Electronic Supplementary Information (ESI)

Ultrahigh electromagnetic interference shielding performance of lightweight, flexible, and highly conductive copper-clad carbon fiber nonwoven fabrics

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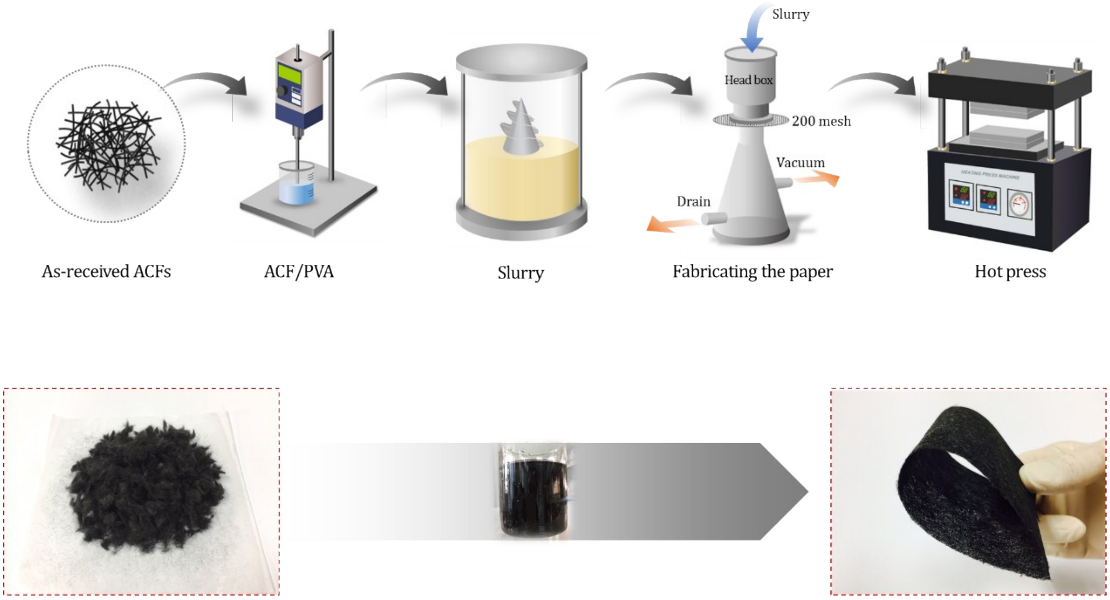

Scheme S1 The schematic preparation diagram of carbon fiber nonwoven fabric.

The overall anodic partial reaction for copper electroless plating process proceeds in at least two elementary steps:

A. Formation of electroactive species
B. Charge transfer from electroactive species to the catalytic surface

Specifically,
A: Formation of electroactive species, **$[HC(OH)O^-]_{ads}$**, proceeds in three steps:

a) Hydrolysis of H_2CO

$$H_2CO + H_2O \rightarrow H_2C(OH)_2 \ (methylene\ glycol) \tag{1}$$

b) Dissociation of $H_2C(OH)_2$,

$$H_2C(OH)_2 + OH^- \rightarrow H_2C(OH)O^- + H_2O \tag{2}$$

c) Dissociative adsorption of the intermediate $H_2C(OH)O^-$,

$$H_2C(OH)O^- \rightarrow [HC(OH)O^-]_{ads} + H_{ads} \tag{3}$$

where the subscript *ads* denotes adsorption of species. The adsorption of intermediate involves breaking of C–H bond.

B: Charge transfer, the electroactive species oxides according to the reaction

$$[HC(OH)O^-]_{ads} + OH^- \rightarrow HCOO^- + H_2O + e \tag{4}$$

The adsorbed hydrogen, H_{ads}, could be desorbed in the chemical reaction

$$H_{ads} \rightarrow \frac{1}{2} H_2 \tag{5}$$

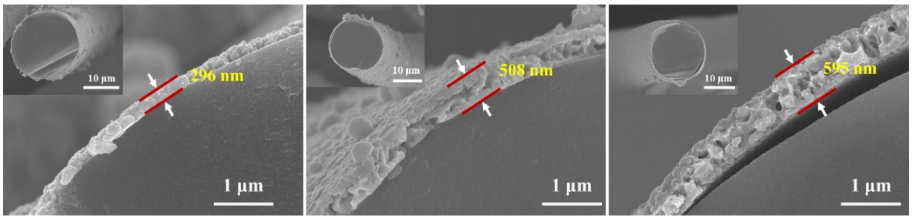

Fig. S1 The cross-section FE-SEM images of Cu@ACFs-3, Cu@ACFs-5 and Cu@ACFs-10, which showed the thickness of Cu coatings on ACFs (296 nm, 508 nm and 595 nm, respectively).

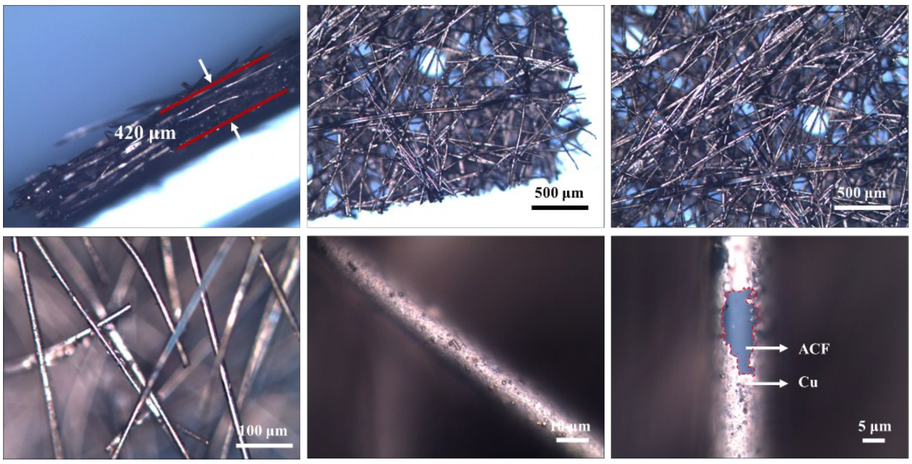

Fig. S2 The morphology images of Cu@ACFs-5 that were observed from optical microscope.

Table S1 Specific EMI shielding performances optimized with the thickness of foam structure-based shielding mateials and pure copper foil.

Samples	Density (g/cm^3)	t (cm)	SE (dB)	SSE (dB cm^3 g^{-1})	SSE/t (dB cm^2 g^{-1})	Ref.
30% rGO + PS	0.45	0.25	29	64.4	257.6	S1
10% rGO/Fe_3O_4 + PEI	0.4	0.25	18	44	176	S2
7% SWCNT + PS	0.56	0.12	18.5	33	275	S3
0.8 wt% Gr + PDMS	0.06	0.16	20	500	3125	S4
5 wt% Gr + PMMA	0.79	0.4	19	25	62.5	S5
Bulk carbon foam	0.166	0.2	40	241	1250	S6
CuNi-CNT	0.23	0.15	54.6	237	1580	S7
Dense Cu foil	6.944	0.0032	46.3	6.67	2084.38	This work
Pure ACFs	0.092	0.03485	11.3	122.8	3523.67	
Cu@ACFs-1	**0.125**	**0.03882**	**16.2**	**129.6**	**3338.49**	
Cu@ACFs-3	**0.131**	**0.04028**	**58.2**	**444.3**	**10491.15**	
Cu@ACFs-5	**0.150**	**0.04235**	**69.8**	**465.3**	**10987.01**	
Cu@ACFs-10	**0.169**	**0.0432**	**81.5**	**482.2**	**11162.04**	

The Specific shielding effectiveness (SSE) and Absolute effectiveness (SSE_t) were calculated by the following equation[S8-10]:

SSE = EMI SE/density = dB cm^3 g^{-1}

SSE_t = SSE/thickness = dB cm^3 g^{-1} cm^{-1} = dB cm^2 g^{-1}

Table S2 Relationship between shielding effectiveness (dB) and shielding efficiency (%).

Shielding Effectiveness (dB)	Shielding Efficiency (%)
0	0
10	90
20	99
30	99.9
40	99.99
50	99.999
60	99.9999
70	99.99999
80	99.999999
90	99.9999999

The EMI shielding efficiency (%) was calculated by the following equation[S8, S9]:

$$\text{Shielding efficiency (\%)} = 100 - \left(10^{\frac{SE}{10}}\right)^{-1} \times 100$$

Table S3 Electrochemical corrosion parameters obtained from polarization curves and r_{corr} tested in a 3.5% NaCl solution.

Samples	E_{corr} (V vs. Ag/AgCl)	E_{pit} (V vs. Ag/AgCl)	ΔE_p	i_{corr} (A/cm^2)
Cu@ACFs-3	-1.04 ± 0.02	6.5×10^{-4}	1.041	(5.75 ± 0.46) $\times10^{-4}$
Cu@ACFs-5	-1.0 ± 0.01	0.178	1.178	(5.13 ± 0.12) $\times10^{-4}$
Cu@ACFs-10	-1.02 ± 0.02	0.03	1.05	(6.96 ± 0.33) $\times10^{-4}$

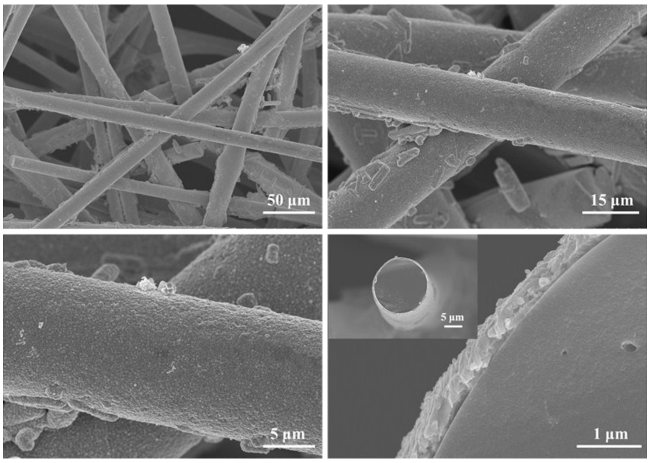

Fig. S3 FE-SEM images of Cu@ACFs-5 after electrochemical corrosion test.

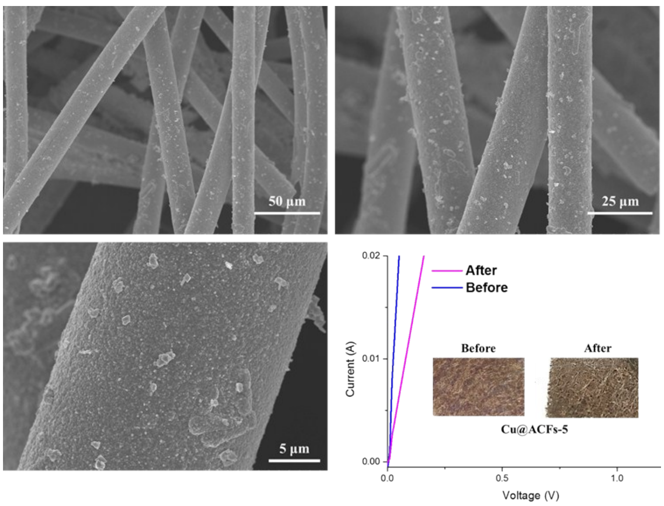

Fig. S4 FE-SEM images and I-V curves of Cu@ACFs-5 sample after salt mist test.

References

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