Electronic Supplementary Material (ESI) for RSC Advances.

Si doped highly crystal mesoporous In_2O_3 nanowires: synthesis, characterization and ultra-high response to NO_x at room temperature

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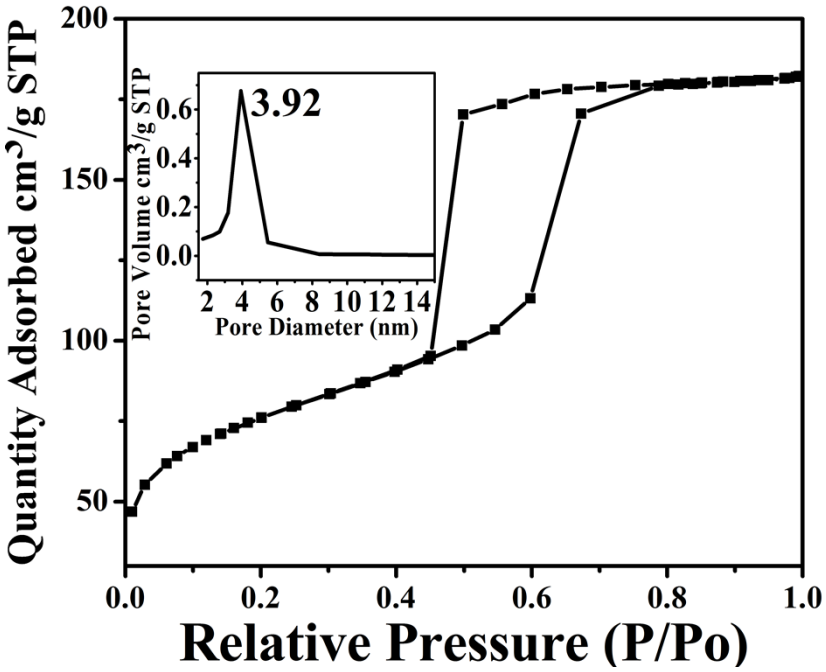

Fig. S1. BET specific surface areas of SBA-16 (BET: 270.99 m^2/g; the pore size is 3.92nm).

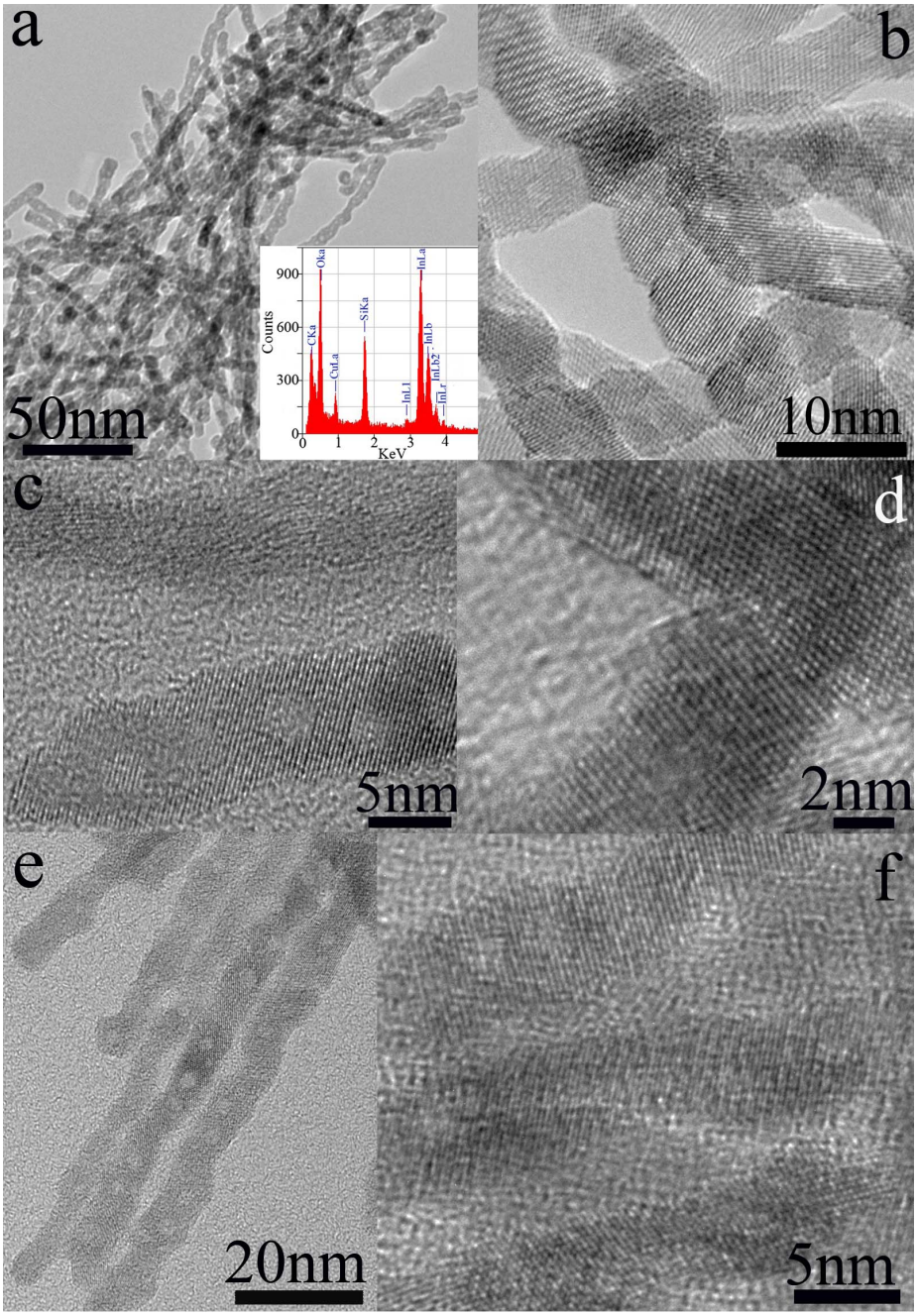

Fig. S2. TEM/HRTEM images of In_2O_3 NWs doped by amorphous silica samples.

(a)~(f) INW-2, and (f) is the HRTEM image of Fig.3e.

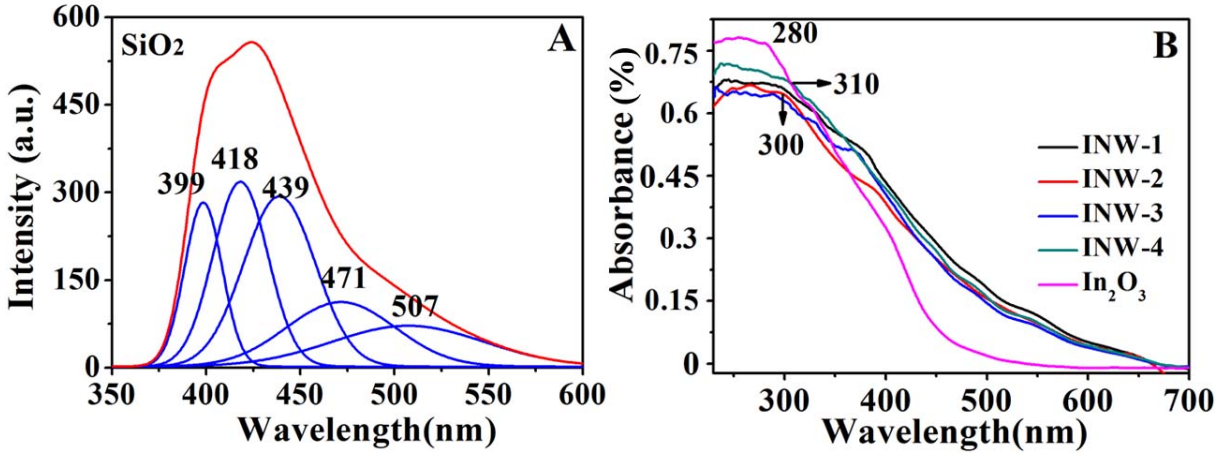

Fig. S3. PL spectra of (A) SiO_2 (SBA-16) with 325 nm excitation at room temperature of and (B) UV-vis diffuse absorption spectra of SiO_2-In_2O_3 composites with different atomic ratios.

Fig.S3A is PL spectra of SiO_2 (SBA-16) with 325 nm excitation at room temperature. In Figure.S3B, the absorption edge around 550 nm was pure In_2O_3 NWs. The absorption edges observed to be around 675 nm were In_2O_3 NWs doped by amorphous silica samples (INW-1, INW-2, INW-3 and INW-4). Besides, it was denoted that the absorption in UV light region decreased for pure In_2O_3 NWs compared with In_2O_3 NWs doped by amorphous silica. This demonstrated that the coverage of SiO_2 on In_2O_3 surface did not restrain the absorption of UV light. This was different from previous studies[1] about the SiO_2-coated TiO_2 (the average thickness of SiO_2 coating layer was 2-3 nm).

Furthermore, In_2O_3 NWs doped by amorphous silica samples (HCMIAs) with a high aspect ratio and peculiar morphologies should favor the existence of large quantities of oxygen vacancies, which would induce the formation of new energy levels in the band gap. The UV absorption of HCMIAs occurred at 300-310 nm indicating that the existence of weak quantum confinement effect[2].

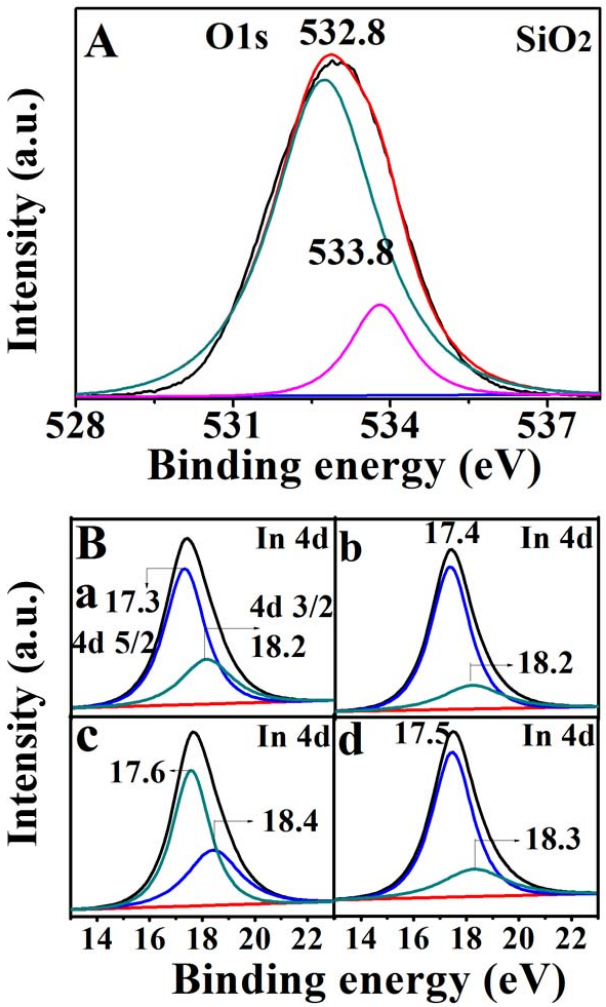

Fig. S4. XPS spectra of (A) O1s of SiO_2 (SBA-16) and (B) low binding energy region in XPS of samples containing valence band in In4d (a) In_2O_3, (b) INW-1, (c) INW-2 and (d) INW-4, respectively.

Fig. S4A showed the O1s spectra of pure SiO_2 (SBA-16) located at 532.8 eV were essentially composed one of a major component, which could be attributed to Si-O binding energy[3]. The spectra depicted a secondary component, which located at higher energy (533.8 eV) and could be ascribed to O-H groups linked to Si cations.

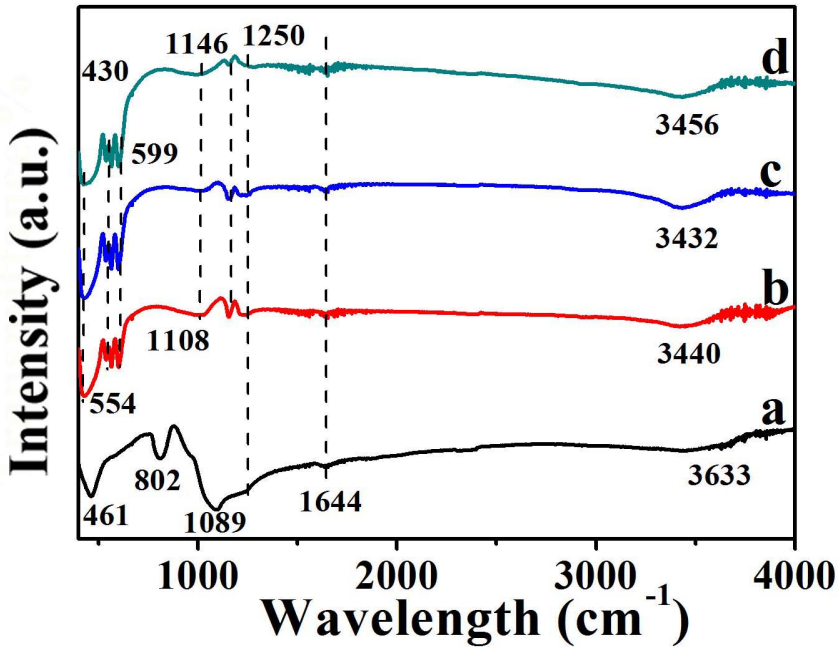

Fig. S5 FT-IR spectra of (a) SiO_2, (b) INW-1, (c) INW-2 and (d) INW-4, respectively.

FT-IR spectra of SiO_2, INW-1, INW-2 and INW-4 samples were shown in Fig. S5. As shown in Fig. S5, there were adsorptive peaks of amorphous silica hydroxyl at 3432-3633 cm^{-1} and the spectrum should be attributed to the stretching of hydrogen (-OH) bond of H_2O[4]. The spectra of INW-1 and INW-2 appeared blue shifted to 3432 cm^{-1}, and red shifted in INW-4. Moreover, the peak appeared at 1644 cm^{-1} and 461 cm^{-1} were assigned to the bending vibrations of -OH) bond and Si-O group[5] respectively. Furthermore, 1089 cm^{-1} was symmetric stretching of Si-O-Si group whereas 802 cm^{-1} was asymmetric stretching of Si-O-Si group. According to previous studies[6-7], the band centered at 1108 $cm^{-1}$was assigned to the stretching vibration of Si-O-metal[5], that was Si-O-In stretching vibration. 500 cm^{-1} absorption could be attributed to the vibrations of In-O bond [6]. So, the absorptions in 554 cm^{-1} and 599 cm^{-1} and 430 cm^{-1} were assigned to the stretching vibration of In-O[7-9], respectively. In-O bond in plane bending vibrations should be appeared at 410 cm^{-1}. Comparing with the references, the adsorptive peaks shifted in Fig. S 5(b-d) might be affected by Si-O-In.

Tab. S1 Comparison of the response-recovery results of (A) response and (B) response time of mesoporous INW composited NFs thin film sensor with different atomic ratios to NO_x (RH: 42 %)

	Volume concentration (ppm)	97.0	48.5	**29.1**	**9.70**	4.85	2.91	0.97
INW-1	Response	39.56	40.42	53.33	23.16	4.63	4.06	-
	Response time/s	196	292.7	295.3	308	48	60.7	-
INW-2	Response	115.6	94.7	**41.64**	**39.18**	30.62	9.54	1.68
	Response time/s	118	109	108	151	330.7	309.3	194.7
INW-3	Response	17.39	13.6	7.07	2.8	-	-	-
	Response time/s	18	70	127	103	-	-	-
INW-4	Response	1.43	1.81	1.15	1.51	-	-	-
	Response time/s	64	92	133.5	63	-	-	-

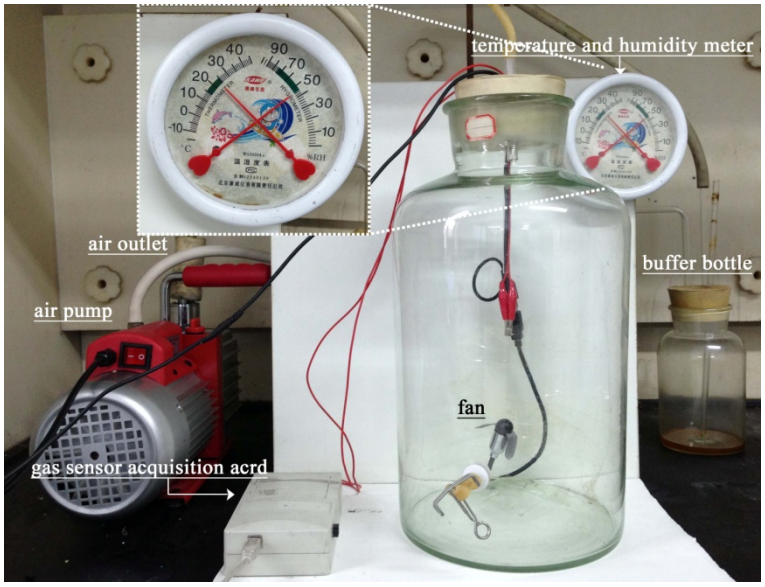

Fig. S6 Images of the gas sensing test device

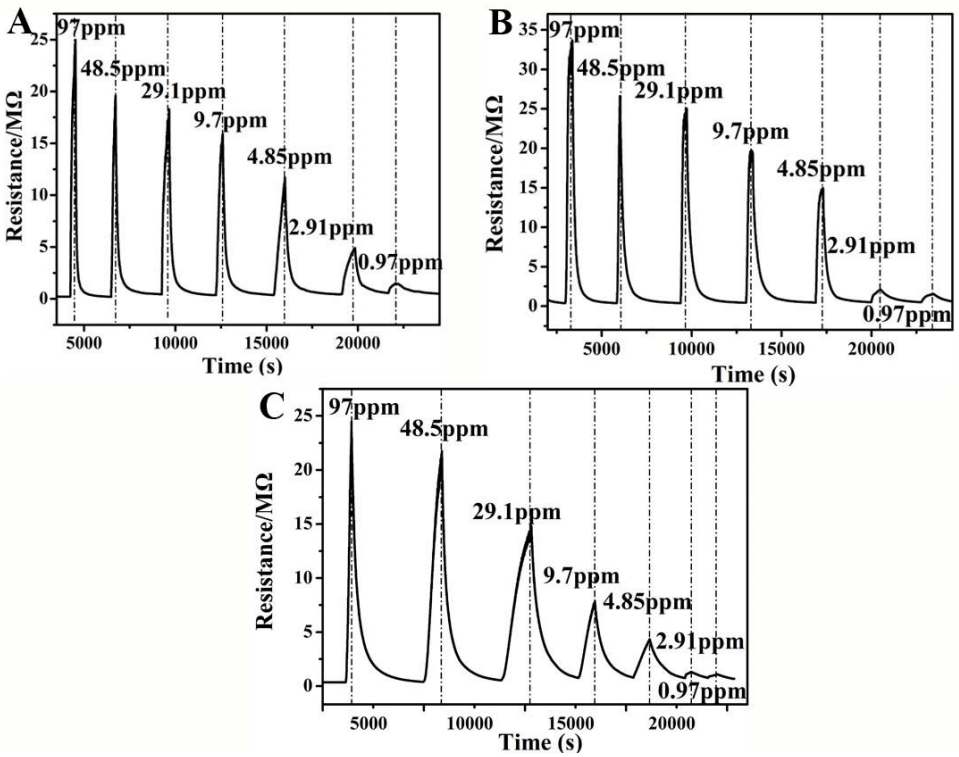

Fig S7. Response-recovery curves of the INW-2 sensor to 97ppm-0.97ppm at room temperature in the different RH (A) 42%, (B) 61% and (C) 80%.

Tab.S2 The gas response of the INW-2 sensor to 97ppm-0.97ppm NO_x at room temperature, the RH range of 42-80%.

C/ppm	97.0	48.5	29.1	9.7	4.85	2.91	0.97
Gas Reponse at 42% RH	115.6	94.7	41.64	39.18	30.62	9.54	1.68
Gas Reponse at 61% RH	110.8	90.6	38.7	35.1	30.7	8.48	1.39
Gas Reponse at 80% RH	93.7	85/4	35.5	31.6	28.6	4.41	0.77

Table S3. The gas sensing properties of similar detection methods

Metal Oxide	Optimal Mixing ratio	Morphology	Optimal Temperature (℃)	Response/ ppm S	C	Reference
In_2O_3	Ta (2.3at. %)	Film	400	3.81	0.08	Chem.Mater, 24(2012), 2864-2871
In_2O_3	SnO_2 (0.1 mol%)	Powders	250	2906	10	Sens. Actuators, B. 151(2010),265-273
In_2O_3	-	Nanosheet	250	164	50	Sens. Actuators, B. 208(2015),436-443
Fe-In_2O_3	Fe (0.05wt. %)	Powders	100	117	1	Sens. Actuators, B. 191(2014),806-812
In_2O_3	-	Microsphere	200	10	1	Sens. Actuators, B. 187(2013),495-502
In_2O_3	-	Particles	275	8	1	Electron.Mater.Lett. 10(2014),509-513
In_2O_3/rGO	GO (0.5wt. %)	Composites	RT	0.25	1	Acs Appl.Mater.Interfaces. 6(2014),21093-21100
In_2O_3	-	Nanowire	150	50	10	Appl.Phys.A 85(2006),241-246
Zn- In_2O_3	In:Zn (7:1)	Flower-like	300	27.4	5	Rsc.Adv., 4(2014),15161-15170
In_2O_3	-	Microsphere	80	323.5	0.5	Rsc.Adv., 5(2015),4609-4614
In_2O_3	-	Nanoplates	150	73	1	Rsc.Adv., 4(2014),4831-4835
In_2O_3	-	Mesoporous	100	37.8	5	Sens. Actuators, B. 187(2013),484-494
In_2O_3	-	Slice-like	250	1.5	5	Sens. Actuators, B. 176(2013),258-263

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