

# Special Issue “Advanced Materials for Gas Sensors”

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Today’s view on gas sensors end-users is more directed toward miniaturization, low power consumption, and intelligent device integration aiming to reply to several hot issues such as high sensitivity, optimum selectivity, fast response/recovery transients, and good long time stability. Spanning the literature related to the gas-sensitive materials, one has to admit that most of the work has been carried out via a trial-and-error approach.

Establishing sensor selective sensitivity for specific gases is challenging, and it depends on many parameters, such as gas adsorption, surface reaction kinetics, and charge transfer from the semiconductor. Thus, a fundamental understanding of the involved processes with specific gas-sensitive materials is of crucial importance for the future unveiling of the structure-functioning relationships.

To meet the increased demand for low power consumption gas-sensing devices, Lee et al. [1] prepared a hybrid composite gas sensor made of tin oxide and reduced graphene oxide with good sensing performances toward CO<sub>2</sub> detection when operating at room temperature. The sensing mechanisms involved in the CO<sub>2</sub> detection were described under a pure nitrogen atmosphere and in the presence of 50% relative humidity. It was demonstrated that based SnO<sub>2</sub>-rGO exhibit a sensor signal to 100 ppm CO<sub>2</sub> of 6.7 times higher than that of simply reduced graphene oxide. The gas interaction of the SnO<sub>2</sub>-rGO hybrid composite was attributed to the high conductivity and active sites of p-n heterojunctions.

Another study [2] focused on H<sub>2</sub>S detection under the presence of humidity using CuWO<sub>4</sub>-based gas sensors. A comprehensive study was conducted in order to explain the major role played by the native Cu(OH)<sub>2</sub> surface layers within the sensing mechanism. Herein, the authors merged insights about structural, morphological, and surface chemistry with phenomenological gas-sensing investigations (via simultaneous electrical resistance and contact potential difference), aiming to highlight the way in which surface hydroxylation plays a major role toward H<sub>2</sub>S sensing. Importantly, a theoretical approach was developed in order to link the as-obtained sensing behavior with the intrinsic properties (in terms of Debye length).

Bratu et al. [3] analyzed the gases released by Golden Delicious apples over a defined period. By using CO<sub>2</sub> laser photoacoustic spectroscopy, the researchers determined low traces of ethylene, ethanol, and ammonia. This is a straightforward investigation method able to provide realistic information about gas species in the downstream gas. According to their results, as the concentration of ethanol increases, ethylene production decreases, and ammonia concentration in the downstream gas increases. Although these outcomes were not connected with an appropriate sensing mechanism, they can be further linked to postharvest fruit management.

In the paper [4], the authors employed CeO<sub>2</sub>:Mn<sub>3</sub>O<sub>4</sub> mesoporous micro-pellistors toward CH<sub>4</sub> detection under the presence of 50% relative humidity. It was found that besides porosity, also the molar ratio between CeO<sub>2</sub> and Mn<sub>3</sub>O<sub>4</sub>, exhibits a major contribution toward CH<sub>4</sub> combustion temperature. Based on the correlation with the additional investigations such as XPS, TPR, and Raman, we found that a few important factors merge toward enhancing the catalytic behavior. These are high surface-to-volume ratio, oxygen vacancies formation, and increased reducibility. It was demonstrated that CeO<sub>2</sub>:Mn<sub>3</sub>O<sub>4</sub> with a 7:3 molar ratio exhibited a parabolic dependence of the catalytic behavior with



**Citation:** Simion, C.E. Special Issue “Advanced Materials for Gas Sensors”. *Materials* **2021**, *14*, 6765. <https://doi.org/10.3390/ma14226765>

Received: 14 October 2021

Accepted: 1 November 2021

Published: 10 November 2021

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respect to the CH<sub>4</sub> concentration. A schematic approach of the involved phenomena was addressed, aiming to follow the logical pathway of the catalytic mechanism.

In the work of Ramanavičius et al. [5], non-stoichiometric WO<sub>3</sub>-based gas sensors were tested toward different volatile organic compounds such as methanol, ethanol, isopropanol, acetone, and additionally to ammonia. Knowing that the operating temperature plays an important role with respect to sensitivity, selectivity, and the associated kinetics, and further transduced in response/recovery transients, the authors tested WO<sub>3</sub> sensors over a wide range of temperatures—spanning from 60 °C up to 270 °C. According to their results, apart from the fact that the analytical sensor signals vary with the operating temperature, an additional dependence feature was observed in relation to the structural properties. The main outcome of this work is reflected through the low operating temperature of WO<sub>3</sub>/WO<sub>3-x</sub>-based gas sensors with optimum sensitivity and selectivity performances when aiming to detect volatile organic compounds and ammonia. Seen in perspective, this may open new ways for mass production of gas sensors array using WO<sub>3</sub>-based materials.

An enhanced catalytic conversion process of acetone with Pd-loaded SnO<sub>2</sub> was proved by the work of Gschwend et al. [6]. Knowing that Pd addition to SnO<sub>2</sub> may enhance or downgrade the sensing performances of based SnO<sub>2</sub> is of crucial importance to tune the desired amount in such a way that maximum sensitivity is attained. Accordingly, PdO<sub>x</sub> clusters with diameters ranging from 4 to 6 nm were found on the SnO<sub>2</sub> surface. In addition, the best operating temperature toward acetone detection decreases with increasing Pd loading. A reverse behavior favor sensing response and recovery times. Based on the spill-over effect, the sensitization effect was explained, and the activation energies were calculated based on the reaction rates.

Solid-state sensors and laser photoacoustic spectroscopy have proven the ability to detect a wide variety of target gases and can be used in many different applications.

The papers published in this Special Issue have already earned a few citations, thus starting to gain readers' attention. It is foreseen that further investigations on the presented materials are strongly related to material preparation strategies to boost the overall knowledge of gas sensing phenomena. This is the driving force of initiating the Special Issue "Advanced Materials for Gas Sensors (Volume II)" with a high scientific impact on the interdisciplinary research.

**Funding:** This work was funded by a grant of Ministry of Research, Innovation, and Digitization CNCS/CCDI-UEFISCDI through the project PN-III-P4-ID-PCE-2020-0506 (Contract No. 116/2021) within PNCDI III and by the Romanian National Authority for Scientific Research through the Core Program PN19-03 (Contract No. 21 N/8 February 2019).

**Acknowledgments:** The Guest Editor expresses their gratitude to the valuable contributions by all authors, referees, the editorial team of Materials, and especially to Elsa Qiu for helping me in managing this Special Issue.

**Conflicts of Interest:** The author declares no conflict of interest.

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