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GaN-Based Threshold Switching Device and Memory Diode

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Background

Resistive random access memory (RRAM) has become one of the most promising memory types due to its scalability, low programming voltage, and fast write/read speeds. For large-capacity, nonvolatile memory applications, the cross-point (or crossbar) array is an attractive RRAM architecture. However, sneak paths—unintended currents flowing across unselected cells of a cross-point array—can diminish performance and increase power consumption. Minimizing sneak paths in RRAM may involve incorporating self-rectification characteristics, or adding threshold switching devices in series with the RRAM cell at each cross-point. Although GaN-based materials have been extensively studied for applications such as light-emitting diodes and lasers, investigation into GaN-based resistive memory is still in its early stage. Therefore, development of an effective and stable GaN switching device is expected to benefit memory structuring with nitride high-electron-mobility transistors (HEMTs) and propel a new generation of integrated devices.

Invention Description

Researchers at Arizona State University have developed a new method for fabricating GaN-based diodes for RRAM memory threshold switching. This is accomplished through epitaxial regrowth of GaN-on-GaN vertical p-n diodes that results in a conductive filament at the regrowth interface. The devices have been shown to reliably switch more than 1000 cycles with very small fluctuations in set voltage and current when in high resistance state (HRS). Breakdown of the diode can be adjusted by changing the thickness of its unintentionally doped (UID) GaN drift layer. Testing at temperatures up to 300 degrees C exhibited stable performance, which to the best of the inventors’ knowledge, has not currently been reported. Additionally, since GaN is a crystal material with a direct bandgap, its use may improve device endurance over switches made from oxides or materials with traps (dislocations).

Potential Applications

- Computer memory
- GaN-based integrated circuits

- Optical electronics

Benefits and Advantages

- Reliable – Demonstrates consistent switching characteristics across more than 1000 cycles.
- Heat-Resistant – Provides stable performance at up to 300 degrees C
- Durable – Use of GaN may improve device lifespan over oxide-based switching devices

Homepage of Professor Yuji Zhao