Metal Silicide Nanowires and Methods for Their Production

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WARF: P06215US

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The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in single crystal metal silicide nanowires.

Overview

As electronic gadgets continue to get smaller, tiny metal silicide nanowires may one day be used as fundamental building blocks in devices from cell phones to lasers. Metal silicides already are integral parts of silicon microelectronics, and metal silicide nanowires could become important nanoscale contact, gate and interconnect materials.

But chemical synthesis of these nanowires has been challenging because of the complex phase behavior of silicides and the difficulty of one-dimensional anistropic crystal growth. The most successful method for growing metal nanowires is the metal-catalyzed vapor-liquid-solid (VLS) technique; however, this technique results in nanowires contaminated with metal catalyst impurities and catalyst “tips.”

The Invention

UW-Madison researchers have developed a simple and unique method of forming single crystal metal silicide nanowires without a metal catalyst. The free-standing nanowires are grown on a silicon substrate covered with a thin (1-2 nm) layer of silicon oxide via a simple chemical vapor deposition (CVD) process using single or multiple source precursors. Alternatively, the nanowires can be grown on the thin silicon oxide film via a chemical vapor transport (CVT) process using solid metal silicide precursors. The CVT process is particularly applicable for the growth of transition metal silicides for which organometallic precursors are not readily available.

Applications

- Nanoelectronics
- Military
- Industrial control
- Information technology
- Nanophotonics
- Biosensors
- Solar cells
- Laser devices
- Biomedicine
- Automotive

Key Benefits

- Unlike typical vapor-liquid-solid (VLS) nanowire growth, the silicide nanowires produced by this method do not require the addition of metal catalysts, have no catalyst tips and depend strongly on the surface used.
- Because this is a catalyst-free method, no catalyst material remains to affect the electrical properties of the final nanowire.
- Nanowires are smooth and straight with a relatively uniform size distribution.
- Branched nanowire structures can be formed by altering the synthetic conditions.

- Because the nanowires grow on silicon surfaces covered with a thin, but not thick, layer of silicon oxide, they may be grown in patterns on a substrate surface.
- Provides—for the first time—the chemical synthesis of free-standing, single-crystalline nanowires of FeSi and CoSi
- Applicable to other transition and rare earth metal silicides—the inventors have successfully used this process to produce $TiSi_2$ nanowires
- An array of nanowire-based transistors has been created using this method.
- Nanowires can be aligned easily.

Additional Information

For More Information About the Inventors

- Song Jin

Related Intellectual Property

- View Continuation Patent in PDF format.

Publications

- Schmitt A. L. and Jin S. 2007. Selective Patterned Growth of Silicide Nanowires without the Use of Metal Catalysts. Chem. Mater. 19, 126-128.
- Schmitt A. L., Bierman M. J., Schmeißer D., Himpsel F. J. and Jin S. 2006. Synthesis and Properties of Single-Crystal FeSi Nanowires. Nano Lett. 8, 1617-1621.
- Schmitt A. L., Zhu L., Schmeißer D., Himpsel F. J. and Jin S. 2006. Metallic Single-Crystal CoSi Nanowires via Chemical Vapor Deposition of Single-Source Precursor. J. Phys. Chem. B. 110, 18142-18146.
- Song Y. and Jin S. 2007. Synthesis and Properties of Single-Crystal $Beta_3$-Ni_3Si Nanowires. Appl. Phys. Lett. 90, 173122.
- Song Y., Schmitt A. L. and Jin S. 2007. Ultralong Single-Crystal Metallic Ni_2Si Nanowires with Low Resistivity. Nano Lett. 7, 965-969.
- Szcech J. R., Schmitt A. L., Bierman M. J. and Jin S. 2007. Single-Crystal Semiconducting Chromium Disilicide Nanowires Synthesized via Chemical Vapor Transport. Chem. Mater. 19, 3238-3243.
- Zhou F., Szczech J., Pettes M. T., Moore A. L., Jin S. and Shi L. 2007. Determination of Transport Properties in Chromium Disilicide Nanowires via Combined Thermoelectric and Structural Characterizations. Nano Lett. 7, 1649-1654.

Tech Fields

- Engineering : Micro & nanotechnologies
- Semiconductors & Integrated Circuits : Components & materials
- Semiconductors & Integrated Circuits : Design & fabrication

For current licensing status, please contact Mark Staudt at mstaudt@warf.org or 608-960-9845