Supporting Information

Self-Assembly Template Driven 3D Inverse Opal Microspheres Functionalized with Catalyst Nanoparticles Enabling a Highly Efficient Chemical Sensing Platform

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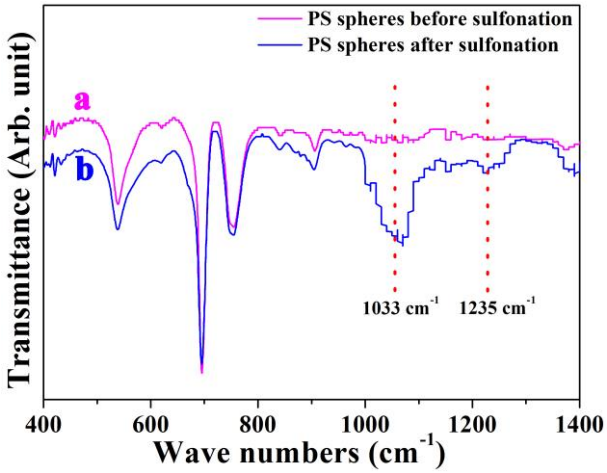

Figure S1. FT-IR spectra of (a) PS spheres before sulfonation and (b) PS spheres after sulfonation.

The powders of PS spheres before and after sulfonation were measured by using FT-IR spectroscopy. The FT-IR spectrum of PS spheres after sulfonation exhibited the peaks at about 1033 and 1235 cm^{-1}, which were attributed to the symmetric and asymmetric stretching vibrations of sulfonic acid ($SO_3^-H^+$) groups.[1, 2] Moreover, PS spheres before sulfonation did not have any distinct vibrational frequency in the 1000-1300 cm^{-1} (**Figure S1**). Therefore, we could conclude that the S-PS spheres were obtained after sulfonation.

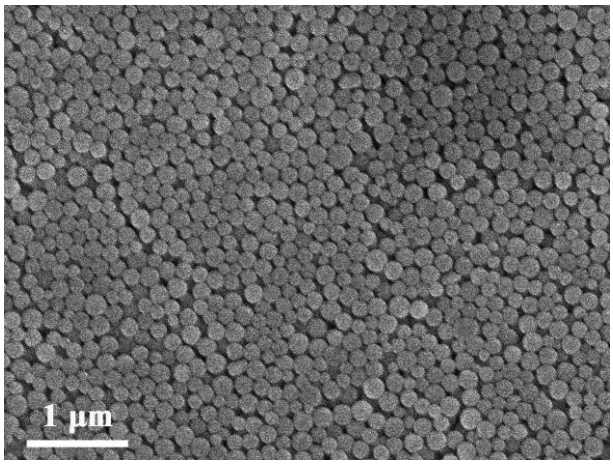

Figure S2. SEM image of S-PS spheres.

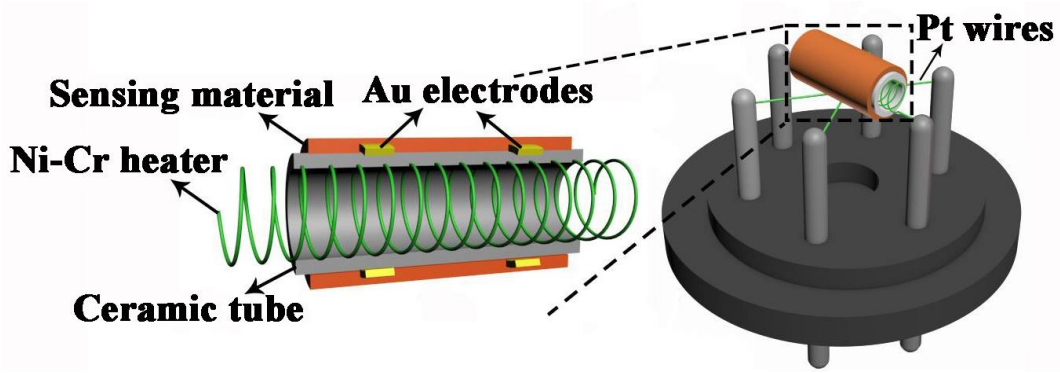

Figure S3. Schematic diagram of the gas sensor.

Detailed parameters of alumina tube: external diameter: 1.2 mm, internal diameter: 0.8 mm, and length: 4 mm; a couple of Au electrodes were previously printed on the end of the tube, and each electrode was connected with a pair of Pt wires.

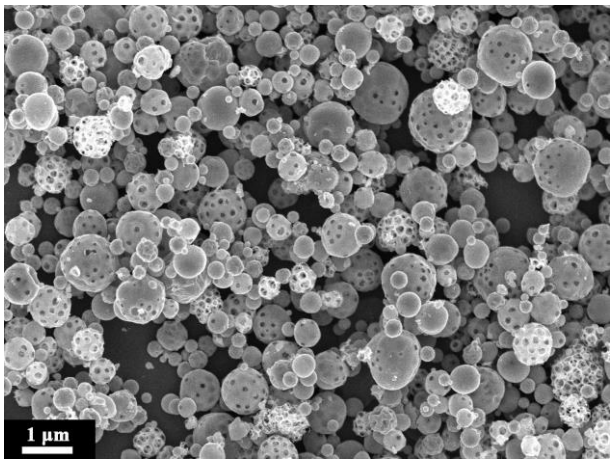

Figure S4. The SEM image of the precursor microspheres used to fabricate 3D-IO In_2O_3 MSs (before annealed under an air atmosphere at a temperature of 600 °C for 3 h).

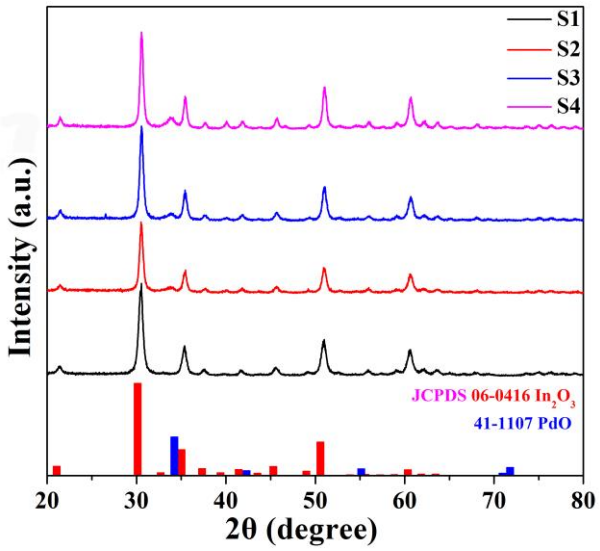

Figure S5. XRD patterns of the S1-S4 samples.

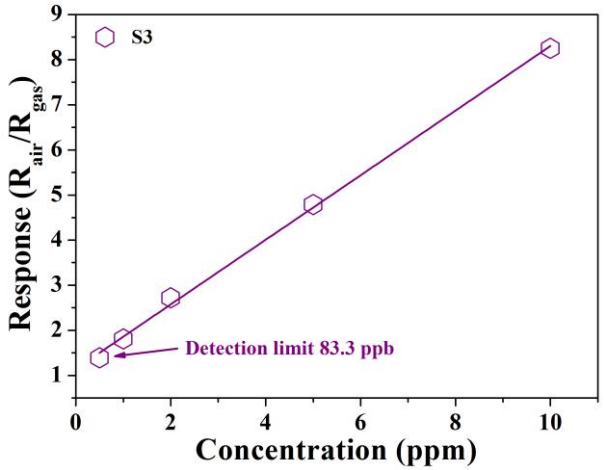

Figure S6. Linear approximation of the detection limit with S3 sensor.

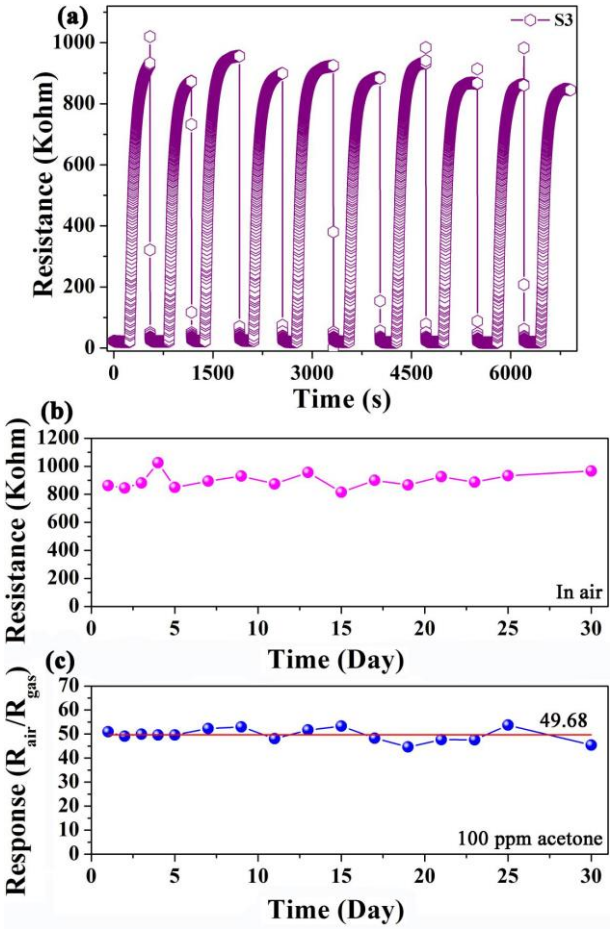

Figure S7. (a) The repeatability of the S3 sensor response at cyclic exposure to 100 ppm acetone at 250 °C; (b) and (c) Long-term stability of the S3 sensor measured at the operating temperature of 250 °C.

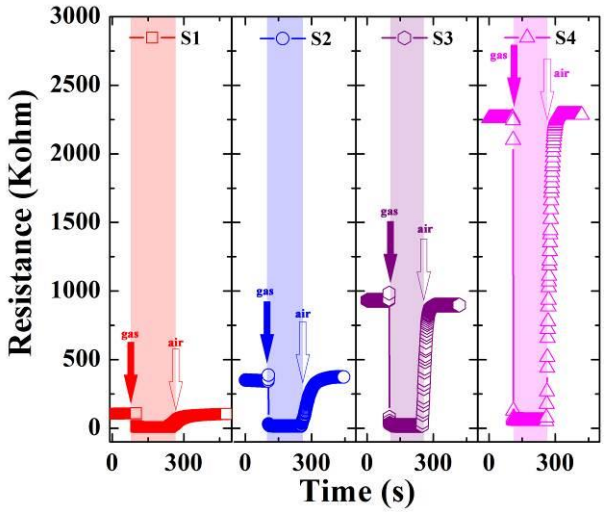

Figure S8. Dynamic resistance transitions of the S1-S4 sensors toward 100 ppm of

acetone at 250 °C.

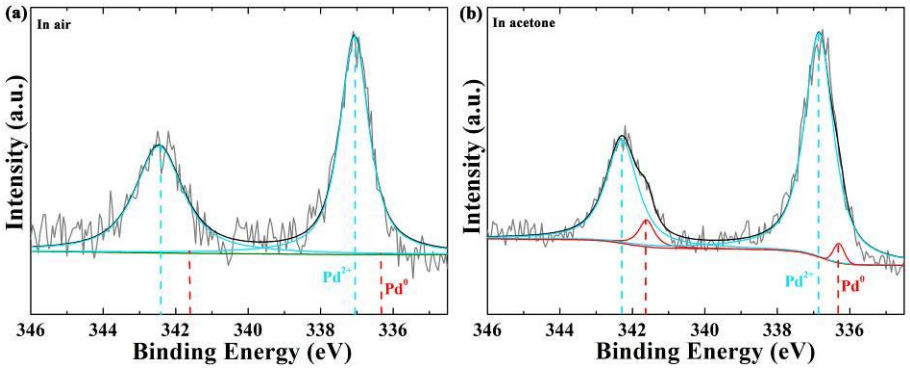

Figure S9. Ex situ XPS analysis spectra of 3D-IO PdO@In_2O_3 MSs (S3 sample) in the vicinity of Pd 3d (a) in air and (b) in acetone after 10 cycles sensing measurement with 100 ppm of acetone at 250 °C.

We have carried out ex situ XPS analysis to elucidate the catalytic effect of PdO NPs. We noted that the PdO NPs are partially reduced to the Pd^0 state when exposed to 100 ppm of acetone, and the binding energy of Pd^0 state shifted to a higher energy compared to the standard binding energy after acetone sensing measurement, which can be attributed to the formation of Pd-In alloy.[3]

REFERENCES

(1) Fitzgerald, J. J.; Weiss, R. A.; Eisenberg, A.; Bailey, F.; Coulombic Interactions in Macromolecular Systems. Washington DC: American Chemical Society. **1980**, 35.

(2) Lei, H.; Bu, N. J.; Chen, R. L.; Hao, P.; Neng, S.; Tu, X. F.; Yuen, K.; Chemical Mechanical Polishing of Hard Disk Substrate with α-Alumina-g-Polystyrene Sulfonic Acid Composite Abrasive. Thin Solid Films. **2010**, 518, 3792-3796.

(3) Rui, N.; Wang, Z. Y.; Sun, K. H.; Ye, J. Y.; Ge, Q. F.; Liu, C.-J.; CO_2 Hydrogenation to Methanol Over Pd/In_2O_3: Effects of Pd and Oxygen Vacancy. Appl. Catal. B-Environ. **2017**, 218, 488-497.