Supplementary Information

Thin-walled SnO_2 nanotubes functionalized with Pt and Au catalysts via protein templating route and their selective detection of acetone and hydrogen sulfide molecules

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Fig S1. (a) Schematic illustration of patterned Au electrodes (front site) on Al_2O_3 substrate and Pt heater line (back side) (b) SnO_2 NTs functionalized by bio-inspired catalytic NPs

Electrospinning of wire in tube structure of catalysts loaded SnO₂ fibers

Figure S2 shows wire in tube structure of Pt-loaded SnO₂ nanotubes (NTs) and Au-loaded SnO₂ NTs. In this case, we assumed that too high concentration (> 0.32 wt%) of catalytic nanoparticles (NPs) hinder diffusion of oxidized Sn particles to outer side. The reason for the formation of metal oxide tubular structure can be explained by different solubility of Sn ions in PVP and in ethanol, which leads to occur Ostwald-ripening behavior, and released gases in the form of CO₂ and H₂O during calcination with fast heating rate. However, excessive amounts of catalytic NPs, which embedded in Sn precursor/polymer composite nanofibers (NFs), partially block the migration of oxidized Sn particles during calcination, thus, residue Sn particles are oxidized at the center of SnO₂ NTs. In conclusion, they formed were wire in tube structure.



Fig S2. Morphologies of SnO₂ NTs functionalized by Pt(0.32 wt%) and Au(0.32 wt%) NPs (Pt-loaded SnO₂ NTs, Au-loaded SnO₂ NTs) (a) SEM image of 0.32 wt% Pt-loaded SnO₂ NTs, (b) SEM image of 0.32 wt% Au-loaded SnO₂ NTs



Fig S3. X-ray diffraction pattern (XRD) of Pt-loaded SnO_2 NTs, Au-loaded SnO_2 NTs and pristine SnO_2 NTs.



Fig S4. X-ray photoelectron spectroscopy spectra in vicinity of the (a) Au 4f, (b) Au $4d_{5/2}$ peaks

Surface area comparison between SnO₂ NTs and SnO₂ NFs

Theoretically, tube structure has an interior and exterior surface area, which serve as reaction sites with gas molecules. On the other hand, densely packed fiber structure has only an exterior surface available for reactions with gases, thus, we assumed that SnO_2 NTs have approximately 2-fold higher surface area compared with densely packed SnO_2 NFs. In fact, BET surface area analysis proved the accuracy of the assumption (Figures S5a and S5b). Surface area of SnO_2 NTs and SnO_2 NFs is 15.7173 m²/g and 8.5847 m²/g respectively. In this regard, SnO_2 NTs have more surface reaction sites than SnO_2 NFs thus theoretically, they will show an enhanced sensing performance.



Fig S5. (a) Isothermal adsorption/desorption plot of SnO_2 NTs and their BET surface, (b) Isothermal adsorption/desorption plot of SnO_2 NFs and their BET surface



Fig S6. Base-resistance in air of Pt-loaded SnO₂ NTs at 350 $^\circ C$ and Au-loaded SnO₂ NTs at 300 $^\circ C$



Fig S7. Response time evolution of (a) Pt-loaded SnO₂ NTs in a concentration range of 1–5 ppm at 350 °C, (b) Au-loaded SnO₂ NTs in a concentration range of 1–5 ppm at 300 °C



Fig S8. Response of (a) Pt-loaded SnO₂ NTs towards acetone, (b) Au-loaded SnO₂ NTs toward H₂S in concentration range of 0.1–5 ppm at 350 °C and 300 °C



Fig S9. (a) X-ray diffraction (XRD) analysis of Au- and Pt-loaded SnO_2 NTs before cycling and after 1 week cycling, and (b) grain size evaluation of Au- and Pt-loaded SnO_2 NTs before and after 1 week cycling.



Fig S10. The stability analysis of 0.16 wt% Pt-loaded SnO₂ NTs: (a) base resistance and (b) response (R_{air}/R_{gas}). The stability analysis of 0.247 wt% Au-loaded SnO₂ NTs: (c) base resistance and (d) response (R_{air}/R_{gas}).