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Pd-SnO_2 Micro-reactor Sensing Film with a Catalytic Co_3O_4 Overlayer for Ultraselective Detection of Sub-ppm-level Benzene

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Abstract

Benzene, one of the most toxic and ubiquitous gases, is known to induce serious disease such as leukemia and aplastic anemia. Hence, precise detection of carcinogenic benzene is very important for monitoring of air quality and to protect human being. Unfortunately, n-type oxide semiconductor gas sensors show low responses to chemically stable BTX gases (benzene, toluene, and xylene). Moreover, similar chemical structure of BTX gases hamper their discrimination by chemiresistive variation. In this contribution, we suggest a new strategy to detect sub-ppm-level benzene vapor with high selectivity using an oxide semiconductor chemiresistors. Due to unique sensor structure consisting of a Pd-SnO_2 yolk-shell sensing film and a thin catalyst Co_3O_4 overlayer, high selectivity and response (resistance ratio = 88) to 5 ppm benzene was accomplished. The sensor response toward benzene was enhanced by reforming highly stable benzene into more active and smaller species, while the cross-responses to the other indoor pollutants became low through the catalytic oxidation of the gases into less- or non-reactive species. The reforming and oxidation reaction were synergistically assisted by Co_3O_4 catalytic overlayer and sensing layer consisting of Pd-SnO_2 yolk-shell micro-reactors. This method will pave a new way to the precise monitoring of critically toxic benzene in both indoor and outdoor atmospheres.

Key words: Benzene, Gas sensor, Pd-SnO_2 micro-reactor, Co_3O_4 overlayer, gas reforming