Composite Materials for Tunable Memristive Behavior

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Summary

This technology uses combinations of materials with different electronic properties of micro- or nanometer-scale grain size to create a memristive device (two-terminal, variable resistance circuit element). Amidst growing interest in memristors, this technology is one of the first to use composite materials, which make the memristive qualities of the material tunable.

Challenges in Memristor Technology

- Macroscopic (i.e. hand-held or "bench-top") memristive devices, which may be used in power-systems, printed circuit boards or electronics prototyping boards, cannot be fabricated today
- Single-material memristors have been demonstrated with thin-film or nanometer-scale geometries, but their memristive properties are completely rigid
- Since there is little to no control over the properties of the memristor, this technology struggles to move from the research lab to commercial application

Technology Description

Memristors are a class of passive two-terminal devices for which the resistive state depends upon the voltage or current history of the device, as characterized by a distinctive charge/flux constitutive relationship. As current flows one way through a memristor, resistance increases, but as current flows the other way, resistance decrease. If current flow stops, the device maintains its most recent resistance value and "remembers" that resistance until current flow begins again. This particular technology uses composite materials that allow for the tunability of these memristive properties, including minimum device resistance, power-dissipation properties, and response time.

These memristive devices consist of two or more nanometer-scale granular materials which are combined in a controlled ratio so as to allow the deliberate tuning of the device electronic properties. The materials used include a highly conductive material, such as a metal or highly doped semiconductor, and a material which exhibits variable conductivity under applied voltage, such as a transition metal oxide. The volumetric ratio of the two materials dictates the degree of conductivity variation possible; an important consideration for such devices. An additional degree of freedom is then also offered by selecting the nanoparticle size, which impacts the response speed of the variable-conductivity element.

Commercial Applications

The unique properties that memristive devices offer have a wide range of application to modern electronics and integrated circuits. One of the most significant of those applications is the potential to create more compact memory storage using the resistive switching capabilities of memristive devices that allow them to realize binary memory elements. This technology also allows for the macroscopic construction of memristors, which has application in power systems, printed circuit boards, and electronics prototyping boards. Furthermore, as the value of memristive properties is realized, the ability to optimize those properties will become invaluable.

Advantages

- The use of composite materials allows memristive properties to be manipulated and optimized
- Composite materials also enables macroscopic construction of memristive devices, greatly expanding their potential application.
- Until this discovery, macroscopic construction of memristive devices was not possible

Intellectual Property and Product Development Status

Vanderbilt has filed a provional patent application.

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