

## Realizing the Control of Fermi Level and Gas-Sensing Selectivity over Gallium-Doped In<sub>2</sub>O<sub>3</sub> Inverse Opal Microspheres

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Herein, formaldehyde sensors based on gallium-doped In<sub>2</sub>O<sub>3</sub> inverse opal (IO-(Ga<sub>x</sub>In<sub>1-x</sub>)<sub>2</sub>O<sub>3</sub>) microspheres were purposefully prepared by simple ultrasonic spray pyrolysis method combined with self-assembly sulfonated polystyrene spheres template. The well-aligned inverse opal structure, with three different-sized pores, plays dual roles of accelerating the diffusion of gas molecules and providing more active sites. The Ga substitutional doping can alter the electronic energy level structure of (Ga<sub>x</sub>In<sub>1-x</sub>)<sub>2</sub>O<sub>3</sub>, leading to the elevation of Fermi level and the modulation of band gap closed to a suitable value (3.90 eV), hence, effectively optimizing the oxidative catalytic activity for preferential CH<sub>2</sub>O oxidation and increasing the amount of adsorbed oxygen. More importantly, the gas selectivity could be controlled by varying the energy level of adsorbed oxygen. Accordingly, the IO-(Ga<sub>0.2</sub>In<sub>0.8</sub>)<sub>2</sub>O<sub>3</sub> microspheres sensor showed high response toward formaldehyde with fast response and recovery speeds, and ultralow detection limit (50 ppb). Our findings finally offer implications for designing Fermi level-tailorable semiconductor nanomaterials for the control of selectivity and monitoring indoor air pollutant.

### Summary

Taken together, the results have demonstrated the electronic energy level structure controllability of the spray pyrolysis-doping synthesis of (Ga<sub>x</sub>In<sub>1-x</sub>)<sub>2</sub>O<sub>3</sub> nanomaterials and its synergistic impact on the oxidative catalytic activity for preferential CH<sub>2</sub>O oxidation.

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