**Electronic Supplementary Information (ESI)**

# Design of $CuO/TiO_2$ heterostructure nanofiber and sensing preformance

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## Experimental section

***Synthesis of $TiO_2$ NFs:*** $TiO_2$ NFs were synthesized by the method our group reported before[1]. Briefly speaking.[1] Brief, tetrabutyl titanate (TBT, 2.0 g) and glacial acetic (2.0 g) were dissolved into ethanol (7.5 g). Then poly-(vinlypyrrolidone) (PVP, 11.5 wt%) solution was added into the above solution. After 4 h stirring, the solution was transferred into a syringe for electrospinning and an applied electric voltage of 20 kV. The obtain products were annealed in air at 500 °C for 2 h.

***Fabrication of CuO NCs:*** 1.7048 g cupric chloride dihydrate was put into 20 mL deionized water with stirring and after the salt was completely dissolved, 0.5 mL of ammonium hydroxide solution (28%) was added into the aqueous solution drop by drop. After another 5 min of continuous agitation, the obtained precursors were then poured into Teflon-lined autoclave which with the capacity of 50 mL. The reaction system was kept at 140 °C for 18 h and cooled naturally, and the final products were collected by centrifugation, then dried under a vacuum pump at 50 °C for 12 h.

***Preparation of CuO/$TiO_2$ HNFs:*** The method of preparation the CuO/$TiO_2$ HNFs was similar to the preparation of CuO NCs, except for the addition of $TiO_2$ NFs. After the resulting solution we mentioned before was transferred into the autoclave, 10 mg of $TiO_2$ NFs was also added to the system.

***Characterizations.*** The product was characterized by X-ray diffraction (XRD) using a Rigaku D/Max-2550 diffractometer with Cu Kα radiation (λ=1.54 Å) (40 kV, 350 mA) in the range of 20-80° (2θ) at a scanning rate of 6° $min^{-1}$. The morphologies and structures of the products were obtained by a XL 30 ESEM FEG field emission scanning electron microscope (FESEM). TEM and HRTEM images were recorded with a Tecnai $G^2$ 20S-Twin transmission electron microscope operating at an accelerating voltage of 120 and 200 kV, respectively.

***Definition of sensing parameter*:** The electrical properties of the sensor were measured by a RQ-2 series Intelligent Test Meter (China). For n-type semiconductor, the response ($S=R_a/R_g$) of the sensor is defined as the ratio of sensor resistance in dry air ($R_a$) to that in a target gas ($R_g$). For p-type semiconductor, the response ($S=R_g/R_a$) of the sensor is defined as the ratio of sensor resistance in a target gas ($R_g$) to that in dry air ($R_a$). The response and recovery time were defined as the time taken by the sensor to achieve 90% of the total resistance change in the case of adsorption and desorption, respectively.[2]

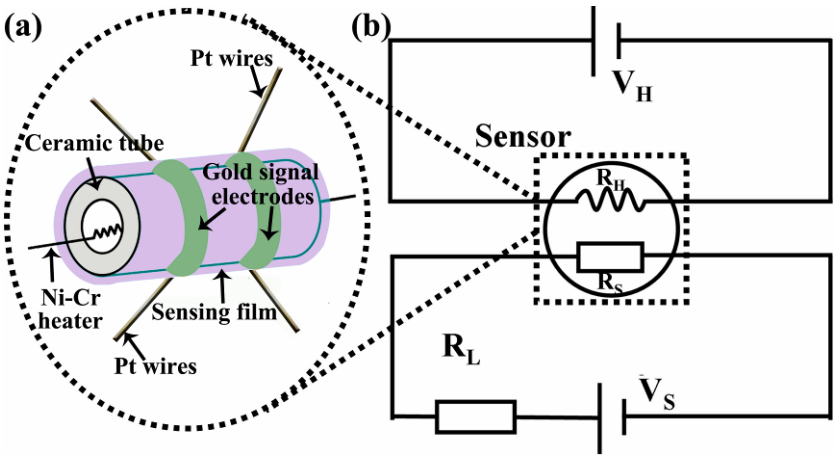


**Figure S1** (a) Schematic image of the CuO/$TiO_2$ HNFs sensor; (b) schematic diagram of the electrical circuit for measuring the CuO/$TiO_2$ HNFs gas sensor.

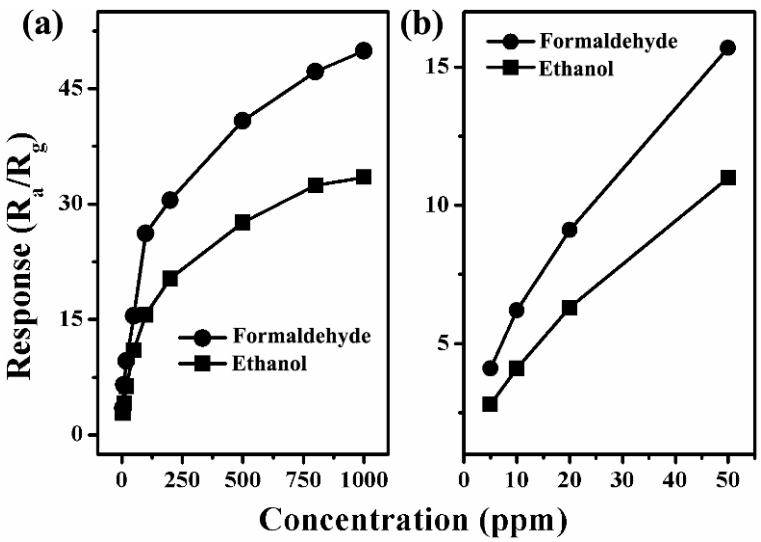


**Figure S2** (a) Comparison in sensor response to different formaldehyde and ethanol concentrations for the $CuO/TiO_2$ HNFs. (b) response of the $CuO/TiO_2$ HNFs sensors to 5-50 ppm formaldehyde and ethanol gas.

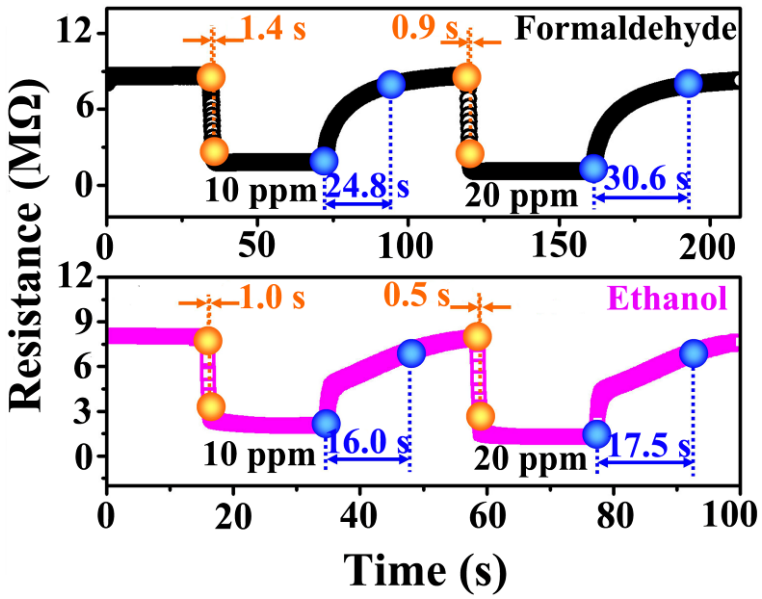


**Figure S3** Response and recovery speed curves of the $CuO/TiO_2$ HNFs to 10 and 20 ppm formaldehyde and ethanol at the operating temperature of 200 and 300 ℃, respectively.

| Materials | Target gas | Concentration [ppm] | Temperature [°C] | Response time [s] | Recover time [s] |
|---|---|---|---|---|---|
| This work | HCHO | 10 | 200 | 1.4 | 24.8 |
| $NiO/SnO_2$ [3] | HCHO | 10 | 200 | 50 | 80 |
| $MnO_2/ZnO$ [4] | HCHO | 200 | 320 | 27 | 12 |
| This work | $C_2H_5OH$ | 10 | 300 | 1.0 | 16 |
| $Sm_2O_3/ZnO$ [5] | $C_2H_5OH$ | 500 | 300 | 15 | 420 |
| $SnO_2/ZnO$ [6] | $C_2H_5OH$ | 100 | 400 | 96 | 400 |

**Table 1** Sensing performance of the heterostructure sensors to formaldehyde and ethanol gases.

## References:


1 J. N. Deng, B.Yu, Z. Lou, L. L. Wang, R. Wang and T. Zhang, *Sens. Actuators B*, 2013, **184**, 21-26.

2 L. L. Wang, Z. Lou, T. Fei and T. Zhang, *J. Mater. Chem.*, 2011, **21**, 19331-19336.

3 Y. G. Zheng, J. Wang and P. J. Yao, *Sens. Actuators B*, 2011, **156**, 723-730.

4 C. S. Xie, L. Q. Xiao, M. L. Hu, Z. K. Bai, X. P. Xia and D. W. Zeng, *Sens. Actuators B*, 2010, **145**, 457-463.

5 M. Bagheri, N. F. Hamedani, A. R. Mahjoub, A. A. Khodadadi and Y. Mortazavi, *Sens. Actuators B*, 2014, **191**, 283-290.

6 S. Hemmati, A. A. Firooz, A. A. Khodadadi and Y. Mortazavi, *Sens. Actuators B*, 2011, **160**, 1298-1303.