principal Investigator of the grant that supported this research.

This research was conducted in collaboration with HORIBA in France, and Professor Stanley Williams of Texas A&M University.

The NUS research team is currently using these molecular platforms to realize brain-inspired functionalities such as unsupervised learning, classification in addition to probabilistic computing.

"We believe this has the potential to revolutionize current technology by orders of magnitude in terms of energy cost," said Prof Venkatesan.

More information: Sreetosh Goswami et al, Nanometer-Scale Uniform Conductance Switching in Molecular Memristors, *Advanced Materials* (2020). DOI: 10.1002/adma.202004370

Provided by National University of Singapore