NAIST® Research Highlights

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Data storage

Improving memory using hot spots

Localized hot spots are the key to the operation of low power consumption electronic memories

An increasing reliance on electronics for processing information has driven a need for devices that can store all this data. NAIST researchers have now used thermal imaging to better understand the storage mechanism in one possible type of memory device[1], and provide insight that could help reduce the power consumption of such components in the future.

Non-volatile memory — devices that retain their data when power is switched off — should squeeze as much information into as small a space as possible, be cheap to produce, and not consume too much energy. Resistive random access memory (ReRAM) is one technology that fulfills these requirements. Resistive devices operate by harnessing the ability of some materials to switch between high and low electrical resistance states. This means that ReRAM offers rapid reading and writing of data, and can be easily integrated with existing silicon-based electronics technologies.

> **“Our future work will attempt to establish a relationship between heat and electrical characteristics of the device.”**

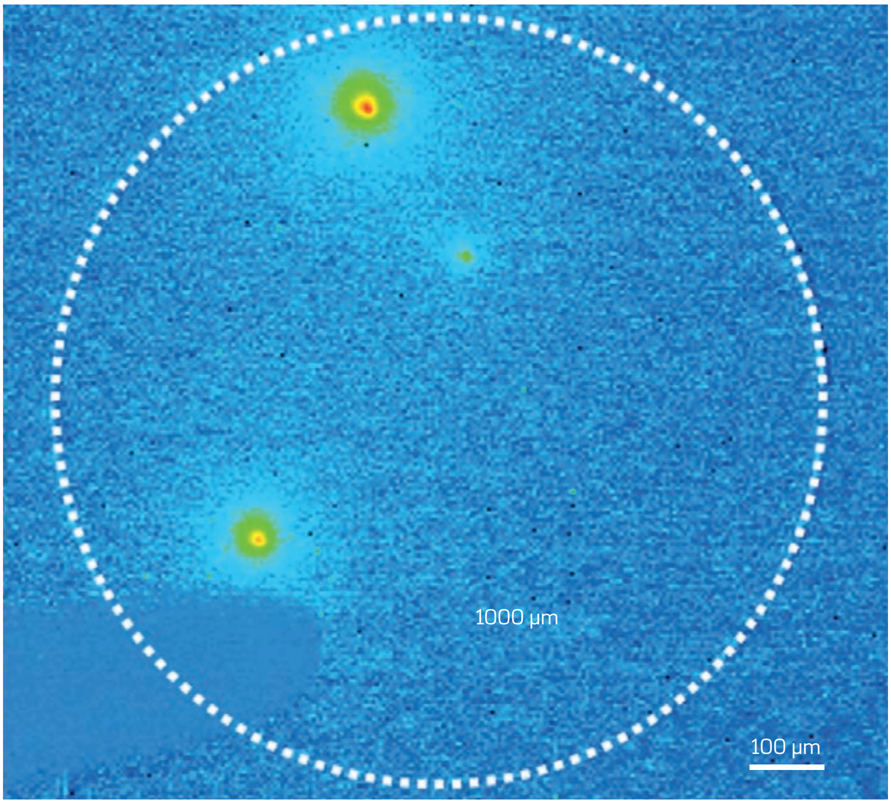
“But the operation mechanism of resistive switching memories is not fully understood,” says NAIST researcher Yukiharu Uraoka, from NAIST’s Information Device Science Laboratory. “So we chose to investigate the heat generated in the device to see if it affected the performance of the memory.”

Uraoka and his co-workers studied the changes in ReRAM during switching by monitoring the surface temperature. They created their ReRAM by sandwiching a 30 nanometre-thick layer of amorphous indium gallium zinc oxide (a-IGZO) between two platinum electrical contacts. They used an infrared detector to create a spatially resolved thermal map of the device as they applied a voltage of up to 1.5 volts across the electrodes.

The team noticed that the voltage created hot spots on the surface of the device (see figure). These localized regions, with a maximum temperature of 186 °C, were a sign of electrical pathways, or current filaments, that pass through the a-IGZO. These filaments significantly alter the resistance of the thin film, thus enabling the switching that is central to the operation of a ReREM.

Current filaments have been observed in resistive materials in the past using techniques such as scanning electron microscopy or electron energy loss spectroscopy. But these methods weren’t able to observe the filaments as the voltage was applied — which means they didn’t provide much information on how the filaments are formed.

“Our method can detect the location of conductive filament, a main contributor to the resistive switching,” says Uraoka. “Our future work will attempt to establish a relationship between heat and electrical characteristics of the device.”



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Hot spots imaged on the surface of a resistive random access memory 1,000 micrometres in diameter are a signature of current filaments that significantly alter the electrical resistance of the device.

Reference

1. Kado, K., Uenuma, M., Sharma, K., Yamazaki, H., Urakawa, S. *et al.* Thermal analysis for observing conductive filaments in amorphous InGaZnO thin film resistive switching memory. *Applied Physics Letters* **105,** 123506 (2014).

More information about the group’s research can be found at Yukiharu Uraoka’s webpage:
http://mswebs.naist.jp/LABs/uraoka/PUBLIC/staffs/uraoka/uraoka.html