National Aeronautics and Space Administration

Copper Nanowire Production for Interconnect Applications

Copper replaced aluminum nearly two decades ago as an interconnect material in integrated circuit manufacturing due to its better electrical and thermal conductivity. Metallic nanowires have interesting physical properties such as quantized conductance and localization effects. These properties can be exploited for applications such as wiring in nanometer scale circuits, and probes for atomic force microscope and scanning tunneling microscope. Many of the previous synthesis techniques require expensive chemicals, complicated procedures, and complex fabrication equipment, which may preclude them from implementation for mass production.

NASA has developed a new technology that can produce copper nanowires directly. This technology provides a simple method to produce copper nanowires on a substrate as an alternative to template approaches and chemical synthesis routes. Copper oxide nanowires (CuO and Cu_2O) are produced from copper film, foil, or commercially available copper wires of any size, through oxidation using a vapor phase technique known previously. The copper oxide nanowires are then reduced in a hydrogen atmosphere to produce the copper nanowires.

This invention is available for licensing from NASA's space program to benefit U.S. industry.

Patent

This technology is protected by a pending U.S. Non-Provisional Patent Application. (Reference No. ARC-16646-1)

Benefits

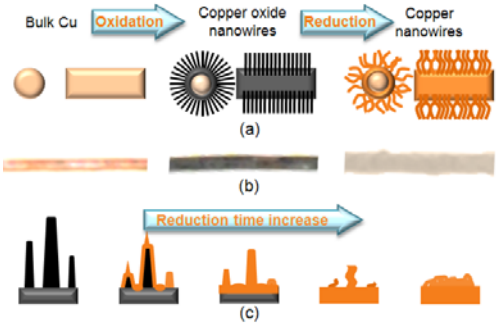
- Better electrical conductivity
- Simple and inexpensive synthesis approach
- Nanowire growth is based on self-catalytic mechanism
- Very low reflectivity
- High absorption of visible light
- The oxide nanowires can be a mixture of CuO and Cu_2O.
- Can be grown either vertically or laterally

Technology Details

This technology presents a simple and inexpensive synthesis approach for direct growth of semiconducting copper oxide (CuO and Cu_2O) nanowires and their subsequent reduction to metallic copper (Cu) nanowires. Copper oxide nanowires are grown from conventional bulk copper wires by thermal oxidation. Both, CuO and Cu_2O. nanowires are produced first on Cu substrate in a simple quartz tube furnace system, using the most basic and primary methods of oxidation and reduction mechanisms. Oxidation is performed in ambient air, and then oxide nanowires are reduced to copper nanowires in the same furnace under a hydrogen flow at 400 C. The reduction process effectively transforms the oxide nanowires into metallic copper nanowires. The development mechanisms of these nanowires were studied by examining the sequential images of nanowires at different time intervals. Electrical characterization reveals a reduction of resistance by six orders of magnitude at the completion of the reduction process which implies that the reduced nanowires are reasonably metallic.

Commercial Applications

- Semiconductor industry
- Photodetectors
- Field emission devices
- Anodes for Li-ion batteries
- Nanometer scale circuits
- Probes for microscopes
- Solar cells
- Gas sensors
- Microheater



Schematic of the evolutionary transformation of nanowire

Contact the Ames Technology Partnerships Office at 1-855-627-2249 or ARC-TechTransfer@mail.nasa.gov