NISTTech

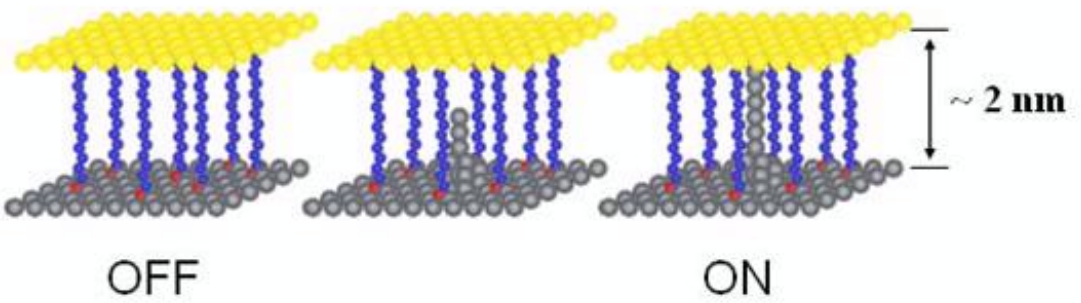
Self-Assembled Monolayer Based Silver Switches

Self-assembling nano-scale switches

Description

Researchers at NIST have demonstrated a prototype nanoscale electronic switch built from self-assembled layers of organic molecules on silver wires. Potential applications range from a replacement technology for magnetic data storage to integrated circuit memory devices. The self-assembled monolayer silver switch operates on the nanoscale and requires little effort to fabricate. In an electric field, silver ions readily form silver "whiskers," tree-like branching growths of crystals. NIST researchers use this growth to make a nanoscale binary switch. An extremely fine silver wire is coated with a molecule that forms a self-assembled monolayer on the wire, typically some organic molecule with a sulfur group on one end to bond to the silver. An equally fine gold wire is laid crosswise to the silver wire and a small voltage is applied across the two wires. When the voltage is increased to a critical level, silver ions form and quickly branch through the organic monolayer to the gold wire just like a lightning bolt, except solid. When a silver filament reaches the gold, it forms a short circuit, causing a change in conductance, which is easily detectable. Reversing the voltage retracts the filament and "opens" the switch.

Images



Credit: NIST

Applications

- **Nanoscale electrical devices**
  The easy to fabricate silver switches can be used in numerous nanoscale electrical devices.
- **Memory and logic for portable electronic devices**
  These silver switches can have a considerable impact on the memory and logic of portable electronic devices such as cell phones.

Advantages

- **Versatile applications**
  The chemistry of the organic monolayer is not critical so the switch can be used with many different self-assembled molecular electronics systems.
- **Simple fabrication process**
  The crossed-wire structure is very simple to engineer and lends itself to large arrays of switches.
- **Scalable**
  Because the difference between "on" and "off" is drastic and the electrical resistance ratios are up to a million or more, this technology makes it easier to reliably scale up the switches into very large arrays.
- **Cost effective**
  When fabricated in bulk, these switches are a cost-effective alternative to traditional silicon devices.
- **High success rate for device fabrication**
  This simplified process of making nanoswitches yields above a 90% success rate.

Abstract

The present invention is a two-state switching device based on two electrodes separated by a self-assembled monolayer. At least one of the electrodes must be composed of silver. In the high-resistance off state, the two electrodes are separated by the organic monolayer. Application of a negative threshold bias causes a silver ion filament to bridge the gap between the two electrodes, changing the device into a low-resistance on state. The device may be turned off by application of a positive threshold bias, which causes the ionic filament to retract back into the silver electrode. This device is easy to fabricate, smaller than currently available devices, and because the only required components are silver and a self-assembled monolayer, it should be possible to incorporate this switch into a variety of device geometries.

Inventors

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Citations

1. 1.) J.M. Beebe and J.G. Kushmerick. Nanoscale switch elements from self-assembled monolayers on silver. Applied Physics Letters 90, 083117 (2007). Posted online Feb. 23, 2007.

Related Items

- NIST presents its nano techologies. See technical session 1, Self-Assembled Monolayer Based Silver Switches.

References

- U.S. Patent #8,101,942 issued 01-24-2012, expires 01/24/2024
- Docket: 06-010

Status of Availability

active patent and available for licensing

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