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Supporting Information

In situ synthesis of copper nanoparticles encapsulated by nitrogen-doped graphene at room temperature via solution plasma

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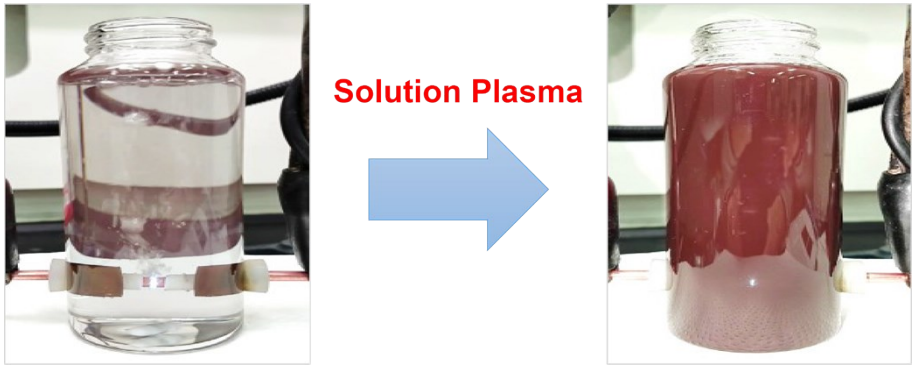

Fig. S1 Solution plasma (SP) synthesis of Cu-NFG.

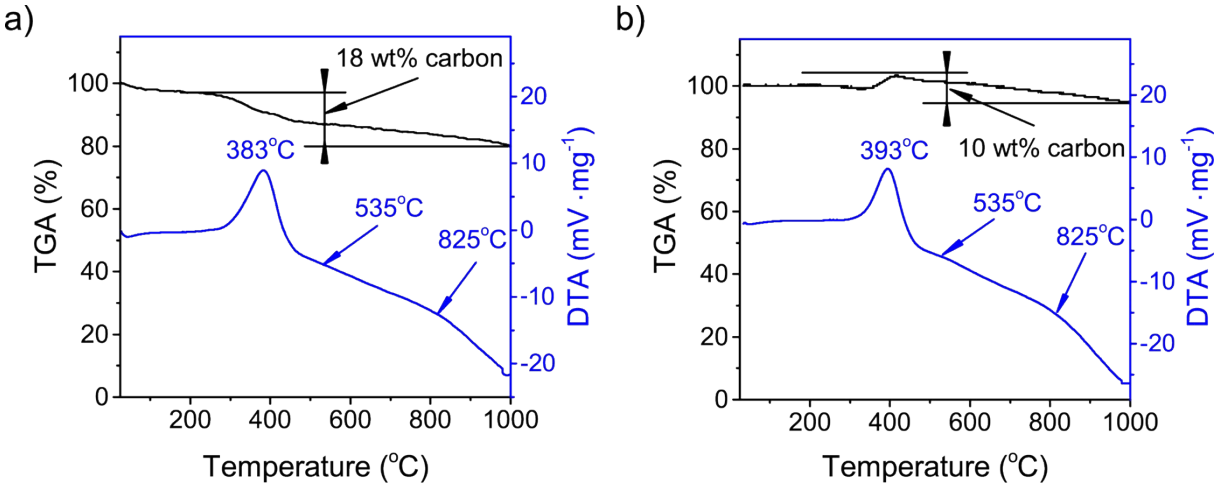

Fig. S2 TGA and DTA results of Cu-NFG-100 (a) and Cu-NFG-200 (b).

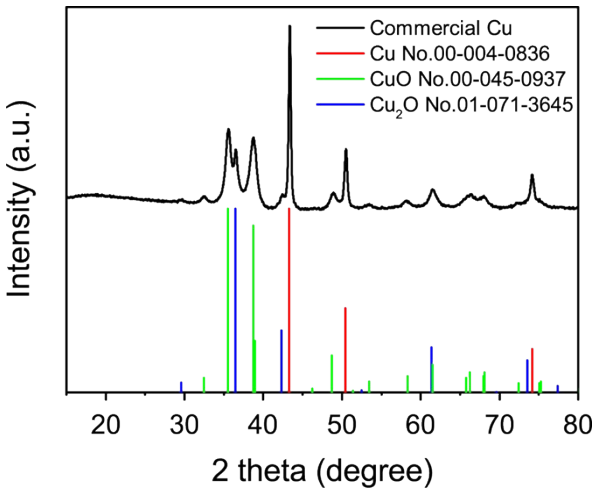

Fig. S3 XRD of commercial Cu and JCPDS of Cu, CuO and Cu_2O.

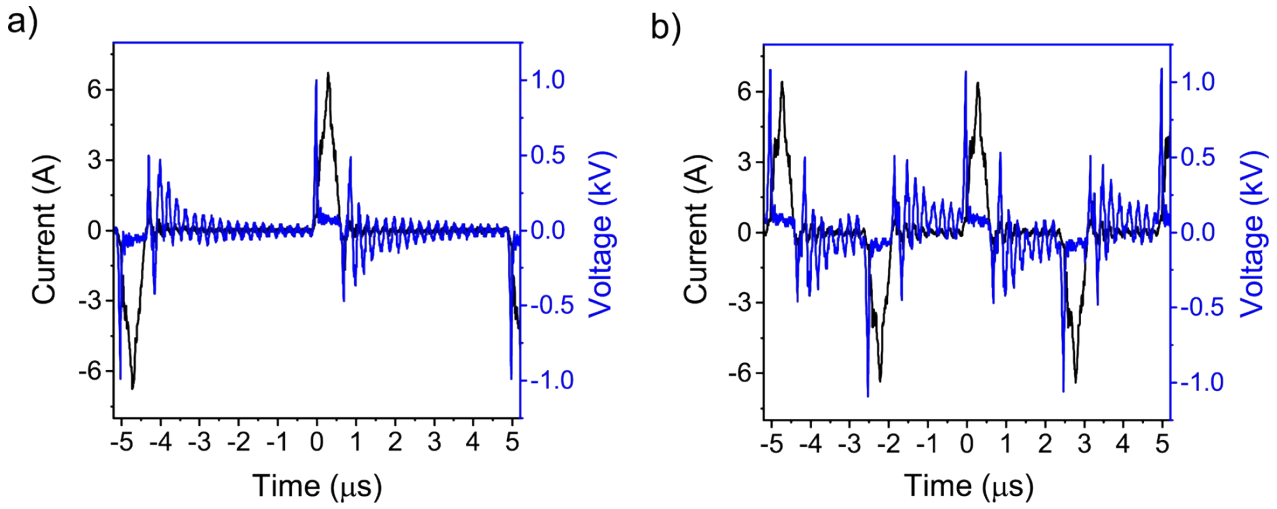

Fig. S4 Current and voltage waveforms during discharge in DMF at 100 kHz (a) and 200 kHz (b).

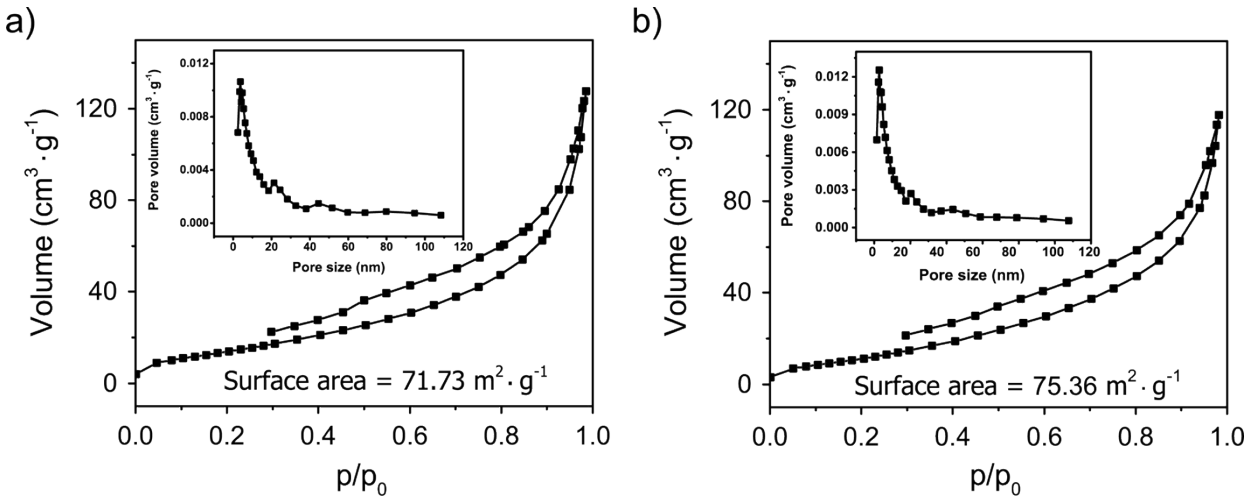

Fig. S5 Nitrogen adsorption-desorption isotherm at -196 °C, Brunauer-Emmett-Teller (BET) surface area and pore volume distribution results of Cu-NFG-100 (a), and Cu-NFG-200 (b).

Calculation of the electron excitation temperature

The electron excitation temperature is calculated using the equation:

$$T_e = -\frac{E_k - E_i}{k}\left[ln\left(\frac{A_k g_k I_i \lambda_i}{A_i g_i I_k \lambda_k}\right)\right]^{-1}$$

where:

E is the energy of the upper level (eV),

k is the Boltzmann constant (8.617×10^{-5} eV·K^{-1}),

A is the transition probability (s^{-1}),

g is statistical weight,

I is spectral intensity (a.u.),

λ is the emission spectrum wavelength (nm).

In this calculation, spectral lines of H_α and H_β were selected to calculate the electron temperature with the detail as table below:

Spectroscopic data of Hydrogen peak present in the solution plasma:

Spectrum	H_α	H_β
Emission spectrum wavelength, λ (nm)	659.32	489.20
Spectral intensity, I at 100kHz (a.u.)	7215.32	2316.38
Spectral intensity, I at 200kHz (a.u.)	22310.22	6812.40
Statistical weight, g	16	32
Upper level energy, E (eV)	12.41	12.75
Transition probability, A (10^6 s^{-1})	44.1	1.7