Commentary

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Nanotubes and Carbon Nanowires

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Carbon nanotubes and nanowires are incredibly small wires, sometimes as little as 1 nanometer in diameter. They might be used to make small transistors for computer chips and other electronic devices, according to scientists. Carbon nanotubes have surpassed nanowires in popularity in recent years. We're still learning a lot about these structures, but what we've discovered so far is fascinating. A carbon nanotube is a carbon atom cylinder that is nanoscale in size. Consider a sheet of carbon atoms that resembles a hexagonal pattern. You can make a carbon nanotube by rolling the sheet into a tube. The characteristics of carbon nanotubes are determined by how the sheet is rolled. In other words, although if all carbon nanotubes are comprised of carbon, how the individual atoms are aligned can make a big difference in how they seem.

You can make a carbon nanotube that is hundreds of times stronger than steel but six times lighter by arranging atoms in the appropriate way. Carbon nanotubes are being developed as a building material, particularly for automobiles and aeroplanes. Vehicles that are lighter are more fuel efficient, and the enhanced strength translates to increased passenger safety. With the appropriate atom configuration, carbon nanotubes can also function as effective semiconductors. Carbon nanotubes are still being researched as a viable choice for transistors in microprocessors and other electronic devices.

Nanowires and nanotubes, which have a diameter of a few billionths of a metre but are thousands or millions of times longer, have become popular materials in recent years. They come in a variety of shapes and sizes, including metals, semiconductors, insulators, and organic compounds, and are being researched for applications in electronics, energy conversion, optics, and chemical sensing, among others. Sumio Ijima, a Japanese physicist, is widely credited with the discovery of carbon nanotubes, which are microscopic tubes of pure carbon that are essentially sheets of graphene coiled up into a cylinder (although some forms of carbon nanotubes had been observed earlier). Almost immediately, there was a surge in interest in this unusual variation of a common substance. Nanowires, which are solid crystalline fibres rather than hollow tubes, became popular a few years later. Nanotubes and nanowires are basically one-dimensional due to their remarkable slenderness. “They are quasi-one-dimensional materials,” says Silvija Gradeak, an MIT associate professor of materials science and engineering. “Two of their dimensions are nanoscale scale.” Because of its one-dimensionality, it has unique electrical and optical properties.

For starters, it means that the electrons and photons within these nanowires are subjected to "quantum confinement effects," according to Gradeak. Unlike other materials that exhibit quantum effects, such as quantum dots, nanowires can connect with other macroscopic devices and the outside world because of their length. According to Gradeak, the structure of a nanowire is so basic that there is no room for imperfections, and electrons pass through unhindered. This avoids a major issue with traditional crystalline semiconductors, such as those produced from silicon wafers: There are always faults in certain formations, and those defects prevent electrons from passing through.

Nanowires can be made of a range of materials and “grown” on a variety of substrates using a vapour deposition process. Tiny beads of molten gold or other metals are deposited on a surface; the nanowire material is then absorbed by the molten gold in vapour, eventually growing as a skinny column of the material from the bottom of that bead. It is possible to precisely regulate the size of the produced nanowire by determining the size of the metal bead.

Furthermore, nanowires can be generated from materials that do not normally combine well. Layers of silicon and germanium, for example, are “extremely difficult to develop together in thin films,” according to Gradeak. “However, they can be generated without difficulty in nanowires.” Furthermore, the equipment required for this type of vapour deposition is commonly utilised in the semiconductor industry and can be simply converted for nanowire fabrication.

1D structure such as nanowires and carbon nanotubes (CNTs) has gained a lot of attention in recent years due to their unique features and novel applications. Inorganic materials in various forms have been created. Both vapor-growth and solutiongrowth techniques have been used to generate nanowires [1]. CNTs Many different types of CNTs, including multiwalled and single-walled CNTs, have been generated methods.

Scanning electron microscopy (SEM), as one of the most powerful and manoeuvrable technologies in nanotechnology, has been crucial in the study of nanowires and carbon nanotubes. It's been widely employed in the research of 1D nanomaterials, for things like studying their morphologies at low and high magnifications, validating their orientation, and so on. In this chapter, we look at how SEM can be used to study nanowires and carbon nanotubes.

Wurtzite is a kind of wurtzite. Gallium nitride (hexagonal GaN), a key III–V semiconductor with a direct band gap of 3.4 eV, is an excellent material for UV and blue photon emitters, photodetectors, high-speed field effect transistors, and high-temperature/high-power electronic devices. GaN nanowires have gotten a lot of attention in recent years because of their promise for photonic and biological nanoscale devices such blue light emitting diodes, short-wavelength UV nanolasers, and biochemical sensors. Template growth, laser ablation, and sublimation metal-organic chemical vapour deposition are some of the known synthetic methods for GaN nanowires.