SUPPLEMENTARY DATA

(13 pages)

Au-deposited porous single-crystalline ZnO nanoplates for gas sensing detection of total volatile organic compounds

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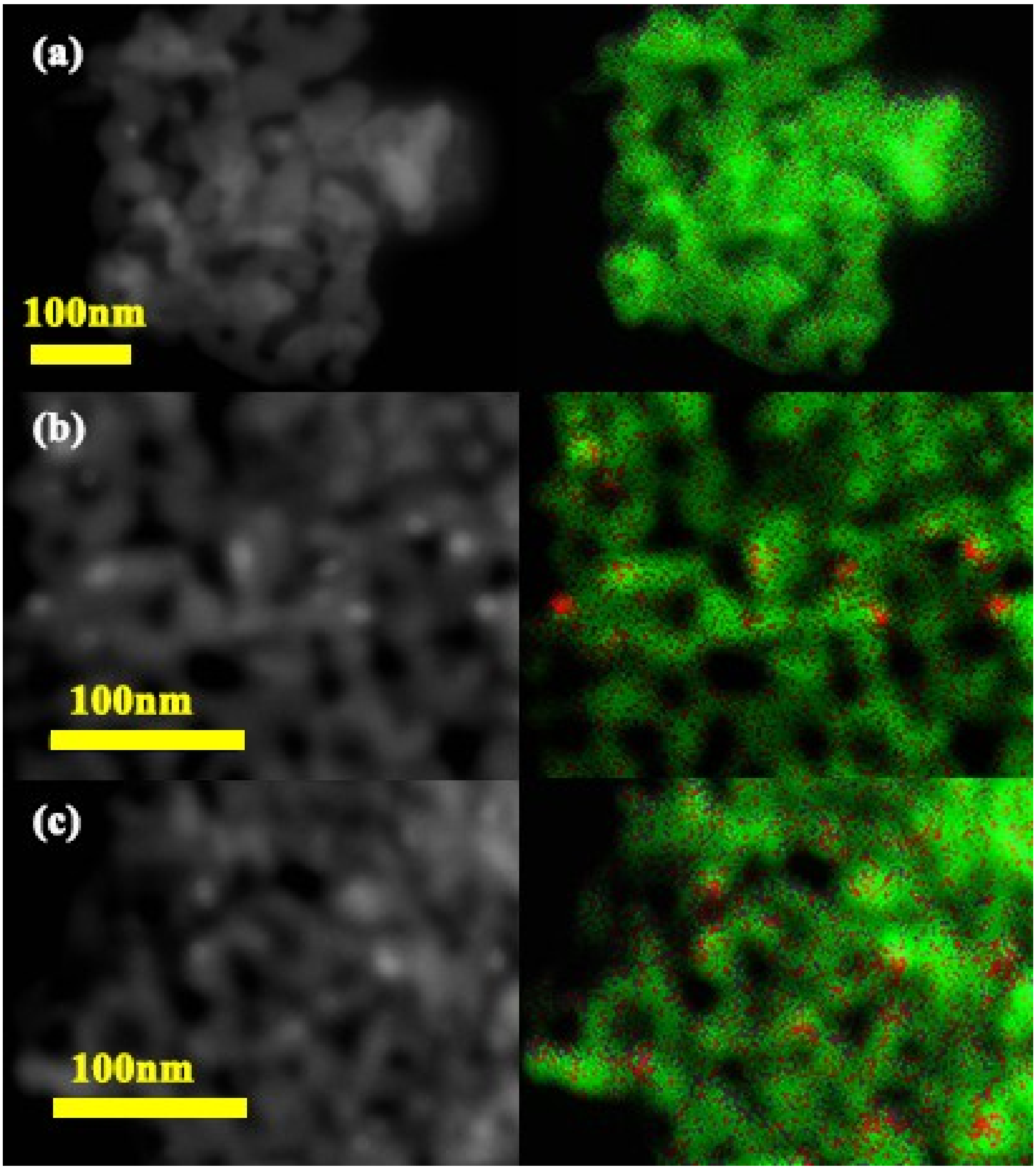

Figure S1. Mapping images of (a) 1% Au@ZnO, (b) 3% Au@ZnO and (c) 5% Au@ZnO.

Table S1 Elemental analysis of 1% Au@ZnO, 3% Au@ZnO and 5% Au@ZnO

Element	1% Au@ZnO	3% Au@ZnO	5% Au@ZnO
O	55.39	57.09	52.55
Zn	43.95	41.78	44.78
Au	0.65	1.14	2.67

Calculation of the average size of Au nanoparticles obtained from XRD pattern.

According to the XRD patterns, the average size also can be calculated by the full width at half maximum (FWHM), using the Scherrer equation:

$$D = K\lambda / B_{\frac{1}{2}} \cos\theta$$

where D represents the average size of the nanocrystalline, λ is the wavelength of incident X-rays radiation (0.15406 nm for Cu Kα), $B_{1/2}$ represents the FWHM of the diffraction peak at 2θ, θ is the diffraction angle, and K is the Scherrer constant. The value for the coefficient "K", which is closed to 0.89, depends on the geometry of the crystallites [1, 2]. Take (111) peak of Au as examples, the average Au nanoparticles sizes of 1% Au@ZnO, 3% Au@ZnO and 5 % Au@ZnO were 12.80nm, 16.93nm and 14.29nm, respectively, which is closed to the results obtained according to TEM images.

[1]. H. P. Klug and L. E. Alexander, *X-ray diffraction procedures*, Wiley New York, 1954.
[2]. T. KumaráSarma, *Chemical Communications*, 2002, 1048-1049.

Table S2 Optimum temperature of each sensor for target gases of VOCs.

Sensor materials	Optimum temperature (°C)	Target gases
Pure ZnO nanoplates	260	diethyl ether, methanol
	360	acetone, formaldehyde, trichloro ethylene, ethyl acetate, isoprene, butyl acetate, hexaldehyde
	460	chlorobenzene, o-xylene, n-heptane, benzene, toluene, n-decane
1% Au@ZnO	360	acetone, methanol, formaldehyde, ethyl acetate, benzene, o-xylene, chlorobenzene, isoprene, butyl acetate, hexaldehyde
	460	diethyl ether, n-heptane, trichloro ethylene, toluene, n-decane
3% Au@ZnO	260	methanol, trichloro ethylene
	360	acetone, formaldehyde, diethyl ether, ethyl acetate, benzene, o-xylene, chlorobenzene, isoprene, butyl acetate, hexaldehyde
	460	n-heptane, toluene, n-decane
5% Au@ZnO	260	methanol, trichloro ethylene
	360	acetone, diethyl ether, ethyl acetate, benzene, toluene, o-xylene, chlorobenzene, isoprene, butyl acetate, hexaldehyde
	460	formaldehyde, n-heptane, n-decane

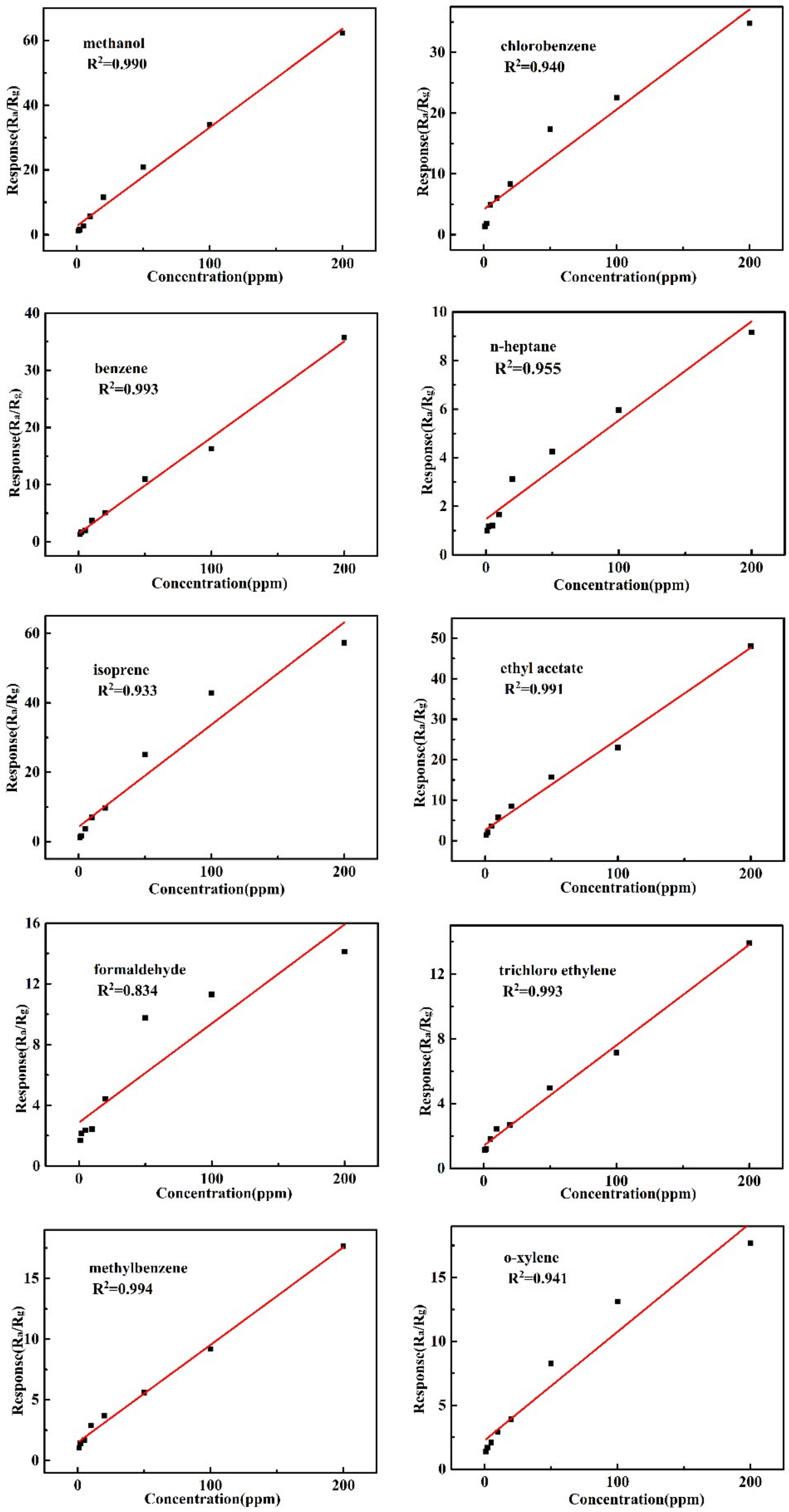

Figure S2. The relation between the sensor sensitivity and VOCs concentration measured at 360 °C for 5% Au@ZnO sensor.

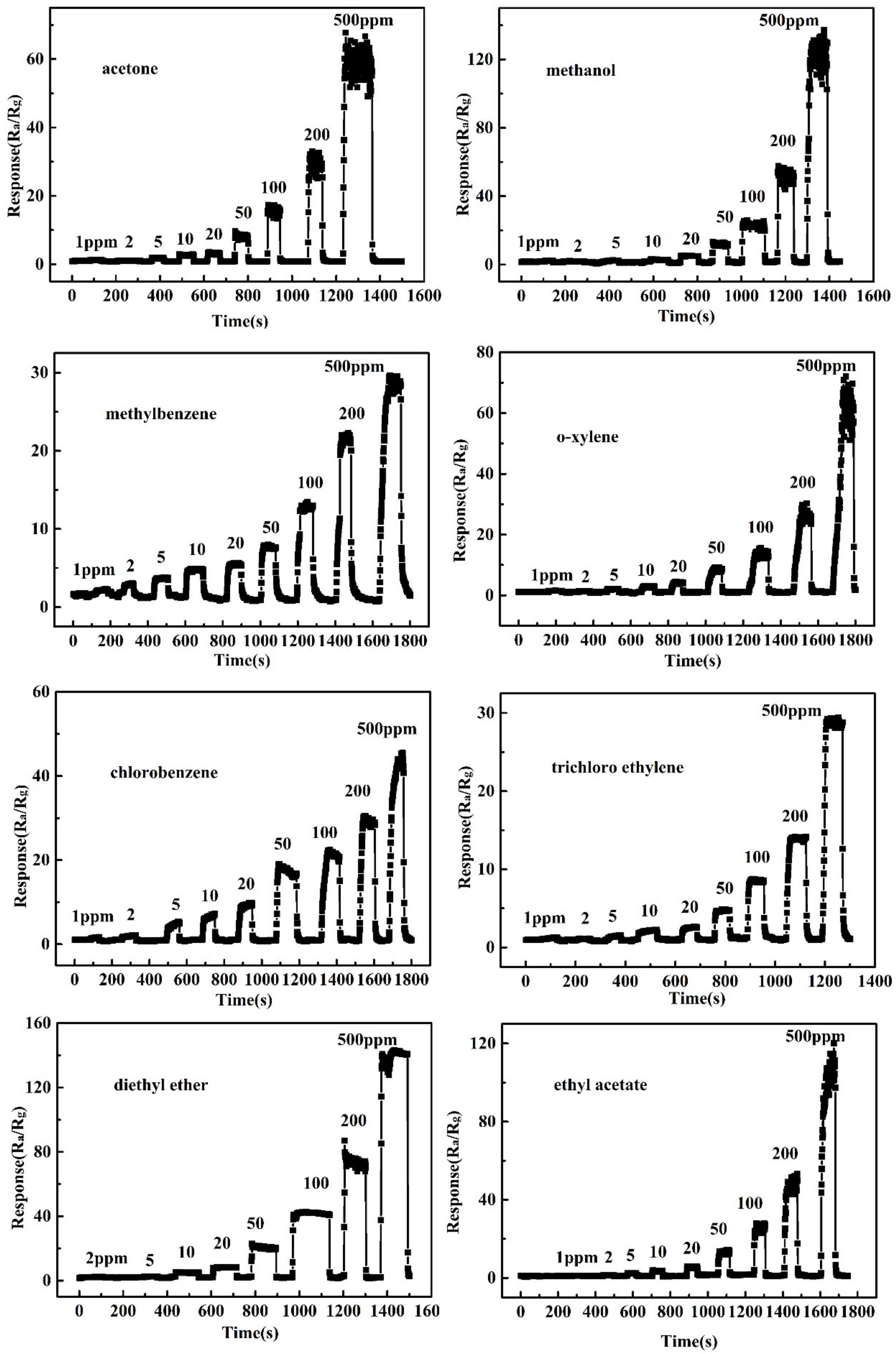

Figure S3. Response curves of 5% Au@ZnO sensor towards methanol, diethyl ether, acetone, chlorobenzene, trichloro ethylene, methylbenzene, o-xylene and ethyl acetate with increasing concentration at 360 ˚C.

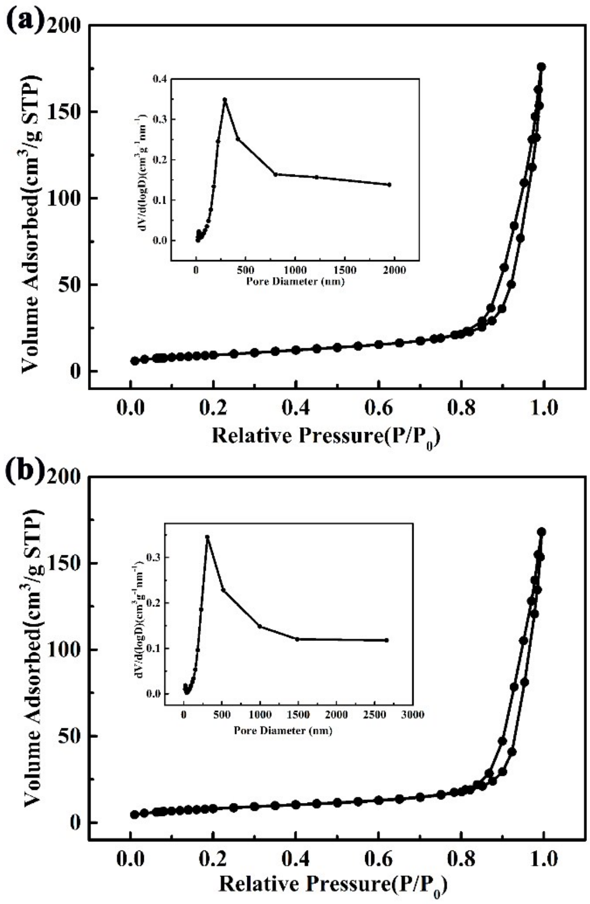

Figure S4. Typical nitrogen adsorption-desorption isotherm and BJH pore size distribution plots (inset) of (a) porous ZnO nanoplates and (b) 5% Au@ZnO.

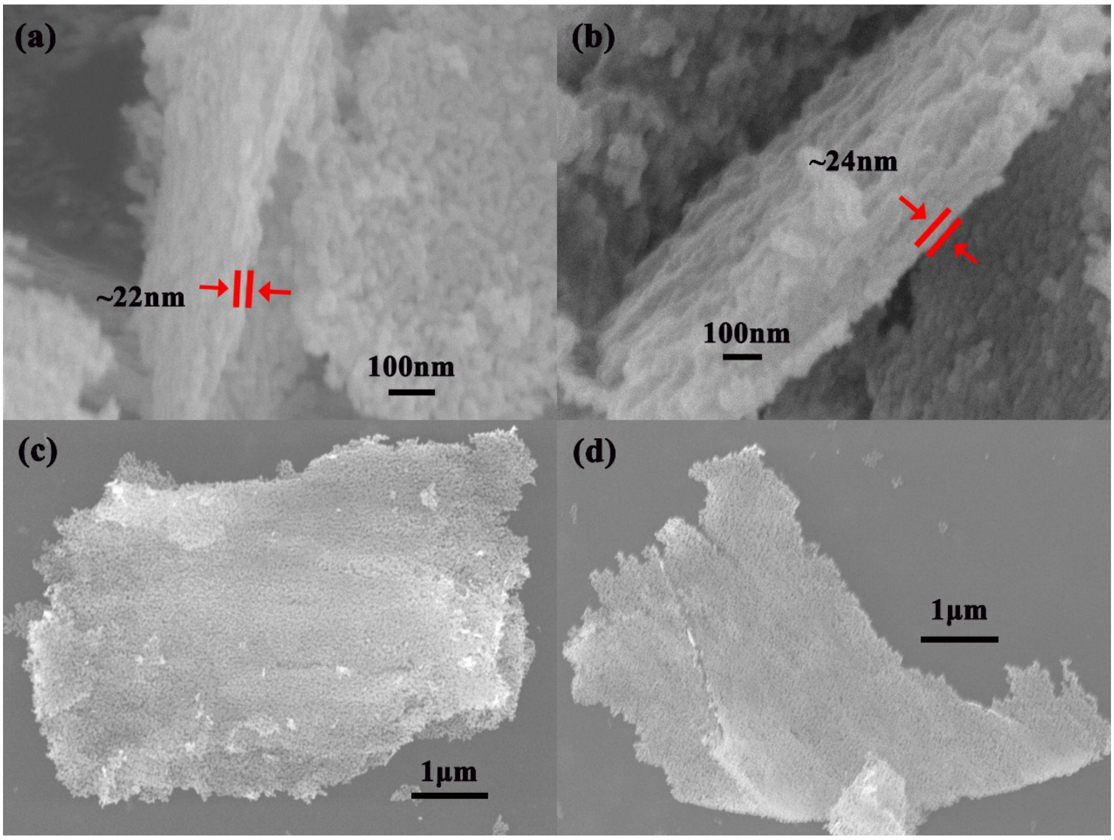

Figure S5. SEM images of (a) (c) porous ZnO nanoplates and (b) (d) 5% Au@ZnO.

Figure S5 (a) shows the pure ZnO, composed of plate-like nanostructures with edge thickness of about 22 nm and porous surfaces. Figure S6 (b) displays the Au@ZnO nanoplates, with the edge thickness of about 24 nm. The dimensions of porous ZnO nanoplates and 5% Au@ZnO were showed in figure (c) (d). The ZnO nanoplates is about 6.5μm long and 4μm wide. And after the photodeposition process, the 5% Au@ZnO still kept plate-like morphology.

Table S3. The response time and recovery time of 5% Au@ZnO sensor at 100ppm

Representative gases	Response time(s)	Recovery time(s)
methanol	**4**	**3**
chlorobenzene	**10**	**14**
benzene	**6**	**4**
n-heptane	**3**	**4**
isoprene	**3**	**4**
ethyl acetate	**4**	**8**
formaldehyde	**30**	**12**

Table S4. The response/recovery characteristics of other sensors based on metal oxide nanostructures.

Representative gases of VOCs (100ppm)	Sensor materials	response/recovery time(s)	References
Oxy hydrocarbons (Methanol)	AuNP-functionalized 3D hierarchically porous ZnO nanomaterials	About 10/60	[3]
Halogenated hydrocarbons (Chlorobenzene)	Porous ZnO Nanoplates	103/22	[4]
Aromatic hydrocarbons (Benzene 10ppm)	Au-functionalized ZnO nanowires	70/27	[5]
Aliphatic hydrocarbons (Butane 0.4mol/L)	TiO_2	About 180/60	[6]
Terpenes (α-Pinene)	Nano-structured WO_3	About 420/180	[7]
Esters (Ethyl acetate)	MOS-based gas sensor array	-	[8]
Aldehydes (Formaldehyde 5ppm)	Au@ZnO core–shell structure	138/104	[9]

Compared the response/recovery times of the sensor materials in the list, the 5% Au@ZnO shows fast response/recovery times.

[3]. X. Liu, J. Zhang, L. Wang, T. Yang, X. Guo, S. Wu and S. Wang, *Journal of Materials Chemistry*, 2011, **21**, 349-356.

[4]. Z. Jing and J. Zhan, *Advanced Materials*, 2008, **20**, 4547-4551.

[5]. L. Wang, S. Wang, M. Xu, X. Hu, H. Zhang, Y. Wang and W. Huang, *Physical Chemistry Chemical Physics*, 2013, **15**, 17179-17186.

[6]. A. Zotti, S. Zuppolini, M. Giordano, M. Zarrelli, A. Borriello and G. De Luca. *2015 XVIII AISEM Annual Conference.*2015,3.

[7]. S. Paczkowski, T. Sauerwald, A. Weiß, M. Bauer, D. Kohl and S. Schütz. *Bioinspiration, Biomimetics, and Bioreplication,*2011,**7975**,05.

[8]. T. Konduru, G. C. Rains and C. Li, *Sensors*, 2015, **15**, 1252-1273.

[9]. F.-C. Chung, Z. Zhu, P.-Y. Luo, R.-J. Wu and W. Li, *Sensors and Actuators B: Chemical*, 2014, **199**, 314-319.

Table S5. Previous reported about sensing performance of Au on ZnO nanoplates.

Materials	Operating temperature (°C)	Target gases (100ppm)	Response value	Response/recovery Time (s)	Ref.
Au-functionalized 3D hierarchically porous ZnO nanomaterials,	300	ethanol	~18	~10/60	[19]
		methanol	~11.5	~10/60	
Au-supported ZnO nanoplates	300	ethanol	~20	13/~100	[52]
		acetone	~16	-	
Au-deposited ZnO nanoplates	360	methanol	35	4/3	This work

19. X. Liu, J. Zhang, L. Wang, T. Yang, X. Guo, S. Wu and S. Wang, *Journal of Materials Chemistry*, 2011, **21**, 349-356.
52. J. Zhang, X. Liu, S. Wu, B. Cao and S. Zheng, *Sensors and Actuators B: Chemical*, 2012, **169**, 61-66.

Table S6. Response of representative gases of each group.

Classification of VOCs	Representative gases	Response at 50 ppm
Oxy hydrocarbons	methanol	20.853
	diethyl ether	21.627
	acetone	10.230
Halogenated hydrocarbons	chlorobenzene	16.698
	trichloro ethylene	4.019
Aromatic hydrocarbons	benzene	11.463
	toluene	6.728
	o-xylene	7.749
Aliphatic hydrocarbons	n-heptane	4.578
	n-decane	10.891
Terpenes	isoprene	25.090
Esters	ethyl acetate	23.543
	butyl acetate	15.775
Aldehydes	formaldehyde	9.579
	hexaldehyde	21.728