Carbon Nanotubes Make Simultaneous Temperature, Pressure Sensors Possible

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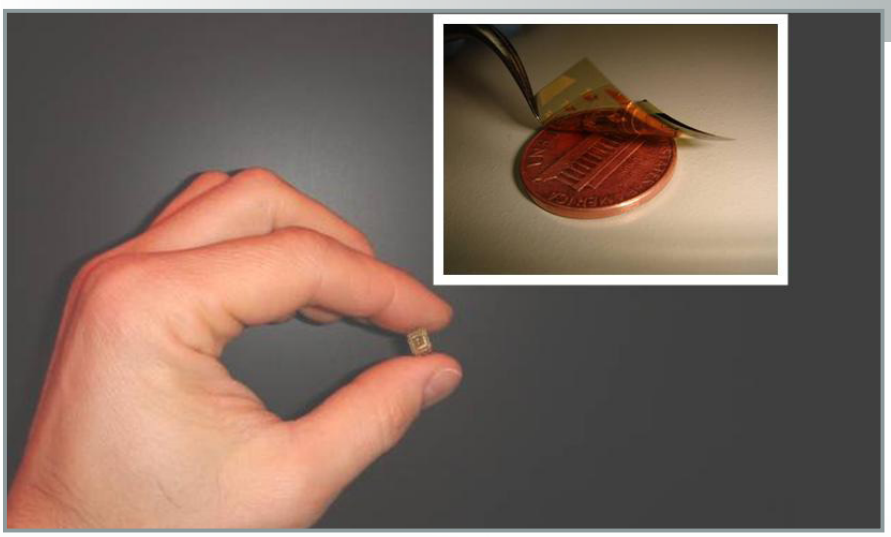

Technology Summary

Carbon nanotubes have high thermal conductivity, an advantage for channeling heat and sensing temperature. The combination of pressure and temperature sensing, with the nanotubes' other unique multifunctional properties—optical transparency, charge dissipation, and electrical shielding strength enhancement—makes the nanotubes attractive for a range of unique applications.

Researchers at ORNL are now adding pressure and temperature sensing to the list of functionalities. They have invented a sensor device containing architectures of bundled nanotubes that can be used to sense temperature and pressure independently, in a single device. The technology offers precise measurements, without these being affected by fluctuations in either system. The sensor readout can then be transmitted wirelessly using radio frequency identification (RFID) technology.

The inventors have arranged the carbon nanotube bundles onto very thin (less than a micron) membranes, in vertical arrays, or as interpenetrating composites. The membrane sensors show temperature sensing with no pressure dependence. Others configurations show sensitivity to pressure, independent of temperature. The temperature sensors can be applied to any surface. They have low power requirements and can operate on alternating voltage of 5 millivolts or less in a broad frequency range.

The researchers produce their own carbon nanotubes by two techniques—laser vaporization of high-quality single-wall carbon nanotubes (SWNTs) and chemical vapor deposition of vertically aligned nanotube arrays (VANTAs)—and then process them into various shapes and composites. SWNT mats form thin, conductive films on substrates which are partially transparent, while VANTAs are highly thermally diffusive, due to the alignment of long nanotubes in a preferred direction. In this way, the invention can exploit both the temperature and pressure sensing capabilities of these two platforms.

The researchers process VANTAs to enable fast linear response to pressure in a wide range of loads when the pressure sensor is placed behind a thick polymer layer. This sensor configuration can be used for touch sensing as well as static-load sensing.

Advantages

Current state-of-the-art utilizes rigid materials, while the flexible nanotubes conform readily to substrates and to techniques such as roll-to-roll processing and spray or inkjet deposition. While polymer-based sensors must separate pressure-related resistance changes from temperature-dependent resistance changes, the two functions can be separated in nanotube-based sensors.

The RFID technology could be implemented using patterned carbon nanotube membranes, thus providing additional functionality to these flexible sensors. This makes it possible to simultaneously measure and wirelessly read out the pressure and temperature sensors.

Potential Applications

Most materials currently being used in devices for sensing temperature and pressure exhibit both responses simultaneously, making it extremely difficult to determine whether a change in temperature, pressure, or both has occurred. The ORNL technology is a combined pressure–temperature sensor for which high temperature and pressure response are achieved simultaneously.

Patent

David B, Geohegan and Ilia N. Ivanov, *Carbon Nanotube Temperature and Pressure Sensors,* U.S. Patent Application 12/547, 562, issued August 26, 2009.

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