Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Three-Dimensional Conductive Networks based on Stacked SiO_2@graphene Frameworks for Enhanced Gas Sensing

Da Huang,[a] Zhi Yang,*[a,b] Xiaolin Li,[a] Liling Zhang,[a] Jing Hu,[a] Yanjie Su,[a] Nantao Hu,*[a] Guilin Yin,[b] Dannong He[b] and Yafei Zhang[a]

[a]Key Laboratory for Thin Film and Microfabrication of Ministry of Education, Department of Micro/Nano Electronics, School of Electronic Information and Electrical Engineering, Shanghai Jiao Tong University, Shanghai 200240, P. R. China. Email: zhiyang@sjtu.edu.cn and hunantao@sjtu.edu.cn

[b]National Engineering Research Center for Nanotechnology, Shanghai 200241, P. R. China

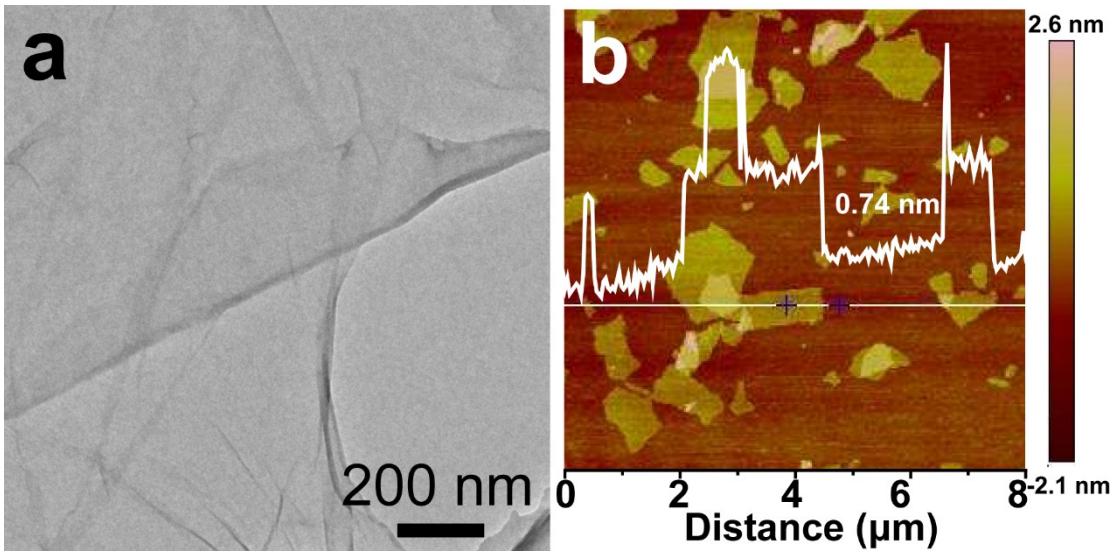

Fig. S1 (a) TEM images of bare GO. (b) Representative AFM image and corresponding thickness analysis, revealing a uniform thickness of 0.74 nm for bare GO nanosheets.

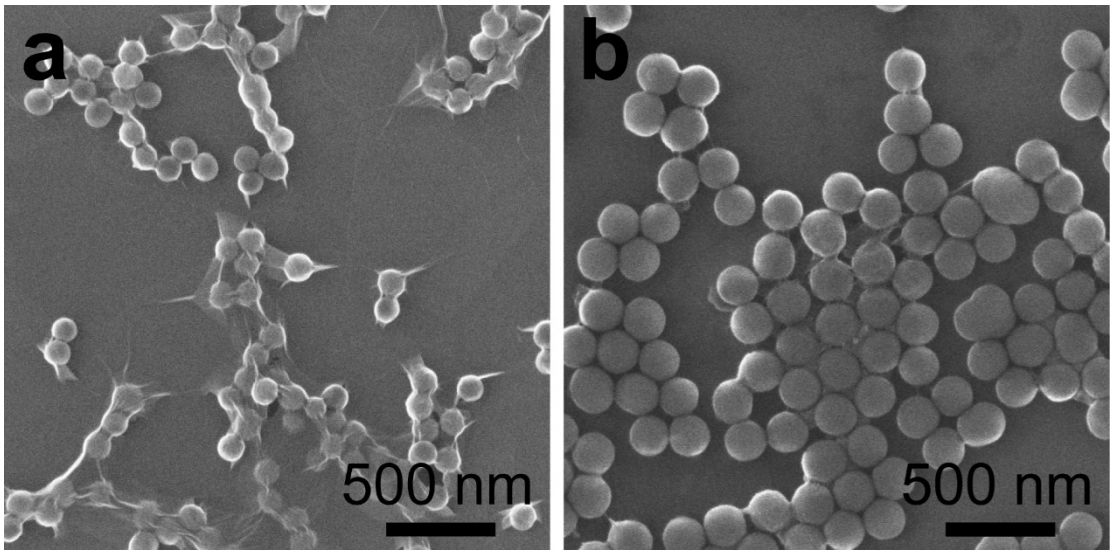

Fig. S2 SEM images of (a) SiO_2@GO composites made from 130 nm SiO_2 spheres. (b) SiO_2/GO mixture, without modification of SiO_2 spheres by APTMS.

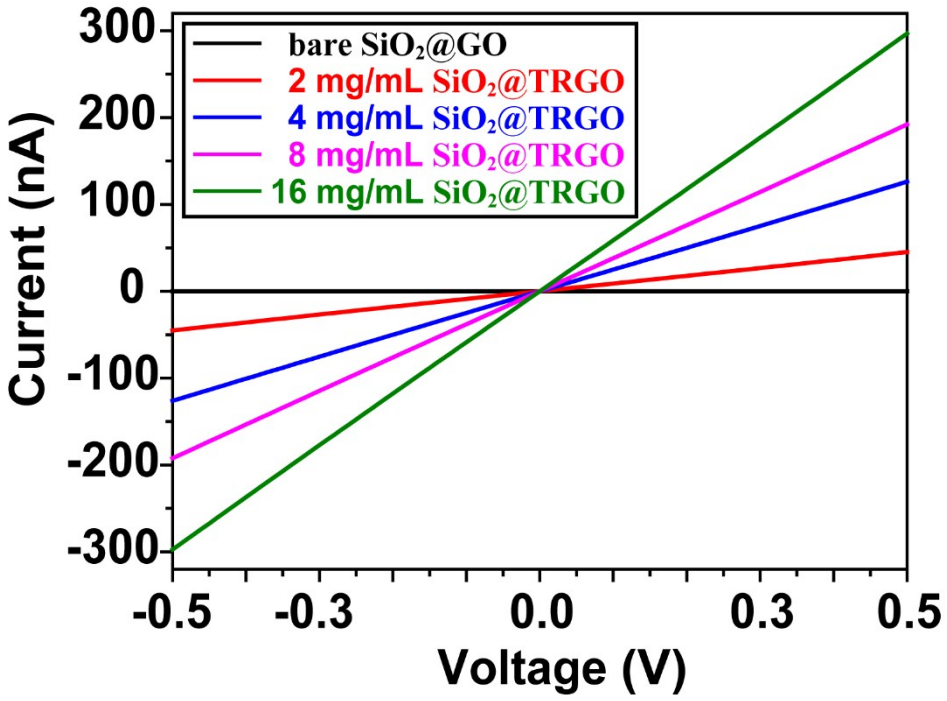

Fig. S3 *IV* curves of bare SiO_2@GO and SiO_2@TRGO with different concentration.

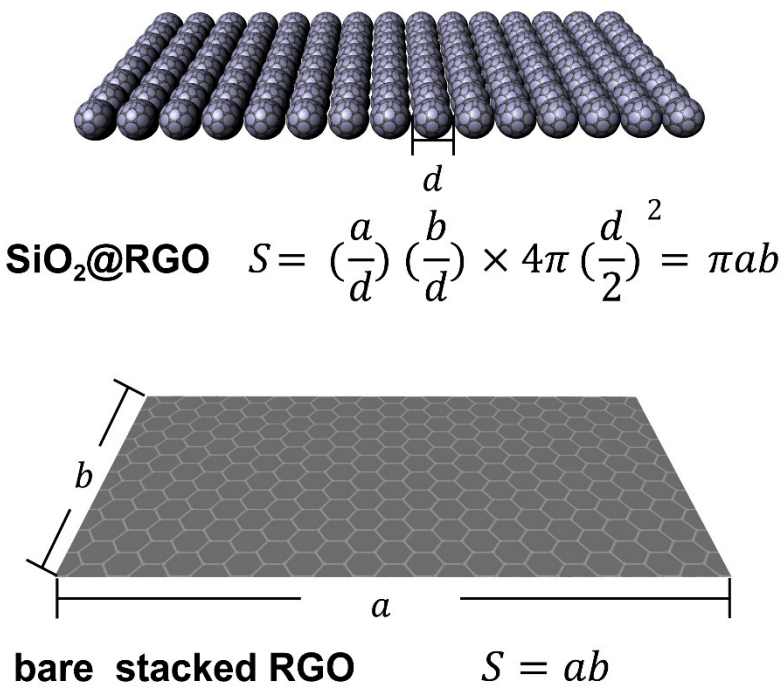

Fig. S4 Schematic illustration of the increased surface area brought by 3D SiO_2@RGO framework.

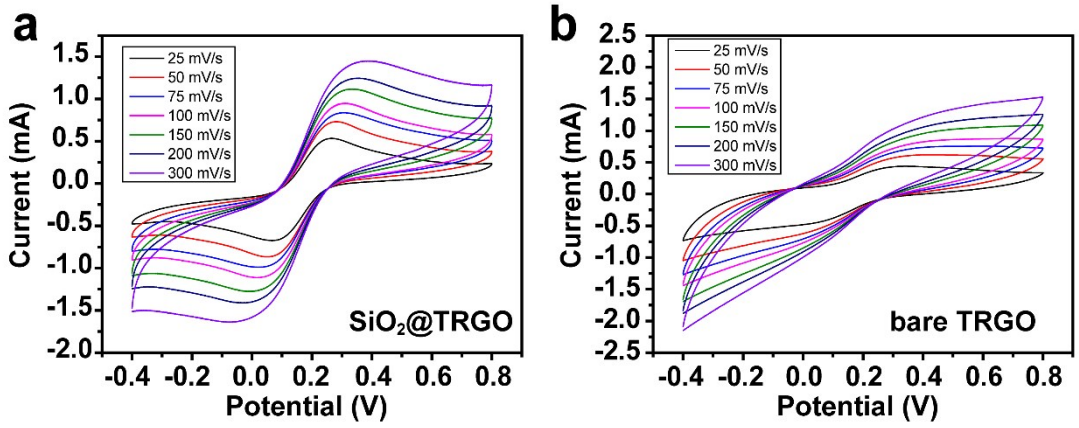

Fig. S5 Cyclic voltammograms of (a) SiO_2@TRGO and (b) TRGO in a 10 mM $[Fe(CN)6]^{3-/4-}$ and 0.1 M KCl solution at different scan rates from 25 to 300 mV s^{-1}.

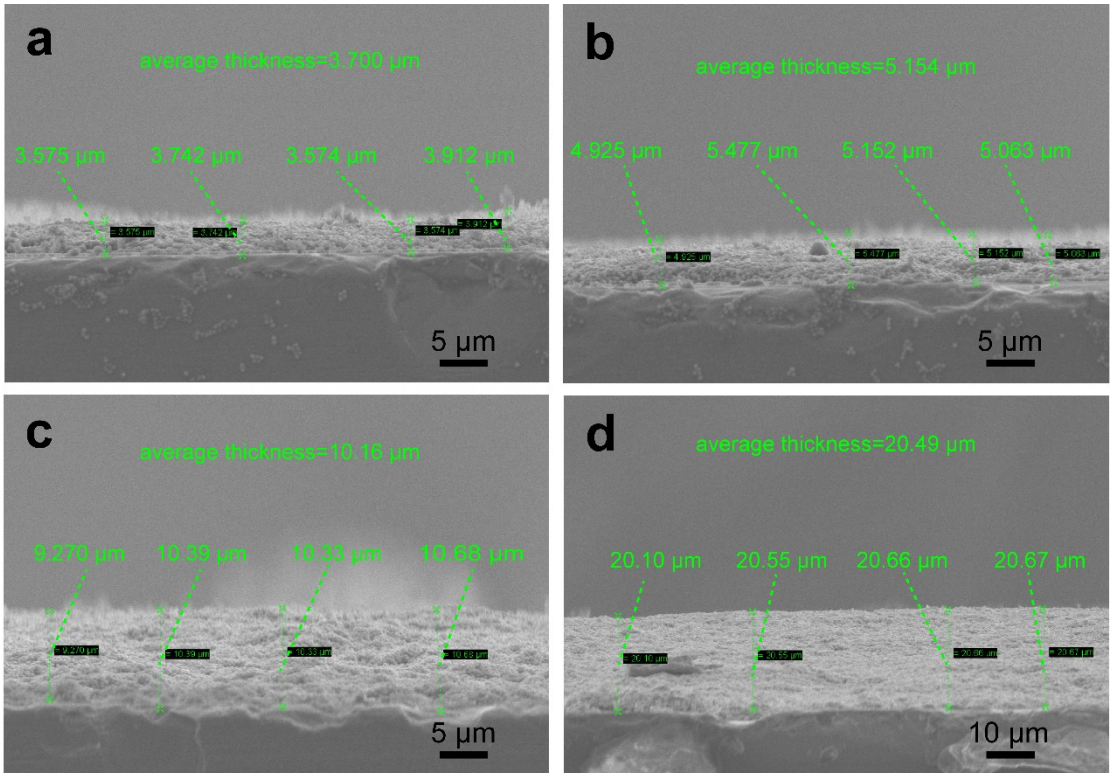

Fig. S6 The thickness of SiO_2@TRGO film on interdigital electrodes with different concentrations of (a) 2 mg/mL, (b) 4 mg/mL, (c) 8 mg/mL and (d) 16 mg/mL.

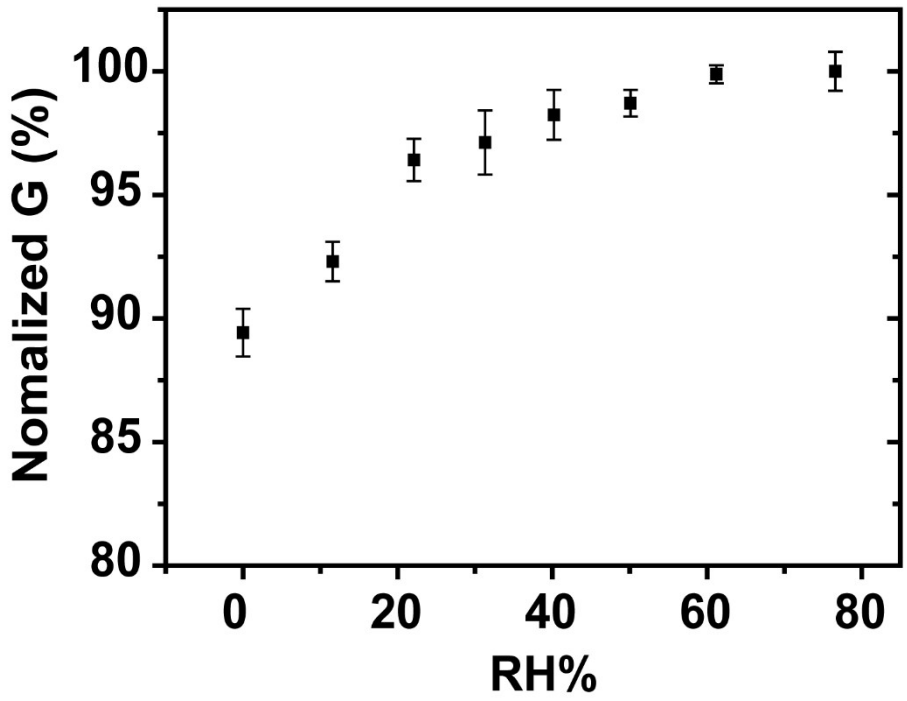

Fig. S7 The change of conductivity of SiO_2@TRGO sensors in different RH.

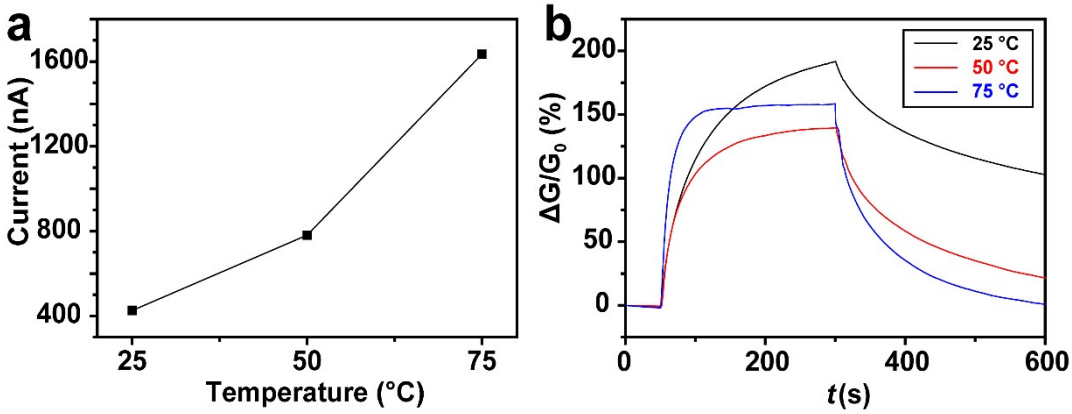

Fig. S8 (a) The change of conductivity of SiO_2@TRGO sensors at different temperature, (b) The response curves of SiO_2@TRGO towards 50 ppm NO_2 at different temperatures.

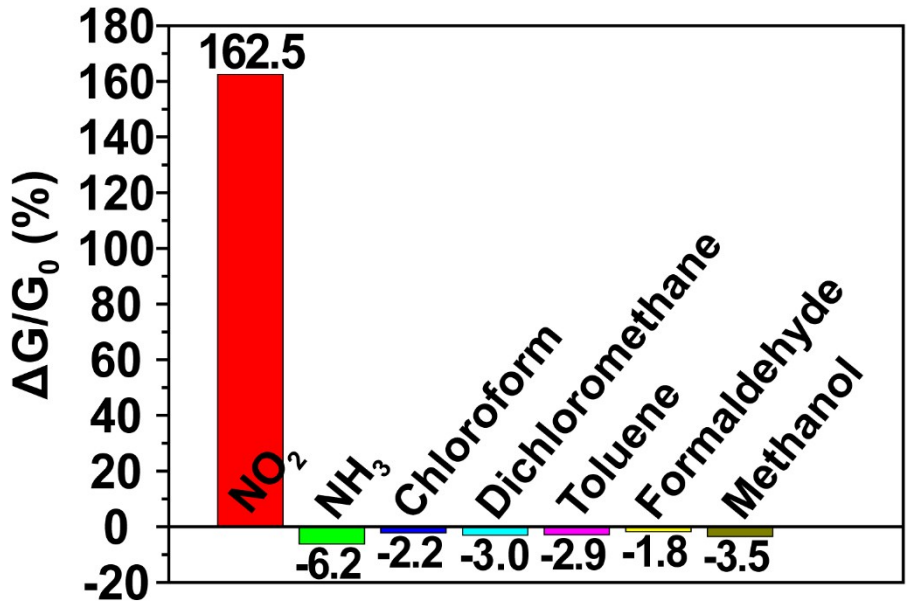

Fig. S9 Selectivity of SiO_2@TRGO based sensing device towards 50 ppm NO_2, 50 ppm NH_3 compared with other analytes with 1% of saturated vapor concentrations.

Table S1. Comparison of sensing performance of some graphene based sensing devices reported previously.

Sensing material	Dimen-sional	Modified graphene	Increased surface	Response towards NH_3 ($\Delta G/R_0$)	Response towards NO_2 ($\Delta G/G_0$)	Ref
SiO_2@TRGO	3D	-	Yes	6.8% for 50 ppm NH_3 in 250 s	35.5% for 1 ppm NO_2 in 250 s	-
Bare TRGO	2D	-	-	27% for 1% NH_3 in 50 min	12% for 2 ppm NO_2 in 40 min	[1]
Chemical reduced GO	2D	Yes	-	5.5%for 200 ppm NH_3 in 500s	-	[2]
Chemical reduced GO	2D	Yes	-	-	88% for 5 ppm NO_2 in 10 min	[3]
CVD graphene foam	3D	-	Yes	30% for 1% NH_3 in 800 s	~4% for 20 ppm NO_2 in 400 s	[4]
RGO/Ag nanowires	-	Yes	-	7.5% for 50 ppm NH_3 in 300s	-	[5]
Vertically oriented graphene	3D	-	Yes	5% for 1% NH_3 in 18 min	157% for 200 ppm NO_2 in 14 min	[6]
Graphene nanomesh	-	Yes	Yes	11.8% for 50 ppm NH_3 in 20 min	6% for 1 ppm NO_2 in 15 min	[7]
RGO on 3D pillars	3D	-	Yes	100% for 40 ppm NH_3 in 2000 s	28% for 5 ppm NO_2 in 15 min	[8]

Notes and references

1. G. H. Lu, L. E. Ocola and J. H. Chen, *Nanotechnology*, 2009, **20**, 445502.
2. R. Ghosh, A. Midya, S. Santra, S. K. Ray and P. K. Guha, *ACS Appl. Mater. Interfaces*, 2013, **5**, 7599–7603.
3. W. J. Yuan, A. R. Liu, L. Huang, C. Li and G. Q. Shi, *Adv. Mater.*, 2013, **25**, 766–771.
4. F. Yavari, Z. P. Chen, A. V. Thomas, W. C. Ren, H.-M. Cheng and N. Koratkar, *Sci. Rep.*, 2011, **1**, 166.
5. T. Quang Trung, H. Huynh Tran My, D.-H. Yoo, C. Tran Viet, S. H. Hur, J. S. Chung, E. J. Kim and P. A. Kohl, *Sens. Actuators, B*, 2014, **194**, 45–50.
6. K. Yu, P. Wang, G. Lu, K.-H. Chen, Z. Bo and J. Chen, *J. Phys. Chem. Lett.*, 2011, **2**, 537–542.
7. R. K. Paul, S. Badhulika, N. M. Saucedo and A. Mulchandani, *Anal. Chem.*, 2012, **84**, 8171–8178.
8. D. Le Thai, D.-J. Kim, T. Tran Quang, D. Vinh Quang, B.-Y. Kim, H. K. Moon and N.-E. Lee, *Adv. Funct. Mater.*, 2015, **25**, 883–890.