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A Multi-MOx Sensor Approach to Measure Oxidizing and Reducing Gases

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Reliable and real-time measurements of gaseous pollutants (e.g., NO₂ and CO) in both indoor and outdoor air are required to implement worldwide air quality legislation designed to protect human health and the environment. While electrochemical sensors are popular for air quality monitoring due to their fast and linear response, low power consumption and excellent selectivity, some applications operate in environments that extend beyond their capability. Gas sensors based on semiconducting metal oxides (MOx) technology offer advantages such as high sensitivity, low manufacturing cost, miniaturization potential and long lifetime. Commercially available MOx sensors are typically based on n-type SnO₂, WO₃ or versions thereof modified by the presence of precious metal catalysts such as Pt or Pd. The shortcomings of these materials i.e. baseline drift, humidity interference and cross-sensitivity to nuisance gases, are well-known. Moreover, exposure to oxidizing and reducing gases have reverse effects on a MOx electrical conductance, governed by its semiconducting characteristics. This introduces a key challenge in interpreting the response of a single MOx sensor exposed to a mixture of oxidizing and reducing gases.

To address the aforementioned shortcomings, Alphasense and partners have adopted a "Multi-MOx"array approach, where p-type and n-type metal oxide sensing elements are combined on a single ceramic chip. A Platinum heater on the underside of the chip heats the sensor to the desired operating temperature. The sensor discussed here is comprised of:
1. p-type CTO (titanium-doped chromium trioxide), a ternary oxide which provides a stable baseline, minimal humidity interference and high sensitivity to reducing gases such as CO, and
2. n-type WO₃, a binary oxide with excellent sensitivity to oxidizing gases such as NO₂ and O₃.
In the case of p-type CTO, exposure to CO causes a decrease in the charge carrier (hole) concentration in the near-surface region and a decrease in the measured conductance. Whereas, the measured resistance of n-type WO₃ increases in exposure to NO₂ due to an increase in the density of charge carriers (electrons) trapped at the oxide surface (see Fig. 1). The use of different MOx materials in conjunction with operating temperature modulation and advanced on-chip filtering can be used to reliably measure both oxidizing and reducing gases. This report summarizes our recent work on the p-type/n-type Multi-MOx gas sensor platform.

Summary

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