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Editorial

Novel 2D-Inorganic Materials for Gas Sensing

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1. Introduction

Nowadays, modern technology is demanding more efficient gas sensors for advanced applications [1]. Consequently, there is a considerable effort towards the goal of high performance gas sensors based on novel sensing materials. Since the first report of graphene, thin two-dimensional (2D) inorganic nanomaterials with atomic or molecular thicknesses have attracted great research interest for gas sensing applications [2], and gas sensors based on these 2D-materials have been used for a wide range of applications [3]. This was due to the distinctive physical, chemical and electronic properties related to their ultrathin thickness, which positively affect the gas sensor performances. The unique properties (e.g., ultra-thin structure, large surface area and tunable energy band diagrams) of novel 2D-inorganic materials (ZnO, MoS_2, SnS_2, WS_2, etc.) have, so far, led to immense research regarding this material's fundamentals, applications and, more recently, its potential for gas sensing [4].

In this Special Issue, a number of reviews and original papers report the latest results and recent advances in the research and development of thin 2D-inorganic nanomaterials for applications in this field. All aspects related to the preparation methods, sensing principle and mechanism, as well as technological aspects and applications have been covered.

2. The Special Issue

According to the title of this Special Issue "Novel 2D-Inorganic Materials for Gas Sensing", the reviews and papers published here highlight the sensing properties of these fascinating materials.

In introducing the feature review, Prof. Neri presented and discussed the general properties of thin 2D-inorganic nanomaterials [5]. Features of single- or few-layered double hydroxides/transition metal oxides/transition metal dichalcogenides have been reviewed. These thin 2D-inorganic nanomaterials could provide the monitoring of harmful/toxic gases with high sensitivity and a low concentration detection limit by means of conductometric sensors operating at relatively low working temperatures. Promisingly, by using thin 2D-inorganic nanomaterials, this may open a simple way for improving the sensing capabilities of conductometric gas sensors.

Transition metal disulfides have been attracting significant attention in recent years. There are extensive applications of transition metal disulfides, especially on gas sensing applications, due to their large specific surface-to-volume ratios, high sensitivity to adsorption of gas molecules and tunable surface functionality depending on the decoration species or functional groups. Gas sensing properties of 2D-transition metal disulfides have been the subject of the review presented by Prof. Jang [6]. The review provides information about various methods to enhance the gas sensing performance of 2D-disulfides, such as surface functionalization, decoration receptor functions and developing nanostructures. Drawbacks such as poor gas selectivity, sluggish recovery characteristics and difficulty in the fabrication of large-scale devices have been also presented and discussed.

Dr. Leonardi addressed attention to two-dimensional zinc oxide (2D-ZnO) [7]. This metal oxide, owing to many advantages such as high sensitivity, stability and low cost, has been one of the most investigated materials for the efficient gas sensing of various hazardous and toxic gases.

The two-dimensionality of ZnO nanostructures can enhance the sensing properties. The review summarizes most of the research articles focused on thin 2D-ZnO nanostructures including nanosheets, nanowalls, nanoflakes, nanoplates, nanodiscs and hierarchically-assembled 2D nanostructures, used as sensitive material for conductometric gas sensors. The synthesis of the materials and the sensing performances such as sensitivity, selectivity, response and recovery times, as well as the main influencing factors were summarized for each work. Moreover, the effect of the mainly exposed crystal facets of the nanostructures on the sensitivity towards different gases was also discussed.

An original work was presented by Dr. Bruno, focused on the synthesis and gas sensing properties of ZnO nanowalls (ZnO NWLs) grown by a simple, inexpensive chemical bath deposition method on a thin layer of aluminum (about 20 nm thick) printed on the Pt interdigitated electrode area of conductometric alumina platforms [8]. Post-deposition annealing in nitrogen atmosphere at 300 °C enabled the formation of a ZnO intertwined 2D foil network. A wide characterization was carried out to investigate the composition, morphology and microstructure of the nanowall layer formed. The gas sensing properties of the films were studied by measuring the changes of electrical resistance upon exposure to low concentrations of carbon monoxide (CO) and nitrogen dioxide (NO_2) in air. The sensor response to CO or NO_2 was found to be strongly dependent on the operating temperature, providing a means to tailor the sensitivity and selectivity toward the selected target gases.

The reviews and papers published in the framework of this Special Issue give a brief, but rigorous point of view of these fascinating materials, highlighting their outstanding properties and providing ideas and solutions to solve many problems so far encountered by researchers working with them in the field of gas sensors.

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