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Photoactivated Titania Nanocrystal Chemiresistors for the Detection of VOCs

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Traditional metal oxide (MOX) gas sensors are widely used due to their high sensitivity and low cost of fabrication. However, such resistive sensing elements require high operating temperatures (> 250 ℃), are difficult to integrate, and feature only limited chemical selectivity. Addressing these problems, photoactivated resistive MOX sensors, which can be operated at room temperature, are attracting increasing attention.

In this work, we investigate the sensing mechanism of photoactivated chemiresistors based on titania nanocrystal (TNC) thin films. The structural properties of the films fabricated from differently shaped TNCs are characterized by XRD, AFM, and SEM. Further, the photocurrent and its perturbation by the photoactivated reaction with volatile organic compounds (VOCs) is studied via in situ charge transport measurements. Adjusting the irradiance of the photoactivation is presented as an additional opportunity to tune the chemiresistive response characteristics. To correlate the photocurrent response with the amount of adsorbed analyte molecules, these charge transport measurements are combined with microgravimetric measurements. First results reveal that these photoactivated sensors are highly selective towards alcohols. This pronounced selectivity is attributed to the selective binding of alcohols to unsaturated Ti3+ species on the surface of the nanocrystals and their subsequent oxidation to aldehydes or ketones. As part of these investigations, the influence of humidity on the gas sensing mechanism is investigated, posing a challenge for technological applications of these sensors under ambient conditions by impeding the chemiresistive responses. To address this loss of sensitivity, the photoactivated sensors are further operated at slightly elevated temperatures.

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