Supplementary Information

Pure thiophene-sulfur doped reduced graphene oxide: synthesis, structure, and electrical properties

Zegao Wang,[a] Pingjian Li,[a*] Yuanfu Chen,[a*] Jiarui He,[a] Wanli Zhang,[a] Oliver G. Schmidt[b,c] and Yanrong Li[a]

[a]State Key Laboratory of Electronic Thin Films and Integrated Devices, University of Electronic Science and Technology of China,Chengdu 610054, P. R. China

[b]Institute for Integrative Nanosciences, IFW Dresden, Helmholtzstrasse 20, 01069 Dresden, Germany.

[c]Center for Advancing Electronics Dresden, TU Dresden, 01062 Dresden, Germany.

*To whom correspondence should be addressed, yfchen@uestc.edu.cn, lipingjian@uestc.edu.cn

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TABLE S1. The S content of S-doped rGO synthesized by different methods.

Method	Thiophene-S Content	Oxide-S Content	Ref
Thermal Annealing	0.96 wt%	0.56 wt%	[1]
	1.06 wt%	0.23 wt%	
Thermal Annealing	1.2 at%	0.6 at%	[2]
	1.3 at%	0.4 at%	
Thermal Annealing	1.0 at%	5.6 at%	[3]
This study	**1.2 at%**	**below the detection limit**	**This study**

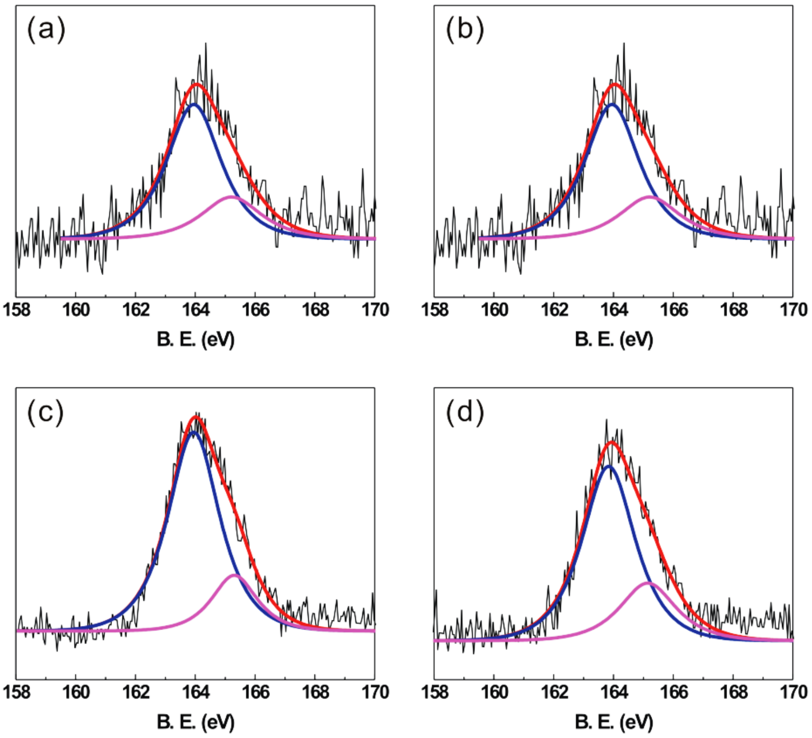

Figure S1. The high resolution S2p XPS spectra of S-doped rGO synthesized at (a) 2 h, (b) 5 h, (c)10 h and (d) 15 h; the ethanol-thermal reaction time is 180 °C.

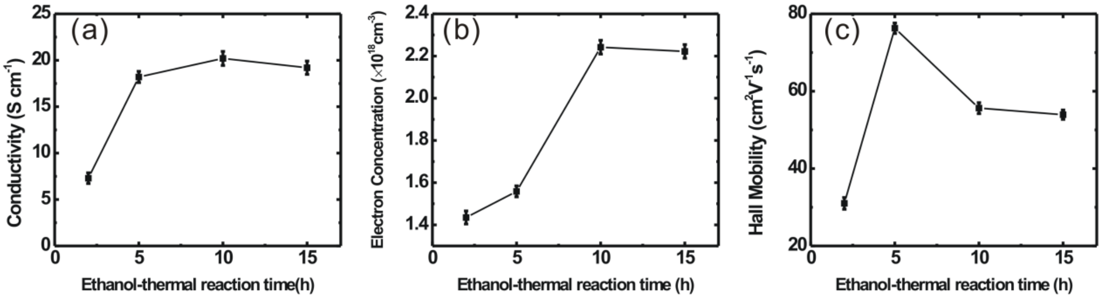

Figure S2. (a) Conductivity, (b) electron concentrations and (c) Hall mobilities of S-doped rGO as a function of ethanol-thermal time at 180 °C. The values are mean and standard deviation (SD) for 5 different samples.

Figure S2a shows the conductivity of S-doped rGO as a function of ethanol reaction time t_{etr}, and the S-rGO-10h has the highest value. This variation can be explained by the effect of t_{etr} on the electron concentration and mobility of S-doped rGO. From Figure S2b, we find that the electron concentration firstly increases and then decreases with t_{etr}, and the variation is consistent with the S content shown in Figure 3a. Thus, we can conclude that the electron concentration increases with the S content, indicating that the S doping is n-type doping. Figure S2c shows the Hall mobility as a function of t_{etr}. Combined with Figure 3a, 3b and S2c, we reveal that firstly, when t_{etr}= 2-5 h, the mobility increases, which is mainly due to the decrease in O content; secondly, when t_{etr}= 5-10 h, the mobility decreases owing to the increase of defects caused by the increase in the S content; thirdly, for t_{etr}= 10-15 h, despite the S content decrease, the mobility still continues to decrease, which is due to an increasing number of defects caused by the breakage of C-S bonds and removal of S atoms.

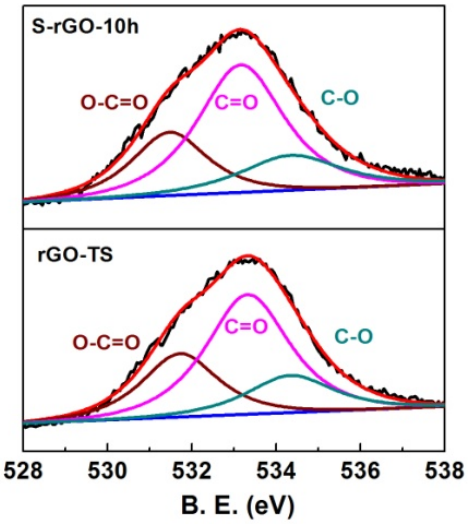

Figure S3. High resolution O1s XPS spectra of S-rGO-10 h and rGO-TS. The peaks at around 531.5, 533.2 and 534.4 eV peaks correspond to O−C=O, C=O and C−O groups, respectively.

TABLE S2. Contents of O species (O−C=O, C=O, C−O and Total O) in S-rGO-10 h and rGO-TS.

	O−C=O (at%)	C=O (at%)	C−O (at%)	Total O (at%)
S-rGO-10h	2.7	5.7	1.8	10.2
rGO-TS	2.7	5.8	1.9	10.4

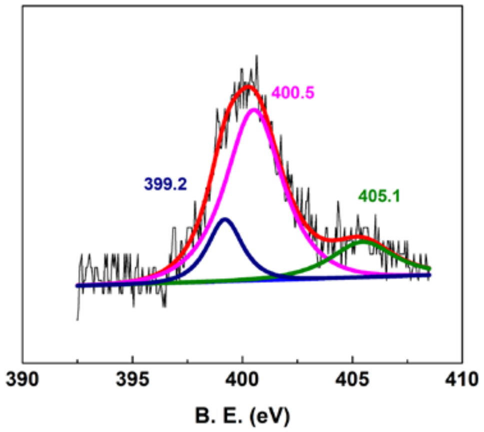

Figure S4. High resolution N1s XPS spectra of N-doped rGO synthesized by the hydrazine reduction.The peaks at around 399.2, 400.5, 405.1 eV peaks correspond to the pyridine-N, pyrrolic-N and oxidized N groups, respectively.

Supplementary References

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3. H. L. Poh, P. Simek, Z. Sofer and M. Pumera, *ACS Nano*, **2013**, **7**, 5262–5272.