

Resistive random-access memory that avoids an initial forming process improves fabrication methods and reliability

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An enhanced design for a promising computer memory technology has been developed by A*STAR researchers. Victor Zhuo and colleagues developed resistive random-access memory (RRAM) that, during fabrication, does not require a harmful high-voltage forming process.

"We demonstrate a forming-free RRAM cell with low operation voltages, a large resistance window and excellent thermal stability," says Zhuo.

RRAM is the most promising nonvolatile memory system as it shows similar functionality to present solid-state memory drives, but has a higher storage density and longevity. RRAM devices can be scaled down to smaller than 14 nanometers. They also offer a straightforward operation mechanism where the memory state of the material that corresponds to the bits used by computers is determined merely by the electrical resistance of the device. This resistance can be 'switched' by orders of magnitude, just by using electrical voltage pulses applied to the RRAM device.

The rudimentary operation mechanism of RRAM means the chips have a simple fabrication method. However, a drawback of RRAM fabrication is that the memory device is not in one of the two electrical resistance states needed for operation. A high forming current is required to set the memory into the right state: this complicates

fabrication and requires further monitoring for damages.

Researchers from the A*STAR Data Storage Institute and the A*STAR Institute of Microelectronics have developed a design for the device that delivers memory in the desired state and avoids the use of forming currents.

On the microscopic level, the resistance switching of RRAM occurs through the migration of [oxygen](#) atoms. As RRAM materials are made from a combination of metal and [oxygen atoms](#); removing oxygen causes an oxygen shortage in the material. This lowers the material's electrical resistance, allowing electrical current to flow. Introducing oxygen back into the material increases its [electrical resistance](#) and makes it an insulator.

The RRAM devices studied by Zhuo's team uses tantalum oxide with electrical contacts made from either titanium nitride or tantalum. When using titanium nitride, which is chemically not very reactive, a forming voltage is required during production. However, when using the more chemically reactive tantalum, the device is ready to use right away. Tantalum has a natural affinity to react with the oxygen that helps to prepare the material in the right state.

The aim is to demonstrate this concept in advanced devices, adds Zhuo. "Our next step is to integrate RRAM memory devices with a selector for ultra-high density nonvolatile [memory](#) applications."

More information: Y. Jiang et al. Forming-Free TaOBased RRAM Device with Low Operating Voltage and High On/Off Characteristics, *ECS Journal of Solid State Science and Technology* (2015). [DOI: 10.1149/2.0101512jss](#)

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