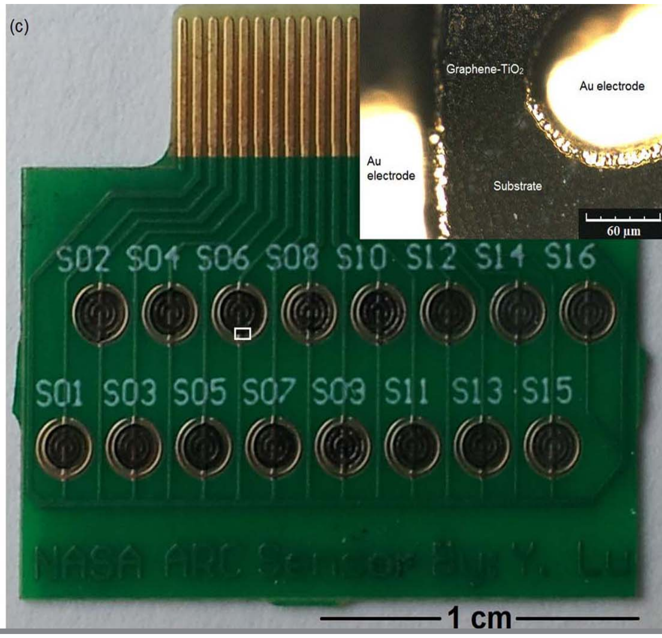


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Sensors

Room temperature oxygen sensors

Small, low-cost, low-power, mass-producible oxygen sensors with room temperature operation

Oxygen (O_2) sensors are used in a wide array of applications, including electronic fuel injection and emissions control in the automotive industry, for monitoring oxygen levels in controlled environments, such as in space craft or space suits, for oxygen monitoring in medical and pharmaceutical applications, and many more. Traditional oxygen sensors, including potentiometric and amperometric sensor designs, have significant drawbacks, as metal oxide gas sensors require high temperature operation of about 300°C, and suffer from high power consumption. NASA Ames Research Center has developed novel oxygen sensors made of a hybrid material comprising graphene and titanium dioxide (TiO_2) that is capable of detecting O_2 gas at room temperature and ambient pressure. The sensors have fast response and recovery times and can also be used to detect ozone. The sensors can be integrated into wearable-sized Internet of Things (IoT) devices.

BENEFITS

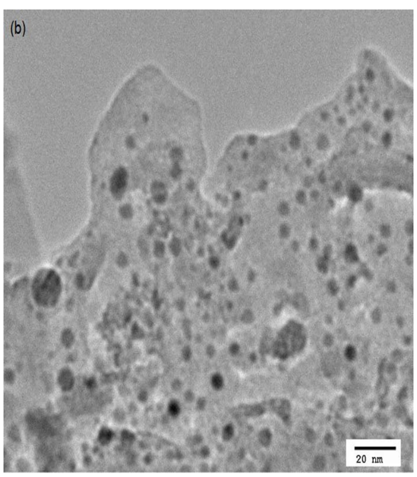
- Composite hybrid graphene-TiO2 material allows O2 sensing at room-temperature operation, unlike traditional metal-oxide sensors
- Able to detect oxygen at concentrations ranging from about 0.2% to about 10% by volume under 365nm UV light, and at concentrations ranging from 0.4% to 20% by volume under short wave 254nm UV light
- Fast response and recovery times
- Small footprint that is one tenth (10%) the size current commercial O2 sensors, and has potential to be integrated in wearable-size IoT devices
- Mass producible: the sensor chip has the potential to scale to thousands or millions of units relatively easily and inexpensively via automated wafer-scale manufacturing processes
- Low-cost and ease of manufacturing: lower cost than current O2 sensors, as it is chip-based and can be manufactured via wafer scale fabrication in low-cost automated manufacturing processes to produce multiple chips on a single wafer
- May be integrated into an artificial intelligence device

THE TECHNOLOGY

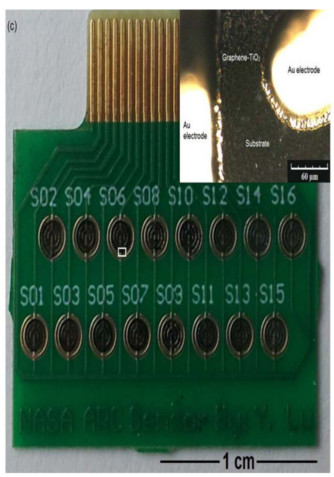
NASA Ames has developed very small-sized oxygen sensors made of a graphene and titanium dioxide (TiO_2) hybrid material. With ultraviolet (UV) illumination, these sensors are capable of detecting oxygen (O_2) gas at room temperature and at ambient pressure. The sensors are able to detect oxygen at concentrations ranging from about 0.2% to about 10% by volume under 365nm UV light, and at concentrations ranging from 0.4% to 20% by volume under short wave 254nm UV light. These sensors have fast response and recovery times and can also be used to detect ozone.

This unique room temperature O_2 sensor provides significant advantages in O_2 sensing applications, especially those applications where high operating temperature requirements cannot be met, or would result in inefficient manufacturing processes. Since graphene is not intrinsically responsive to O_2, and TiO_2 is not responsive to oxygen at room temperature, the materials are first synthesized as a hybrid material. The synthesized graphene- TiO_2 hybrid material is then ultrasonicated and then drop-casted onto a series of Interdigitated Electrodes (IDE) to form the sensors.

Ultrasonication ensures effective charge transfer at the graphene- TiO_2 interphase. The graphene and the titanium dioxide may be present in the composite material in different ratios to ensure optimal oxygen detection. It is the combination of graphene with TiO2 that yields a semiconducting material capable of O_2 sensing at room-temperature operation.



A SEM image of the graphene and titanium dioxide hybrid material for oxygen sensing



16 identical oxygen sensors on a PCB chip with insert shows the detail of Graphene-TiO2 deposited between gold electrodes

APPLICATIONS

The technology has several potential applications:

- Oxygen sensor manufacturers
- Automotive combustion control and emissions control applications
- Chemical sensing
- Hybrid material development
- Spacecraft cabin
- Environmental monitoring
- Medical applications
- Food processing industry
- Steel and cement production industry
- Laboratory safety
- Electronic fuel injection industry
- Space suits and helmets

PUBLICATIONS

Patent No: 11,796,457

technology.nasa.gov

More Information

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