Electronic Supplementary Information

Simple fabrication of Co$_3$O$_4$ nanoparticles on N-doped laser-induced graphene for high-performance supercapacitors

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Equations for evaluating the electrochemical performance of a supercapacitor

The areal specific capacitance ($C_A$) was calculated based on the galvanostatic charge–discharge curves using Eq. (1):

$$C_A = \frac{I \Delta t}{A \Delta V},$$

(1)

where $C_A$ (mF/cm$^2$), $I$ (A), $\Delta t$ (s), $A$ (cm$^2$), and $\Delta V$ (V) are the areal specific capacitance, current, discharge time, active area of the electrode (1 × 1 cm$^2$), and potential window after excluding the IR drop, respectively.

The areal energy density ($E_A$: µWh/cm$^2$) and power density ($P_A$: mW/cm$^2$) were calculated using Eqs. (2) and (3), respectively:

$$E_A = \frac{1}{2} \times C_A \times \frac{(\Delta V)^2}{3600},$$

(2)

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\[ P_A = \frac{E_A \times 3600}{\Delta t}, \]  

where \( C_A \) (mF/cm\(^2\)), \( \Delta V \) (V), and \( \Delta t \) are the areal specific capacitance at different current densities, potential window, and discharge time (s), respectively.
Figure S1. High-resolution (a) C1s and (b) N1s spectra of NLIG.

Figure S2. Cross-sectional images of NLIG (a) and Co$_3$O$_4$-NLIG-20 (b).
Figure S3. Selected area electron diffraction patterns of (a) NLIG and (b) Co$_3$O$_4$-NLIG-20.

Figure S4. Multiple cycle data at each current density.
Figure S5. EIS curve of $\text{Co}_3\text{O}_4$-NLIG-SC.
Figure S6: Capacitance retention of $\text{Co}_3\text{O}_4$-NLIG-SC under different bending radii at a current density of 1 mA/cm$^2$. 
Table S1. Elemental composition of carbon (C), oxygen (O), nitrogen (N), and cobalt (Co) elements present in Co$_3$O$_4$-NLIG and NLIG.

| Sample(s)       | C (at.%) | O (at.%) | N (at.%) | Co (at.%) |
|-----------------|----------|----------|----------|-----------|
| N-LIG           | 97.03    | 1.90     | 1.08     | -         |
| Co$_3$O$_4$-NLIG | 92.02    | 4.4      | 0.87     | 2.71      |

Table S2. Electrochemical performance of Co$_3$O$_4$-NLIG-SC compared with previously reported heteroatom-doped LIG/LIG composites with metal oxide-based supercapacitors (SCs)/micro SCs (MSCs)/planar SCs (PSCs) obtained by CO$_2$ laser irradiation of commercial polyimide sheet.

| Electrode material(s) | Type    | Electrolyte | $C_A$ (mF/cm$^2$)                  | Ref(s) |
|-----------------------|---------|-------------|------------------------------------|--------|
| Co$_3$O$_4$-NLIG-SC   | Sandwich| PVA-H$_3$PO$_4$ | 17.96 at 0.1 mA/cm$^2$              | This work |
| B-LIG                 | MSC     | PVA-H$_2$SO$_4$ | 16.5 at 0.05 mA/cm$^2$              | 1      |
| SN-LrGO               | PSC     | PVA-H$_3$PO$_4$ | 11.35 at 0.125 mA/cm$^2$            | 2      |
| Co$_3$O$_4$/LIG-80 J cm$^{-2}$ | MSC | PVA-H$_3$PO$_4$ | 22.3 mF/cm$^2$ at 0.05 mA/cm$^2$    | 3      |
| Co$_3$O$_4$/LIG-60    | MSC     | PVA-H$_2$SO$_4$ | 10.9 mF/cm$^2$ at 5 mV/s            | 4      |
| MnO$_2$/LIG           | MSC     | PVA-KOH      | 15.04 mF/cm$^2$ at 5 mV/s           | 5      |
References

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