Electronic Supplementary Material (ESI) for RSC Advances.
This journal is © The Royal Society of Chemistry 2017

Supporting Information

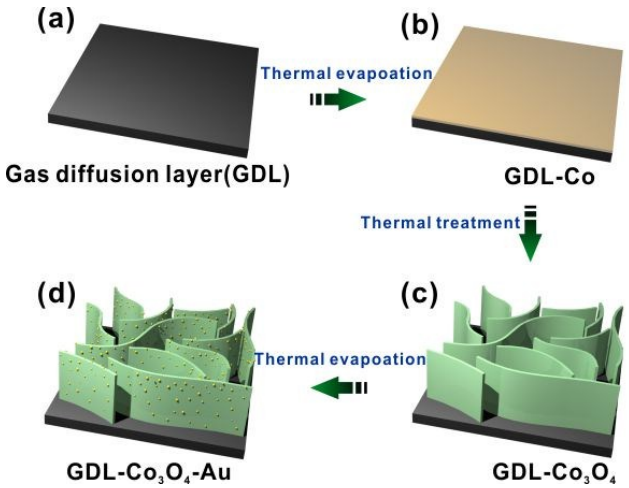
Rational design of Au Dotted Co_3O_4 Nanosheets as an Efficient Bifuctional Catalyst for Li-Oxygen Batteries

Juan Xiang [a‡], Taeseup Song [a‡], Ungyu Paik[a]

[a] Department of Energy Engineering, Hanyang University, Seoul 133-791, South Korea.

E-mail: upaik@hanyang.ac.kr

‡ These authors contributed equally to this work.



Scheme 1. Schematic illustration for the preparation of GDL-Co_3O_4 NSs-10/30/50Au cathode

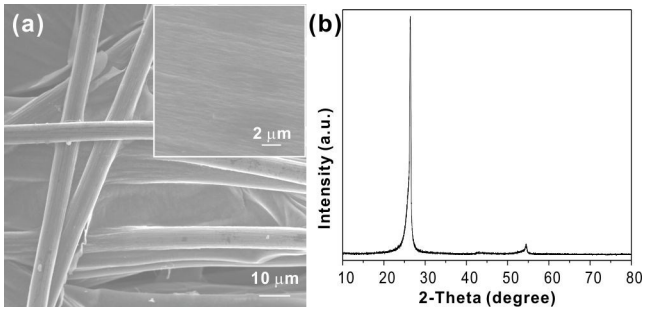


Fig. S1. (a) SEM image of pristine GDL. Inset in (a) shows a magnified SEM image; (b) XRD pattern of GDL.

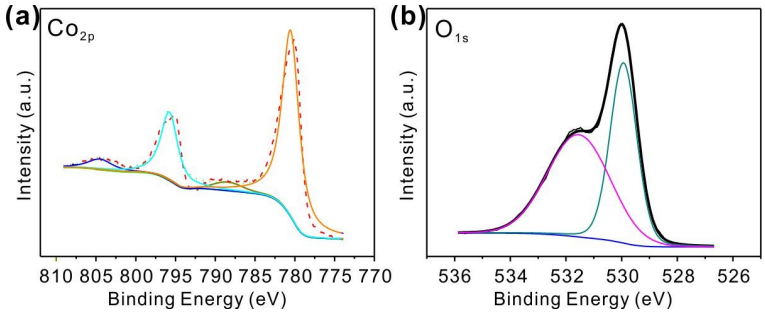


Fig. S2. XPS high-resolution spectra of (a) Co 2p, (b) O 1s of Co_3O_4 ultrathin NSs.

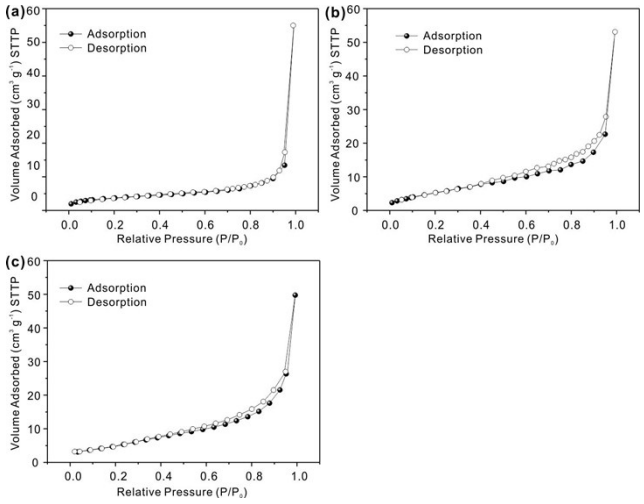


Fig. S3. Nitrogen adsorption isotherms of (a) GDL-30Au, (b) GDL-Co_3O_4 NSs and (c) GDL-Co_3O_4 NSs-30Au.

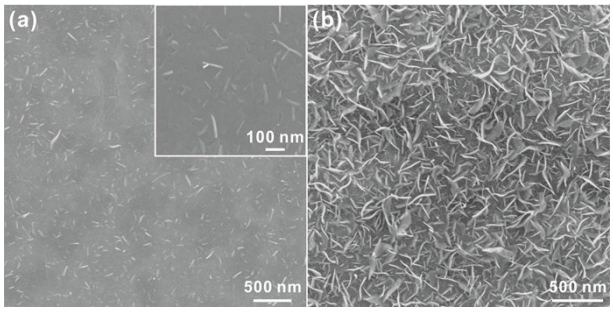


Fig. S4. SEM images of GDL-Co_3O_4 NSs with (a) 50 nm Co deposition and (b) 200 nm Co deposition

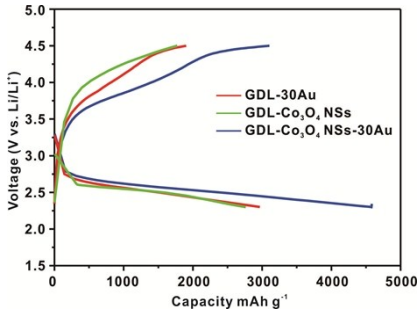


Fig. S5. Initial charge/discharge curves of GDL-30Au, GDL-Co_3O_4 NSs and GDL-Co_3O_4 NSs-30Au composite in a voltage window between 4.5 and 2.3 V at a current density of 0.5 mA cm^{-2}.

Table S1 Comparison of OER/ORR electrochemical characterizations of the electrode with different catalysts at the capacity of 500 mAh g^{-1}. (E^o = 2.96 V).

Catalyst	Discharging process (E(OER) – E^o) : E(V)	Charging process (E^o – E(ORR)) : E(V)	Oxygen electrode Δ (OER – ORR): E(V)
GDL-30Au	0.70	0.57	1.27
GDL-Co_3O_4 NSs	1.11	0.38	1.49
GDL-Co_3O_4 NSs-30Au	0.53	0.36	0.89

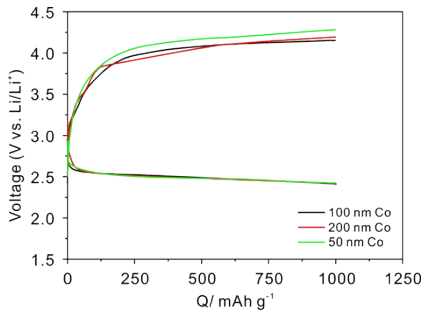


Fig. S6. Initial charge/discharge curves of GDL-Co_3O_4 NSs with 50, 100 and 200 nm Co deposition.

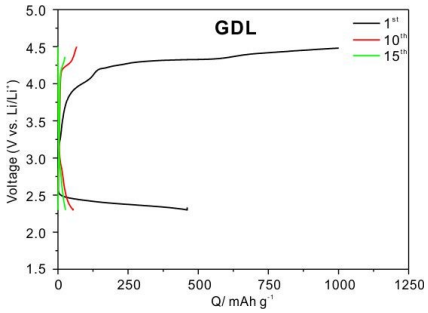


Fig. S7. charge/discharge profiles of GDL equipped Li-O_2 batteries upon repeated cycles between 2.3 V to 4.5 V with the capacity limited to 1000 mAh g^{-1}.

Table S2 The summarized electrochemical performances of Li-O_2 batteries containing Au electrocatalyst from recent literatures.

Literature	Capacity	Cycle	Current density	Note
1	775 mAh g^{-1}	12	0.13 mA cm^{-2}	Au-Pd-β-MnO_2
2	1100 mAh g^{-1}	16	0.1 mA cm^{-2}	AuNPs-CNT
3	1530 ~ 400mAh g^{-1}	120	0.6 mA cm^{-2}	Au NPs-rGO
4	1000 mAh g_c^{-1}	50	300 mA g_c^{-1}	Au NPs-MoS_2
5	500 mAh g^{-1}	200	200 mA g^{-1}	Au-δ-MnO_2
6	300 mAh g^{-1}	100	500 mA g^{-1}	Porous Au
Current work	1000 mAh g^{-1}	70	0.5 mA cm^{-2}	Au-Co_3O_4 NSs

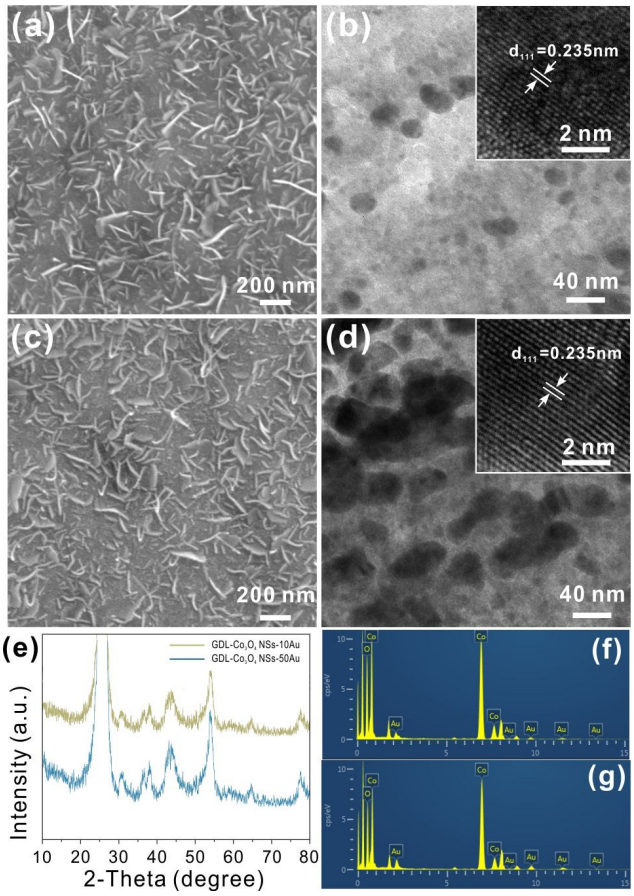


Fig. S8. (a) SEM image and (b) TEM image of GDL-Co_3O_4 NSs-10Au. (c)SEM image and (d) TEM image of GDL-Co_3O_4 NSs-50Au; inset in (b) and (d) shows a corresponding HRTEM image of Au NP; (e) XRD pattern of GDL-Co_3O_4 NSs-10Au and GDL-Co_3O_4 NSs-50Au; EDS spectra of (f) GDL-Co_3O_4 NSs-10Au and (g) GDL-Co_3O_4 NSs-50Au.

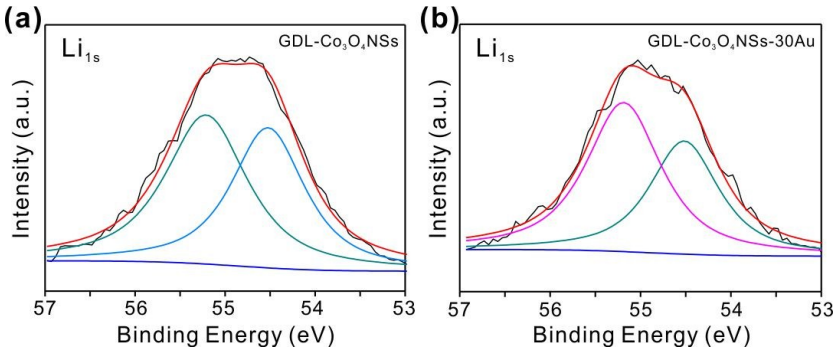


Fig. S9. XPS spectra of of Li 1s for GDL-Co_3O_4 NSs and GDL-Co_3O_4 NSs-30Au after 1st discharge cycle with LiTFSI in TEGDME as electrolyte.

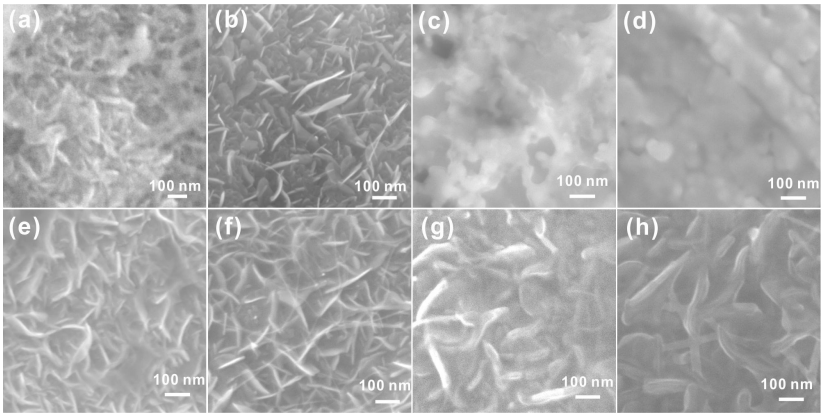


Fig. S10. SEM images of the GDL-Co_3O_4 NSs cathode with (a)1st discharged, (b) recharged, (c) 50th discharged and (d) 50th recharged state; The GDL-Co_3O_4 NSs-30Au cathode with (a)1st discharged, (b) recharged, (c) 50th discharged and (d) 50th recharged state.

References

1. A. K. Thapa, T. H. Shin, S. Ida, G. U. Sumanasekera, M. K. Sunkara, T. Ishihara, *J. Power Sources* **2012**, *220*, 211-216.
2. W. Fan, X. Guo, D. Xiao, L. Gu, *J. Phys. Chem. C* **2014**, *118*, 7344-7350.
3. S. Kumar, C. Selvaraj, N. Munichandraiah, L. G. Scanlon, *RSC Adv.* **2013**, *3*, 21706.
4. P. Zhang, X. Lu, Y. Huang, J. Deng, L. Zhang, F. Ding, Z. Su, G. Wei, O. G. Schmidt, *J. Mater. Chem. A* **2015**, *3*, 14562-14566.
5. G. Wang, L. Huang, S. Liu, J. Xie, S. Zhang, P. Zhu, G. Cao, X. Zhao, *ACS Appl. Mater. Interfaces* **2015**, *7*, 23876-23884.
6. F. S. ZhPeng Z, Chen Y, Bruce PG., *Science* **2012**, *337*, 563-566.