In situ self-assembly of Ni_3S_2/MnS/CuS/reduced graphene composite on nickel foam for high power supercapacitors

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□. Electrochemical analysis of electrodes.

1. the electrochemical performance of the negative electrode.
2. Specific capacitance of the oxidation of Ni foam.
3. the different mass loading of positive and negative electrode.
4. the Ni foam that be corrosive make contribution to the ion penetration.

二 . Analysis.

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三. Table

1. Table S1: The element content of the Ni_3S_2/MnS/CuS@rGO composite.
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□□ **Electrochemical analysis of electrodes.**

1. CV and GCD of rGO at different scan rates in KOH is Fig. S1 (a) and (b). The rGO electrode shows the main of capacitive behavior, rGO also shows pseudocapacitance besides electric double-layer capacitance at the potential window of -1.0 ~ -0.3 V. An potential redox reaction probably exists as follows within this potential window (Fig. S1 a). The specific capacitance of rGO is 124 F/g at 1 A/g (Fig. S1 b).[1]

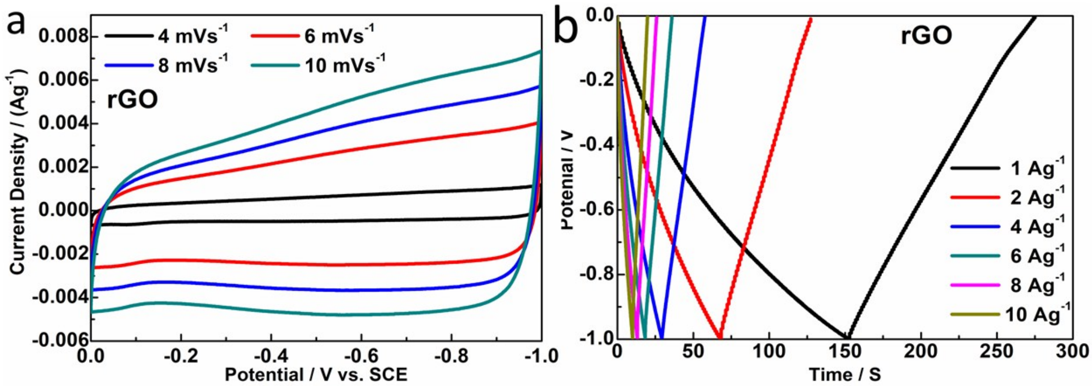

Fig.S1 (a) CV and (b) GCD curves of the reduced graphene oxide (rGO).

2. Specific capacitance of the Ni oxide foam is 44.29 F/g. Oxidized nickel foam has no significant contribution to pseudocapacitance (Fig.S2).

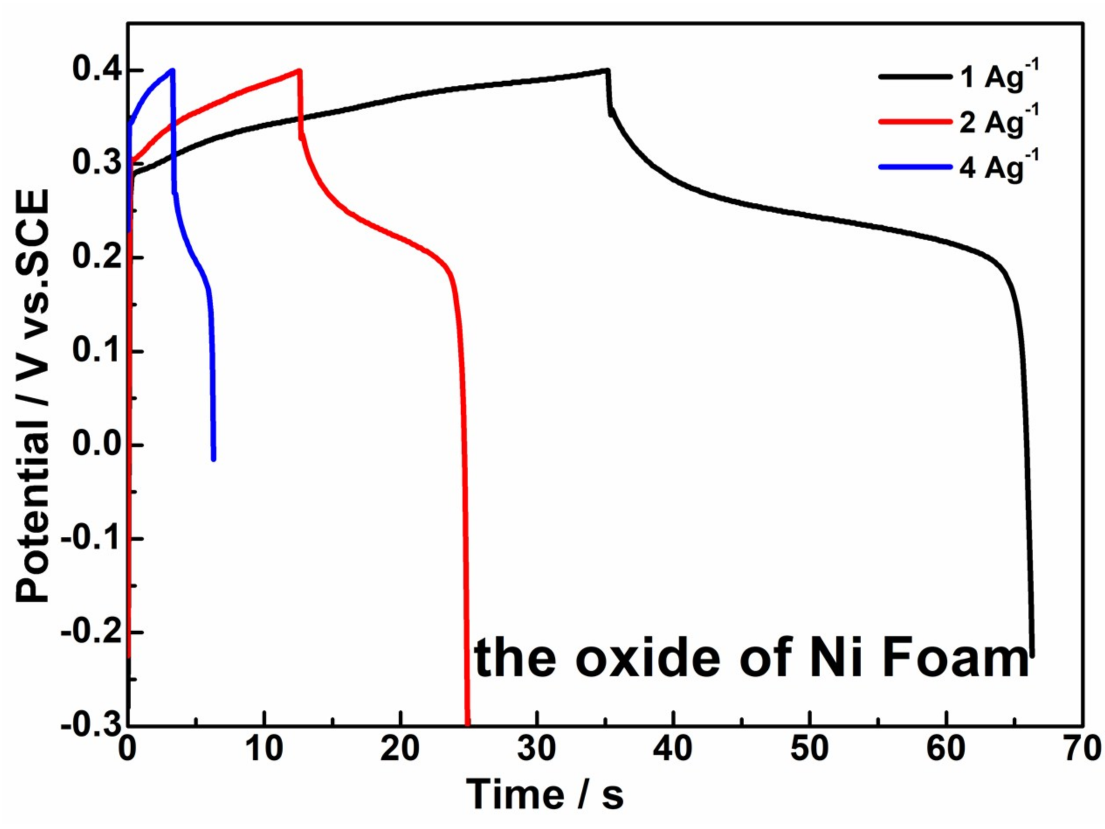

Fig.S2 GCD analyses of the oxide of Ni Foama various current densities (1,2 and 4 A/g) in 6.0 M KOH.

3. Fig.S3 (a) and (b) show the specific capacitance of the different mass loading of Ni_3S_2/MnS/CuS@rGO (positive) and rGO (negative).

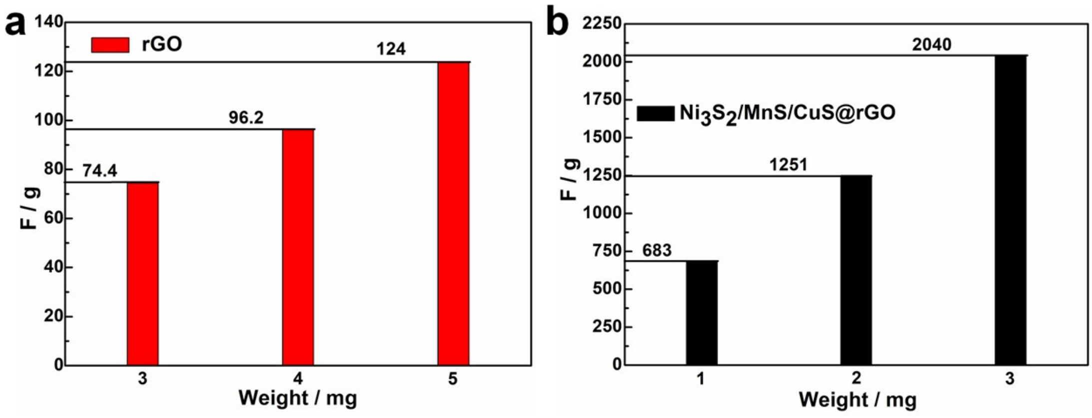

Fig. S3 (a) and (b) the different mass loading of Ni_3S_2/MnS/CuS@rGO (positive) and rGO (negative).

4. The electrode surface reaction is diffusion-controlled that was analyzed by the linear relationship of redox peak current and the scan rate. The diffusion of nickel foam on ions is not significant (Fig.S4).[2]

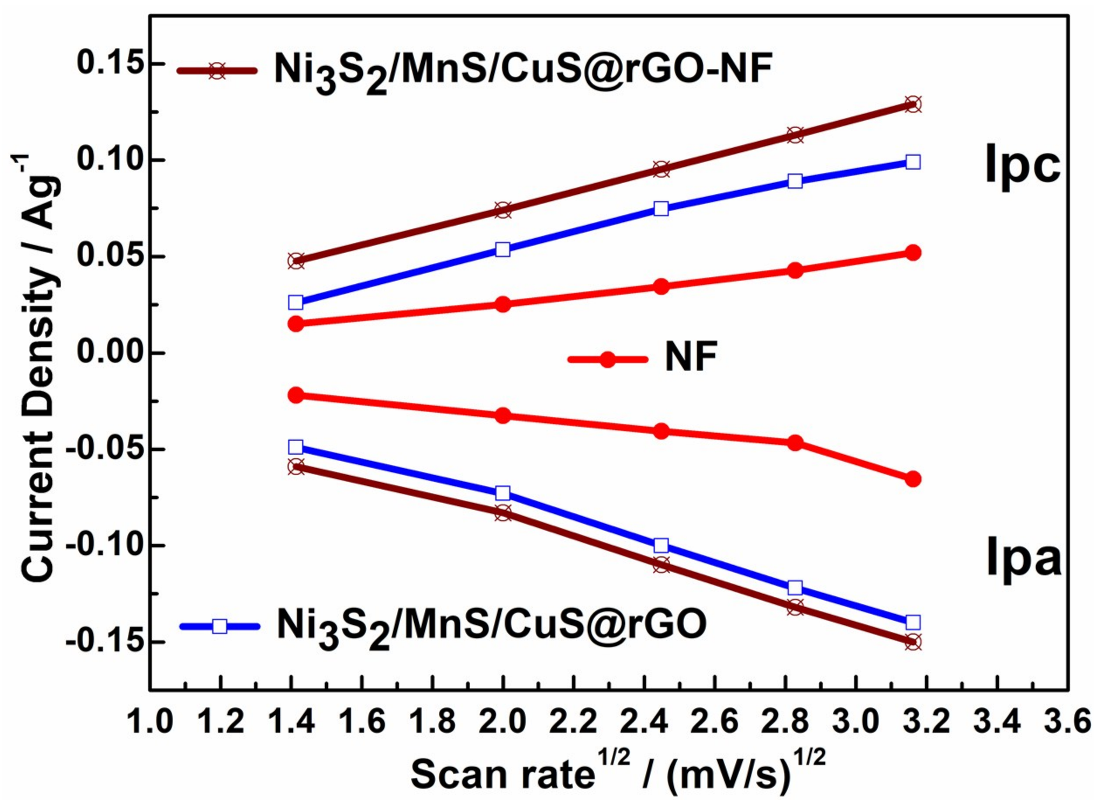

Fig. S4 peak current density as a function of scan rate.

□□ **Analysis**.

1. The adsorption and desorption isotherms observed for the Ni_3S_2/MnS/CuS@rGO composite and the Ni_3S_2/MnS/CuS are suitable for IV-type isotherm with H_3 hyteresis. Fig. S4 a and b show the Brunauer - Emmett - Teller (BET) surface areas for the Ni_3S_2/MnS/CuS@rGO and Ni_3S_2/MnS/CuS are ensue to be 238 m^2/g, 198 m^2/g, respectively. From Fig. S5 (c) and (d) indicate that Ni_3S_2/MnS/CuS@rGO belong to microporous structure and Ni_3S_2/MnS/CuS belong to mesoporous structure.[3]

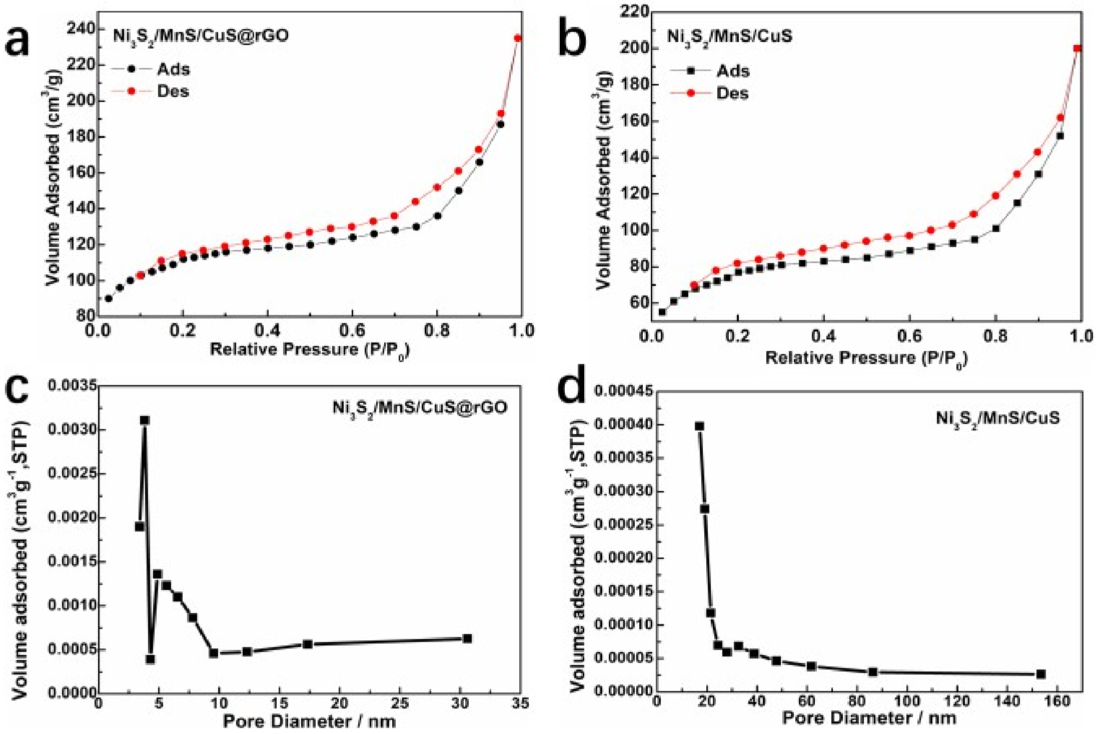

Fig S5 N_2 adsorption-desorption isotherms of Ni_3S_2/MnS/CuS@rGO (a) and Ni_3S_2/MnS/CuS@rGO (b) annealed at 200 ℃. (c) and (d) are pore size distribution curve

2. **Table**

Table S1: The element content of the Ni_3S_2/MnS/CuS@rGO composite

Element	ICP(%)	Element	EA(%)
Ni	23.2375	C	1.870
Cu	23.6714	S	20.922
Mn	61.009		

Table S2: The element content of the Ni_3S_2/MnS/CuS composite

Element	ICP(%)	Element	EA(%)
Ni	23.7784	S	22.472
Cu	29.3466		
Mn	10.7670		

In this experiment, we use the change weight of pure nickel foam before and after is as the weight of active materials.

Table S3 the mass loading of active material

1 cm×1 cm NF / mg	①Pure Nickel foam / mg	②Ni_3S_2/MnS/CuS@rGO-NF / mg	Δm (②-①)
1	43.2	45.9	2.7
2	36.8	39.9	3.1
3	41.5	45.1	3.6
4	42.7	45.3	2.6
5	38.6	41.5	2.9
6	40.8	43.8	3
7	39.4	43.5	3.1
8	27.5	29.7	2.2
9	31.3	34.5	3.2
10	40	43.6	3.6
average	38.2	41.3	3.1

Notes and References

[1] Wei. Si, Xiao. Wu, Jin Zhou, Fei. Guo, Shuping Zhuo, Hong. Cui, and Wei Xing, *Nanoscale Res. Lett.*, 2013, **8**, DOI: 10.1186/1556-276x-8-247.

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