Supporting Information

Hierarchical SnS_2/SnO_2 nanoheterojunctions with increased active-site and charge transfer for ultrasensitive NO_2 detection

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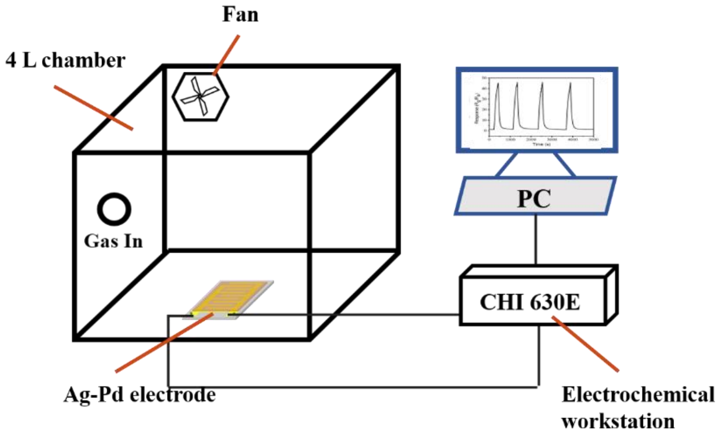

Fig. S1. Schematic diagram of the sensor measurement.

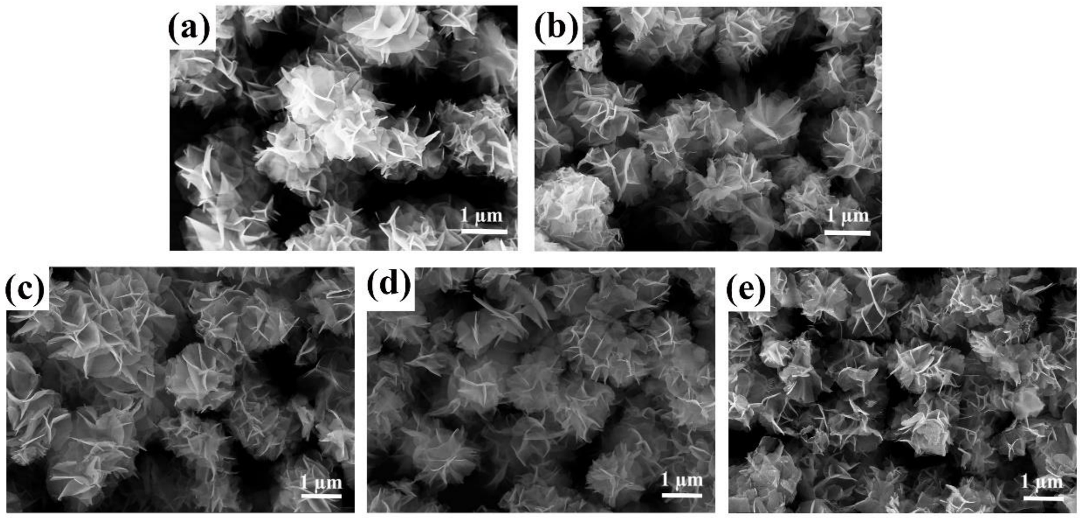

Fig. S2. SEM images of (a) pristine SnS_2, (b) SnS_2-SnO_2-0.5h, (c) SnS_2-SnO_2-1h, (d) SnS_2-SnO_2-2h, and (e) pure SnO_2.

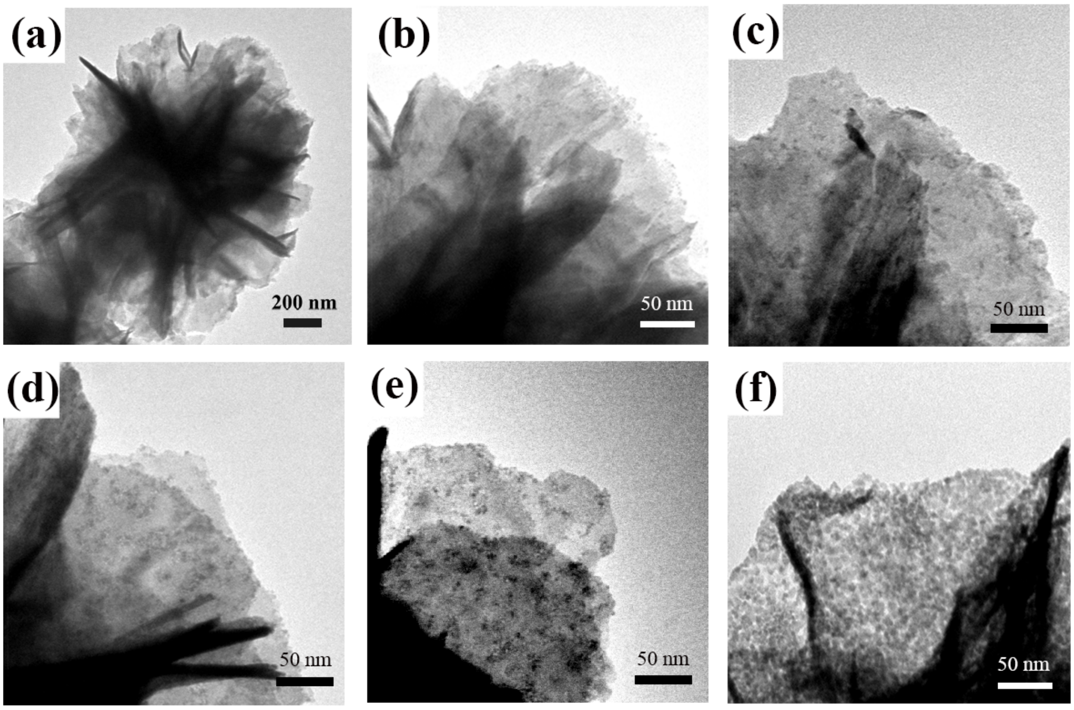

Fig. S3. TEM images of pristine SnS_2 with low magnification (a) and high magnification (b), (c) SnS_2-SnO_2-0.5h, (d) SnS_2-SnO_2-1h, (e) SnS_2-SnO_2-2h, and (f) SnO_2.

Table S1. EDS elemental analysis of pure SnS_2, pure SnO_2, and SnS_2 with different oxidation time.

Sample	O	Sn	S	S/Sn
pure SnS_2	0	36.14	63.86	1.77
SnS_2-SnO_2-0.5h	63.17	16.22	20.62	1.27
SnS_2-SnO_2-1h	63.17	17.63	19.20	1.09
SnS_2-SnO_2-2h	76.48	13.15	10.36	0.79
Pure SnO_2	87.70	11.76	0.65	0.06

Table S2. The response and recovery time of the sensors based on pure SnS_2, pure SnO_2, and SnS_2/SnO_2 with different oxidation time toward 1 ppm NO_2 at operating temperature of 100 °C.

Sample	Response time (s)	Recovery time (s)
pure SnS_2	148	90.4
SnS_2-SnO_2-0.5h	281	98.2
SnS_2-SnO_2-1h	299	143
SnS_2-SnO_2-2h	408	110
SnO_2	301	561

Table S3. The response and recovery time of the sensors based on SnS_2-SnO_2-1h with different operating temperature toward 1 ppm NO_2.

Operating temperature (°C)	Response time (s)	Recovery time (s)
80	354	205
100	299	143
120	228	134
140	113	108

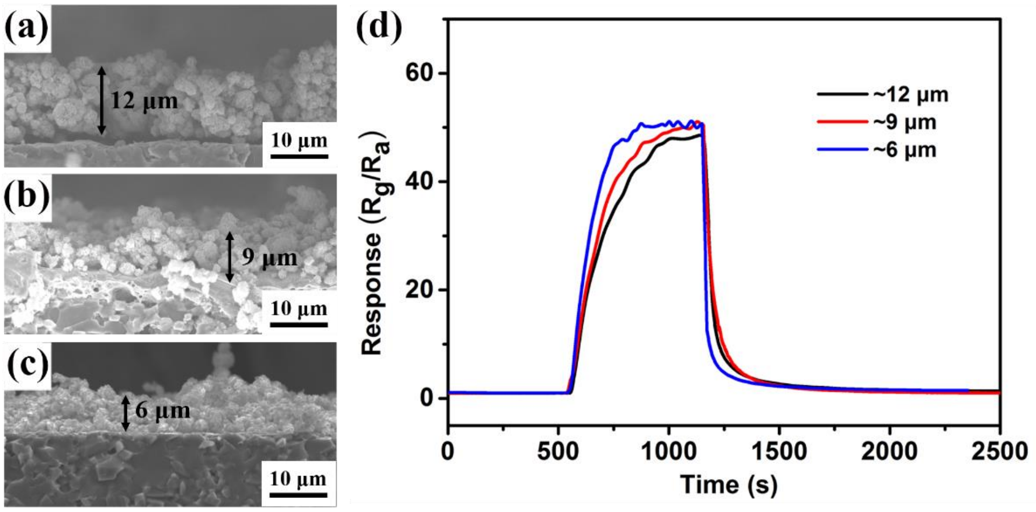

Fig. S4. Cross-sectional-view SEM images of SnS_2-SnO_2-1h sensor with different thickness: (a) ~12 μm, (b) ~9 μm, (c) ~6 μm, and their sensing response curves toward 1 ppm NO_2 at operating temperature of 100 °C (d).

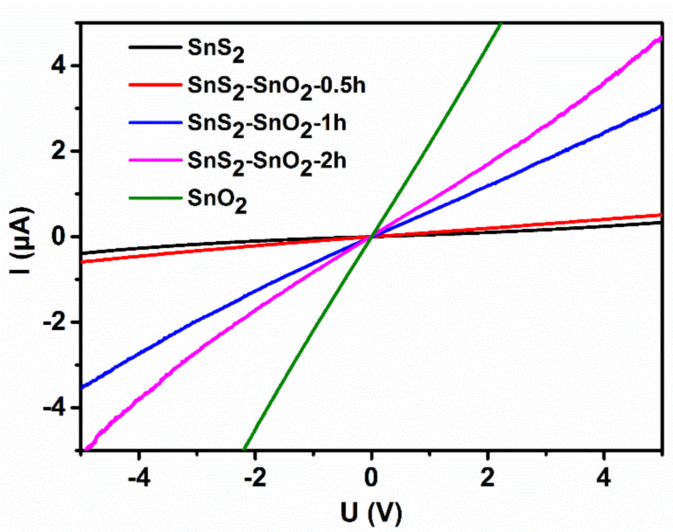

Fig. S5. I–V curves of the pure SnS_2, pure SnO_2, and SnS_2/SnO_2 with different oxidation time at 100 °C.

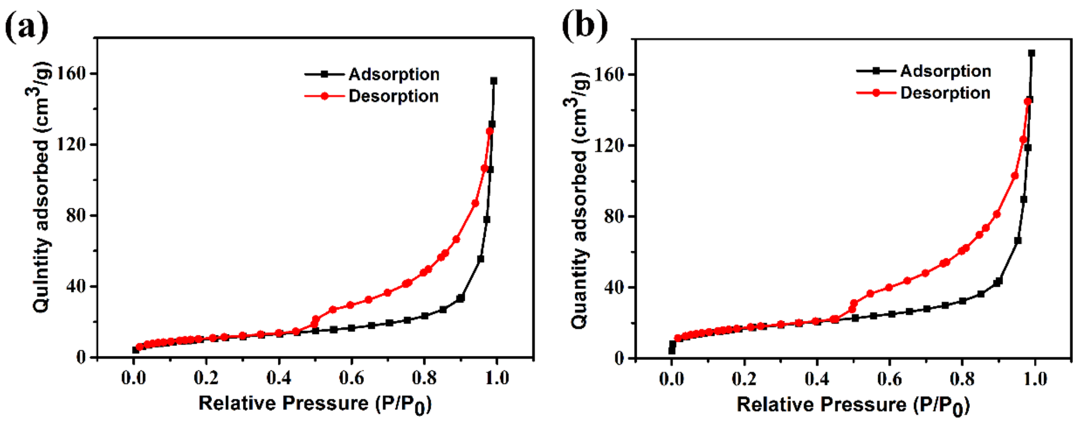

Fig. S6. N_2 adsorption-desorption isotherms of (a) pure SnS_2 and (b) SnS_2-SnO_2-1h samples.

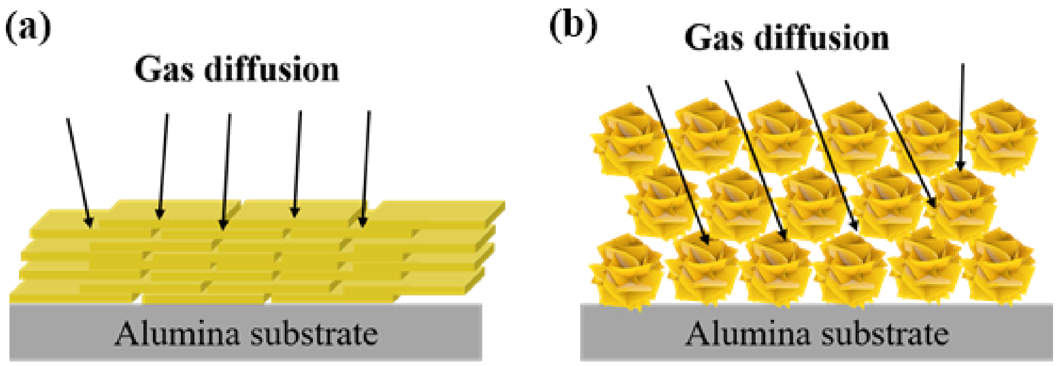

Fig. S7. Schematic illustration of gas diffusion on flat (a) and hierarchical (b) sensing materials.

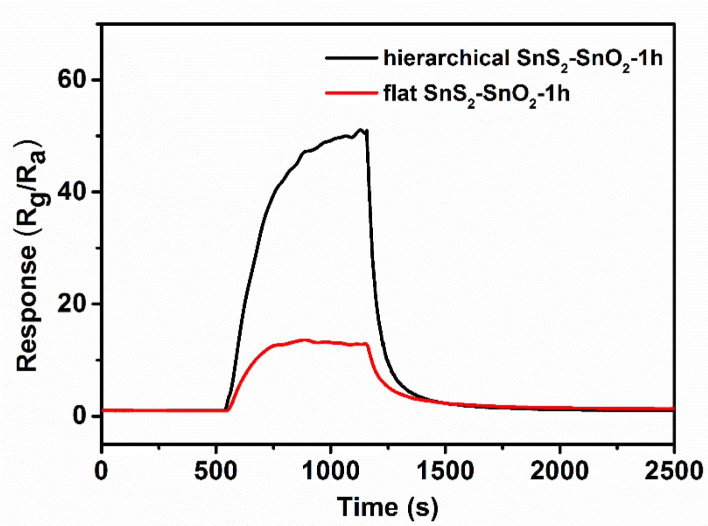

Fig. S8. Response curves of the sensors based on flower-like hierarchical SnS_2-SnO_2-1h and flat SnS_2-SnO_2-1h nanosheets towards 1 ppm NO_2 at operating temperature of 100 °C.

Section S1. Flat SnS_2-SnO_2-1h material synthesis and characterization.

The flat SnS_2-SnO_2-1h nanosheets were synthesized by partial oxidized flat SnS_2 nanosheets. First, the flat SnS_2 nanosheets were prepared according to the methods reported previously.[1] Typically, 0.6 mmol of sodium dodecyl benzenesulfonate (SDBS), 0.25 mmol of $SnCl_4 \cdot 5H_2O$, and 2 mmol of L-cysteine were dissolved in 30 mL of deionized water under magnetic stirring. After 20 minutes, the mixture was then transferred into a 50 mL Teflon-lined stainless-steel autoclave and heated at 160 °C for 10 h. The obtained products were washed with ethanol and water for three times, respectively, and dried in vacuum oven overnight for further preparation. The XRD result was shown in Fig. S9a. The SnS_2 nanosheets were further oxidized by putting in a porcelain boat kept at 300 °C for 1 h in an air environment. The SEM images of the sensor based on flat SnS_2-SnO_2-1h nanosheets were shown in Fig. S9b & c.

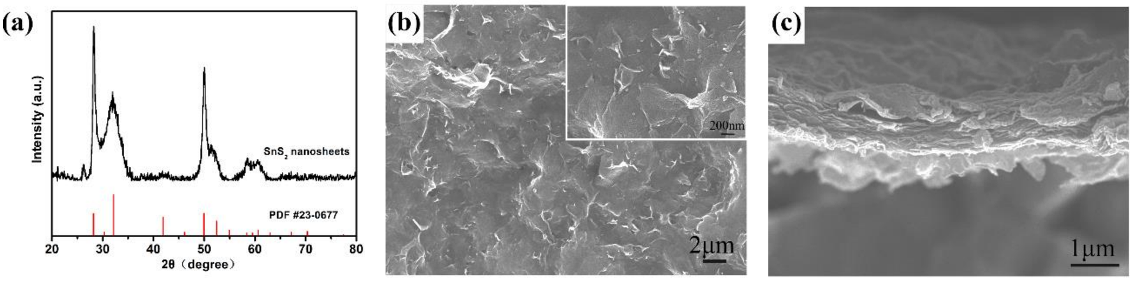

Fig. S9. (a) XRD of flat SnS_2 nanosheets, and SEM images of the flat SnS_2-SnO_2-1h nanosheets: (a) top view; (b) cross section view.

Reference

1. X. C. Jiao, X. D. Li, X. Y. Jin, Y. F. Sun, J. Q. Xu, L. Liang, H. X. Ju, J. F. Zhu, Y. Pan, W. S. Yan, Y. Lin and Y. Xie, *J. Am. Chem. Soc.* 2018, **139,** 18044-18051.