Supporting Information

Room-temperature sensing performance of binary Co-Zn doped MoS_2/graphite composite toward ppb-level NO_2

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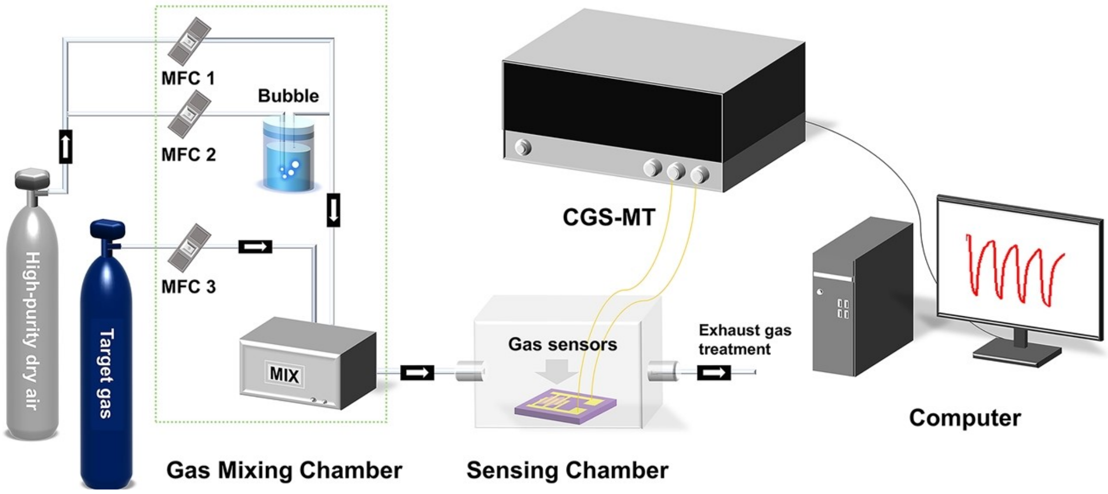
The room-temperature sensing performance of the sensors was measured by an intelligent gas-sensing platform (Elite Tech Co. Ltd, China) with High-purity dry air (HPDA) as background gas. Note that all initial gases are in the standard 4 L cylinders with a purity larger than 99.9% before they are adjusted to a determined concentration. Then, the target gases were achieved by adjusting the ratio of target gases to the carrier gas (High-purity dry air (HPDA)) via the computer-controlled mass flow controllers (MFC), and the total flow rate of the gas mixture was 300 mL·min^{-1}. According to the equation: $C_1 = \frac{F_0}{F_0 + F_1} \cdot C_0$ (where C_1 is the mixed target gas concentration, C_0 is the standard gas concentration in the cylinder, and F_0 and F_1 are the flow rates of target gas and HPDA, respectively. The sum of F_0 and F_1 is 300 mL·min^{-1}.), when C_0 is 300 ppm NO_2, and F_0 and F_1 are controlled to be 5 and 295 mL·min^{-1}, respectively, C_1 is expected to be 5 ppm. The other NO_2 gases with concentrations of 0.05 ppm, 0.1 ppm, 0.3 ppm, 0.5 ppm, 1 ppm, and 3 ppm and the other gases of 5 ppm NO, 50 ppm NH_3, 100 ppm H_2, 50 ppm CO, and 50 ppm ethanol were obtained in the same way.

Note that in the study of the effect of humidity toward NO_2, the dry air was divided into two ways, and one way was fed into the bubble to get humidity gas. Then, the stable relative humidity (RH) values were obtained by adjusting the mass flow ratios of dry and humidity gases.



Scheme S1. Schematic diagram of the intelligent gas sensing platform.

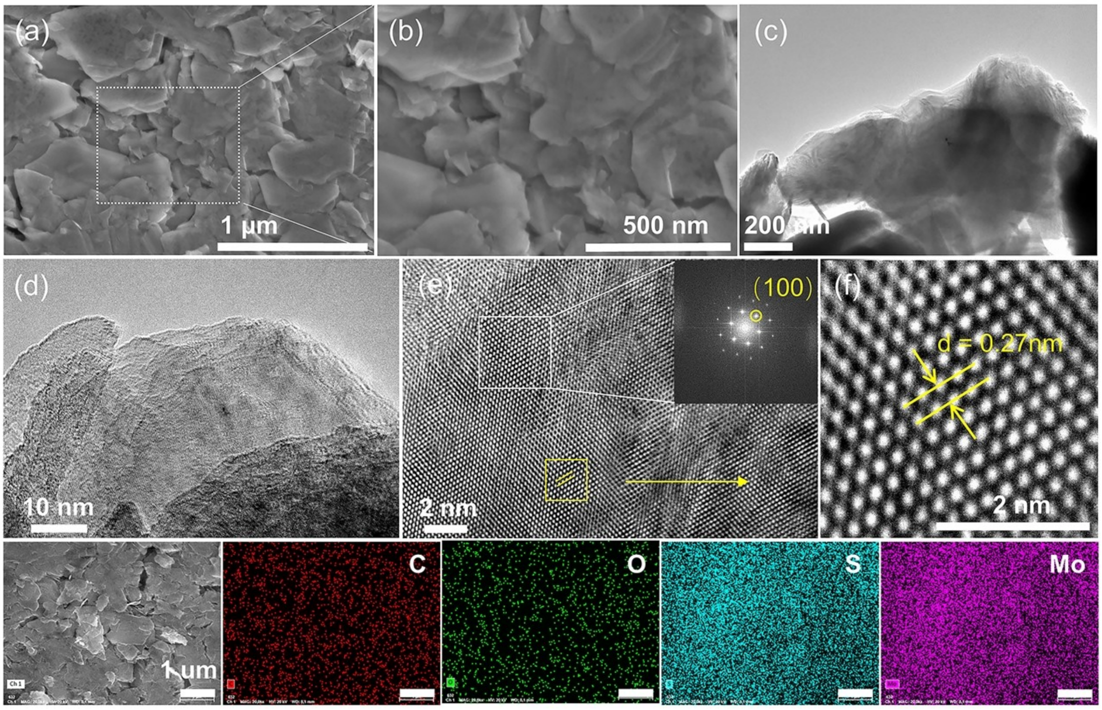


Fig. S1. Structural characterization of the pristine MoS_2 sample. (a) and (b) SEM images. (c-e) HRTEM images at different scales and the inset of Fig. (e) is the corresponding FFT pattern. (f) Enlarged image for the selected area. (g). Elemental mapping of C, O, S, and Mo, respectively.

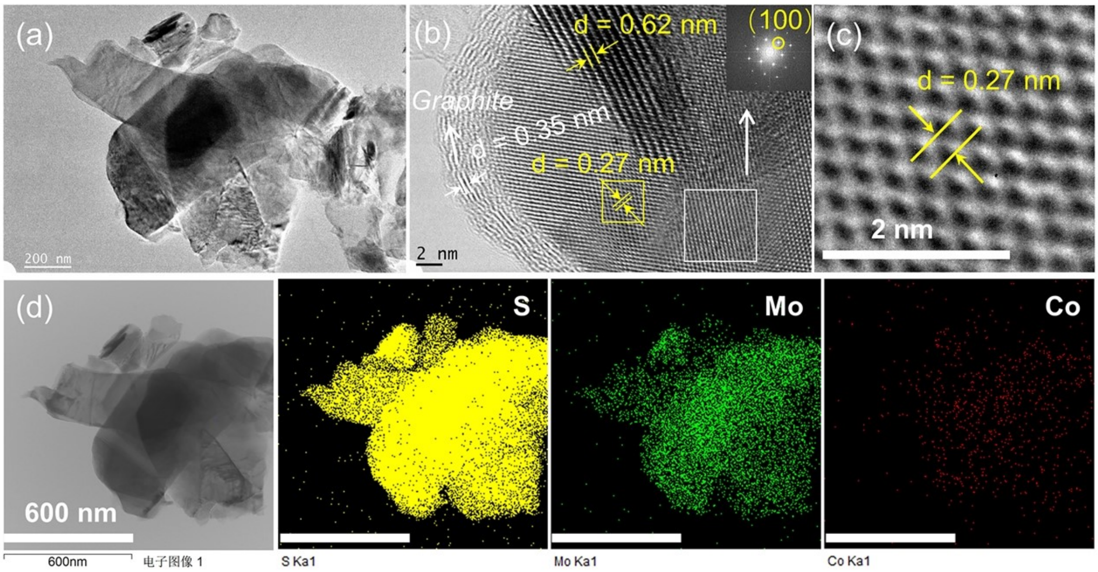


Fig. S2. Structural characterization of the Co/MG sample. (a) and (b) HRTEM images at different scales and the inset of Fig. (b) is the corresponding FFT pattern. (c) Enlarged image for the selected area in Fig. (b). (d) Elemental mapping of the S, Mo, and Co, respectively.

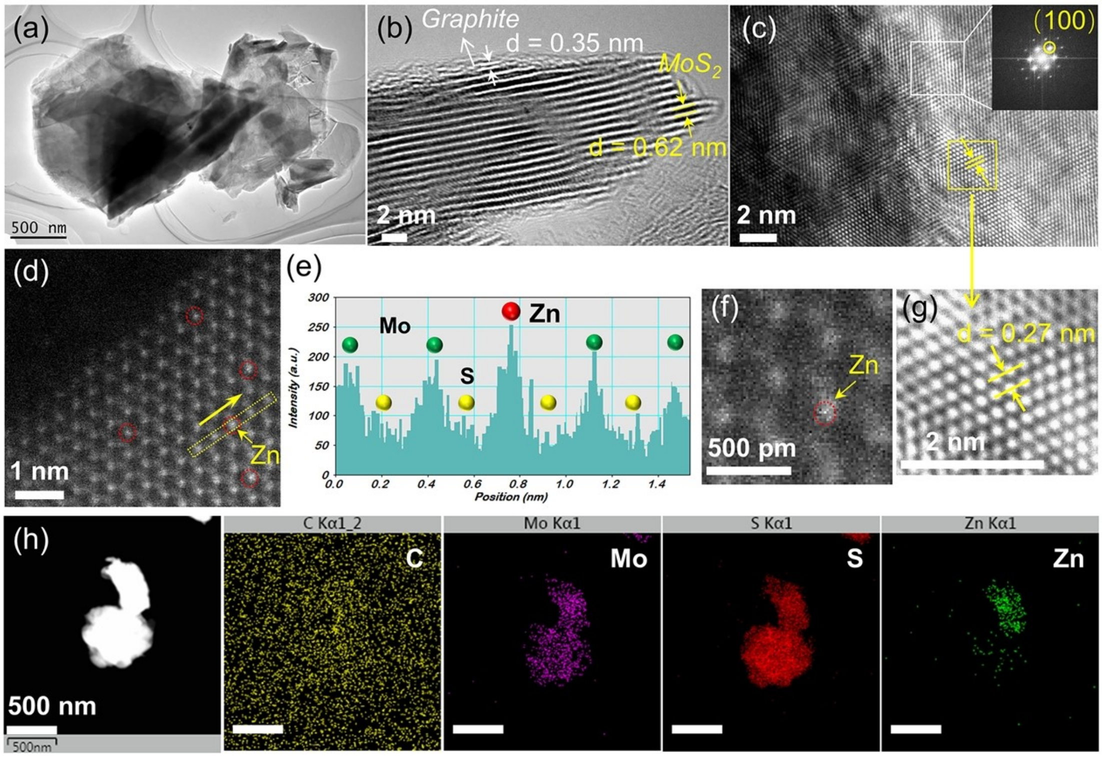


Fig. S3. Structural characterization of the Zn/MG sample. (a-c) HRTEM images at different scales and the inset of Fig. (c) is the corresponding FFT pattern. (d) HAADF-STEM image. (e) Intensity profile of the selected line in Fig. (d). (f) Enlarged image of the small area in Fig. (d). (h) Elemental mapping of the C, Mo, S, and Zn, respectively.

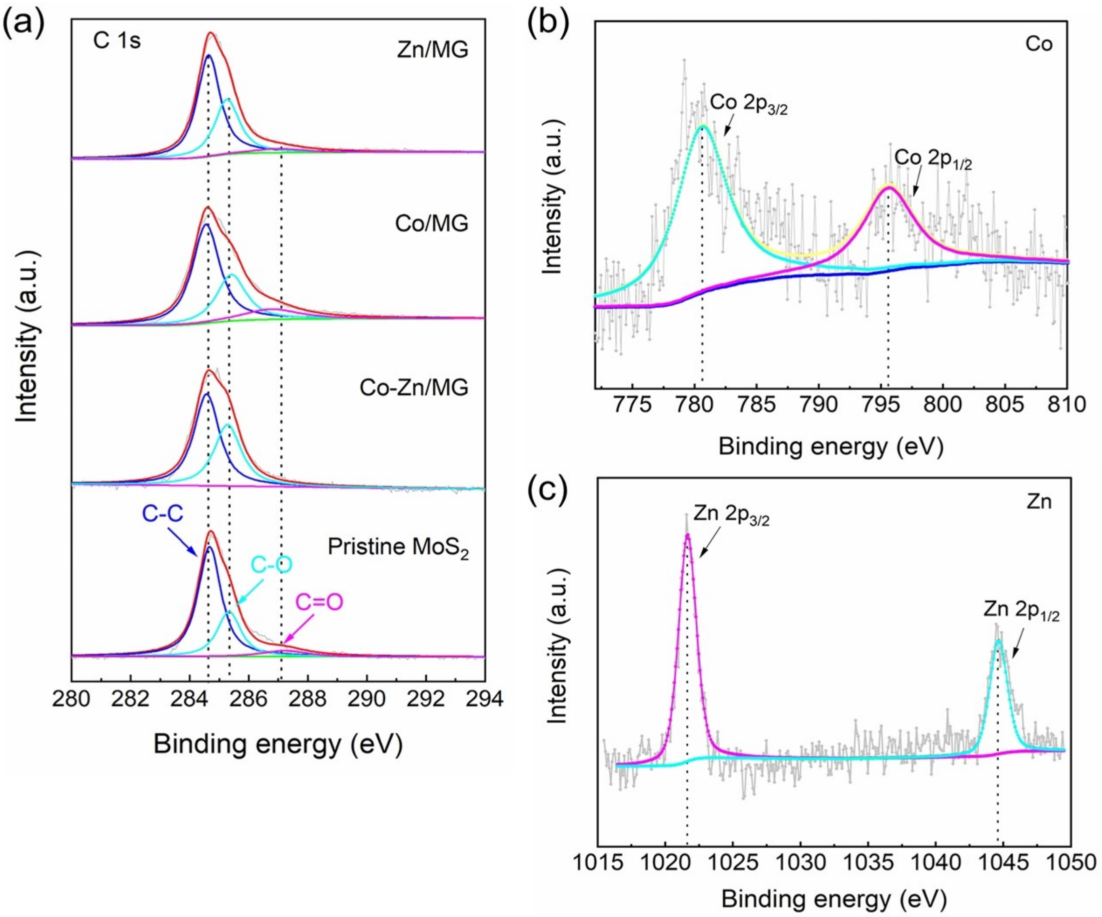


Fig. S4. (a) C 1s spectra of the pristine MoS_2, Co-Zn/MG, Co/MG, and Zn/MG samples. (b) XPS analysis of Co element in the Co/MG sample. (c) XPS analysis of Zn element in the Zn/MG sample.

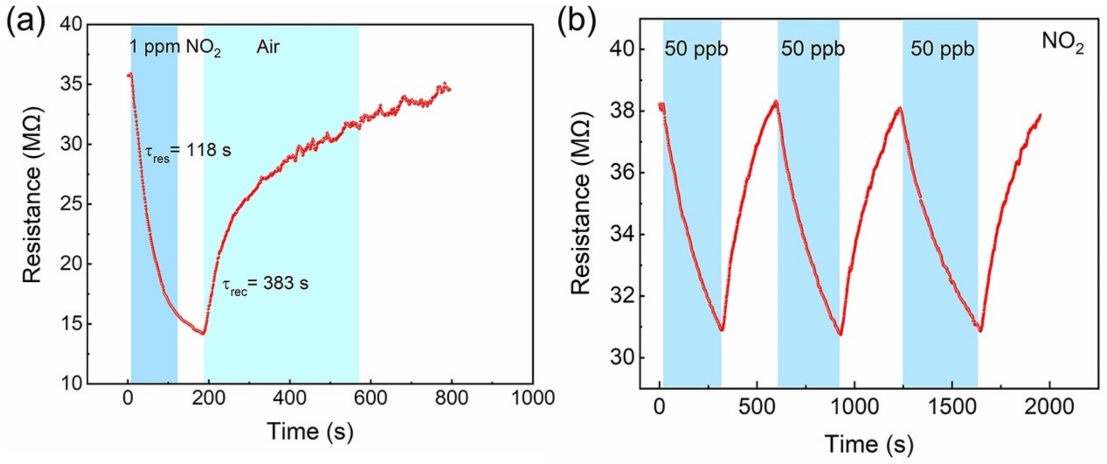


Fig. S5. (a) Response-recovery times of the Co-Zn/MG sensor toward 1 ppm NO_2 at RT. (b) Repeatability of the Co-Zn/MG sensor toward 50 ppb NO_2 at RT.

Table S1. The calculated reaction rates (k) of the sensor for six widely-used gases with a determined concentration at different operating temperatures (Kelvin).

Temp (K)	Type and concentration of gases					
	NO_2 (5 ppm)	NO (5 ppm)	NH_3 (50 ppm)	CO (50 ppm)	H_2 (100 ppm)	Ethanol (50 ppm)
	k	k	k	k	k	k
315.5	0.02522	0.01829	0.00453	0.00941	0.00758	0.00885
323.5	0.02898	0.02	0.00594	0.01273	0.00962	0.01241
342.6	0.03472	0.02534	0.00853	0.01571	0.01278	0.0154
366.7	0.04154	0.03287	0.01381	0.02007	0.01966	0.01998
389.9	0.04975	0.03949	0.01836	0.02514	0.02793	0.03028

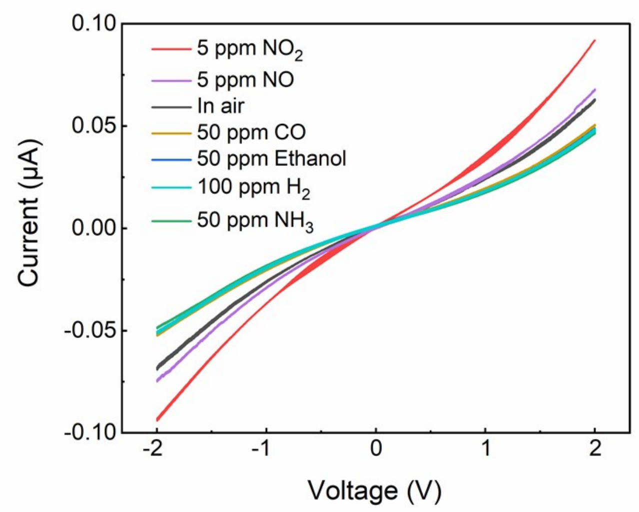


Fig. S6. I-V curves of the binary Co-Zn/MG composite sensor under different gas atmospheres measured by the electrochemical workstation (CHI600E, Beijing Join Co. Ltd, China).