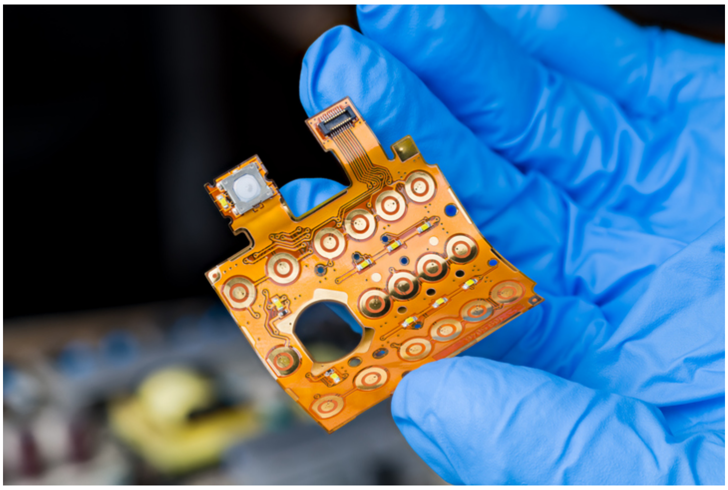
Nanoscale Amorphous-Silicon Based Ultra-High Density Resistance Switching Memory and Logic Devices

TECHNOLOGY NUMBER: 3526



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Hardware
Engineering & Physical Sciences
Semiconductor, MEMS, and Electronics

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OVERVIEW

Nanoscale resistive-switching devices for nonvolatile memory with intrinsic rectifying behavior

- Minimized forming voltage, excellent scalability, and reduced crosstalk
- Ultra-high density memory, logic devices, crossbar memory arrays

BACKGROUND

Nonvolatile memory devices like Ferroelectric RAM, Magneto-resistive RAM, Organic RAM, Phase Change RAM, and Conductive Bridging RAM are pivotal in advancing data storage technologies. Crossbar structures with conductive bridging devices offer ultra-high density and innate defect tolerance but suffer from poor electrical properties, low yield, slow switching, and thermal instability. Micron-scale amorphous silicon (a-Si) switching devices also present issues, requiring high formation voltages and demonstrating questionable scalability. Conventional resistive-switching devices typically exhibit symmetric I-V behavior, leading to crosstalk complications in dense arrays. Thus, there is a need for innovative memory devices that combine high scalability, low voltage operation, fast switching, and reliable performance while maintaining a cost-effective production process.

INNOVATION

Researchers at the University of Michigan have developed nanoscale Ag/a-Si:H/c-Si resistive-switching devices that significantly minimize the effect of forming by utilizing a heavily doped crystalline silicon substrate. These devices are fully CMOS compatible and show comparable scalability with enhanced performance over molecule-based devices. They exhibit rectifying I-V behavior, reducing crosstalk and enabling efficient crossbar memory and logic operations. The devices demonstrate a high on/off resistance ratio (>10^4) and robust switching, surviving over 10^5 cycles without performance degradation. Typical threshold voltages range from 3.5V to 4.5V for "on" and -3V to -4V for "off" states. Scalability has been confirmed down to $50 \times 50\ nm^2$, with potential extension to 20 nm. These characteristics make the device structure ideal for ultra-high density memory applications and integrated logic circuits, marking a promising advance in nanotechnology-based data storage solutions.

ADDITIONAL INFORMATION

REFERENCES:

Sung Hyun Jo and Wei Lu, "Ag/a-Si:H/c-Si resistive switching nonvolatile memory devices," 2006 IEEE Nanotechnology Materials and Devices Conference, Gyeongju, 2006, pp. 116-117, doi: 10.1109/NMDC.2006.4388711

INTELLECTUAL PROPERTY:

US10134985 “Non-volatile solid state resistive switching devices”