TECHBRIEF

BOTTOM-UP ASSEMBLY OF GRAPHENE QUANTUM DOTS TO FORM TWO-DIMENSIONAL AMORPHOUS CARBON FILM

OPPORTUNITY:

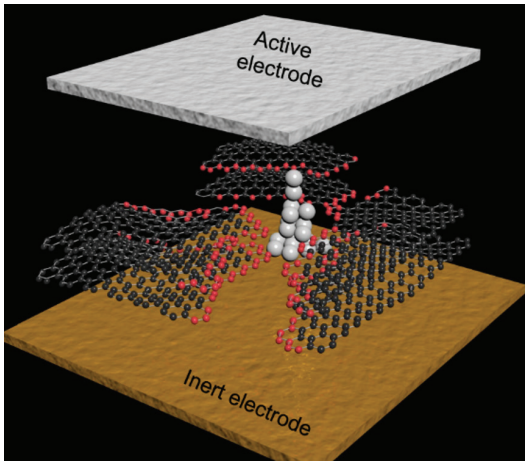
This invention describes a uniquely engineered 2-D amorphous carbon film and a memristor fabricated with coal-derived carbon quantum dots as the dielectric (switching) media for resistive random-access memory (RRAM). The atomic dielectric carbon layer can provide large storage density and 3-D packing ability, allowing memory and logic devices to be integrated in one chip, providing faster data processing with low energy consumption. This patent application is jointly owned by NETL and the University of Illinois-Urbana Champaign (UIUC) and it is available for licensing and/or further collaboration.

CHALLENGE:

Memory is essential to future computing with the exponential growth of data. These emerging memory technologies aim to revolutionize the existing memory hierarchy. Various emerging memory technologies are actively being investigated to meet ideal performance characteristics. RRAM has various advantages such as easy fabrication, simple metal-insulator-metal structure, excellent scalability, nanosecond speed, and long data retention. RRAM has been commercialized since 2013. Despite showing great promise over conventional RAM and its popularity in academia, RRAM has not become commercially popular. This is due to high device variability and high operation voltage.

OVERVIEW:

Researchers at NETL and UIUC used a novel method to fabricate amorphous 2-D carbon film using coal-derived carbon quantum dots. This carbon film with continuous random network region can act as an excellent dielectric material. One of the applications that takes advantage of this amorphous 2-D carbon film is RRAM. Due to the atomically thin structure of the carbon film, the RRAM device made with this invention requires extremely low operating voltage (low energy consumption). Furthermore, the memristor fabricated with this amorphous carbon film provides pre-defined, stabilized, areas for the filament formation. This helps the RRAM device to display minimal variability and achieve improved endurance as well as longer memory retention. Integrating the amorphous carbon film into RRAM enables low-voltage operation, reduces or eliminates device-to-device (spatial) and cycle-to-cycle (temporal) variability and provides improved endurance, and long-term data retention.



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ADVANTAGES:

- Domestically sourced manufacturing feedstocks
- Easy fabrication
- Provides a new, innovative use for coal resources
- Longer data retention
- Superior speeds
- Excellent scalability
- Minimal device variation
- Low energy consumption
- Direct integration with logic devices

APPLICATIONS:

Amorphous 2-D carbon film using coal-derived graphene quantum dots can be applied to the production of RRAM, which could significantly advance development of new computer architecture by improving the performance of memory storage devices.

PATENT STATUS:

U.S. Patent Pending (provisional patent application)

Title: 2D Amorphous Carbon Film Assembled from Graphene Quantum Dots

Filed: 03/29/2021

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