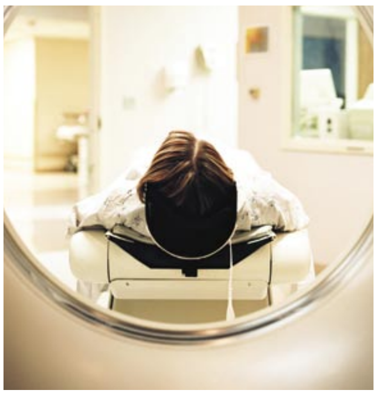
National Aeronautics and Space Administration

nanotechnology

NanoCompass Provides New Capabilities in Magnetometry and Strain Sensing

... using an intrinsically nanoscale technology that reduces power, mass, and size



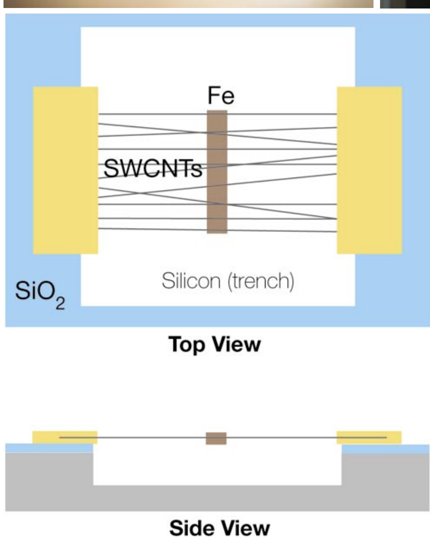


Figure 1.
Schematic of SWCNT magnetometer design. The functional components consist of a mechanically suspended SWCNT basis, a magnetically responsive Fe bar, and electrodes to record an electromechanical response as the Fe needle experiences torque in magnetic field.

Benefits

- Intrinsically nanoscale dimensions enable new capabilities in magnetometry, including determinations of spatial variations in magnetic fields using parallel measurements.
- Temperature resilience makes a wide range of operating conditions possible.
- Superior sensitivity to strain compared to conventional electromechanical materials is achieved through a one-dimensional structure.
- Simple design provides reliability, ensuring uninterrupted operation while reducing power consumption and costs.
- Agile technology is capable of adapting to zero-gravity environments and large, dynamic measurement ranges.

NASA Goddard Space Flight Center invites companies to license a new design of a lightweight, low-power magnetometer based on a single-walled carbon nanotube (SWCNT) network. Called the “NanoCompass,” the sensor’s dimensions are intrinsically nanoscale, allowing for new capabilities in magnetometry. The NanoCompass also demonstrates high resilience to temperature fluctuations, making it ideal for a wide range of operating conditions. Compared to conventional magnetometers in use today, the NanoCompass promises lower power consumption, mass, and size, helping to lower operating costs and increase potential possible applications.

technology opportunity

Applications

Magnetometry:

- *In situ* magnetic field measurements in space
- Attitude control of spacecraft in Earth's orbit
- Study of the magnetosphere of Earth and other planets in orbit

Strain Sensing:

- Military and homeland security
- Oil, gas, and nuclear industries
- Health care diagnostics
- Current sensors/probes for electronics
- Magnetic ink recognition (MICR) readers and RFID tags
- Navigation systems (large-scale and personal)
- Calibration of laboratory field sources (e.g., solenoids, Helmholtz coils)
- Ore analysis (e.g., measuring weak fields in rocks)

For More Information

If you are interested in more information about this technology (GSC-15060-1), please contact:

Innovative Partnerships Program Office
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Technology Details

What It Is

NASA Goddard's NanoCompass is a nanoelectromechanical systems (NEMS)-enabled magnetometer technology that addresses the limited payload allowance expected in next-generation spaceflight missions. The sensor design takes advantage of the sensitivity of SWCNT electrical properties to strain, making very detailed measurements possible. An array of several of these nanoscale magnetometers can be used for high-spatial resolution magnetometry, a capability not possible with most conventional magnetometers.

The magnetometer design is illustrated by the schematic in Figure 1. It consists of a free-standing network of SWCNTs suspended between electrodes and mechanically coupled to a magnetically responsive, high aspect-ratio ferromagnetic component, analogous to a compass needle. Whereas a conventional compass typically employs an optical readout, torque on the Fe needle during operation of the NanoCompass transduces ambient magnetic field strength into an electronic signal. The straightforward design helps to drive high device reliability and robustness, and compatibility with integrated circuit manufacturing suggests easy incorporation into a portable package. Operation of the magnetometer requires additional components, including a voltage supply, current amplifier, and digital data acquisition. Current laboratory testing employs rack-mounted electronic instrumentation and PC-based LabView automated data acquisition, but low-power operation can potentially be supported by a simple battery.

Why It Is better

Compared to Goddard's NanoCompass design, existing fluxgate-type sensors (which utilize electrical current induction in large coils of wire to sense the intensity and spatial direction of magnetic fields) are bulky and inefficient instruments that utilize aging technologies and materials that are suffering a shortage within commercial markets. By contrast, Goddard's design offers orders-of-magnitude reductions in sensor weight and sensor power, enabling redundancy in spaceflight applications without additional propulsion cost. What's more, Goddard's design offers nanoscale measurements, whereas fluxgate designs provide only cm-scale resolution.

In addition, carbon nanotubes exhibit an electromechanical response that is orders-of-magnitude higher in electrical conductance than the response seen in more conventional electromechanical materials, such as silicon. This exceptional sensitivity to strain is partly due to the nanotube's one-dimensional nature and makes the carbon nanotube material ideal as a structural and electronic foundation for a strain-based magnetometer. While taking advantage of their sensitivity to strain, Goddard's magnetometer design also overcomes the difficulties inherent in using SWCNTs, such as avoiding inhomogeneities in electronic properties (SWCNTs can vary from semiconducting to metallic) and precisely placing individual tubes. Finally, Goddard's use of an as-grown chemical vapor deposited network requires minimal processing of the SWCNTs used in the sensor, hence minimizing defects and impurities common to solution-processed nanotubes.

Patents

NASA Goddard is seeking patent protection for this technology.

Licensing and Partnering Opportunities

This technology is part of NASA's Innovative Partnerships Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the Design of a Lightweight, Low-power Magnetometer based on a Single-Walled Carbon Nanotube Network technology (GSC-15060-1) for commercial applications. For information and forms related to the technology licensing and partnering process, please visit the Licensing and Partnering page (http://techtransfer.gsfc.nasa.gov/lic-partnerships.html).