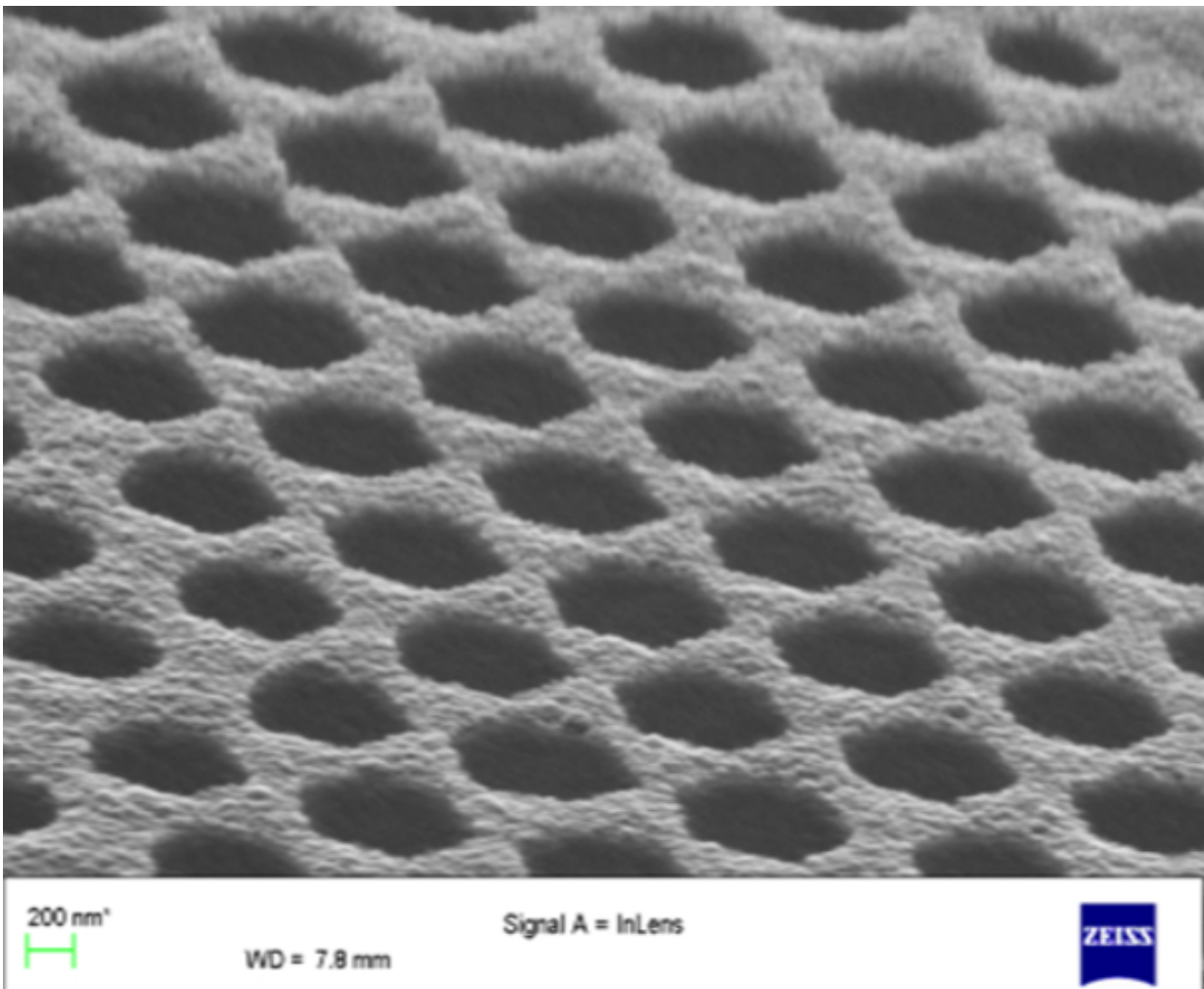


Low-cost CO sensor developed using nanoscale honeycomb structures

July 14 2017



Honeycomb type ZnO nanostructure. Credit: Indian Institute of Science

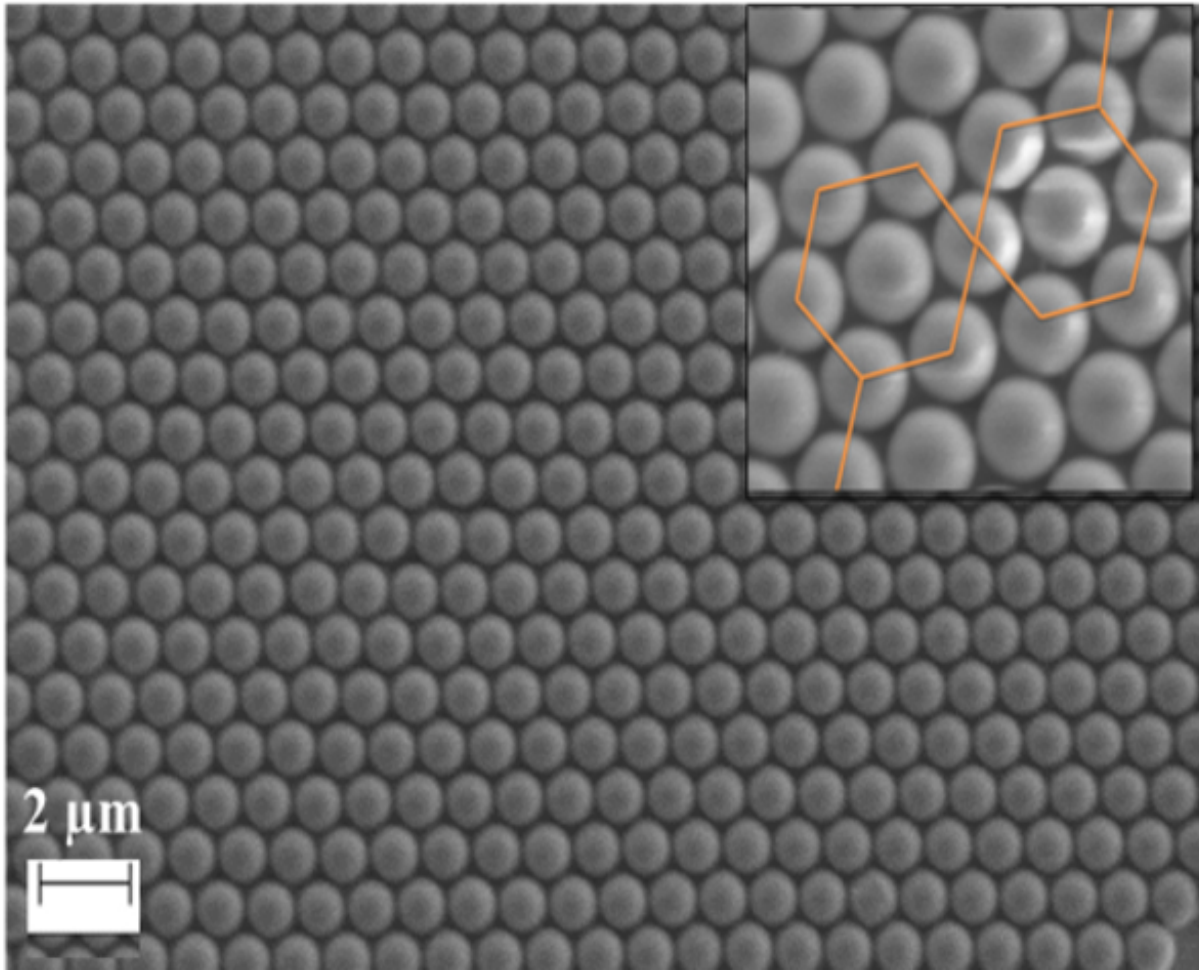
Researchers at the Indian Institute of Science (IISc) have developed a highly sensitive, low-cost nanosensor that can quickly detect minute changes in carbon monoxide (CO) levels, with potential applications in environmental pollution monitoring.

The team used a novel fabrication technique that leaves out lithography, a time-consuming and expensive process, to construct a honeycomb-like nanostructure made up of [zinc oxide](#). The sensor was able to detect a difference in CO level as low as 500 parts per billion and selectively respond to CO even in the presence of other gases. The non-lithography technique also significantly cuts down the time and cost involved in making nanostructured [gas sensors](#).

The study was carried out by Chandra Shekhar Prajapati, postdoctoral fellow, and Navakanta Bhat, Chair & Professor, Centre for Nano Science and Engineering (CeNSE), IISc, along with researchers at the KTH Royal Institute of Technology, Sweden.

"The size of the sensor itself is less than 1 mm," says Bhat. "If you combine it with the rest of the signal processing electronics and a small display, it may not be more than a couple of cm. This can be integrated with a cell phone or a small device at every traffic signal which can transmit the data to your cell phone through Bluetooth."

Conventional micro-machined CO [sensors](#) have a flat layer of zinc oxide, a [metal oxide semiconductor](#), through which current flows. When exposed to CO, the resistance of the layer changes, affecting the amount of current flowing through. How much the resistance changes can be mapped to how much CO there is.



Hexagonal arrangement of polystyrene beads. Credit: Indian Institute of Science

Creating nanostructures on flat zinc oxide improves the sensitivity, as the area available for gas interaction increases. However, making these nanosensors using traditional lithography—a time-consuming, multi-step process in which metal oxide templates are etched on a light-sensitive material—requires sophisticated equipment.

Instead, the researchers used tiny beads of polystyrene that arrange themselves into a closely packed layer when spread on an oxidized silicon surface. When zinc oxide is added, it settles into the hexagonal

gaps between the beads. When the beads are then "lifted off," what remains is a 3-D honeycomb of zinc oxide, with a much larger surface area available for gas interaction than a flat plate.

The technique could cost significantly less than lithography-based methods, the researchers say. "You can buy a packet of these micron-sized polystyrene beads on the market for Rs. 4000-5000, which can be used to create nanostructures on thousands of sensors. This results in significant cost reduction compared to traditional lithography-based techniques to form such honeycombs," says Prajapati. In addition, the process only takes a few minutes, while lithography-based multi-step methods can take a few hours, he adds.

For environmental applications, gas sensors need to be both highly sensitive (detect very low levels) and selective (detect a specific gas in the presence of other gases). The researchers developed sensors with varying honeycomb wall width, and found that the one with the smallest width (~100 nm) was able to detect a change of even 500 parts per billion in CO concentration. When tested with a mixture of gases, the sensor also showed a distinctly greater response for CO.

The polystyrene-based method can be used to develop similar honeycomb nanostructures for other metal oxides to detect other gases, the researchers say. "What we have is a generic platform. You can do the same nano-structuring for different metal [oxide](#) semiconductor sensors," says Bhat.

Bhat and his team have been working on developing miniature sensors for air quality monitoring for several years. They previously developed a hybrid sensor array to detect four different gases simultaneously.

More information: C.S. Prajapati et al, Honeycomb type ZnO nanostructures for sensitive and selective CO detection, *Sensors and*

Actuators B: Chemical (2017). [DOI: 10.1016/j.snb.2017.06.070](https://doi.org/10.1016/j.snb.2017.06.070)

Provided by Indian Institute of Science

Citation: Low-cost CO sensor developed using nanoscale honeycomb structures (2017, July 14)
retrieved 20 March 2024 from <https://phys.org/news/2017-07-low-cost-sensor-nanoscale-honeycomb.html>

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