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Oxide Semiconductor Gas Sensors with Nanoscale Catalytic Overlayer: Toward Highly Selective and Sensitive Gas Detection using Bilayer Design

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Oxide semiconductor gas sensors have been widely used to detect hazardous gases and their applications are being expanded to wide range of applications including disease diagnosis, indoor air quality monitoring, fruit quality control, and the discrimination of different smells/odours. Although various noble metals or oxide catalysts have been loaded or doped to oxide semiconductor chemiresistors in order to enhance the gas selectivity and sensitivity, gas sensing materials are limited and their sensing characteristics are still insufficient to cover numerous chemicals. Moreover, the catalyst loading often leads to the significant increase of sensor resistance by oxygen spillover or charge transfer from sensing to catalytic materials, which hampers the measurement of sensor resistance using conventional electronic circuit. In the literature, relatively thick configuration of catalytic overlayers have ever been coated on the sensing film in order to filter interference gases. However, the enhancement of response to less reactive analyte gases via gas reforming using nanoscale catalytic overlayer has been barely investigated. In this presentation, we will demonstrate that the bilayer sensor design can provide not only the separation of catalytic and sensing reaction but also the tuning of both gas selectivity and sensitivity. For instance, two different bilayer sensor designs, Pd-SnO2 thick film coated with nanoscale Co3O4 overlayer[1] and Co3O4 thick film coated with nanoscale TiO2 (or SnO2) overlayer,[2] are suggested to show highly selective and sensitive detection of benzene and methylbenzenes, respectively. The increase of less reactive analyte gases and the decrease of highly reactive interference gases could be explained successfully by gas reforming and oxidative filtering, respectively. And gas sensing mechanisms of bilayer sensors were discussed and explained in relation to the material and thickness of catalytic overlayer, sensing layer, and sensing temperature. The bilayer sensor design can provide a new and versatile platform to control gas selectivity and sensitivity, which will make gas sensing library more abundant.

References
[1] S.-Y. Jeong et al. J. Mater. Chem. A 5, 1446-1454 (2017)
[2] H.-M. Jeong et al. ACS Appl. Mater. Interfaces, 9, 41397-41404 (2017)

Summary

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