Supporting Information

Ultrathin 2D silver sulphate nanosheets for visible-light-driven NO_2 sensing at room temperature

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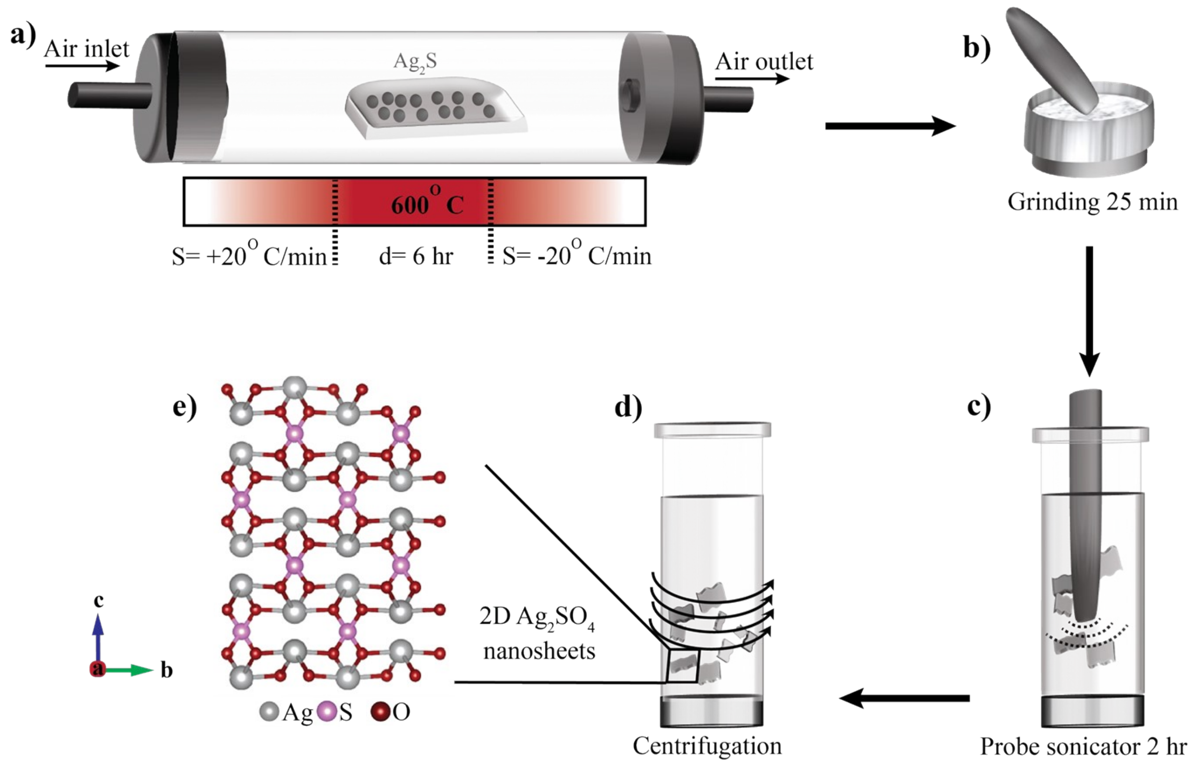

Fig. SI-1. a) Schematic representation of the tube furnace oxidation process for the conversion of Ag_2S bulk powder to Ag_2SO_4 bulk powder; the furnace was maintained at a temperature of 600°C. Air was used as the carrier gas with a flow rate of ~100 sccm. b-d) Schematic diagram illustrating the delamination of 2D Ag_2SO_4 nanosheets from bulk Ag_2SO_4. e) Crystal structures of Ag_2SO_4 with a-axis orientation.

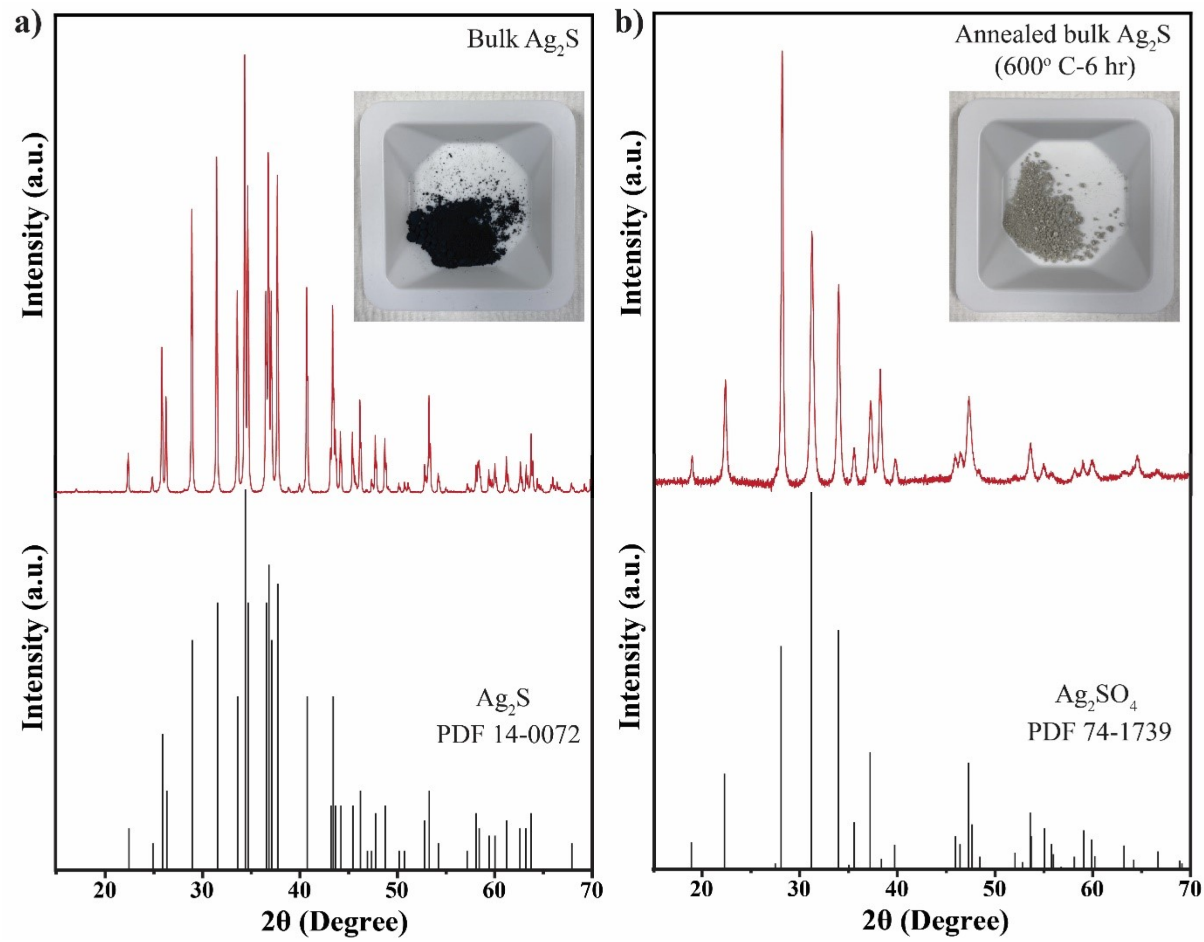

Fig. SI-2. a) The XRD for the bulk Ag_2S as it received (black powder). b) The XRD for the bulk Ag_2SO_4 After annealing the bulk Ag_2S at ~600° C for 6 hr (grey powder) is shown for comparison and confirming the transformation.

Table SI-1. The exciton lifetime fitting result of 2D Ag_2SO_4 nanosheets.

	Value
y_0	11.97404
A_1	45.95723
t_1	1.84248
A_2	91.99347
t_2	2.0472
A_3	80.26619
t_3	2.25192
Average lifetime ~ 2.06 ns	

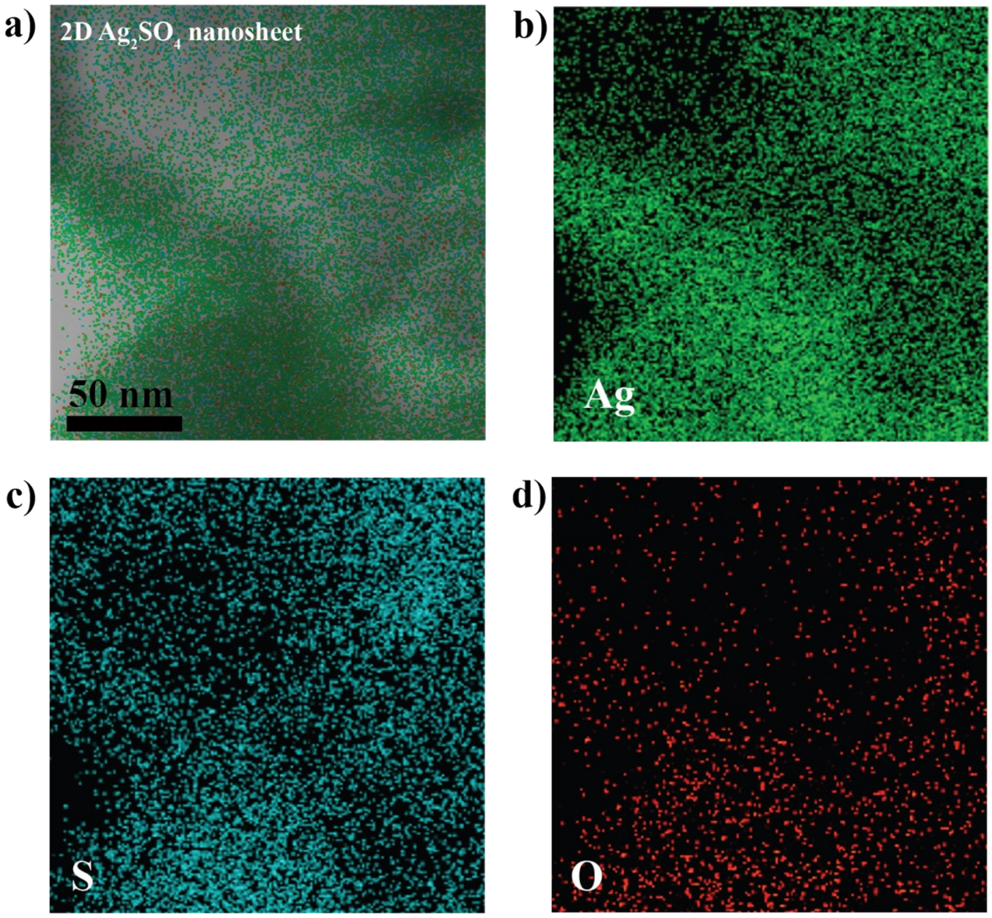

Fig. SI-3. Elemental mapping of a selected area on the sample: (a) Elemental mapping image of a selected area on the sample. (b) Ag mapping. (c) S mapping. (d) O mapping.

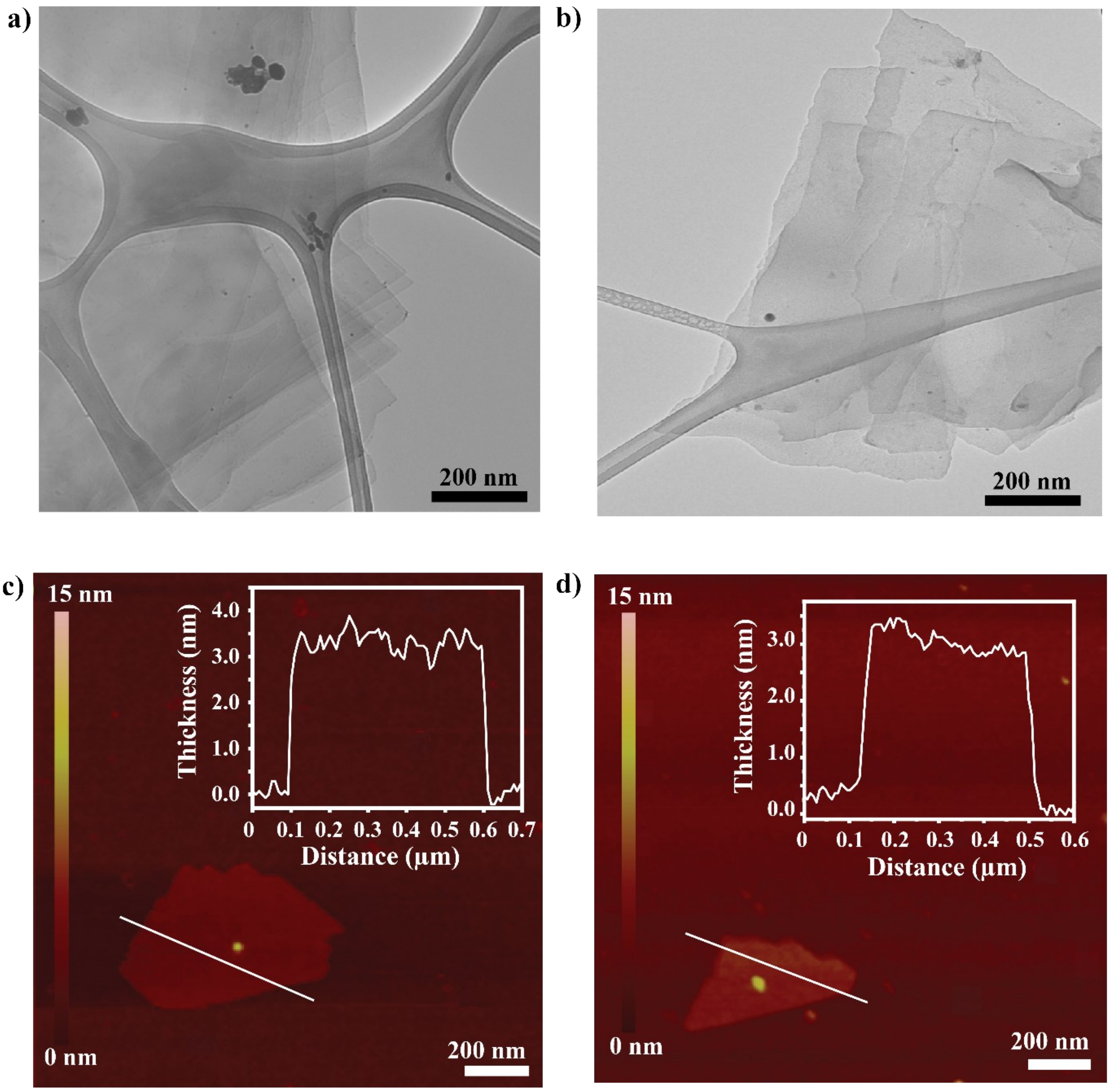

Fig. SI-4. TEM and AFM images of prepared 2D Ag_2SO_4 nanosheets.

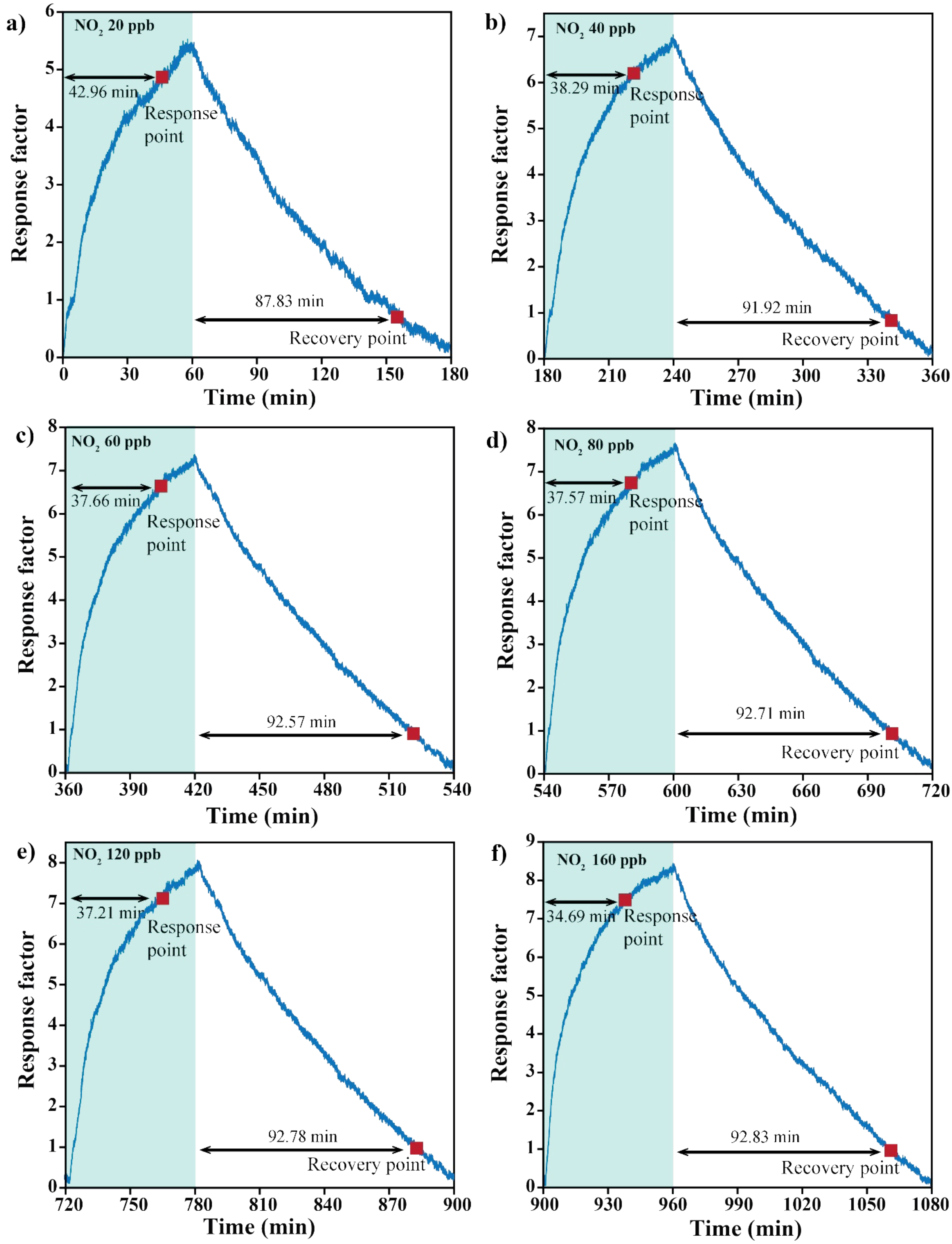

Fig. SI-5. Measurement of the response and recovery time of the 2D Ag_2SO_4 based sensor upon exposure to NO_2 at the concentrations of a) 20, b) 40, c) 60, d) 80, e) 120 and d) 160 ppb.

Table SI-2. Comparison of gas sensing performances of previously reported NO_2 gas sensors based on metal sulphide and oxysulphide nanostructure at room temperature.

Material	Method	Operating condition	Low detection limit (ppb)	Sensitivity ($^{\Delta R}/_{R}$) @ (NO_2 ppm)	Ref.
NbS_2	CVD*	RT	241	28.32 (10 ppm)	1
WS_2	LE*	RT	-	29% (10 ppm)	2
WS_2	Hydrothermal	RT	0.1	84.7% (10 ppm)	3
MoS_2	ME*	RT	-	41.7 (200 ppm)	4
SnS_2	Hydrothermal	RT/ Green light	38	10.8 (8 ppm)	5
InS_xO_y/In_2S_3	LPE	RT/ Blue light	0.363	2.75% (0.44 ppm)	6
$PdSO_4$	LPE	RT/ Blue light	1.84	3.28% (0.16 ppm)	7
Ag_2SO_4	LPE	RT/ Blue light	0.458	8.39% (0.16 ppm)	This work

* CVD: Chemical vapor deposition. LE: Liquid exfoliation. ME: Mechanical exfoliation

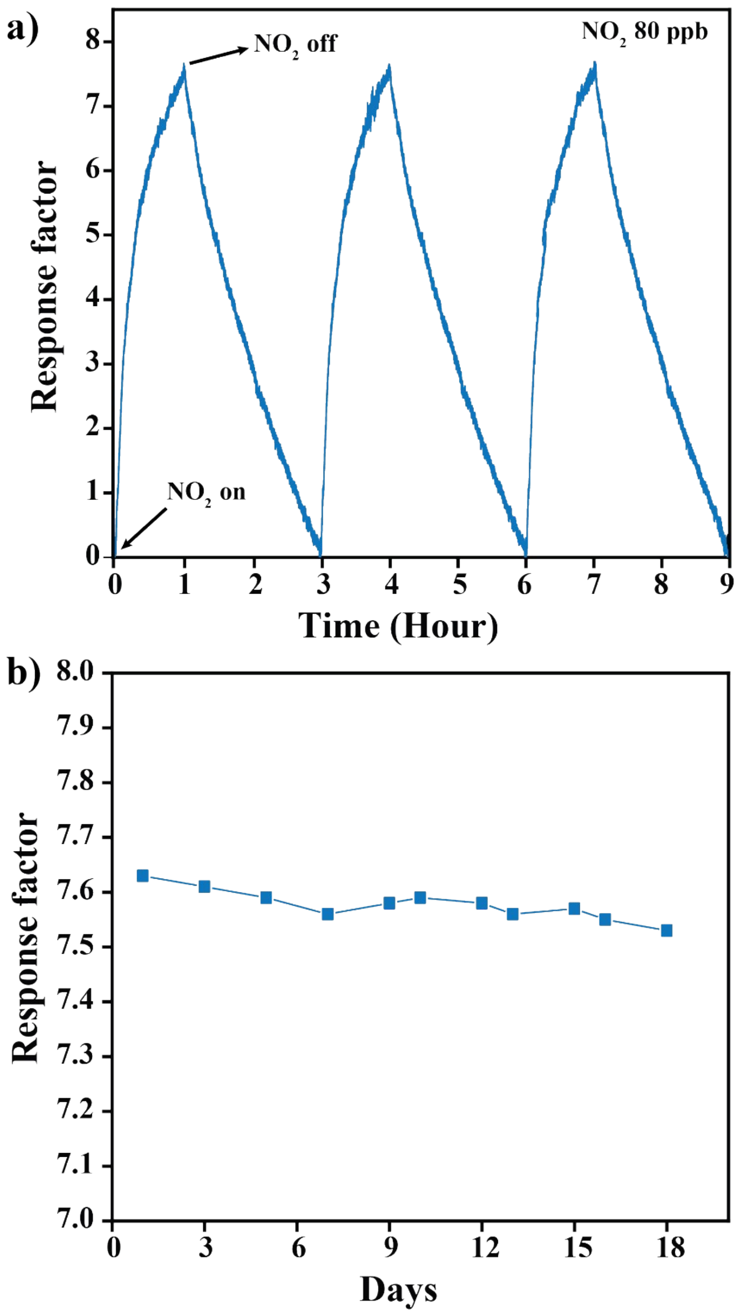

Fig. SI-6. a) Cyclic response of the 2D Ag_2SO_4 based sensor towards 80 ppb of NO_2 for 3 cycles. b) The long-term stability of the sensor towards NO_2 gas at a concentration of 80 ppb in the balance of N_2 gas at room temperature under blue light illumination.

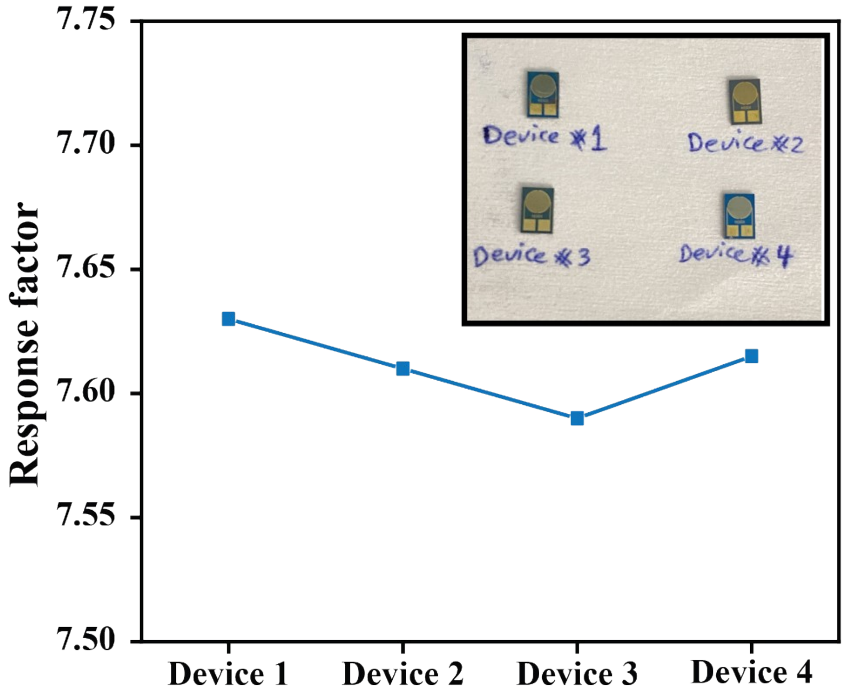

Fig. SI-7. Reproducibility test of the prepared Ag_2SO_4-based sensors towards NO_2 gas at the concentration of 80 ppb in the balance of N_2 gas. Inset: Ag_2SO_4-based sensors prepared on different days.

References

1. Y. Kim, K. C. Kwon, S. Kang, C. Kim, T. H. Kim, S.-P. Hong, S. Y. Park, J. M. Suh, M.-J. Choi and S. Han, *ACS sensors*, 2019, **4**, 2395-2402.
2. D. Simon Patrick, P. Bharathi, M. Krishna Mohan, C. Muthamizchelvan, S. Harish and M. Navaneethan, *Journal of Materials Science: Materials in Electronics*, 2022, **33**, 9235-9245.
3. T. Xu, Y. Liu, Y. Pei, Y. Chen, Z. Jiang, Z. Shi, J. Xu, D. Wu, Y. Tian and X. Li, *Sensors and Actuators B: Chemical*, 2018, **259**, 789-796.
4. W. Li, Y. Zhang, X. Long, J. Cao, X. Xin, X. Guan, J. Peng and X. Zheng, *Sensors*, 2019, **19**, 2123.
5. D. Gu, X. Wang, W. Liu, X. Li, S. Lin, J. Wang, M. N. Rumyantseva, A. M. Gaskov and S. A. Akbar, *Sensors and Actuators B: Chemical*, 2020, **305**, 127455.
6. K. Xu, B. Y. Zhang, M. Mohiuddin, N. Ha, X. Wen, C. Zhou, Y. Li, G. Ren, H. Zhang, A. Zavabeti and J. Z. Ou, *Nano Today*, 2021, **37**, 101096.
7. T. Alkathiri, K. Xu, B. Y. Zhang, M. W. Khan, A. Jannat, N. Syed, A. F. Almutairi, N. Ha, M. M. Alsaif, N. Pillai, Z. Li, T. Daeneke and J. Z. Ou, *Small Science*, 2022, **2**, 2100097.