Supporting Information

Electronic Nano Sponge Breath Ammonia Sensors by Using Hygroscopic Polymers on Vertical Channel Nano-Porous Structure

Wei-Lun Chen,[a] *Huang-Cheng Chiu,*[a] *Hsuan Chu,*[a] *Ju-Chun Hsieh,*[b,c] *Bing-Xin Chen,*[b,c] *Ya-Chun Tian,*[d,e] *Shuh-Kuan Liau,*[e] *Ming-Jen Chan,*[e] *Chia-Jung Lu,*[f] *Hsin-Fei Meng,*[g,h] *Sheng-Fu Horng,*[a,*] *Chien-Lung Wang,*[i,j,*] *Hsiao-Wen Zan*[b,c,*]

Wei-Lun Chen and Huang-Cheng Chiu contributed equally to this work.

[a] Institute of Electronics Engineering, National Tsing Hua University, No. 101, Section 2, Guangfu Road, 300 Hsinchu, Taiwan.

[b] Department of Photonics, College of Electrical and Computer Engineering, National Chiao Tung University, No. 1001, Ta Hsueh Road, 300 Hsinchu, Taiwan.

[c] Department of Photonics, College of Electrical and Computer Engineering, National Yang Ming Chiao Tung University, No. 1001, Ta Hsueh Road, 300 Hsinchu, Taiwan.

[d] Department of Medicine, Chang Gung University, No.259, Wenhua 1st Rd., Guishan Dist., 333 Taoyuan, Taiwan.

[e] Kidney Research Center and Department of Nephrology, Linkou Chang Gung Memorial Hospital, No.5, Fuxing St., Guishan Dist., 333 Taoyuan, Taiwan.

[f] Department of Chemistry, National Taiwan Normal University, 162, Heping East Road, Section 1, 106 Taipei, Taiwan.

[g] Institute of Physics, National Chiao Tung University, No. 1001, Ta Hsueh Road, 300 Hsinchu, Taiwan.

[h] Institute of Physics, National Yang Ming Chiao Tung University, No. 1001, Ta Hsueh Road, 300 Hsinchu, Taiwan.

[i] Department of Applied Chemistry, National Chiao Tung University, 300 Hsinchu, Taiwan.

[j] Department of Applied Chemistry, National Yang Ming Chiao Tung University, 300 Hsinchu, Taiwan.

Corresponding Author

*Email: sfhorng@ee.nthu.edu.tw

*E-mail: kclwang@g2.nctu.edu.tw

*E-mail: hsiaowen@nycu.edu.tw

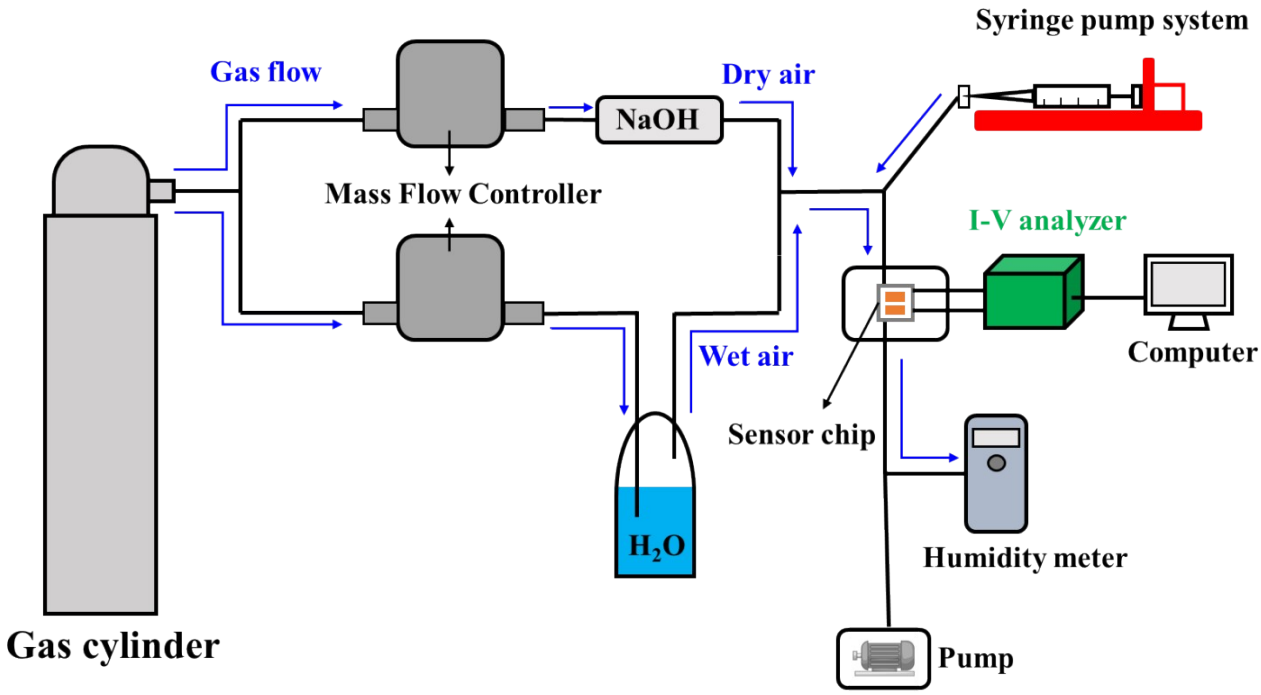

Figure S1. The gas sensing system with the humidity modulation set-up.

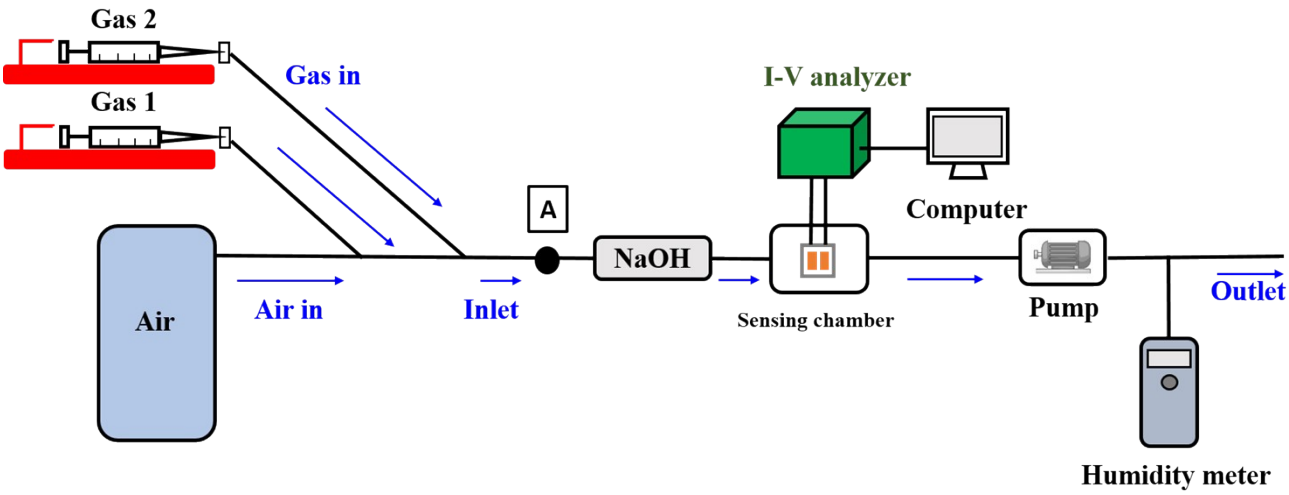

Figure S2. The gas sensing system with the mixture sensing setup (two analytes, Gas 1 and Gas 2) at fixed humidity (RH = 11%).

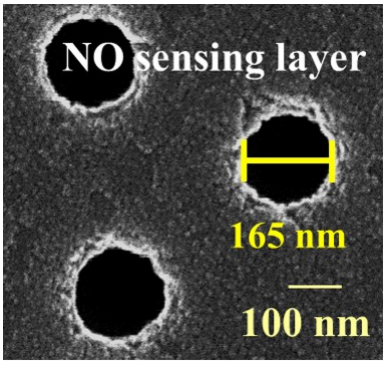

Figure S3. SEM image of the nano-porous structure before depositing the sensing layer

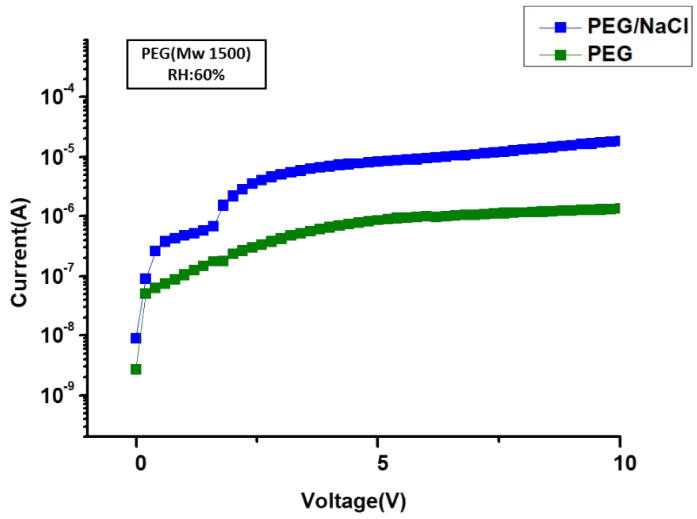

Figure S4. The current-voltage plot of Mw 1500 PEG sensor with and without adding NaCl

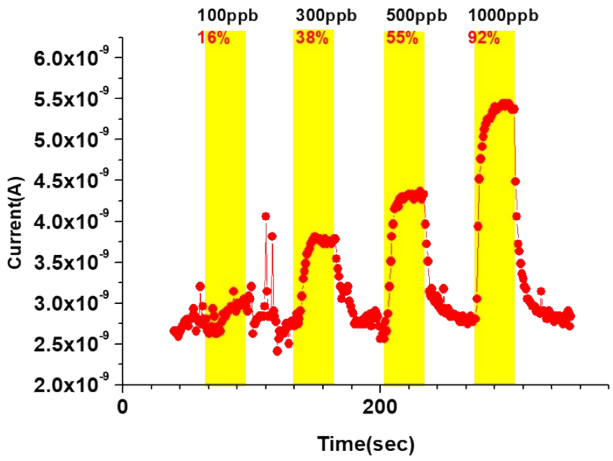

Figure S5. The real-time sensing response of the Mw 10000 PVA sensor to ammonia with different concentrations when RH = 53%

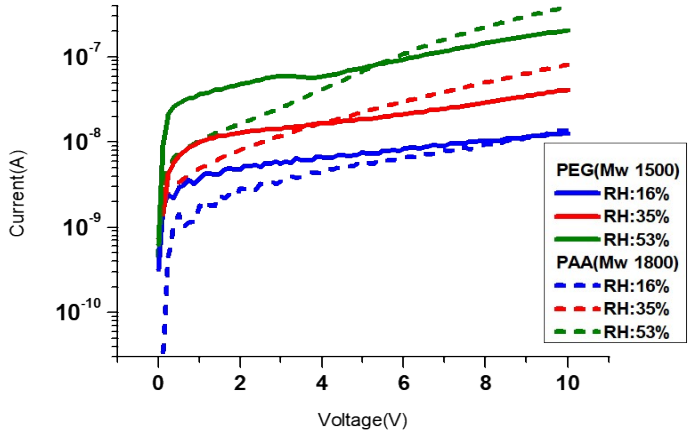

Figure S6. The I-V curves of the Mw 1800 PAA sensor with Mw 1500 PEG sensor

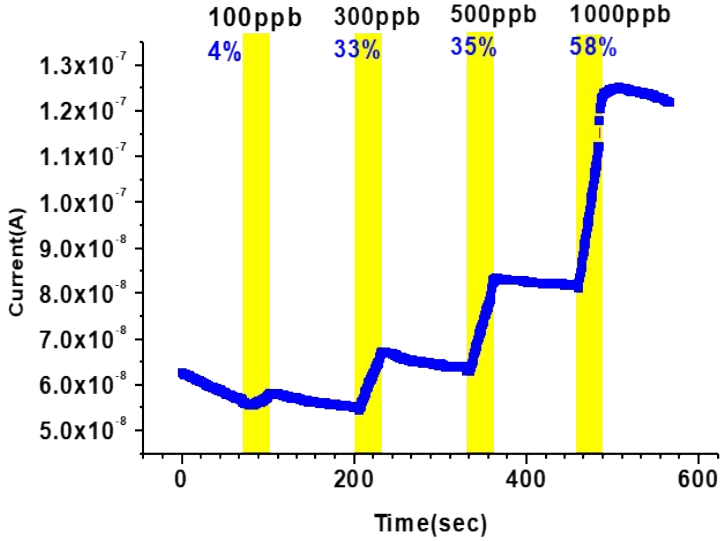

Figure S7. The real-time response of the Mw 1800 PAA sensor to ammonia with different concentrations

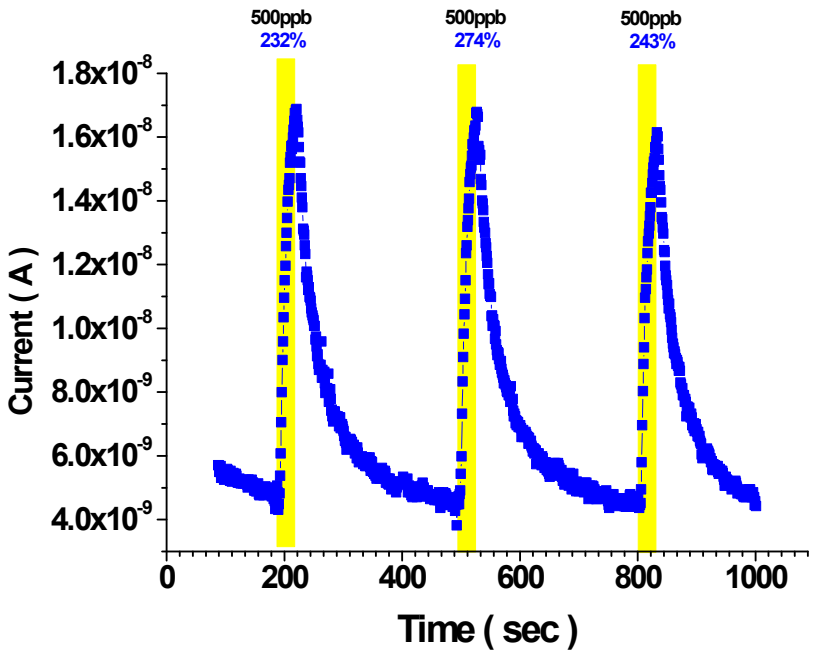

Figure S8. The real-time current tracking measurement when using Glycerol/PEG *Nano Sponge* sensor to repeatedly detect 500 ppb ammonia in the fixed humidity sensing system.

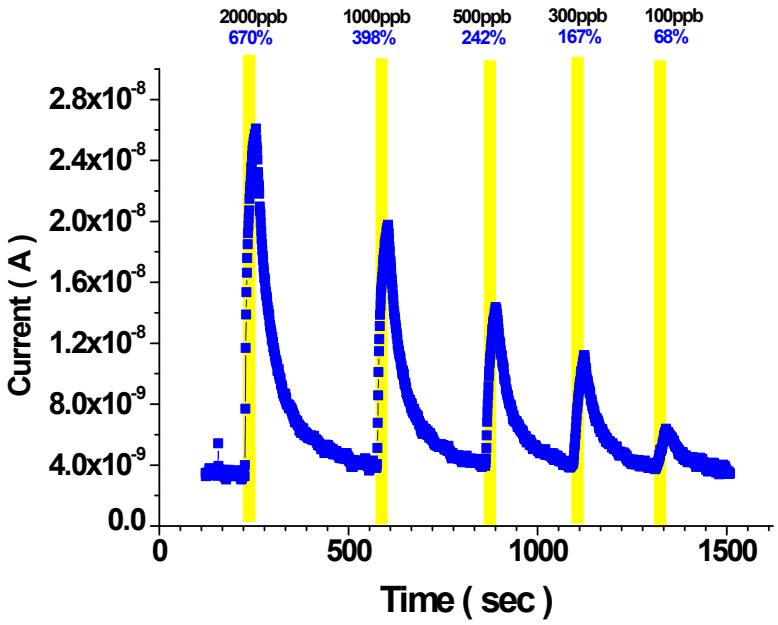

Figure S9. Real-time current tracking measurement when using Glycerol/PEG *Nano Sponge* sensor to detect ammonia from 100 ppb to 2000 ppb in the fixed humidity sensing system.

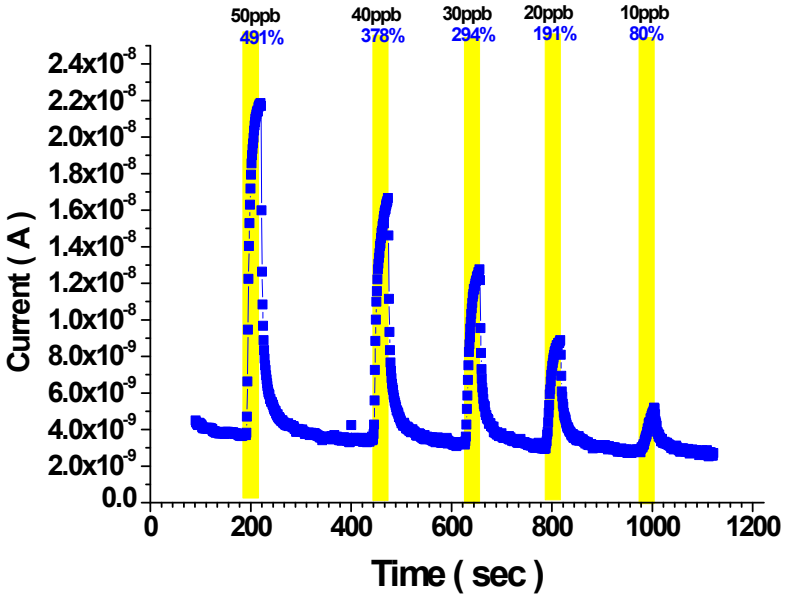

Figure S10. Real-time current tracking measurement when using Glycerol/PEG *Nano Sponge* sensor to detect ammonia from 10 ppb to 50 ppb in the modulated humidity sensing system without the NaOH tube.

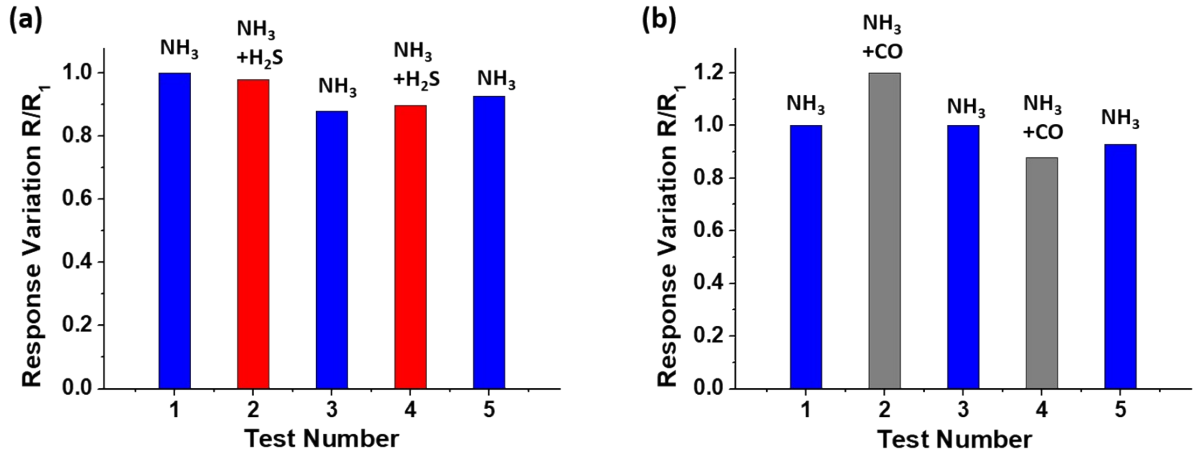

Figure S11. The normalized response plotted versus the test number when using Glycerol/PEG *Nano Sponge* sensor in the fixed humidity sensing system to detect the mixed gas effect when switching the analytes (a) between 500-ppb NH_3 and 500-ppb NH_3 with 1-ppm H_2S or (b) between 500-ppb NH_3 and 500-ppb NH_3 with 2.5-ppm CO. R_1 represents the response in the 1st time measurement.

Table S1 Comparison of ammonia sensor performance in recent reports using various materials.

Material	Material detail	Structure	Sensing Range	Response Time	Selectivity	Ref.
Organic Semiconductor (OSC)	DPP_2T-TT	Transistor	10 ppb ~ 10 ppm	< 1 min	Good among ACE, Hexane, and Ethanol	[14]
	DNTT	Chemiresistor	10 ~ 100 ppb		Good among ACE, EtOH, H_2, O_2, and NO	[15]
	TFB	Vertical Chemiresistor	100 ppb ~ 1 ppm	< 1 min	Good among ACE, NO, Ethanol, CO_2, and Isoprene	[17]
	DNTT	Transistor	0.5 ~ 10 ppm	1~5 mins	Good among HCL, H_2O_2, Hexane, DMMP, DMC, $CHCl_3$, ACE, EtOH, and H_2O	[18]
	P3HT	Transistor	10 ppb ~ 25 ppm		N/A	[20]
	PBDTTT-C-T / P3HT	Vertical Chemiresistor	100 ~ 5600 ppb		Good among CO, NO, ACE	[21]
rGO	rGO–Co_3O_4	Chemiresistor	5 ~ 100 ppm	< 1 min	Good among Methanol, Benzene, Methylbenzene, Formaldehyde, ACE, Ethanol	[24]

	Co porphyrin / graphene	Chemiresistor	100 ~ 7000 ppb	> 5 mins	N/A	[25]
	rGO	Chemiresistor	1 ppb ~ 50 ppm	< 1 min	Poor	[26]
	PANI* / rGO-PANI	network structure film	100 ~ 5000 ppb	< 1 min	Good among ACE, Methanol, Ethanol, Glycol, Isopropanol, Dichloromethane, and Acetic acid	[27]
CNT	CNT	Chemiresistor	10 ~ 75 ppm		N/A	[34]
	CNTs/PANI		20 ~ 100 ppm	< 1 min	Good among ACE, Methanol, Ethanol, Xylene, Isopropanol, Toluene, Chloroform, Benzene, and n-Butanol	[37]
2D	Au-$MoSe_2$	Chemiresistor	10 ~ 100 ppm	< 1 min	Good among Formaldehyde, Benzene, ACE, and CO	[38]
	NDI**	Transistor	10 ppb ~ 100 ppm		N/A	[39]
Electrochemical type	Ionic liquid	Chemiresistor	5 ~ 25 ppm	< 1 min	Good among NO, NO_2, CO, C_2H_5OH, H_2, and C_3H_6	[40]

	La gallate	Chemiresistor	3 ~ 40 ppm	< 1 min	N/A	[41]
Hygroscopic	Hydrogel	Chemiresistor	5-50 ppm	1~5 mins	Good Response to 0.5-5 ppm NO_2	[31]
	Glycerol/ PEG	**Vertical chemiresister**	**5 - 2000 ppb**	**< 1 min**	**Good among H_2S, CO, NO, and ACE**	**This work**

*PANI: polyaniline

**NDI: NDI3HU-DTYM2

Table S2. The solubility and dissociation constant of NH_3, H_2S, CO, NO, and acetone.

Gas	NH_3	H_2S	CO	NO	Acetone
Solubility(g/100g)	**56**	**0.33**	**0.0026**	**0.0056**	**N/A**
Dissociation constant	**1.8×10^{-5}**	**6.3×10^{-8}**	**4.3×10^{-7}**	**N/A**	**N/A**
*** Response (%) in Mw 1500 PEG sensor**	**533**	**19**	**23**	**9**	**0**

*The response (%) of Mw 1500 PEG sensor to 1-ppm NH_3, H_2S, CO, NO, and acetone are listed. The measurement was in the modulated humidity sensing system (without NaOH tube) when RH = 53%.