

# Room-temperature Drift Reduction in Chemoresistive Gas Sensors by UV Illumination Tuning

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## Summary:

Chemoresistive metal-oxide gas sensors are attractive for low-cost sensing but typically require elevated temperatures to operate and suffer from baseline drift that degrades long-term accuracy. We report a room-temperature strategy to mitigate drift by illuminating site-selectively grown tin oxide (SnO<sub>2</sub>) nanowire (NW) assemblies with ultraviolet (UV) light. By choosing the illumination wavelength and tuning the light intensity, the nanowire electrical behavior transitions from semiconducting to metallic, and gas-response magnitude and speed can be adjusted, while the baseline slope is reduced 3 orders of magnitude. The approach aims at reducing the need of frequent recalibration against external reference instruments for practical deployments.

**Keywords:** photoactivation, tin oxide nanowires, baseline drift, room-temperature sensing, sulfur gases

## Headlines

- UV activation of semiconducting nanowire assemblies enables control over response speed and magnitude at room temperature.
- Increasing illumination intensity can minimize baseline drift, reducing the need for frequent external calibration.
- In SnO<sub>2</sub> NWs, a light-driven transition in electrical behavior accompanies improved sensing dynamics for sulfur gases.

## Background, Motivation and Objective

Crystalline metal-oxide (MOx) chemoresistive gas sensors have been widely investigated and commercialized due to their sensitivity, robustness, miniaturization potential, and comparatively low cost. However, optimal operation often requires heating (typically 100–400 °C) [1], which complicates integration in everyday electronics and increases power consumption. In addition, baseline drift limits precision over time, increasing dependence on reference-grade instruments and frequent recalibration—undermining the low-cost advantage.

Here, our objective is to improve the reliability of MOx chemoresistors by operating at room temperature while reducing baseline drift, paving the

way towards denser and more affordable sensing networks to complement limited numbers of reference monitoring stations.

## Description of the New Method or System

We use UV light to activate site-selectively synthesized SnO<sub>2</sub> NW sensor devices at room temperature. SnO<sub>2</sub> NWs were site-selectively synthesized by chemical vapor deposition via a vapor-liquid-solid mechanism bridging pre-patterned Cr/Pt electrodes, yielding functional devices within hours. Material quality and crystallinity were confirmed by X-ray diffraction, NW semiconducting nature via I–V electrical measurements, and their indirect bandgap of ~3.5 eV by means of UV–Vis transmission.

Gas measurements were carried out in a custom stainless-steel chamber and using Bronkhorst mass-flow controllers and a Keithley 2400 SourceMeter. Sensors were exposed to 200 ml·min<sup>-1</sup> flows of dry or humid air with pulses of regulatory-relevant concentrations of H<sub>2</sub>S, SO<sub>2</sub>, CO<sub>2</sub>, CH<sub>4</sub> and CO, under dark conditions and under 360 nm illumination at intensities up to ~90 µW. The novelty resides in the systematic tuning of illumination intensity to simultaneously (i) modulate the nanowire electrical response to

surrounding gases and (ii) reduce baseline drift while maintaining room-temperature operation.

## Results

Under increasing UV intensity, n-type SnO<sub>2</sub> NW devices progressively shifted from semiconducting behavior (double-Schottky-like) in the dark to ohmic behavior above approximately 20  $\mu$ W (see Fig.1), whereas p-type NW devices remained ohmic across the studied conditions. Among the tested gases, both device types responded to H<sub>2</sub>S and SO<sub>2</sub>. Notably, p-type SnO<sub>2</sub> responded to SO<sub>2</sub> only in humid atmospheres, while n-type devices responded under both dry and humid conditions.

Stronger illumination led to faster response dynamics (see Fig.2), e.g. reducing response time to 1.25 ppm SO<sub>2</sub> from ~16 minutes in dark conditions to <3 minutes under 50  $\mu$ W, while the relative response exhibited a maximum of ~40% around ~20  $\mu$ W (6 minutes). Notably, increasing light intensity, especially above ~20  $\mu$ W in p-type SnO<sub>2</sub>, also reduced baseline drift, i.e., baseline slope changed from  $1.8 \cdot 10^{-2}$   $\Omega$ /s at 13  $\mu$ W to  $-2.7 \cdot 10^{-5}$   $\Omega$ /s at ~90  $\mu$ W (see Fig.3). These trends are consistent with a sequence in which photo-generated carriers reduce the effective barrier, on-setting a tunneling-dominated transport regime, while above certain illumination intensity desorption of pre-adsorbed surface species is promoted. Building on this photon–SnO<sub>2</sub> interaction analysis, we will outline a procedure intended to enable sensor self-recalibration at room temperature, targeting reduced dependence on frequent external calibration.

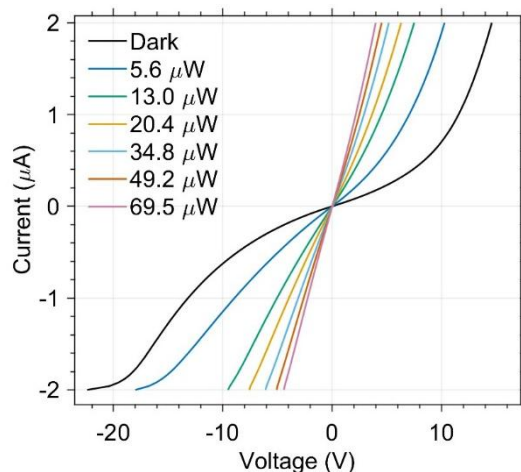


Fig. 1. Current–voltage (I–V) characteristics of Pt/n-type SnO<sub>2</sub>/Pt exhibiting double Schottky behavior under dark conditions and ohmic above ~20  $\mu$ W.

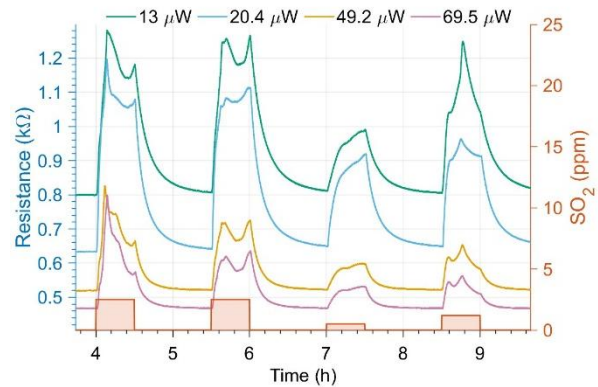


Fig. 2. Resistance as a function of time when n-type SnO<sub>2</sub> is exposed to alternating pulses of sulphur dioxide and to different light intensities where it can be observed the variation magnitude and speed of response.

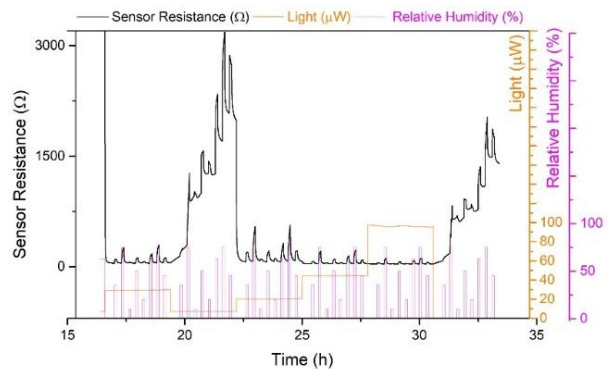


Fig. 3. Resistance over time when p-type SnO<sub>2</sub> is exposed to alternating pulses of relative humidity where the effects of drift reduction and changes in the magnitude and speed of response can be observed when the illumination intensity varies.

## References

- [1] P. Shankar, J.B.B. Rayappan, Gas sensing mechanism of metal oxides: The role of ambient atmosphere, type of semiconductor and gases - A review, *Science Letters Journal* 4, 126 (2015); doi: NA.

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