**Docket #:** S18-116

# Multi-bit per cell Resistance Distribution Control for Fast, Efficient Read and Program for Resistive RAM

Researchers in the Robust Systems Group at Stanford University developed a method for dividing the available resistance window in a multi-bit per cell Resistive RAM into varying resistance distributions to improve read and program performance. Controlling resistance distribution is critical for optimal read and program performance in multi-bit per cell ReRAM. Stanford researchers' method assigns non-uniform resistance ranges based on the intrinsic variation of ReRAM memory cells; and assigns non-uniform gaps between the distributions based on sense-amplifier margin requirements. This approach achieves the best read and program performance, and makes ReRAM a more competitive non-volatile memory option for wearables and Internet of Things technology.

**Stage of Research**

Researchers successfully tested the method at the array level on a 4Kb 1T1R $HfO_2$-based ReRAM using 130nm silicon CMOS technology for storing 3 bits per each cell where 8 resistance distributions were precisely controlled.

Related work optimizing read and write performance for ReRAM is covered in Stanford Docket
18-124.

## Applications

- Non-volatile memory – especially for cost-sensitive, low power consumption, or lower memory density applications including solid state drives, mobile computing, wearables, and other IoT technology.

## Advantages

- Energy efficient
- Faster read and write performance compared to flash memory
- More stable - technique to compensates for temperature-dependent shifts in the distributions that may affect the sensing margin

## Publications

- Binh Q. Le, Alessandro Grossi, Elisa Vianello, Tony Wu, Giusy Lama, Edith Beigne, H.S. Philip Wong, and Subbhasish Mitra, "Resistive RAM With Multiple Bits Per Cell: Array-Level Demonstration of 3 Bits Per Cell". *IEEE Transactions on Electron Devices*, November 26, 2018.

## Patents

- Published Application: 20210035638
- Issued: 11,217,307 (USA)

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