This First Non-Chemical Gas Sensor based on Freestanding Nanowires

Conventional nanowire based gas sensors suffer from selectivity and reversibility issues. This is because they react based on changes in the electrical properties of the catalyst upon exposure to gas, while different gases when adsorbed may induce similar changes.

Gas ionization sensors (GIS) built around carbon nanotubes, were mainly introduced to solve the selectivity issues of the catalyst-based devices. These sensors work by fingerprinting the ionization breakdown voltage of the unknown gas. It is well-known that at a constant temperature and pressure every gas displays a unique breakdown electric field. Since this technique does not involve any chemical reaction, ionization sensors are not limited by considerations of reversibility and display fast response and recovery times compared to their catalyst-based counterparts.

In an alternative approach, in this research, we are to introduce a novel gas sensor that uses the tunneling field-ion $I-V$ characteristic as a fingerprint to identify the unknown gas type and measure its concentration. The phenomenon of field ionization consists of extracting an electron (or electrons) from gas atoms (molecules), using positive high electric fields generated at sharp tips. It has been widely used in field-ion microscopy and mass spectrometry. However, the electric fields required to field-ionize gaseous species are in the range of $2–5 \text{ V} / \mu \text{m}$, orders of magnitude higher than their electric breakdown fields. An ionization cell is being designed in a manner to prevent electrical breakdown.

With the provision of low voltage operation, this method can be utilized in detection of gases at very low concentrations. In addition, because this technique does not involve adsorption or desorption of gases, the sensor exhibits a fast response and is not limited by considerations of reversibility and recovery. The project entails fabrication of high aspect ratio field-intensifying nanostructures, and then tailoring these nanostructures to enable field-ionization of gas molecules at sub-10V voltages. The
sensor will be characterized in a custom-made vacuum chamber with several gas inlets and electrical feedthroughs.