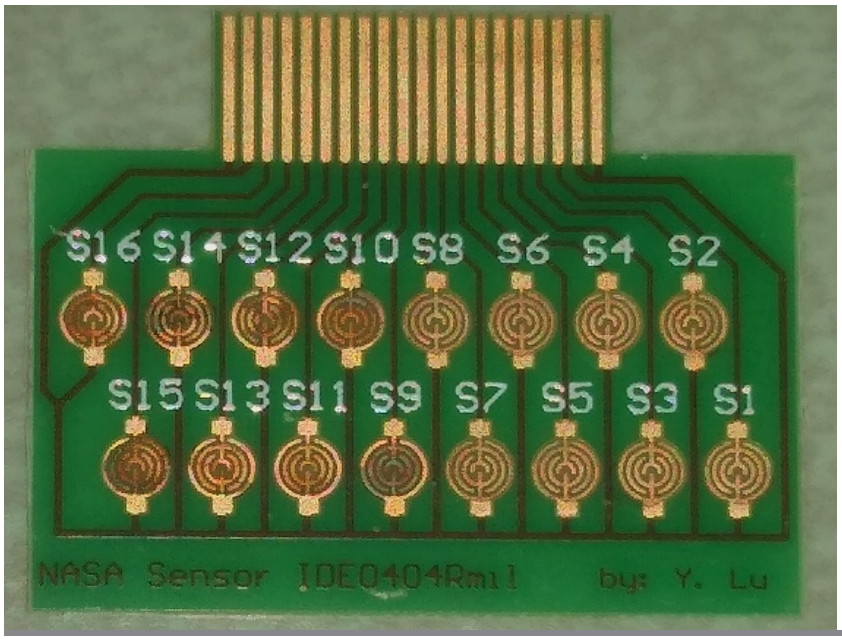


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Sensors

Solid State Carbon Dioxide (CO2) Sensor

Miniaturized, chip size solid state CO2 sensor

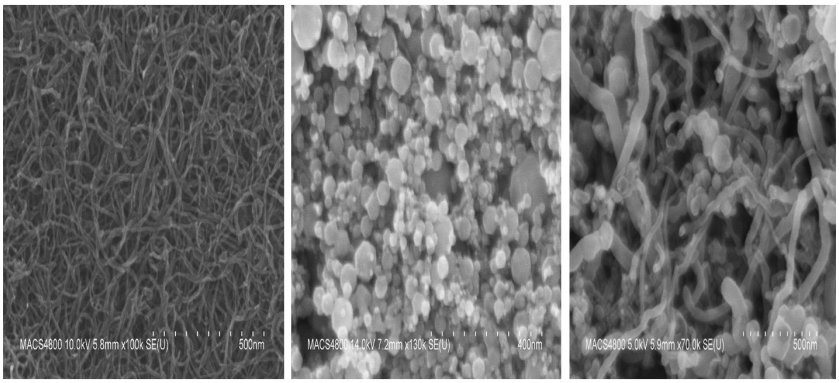
Detection of Carbon Dioxide (CO2) is very important for environmental, health, safety and space applications. CO2 is a harmful pollutant at higher concentrations due to its ability to displace oxygen in large concentrations. Current commercial sensors for CO2 have issues and shortcomings particular with precision at different temperatures, pressures and high humidity levels. NASA Ames has developed a novel solid state, CO2 sensor configured for sensitive detection of CO2 having a concentration within the range of about 100 Parts Per Million (ppm) and 10,000 ppm in both dry conditions and high humidity conditions. The composite sensing material comprises Oxidized Multi-Walled Carbon Nanotubes (O-MWCNT) and a metal oxide. The composite sensing material has an inherent resistance and corresponding conductivity that is chemically modulated as the level of CO2 increases. The CO2 sensor can be easily integrated into existing electronic circuitry and hardware configurations, including the hardware of a mobile computing device, such as a smart phone or tablet device.

BENEFITS

- Accurate and rapid response - quickly provides accurate readings (in seconds) at different temperatures and pressures
- High CO2 sensitivity: CO2 can be measured in the 100-10,000 ppm range
- Operates at room temperature: Unlike standard metal oxide sensors which must operate at ~300 Celsius or higher, these sensors operate at room temperature (~25 Celsius)
- Small footprint: Chips can be made 0.5 cm x 0.5 cm x 3 mm size with multiple sensors per chip
- Light weight: Sensor only weighs a few grams
- Low cost and low power: Less than 50 microwatts are required for power, and the sensor functions on a change in resistivity
- Easy to integrate: Can be easily coupled with existing programmable electronic or hardware systems
- Sensor is solid state; so extra materials are required to maintain operation
- Provides in-situ monitoring; and calibration of the CO2 sensor that can be automated

THE TECHNOLOGY

The technology is a solid state, Carbon Dioxide (CO2) sensor configured for sensitive detection of CO2 having a concentration within the range of about 100 Parts per Million (ppm) and 10,000 ppm in both dry conditions and high humidity conditions (e.g., > 80% relative humidity). The solid state CO2 sensor achieves detection of high concentrations of CO2 without saturation and in both dynamic flow mode and static diffusion mode conditions. The composite sensing material comprises Oxidized Multi-Walled Carbon Nanotubes (O-MWCNT) and a metal oxide, for example O-MWCNT and iron oxide (Fe2O3) nanoparticles. The composite sensing material has an inherent resistance and corresponding conductivity that is chemically modulated as the level of CO2 increases. The CO2 gas molecules absorbed into the carbon nanotube composites cause charge-transfer and changes in the conductive pathway such that the conductivity of the composite sensing material is changed. This change in conductivity provides a sensor response for the CO2 detection. The solid state CO2 sensor is well suited for automated manufacturing using robotics and software controlled operations. The solid state CO2 sensor does not utilize consumable components or materials and does not require calibration as often as conventional CO2 sensors. Since the technology can be easily integrated into existing programmable electronic systems or hardware systems, the calibration of the CO2 sensor can be automated.



A B C

FE-SEM images for (A) oxidized MWCNTs deposited onto a silicon substrate, (B) iron oxide nanoparticles and (C), oxidized MWCNT/ iron oxide composite material.

APPLICATIONS

The technology has several potential applications:

- Wearable sensor for environmental monitoring
- Astronaut atmospheric monitoring; CO2 in a space suit, particularly within the astronauts' helmets
- Modified atmospheres or closed crew cabin to continuously monitor real-time CO2 concentrations for permissible exposure limit levels; space-medicine
- Determining the catalyzing efficiency of the CO2 splitting process; in-situ resource utilization of CO2 on Mars
- Aerospace industry - for cabin air monitoring on the airplane
- Medical diagnosis and monitoring
- Indoor air quality
- Stowaway detection
- Monitoring landfill gas
- Confined spaces; Cryogenics; Ventilation management, Mining industry
- Rebreathers (SCUBA)
- Cellar and gas stores; Marine vessels, and Greenhouses
- Food industry
- Monitoring global warming
- CO2 scrubber industry

PUBLICATIONS

Patent No: 11,719,660

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6767332/

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NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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More Information

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