

## *Supporting Information*

# **Practical room temperature formaldehyde sensing based on combination of visible-light activation and dipole modification**

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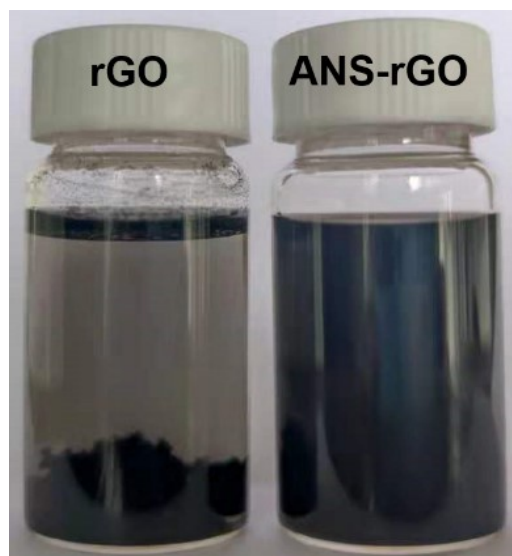


Figure S1. The photo pictures of pristine rGO and ANS-rGO water dispersions.

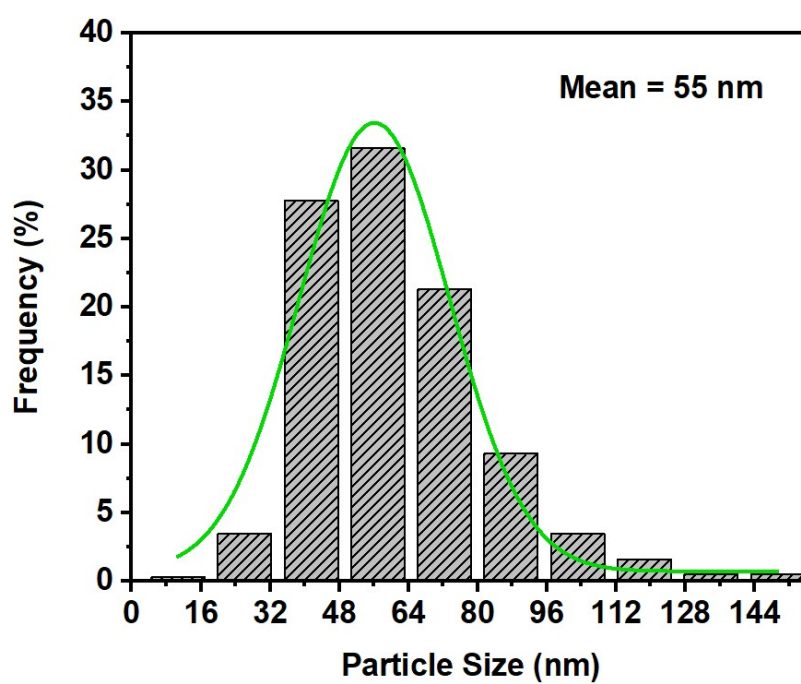


Figure S2. Particle size distribution of pure ZnO<sub>x</sub> nanoparticles.

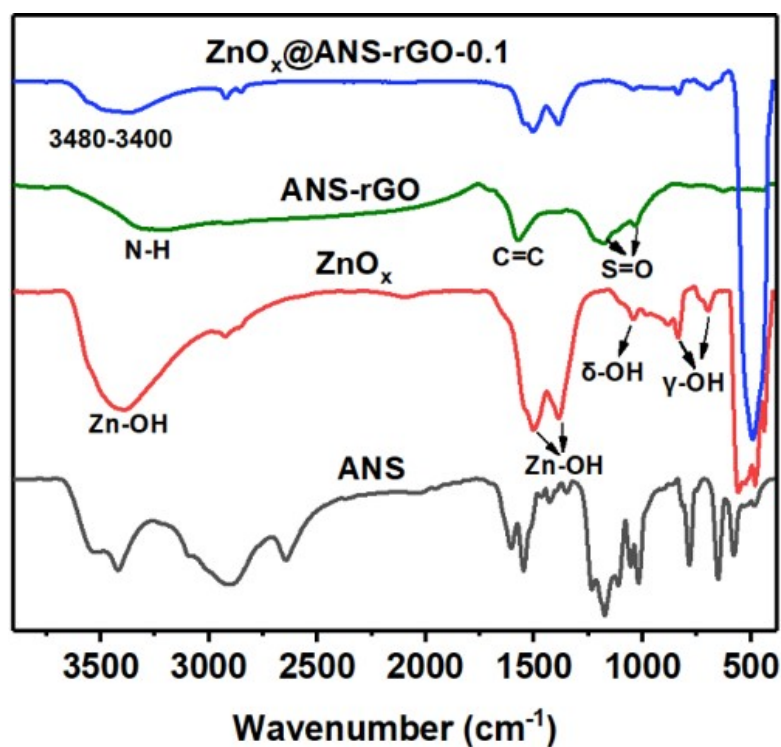


Figure S3. FTIR spectra of ANS,  $\text{ZnO}_x$ , ANS-rGO and  $\text{ZnO}_x\text{@ANS-rGO-0.1}$  nanocomposites.

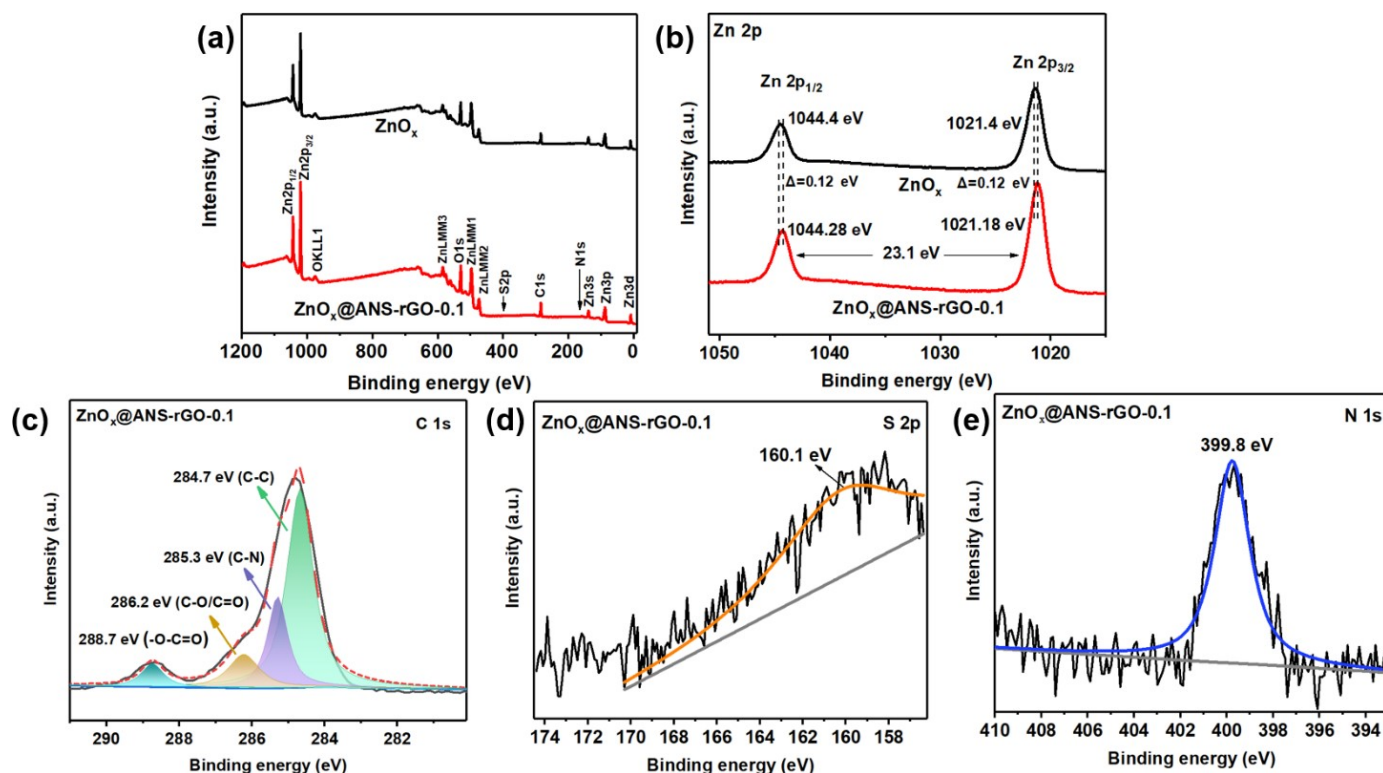


Figure S4. XPS survey spectra (a) of pure  $\text{ZnO}_x$  and  $\text{ZnO}_x\text{@ANS-rGO-0.1}$ ; Zn region (b) of pure  $\text{ZnO}_x$  and  $\text{ZnO}_x\text{@ANS-rGO-0.1}$ ; high-resolution spectra of C 1s (c), S 2p (d) and N 1s (e) in  $\text{ZnO}_x\text{@ANS-rGO-0.1}$ .

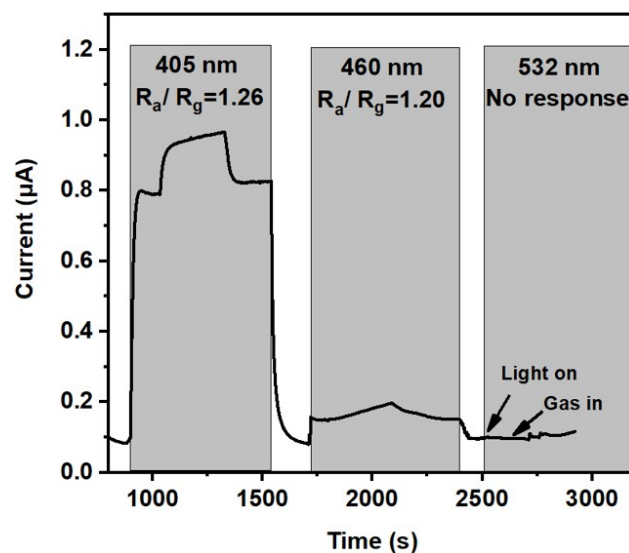


Figure S5. Typical response curve of 0.4 ppm HCHO under different wavelengths including 405, 460 and 532 nm visible light.

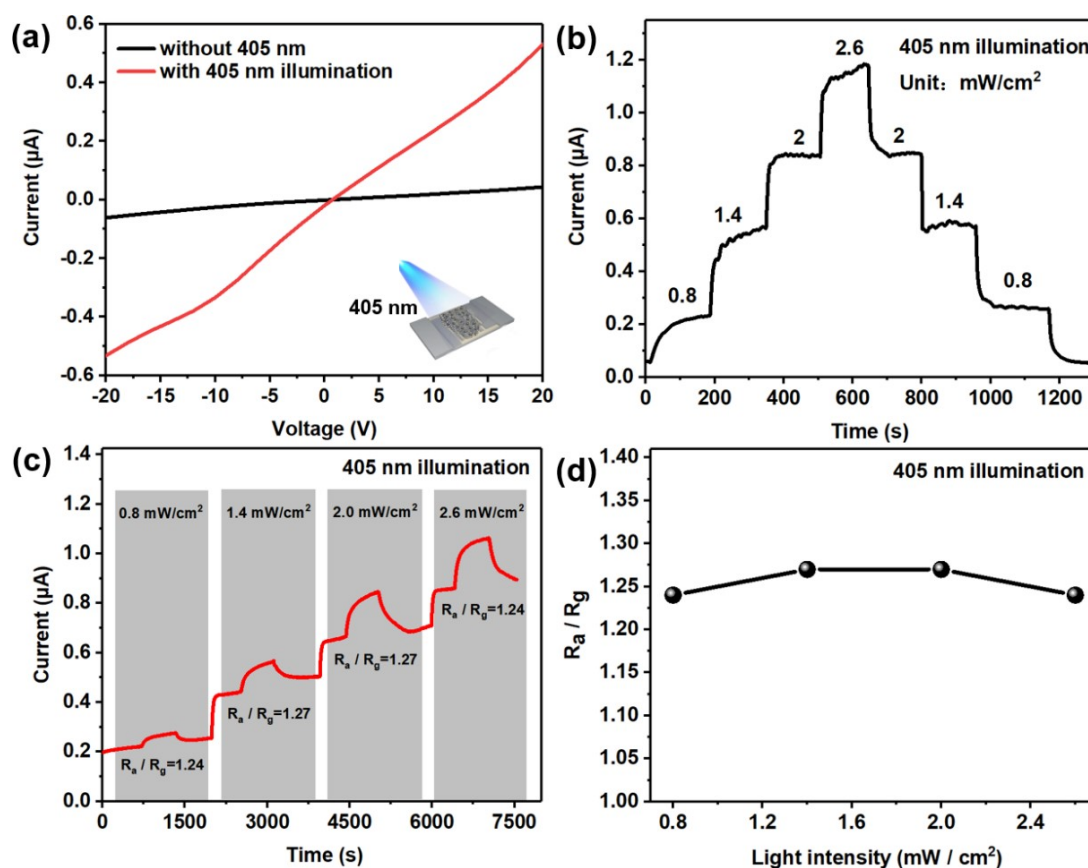


Figure S6. I-V characterizes (a) of ZnO<sub>x</sub>@ANS-rGO-0.1 based sensor under 405 nm illumination and dark condition; Reproducibility (b) of the sensor upon 405 nm illumination with different light intensity; Typical response curve (c) of 0.4 ppm HCHO under different 405 nm light intensity (0.8-2.6 mW/cm<sup>2</sup>) and its corresponding response value (d).

**Table S1** Comparison of the gas sensing performances for different samples

Samples	S	T <sub>res</sub> (s)	T <sub>rec</sub> (s)
ANS-rGO@ZnO <sub>x</sub> -0.1	1.58	47	39
NA-rGO@ZnO <sub>x</sub> -0.1	1.48	181	65
ANS-rGO@ZnO <sub>x</sub> -0.01	1.37	87	40
ANS-rGO@ZnO <sub>x</sub> -1	1.24	50	23
rGO/ZnO <sub>x</sub> -0.1	1.18	156	111
ZnO <sub>x</sub>	1.41	200	77
ANS-rGO	-	-	-

Sensitivity (S), Response time (T<sub>res</sub>), Recovery time (T<sub>rec</sub>)

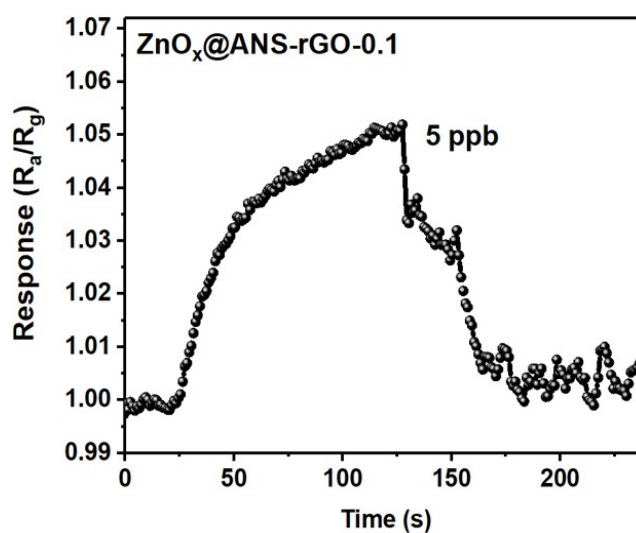


Figure S7. dynamic response of the ZnO<sub>x</sub>@ANS-rGO-0.1 based sensor toward 5 ppb HCHO under 405 nm illumination.

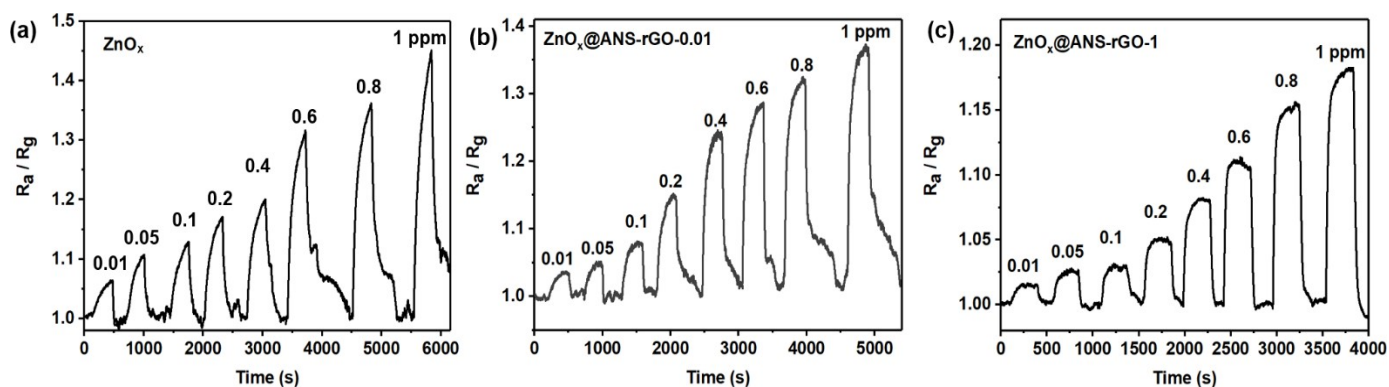


Figure S8. Response curves of ZnO<sub>x</sub> (a), ZnO<sub>x</sub>@ANS-rGO-0.01 (b) and ZnO<sub>x</sub>@ANS-rGO-1 (c) based sensors to HCHO at concentration vary from 0.01 ppm to 1 ppm under 405 nm visible light illumination.

**Table S2** Comparison of HCHO concentration detected by our sensor and ultraviolet spectrophotometer (calibration)

Number	Our sensor (ppb)	Calibration (ppb)
1	925	893
2	824	829
3	598	551
4	345	323
5	222	190

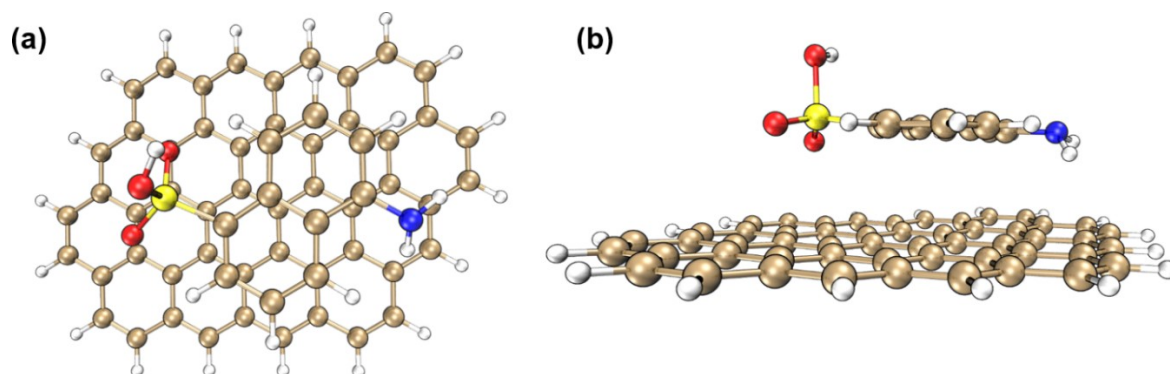
Figure S9. Picture of a 30 m<sup>3</sup> test chamber we used in Guangdong Mixwell Technology Co., Ltd. for this work.

Figure S10. Optimized geometries of the ANS-rGO molecular structures: (a) vertical view; (b) front view. (The detailed simulation procedure is shown in the computational details part)