BISMUTH FERRITE-BASED FLEXIBLE DEVICE FOR ROOM TEMPERATURE GAS SENSING

IITM Technology Available for Licensing

Problem Statement

- **Toxic gas (NO_2/CO_2) sensors** require **elevated temperatures** (150-500°C) that **complicate integration with electronics** and result in high energy consumption.
- Conventional sensors are hence **limited in their applications in real-world environments** such as residential, industrial, and commercial spaces.
- **Current sensors cannot detect these gases at room temperature (25-40°C),** while pollutant levels in industrial exhaust are often at ambient temperatures.
- There is a need for **a flexible nanocomposite-based gas sensors** that can **operate efficiently at room temperature**

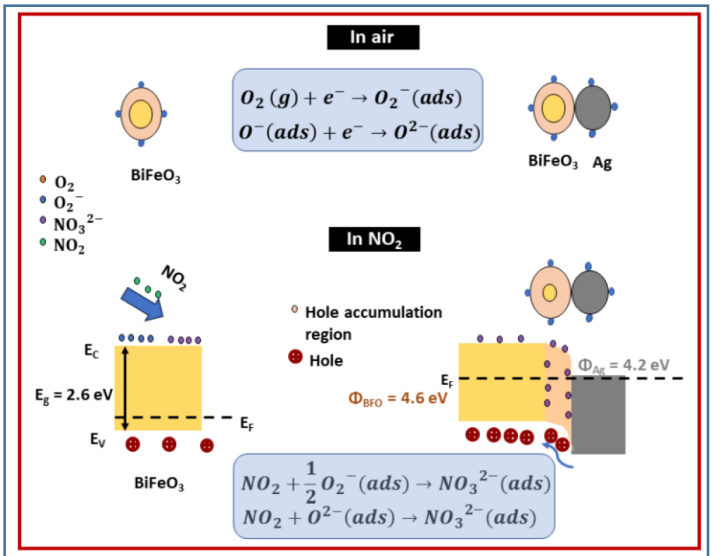

Figure: An illustration of the NO_2 sensing mechanism for $BiFeO_3$ – Ag NW (BFO-Ag NW) heterojunction.

Intellectual Property

- IITM IDF Ref 2653
- **IN 549328 Patent Granted**

TRL (Technology Readiness Level)

TRL 4 Technology Validated in Lab

Technology Category/ Market

Category- Micro & Nano Technologies
Industry Classification:
Air quality testing equipment manufacturing, Manufacturing of Gas sensors;
NIC (2008)- 26512 Manufacture of automotive emissions testing equipment; **2610-** Manufacture of electronic components
Applications:
Environmental Monitoring and Air Quality Control ; Industrial Emissions Detection; Wearable and Flexible Environmental Sensors; Smart Building and HVAC Systems
Market report:
The global gas sensor market was valued at USD 1.5 Billion in 2023 and is projected to grow to USD 2.3 Billion by 2028 with a CAGR of 9.7 %

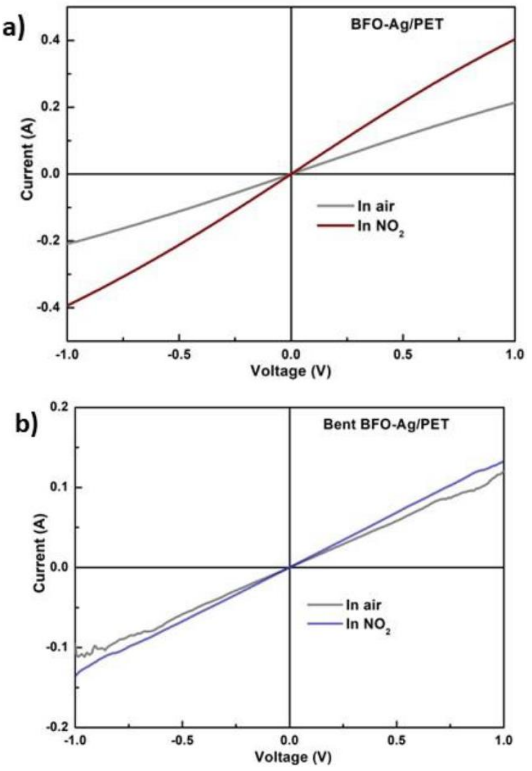

Figure: It is evident from the current-voltage characteristics of $BiFeO_3$-Ag/PET that the device in **(a)** straight device as well as **(b)** bent conditions exhibited appreciable response to NO_2 even at a low voltage of 1 V exhibiting its potential for use in low powered sensors for practical application

Research Lab

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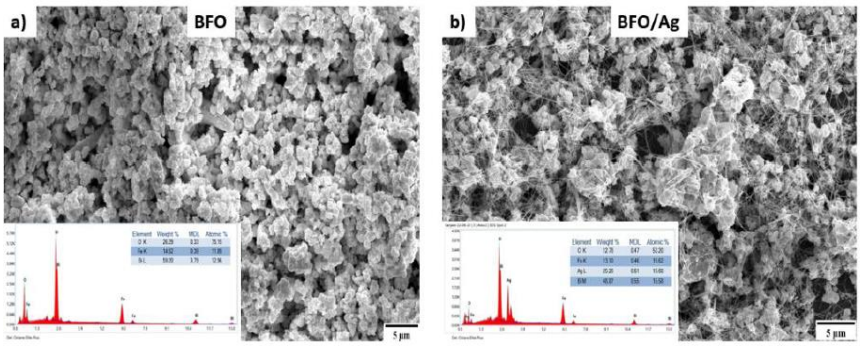

Figure: Surface morphology of **(a)** pristine BFO nanoparticle film and **(b)** BFO-Ag NW nanocomposite with BFO nanoparticles in a network of Ag nanowires. Inset images show EDS spectra peaks for Bi, Fe, O confirming stoichiometric phase formation in (a) and Bi, 15 Fe, O with Ag peaks in (b).

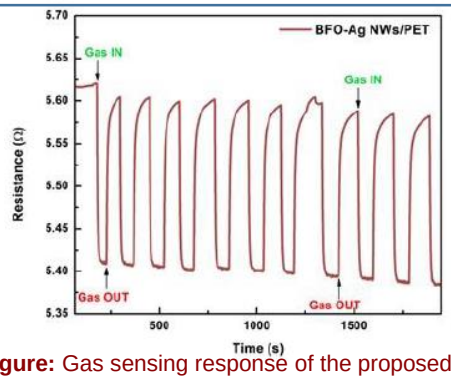

Figure: Gas sensing response of the proposed sensor with flexible substrate as well as for rigid substrates including glass and quartz, observed by the change in resistance with time as a function of target gas exposure which is CO2.

Technology

The invention features a flexible gas sensor fabricated on substrates like PET, glass, or quartz, making it suitable for wearable electronics and flexible applications, with a lightweight and bendable structure.

The sensor uses a composite of $BiFeO_3$ nanoparticles and silver nanowires (Ag NWs), enhancing gas adsorption, charge carrier mobility, and overall sensitivity for NO_2 detection, with Ag providing a conductive network for faster response.

This sensor operates efficiently at room temperature (25-40°C), requiring only 1V for NO_2 detection, ensuring low power consumption and suitability for portable, battery-powered devices without the need for heating elements.

The p-type $BiFeO_3$-Ag composite demonstrates an effective sensing mechanism where NO_2 gas interaction reduces resistance, aided by Ag nanowires enhancing electron capture, enabling quicker response and higher sensitivity compared to traditional metal oxide sensors.

The sensor shows fast response (7s) and recovery (8.5s) times, outperforming conventional gas sensors. Its performance remains consistent even on flexible substrates, offering high stability, reproducibility, and reliable gas detection in dynamic environments.

Key Features / Value Proposition

- The magnitude of resistance change observed is 0.2 Ω which translates to a 5 A current signal at a low voltage of 1 V, implying superior gas response compared to state-of-art MOS-based NO_2 sensors.
- The sensor is fabricated on flexible substrates, such as polyethylene terephthalate (PET), making it suitable for integration into flexible electronics and wearable devices.
- The sensor exhibits stable performance over multiple cycles, with resistance returning to baseline after gas exposure. This durability, combined with good reproducibility, ensures reliable and repeatable NO_2 detection, making it more practical for real-world applications than many sensors that suffer from drift or loss of sensitivity over time.
- The sensor offers versatility in terms of applications. It is also capable of detecting a wide range of oxidizing/reducing gases (CO_2 detection has also been demonstrated), expanding its potential use in various environmental monitoring and industrial applications.

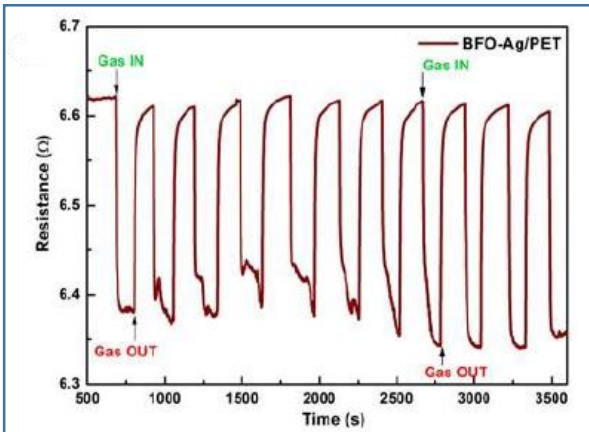

Figure: Shows the gas sensing response exhibited by the BFO-Ag nanocomposite devices on PET substrates at room temperature for static gas purging conditions of 0.2 ppm NO_2. The magnitude of resistance change observed is 0.2 Ω which 25 translates to a 5 A current signal at a low voltage of 1 V, implying superior gas response compared to state-of-art MOS-based NO_2 sensors.

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