Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Supporting information

Lightweight and high-performance electromagnetic radiation shielding composites based on surface coating of Cu@Ag nanoflakes on leather matrix

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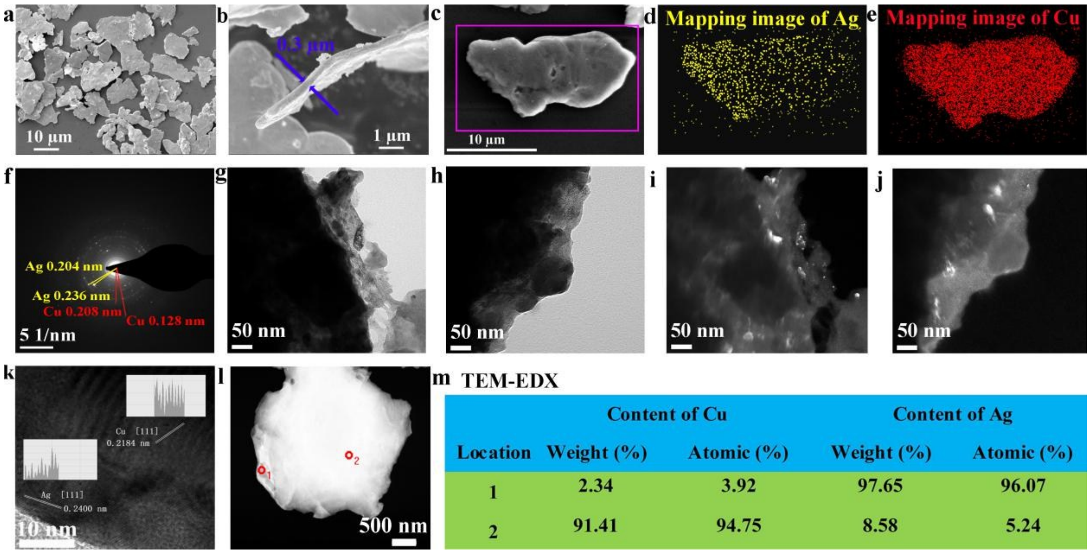

	Content of Cu		Content of Ag	
Location	Weight (%)	Atomic (%)	Weight (%)	Atomic (%)
1	2.34	3.92	97.65	96.07
2	91.41	94.75	8.58	5.24

Fig. S1. Characterization of Cu@Ag nanoflakes. SEM images (a, b), SEM-EDX mapping images (c-e) of Cu@Ag nanoflakes, SAED pattern (f) of Cu@Ag nanoflakes, TEM image (g, h) and corresponding HADDF images (i, j) of Cu@Ag nanoflakes, HRTEM image (k) of Cu@Ag nanoflakes, TEM-EDX analyses (l, m) of Cu@Ag nanoflakes.

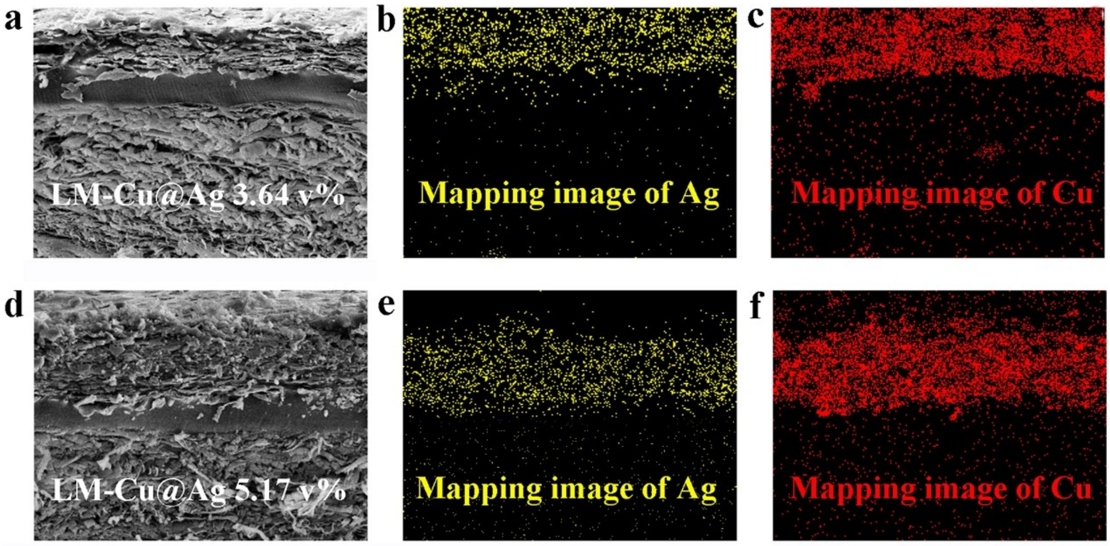

Fig. S2. SEM-EDX of LM-Cu@Ag with different volumetric fractions of 3.46 v% (a-c) and 5.17 v% (d-f), respectively.

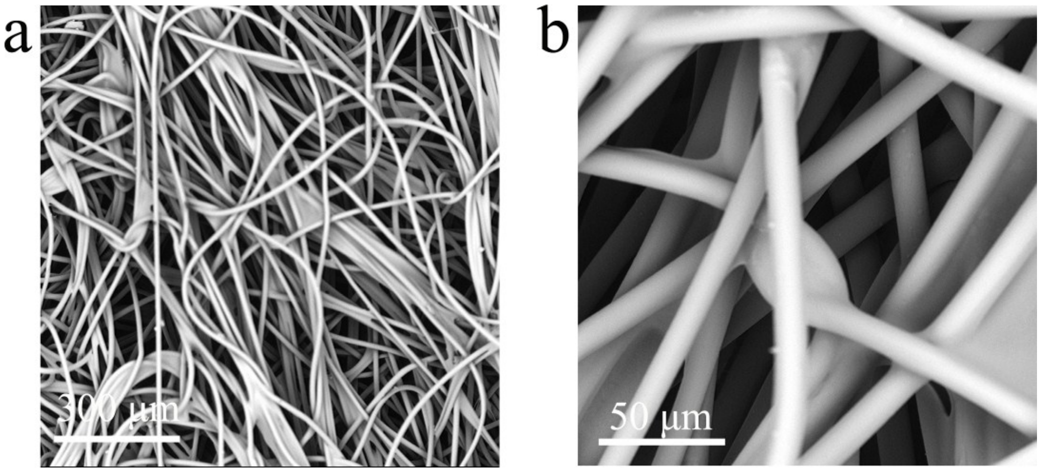

Fig. S3. SEM images of nonwoven fabrics at different magnifications.

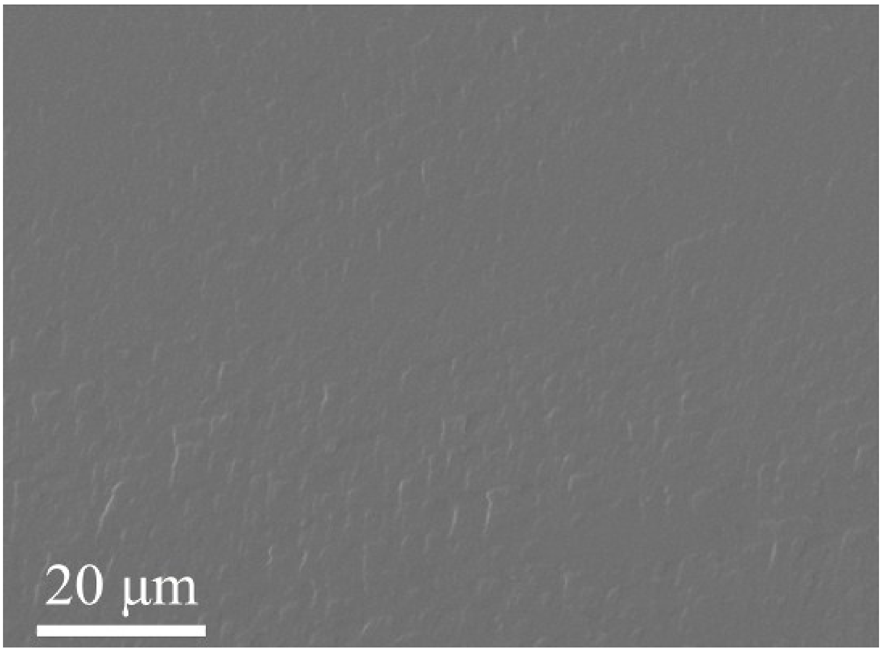

Fig. S4. SEM image of PMMA film.

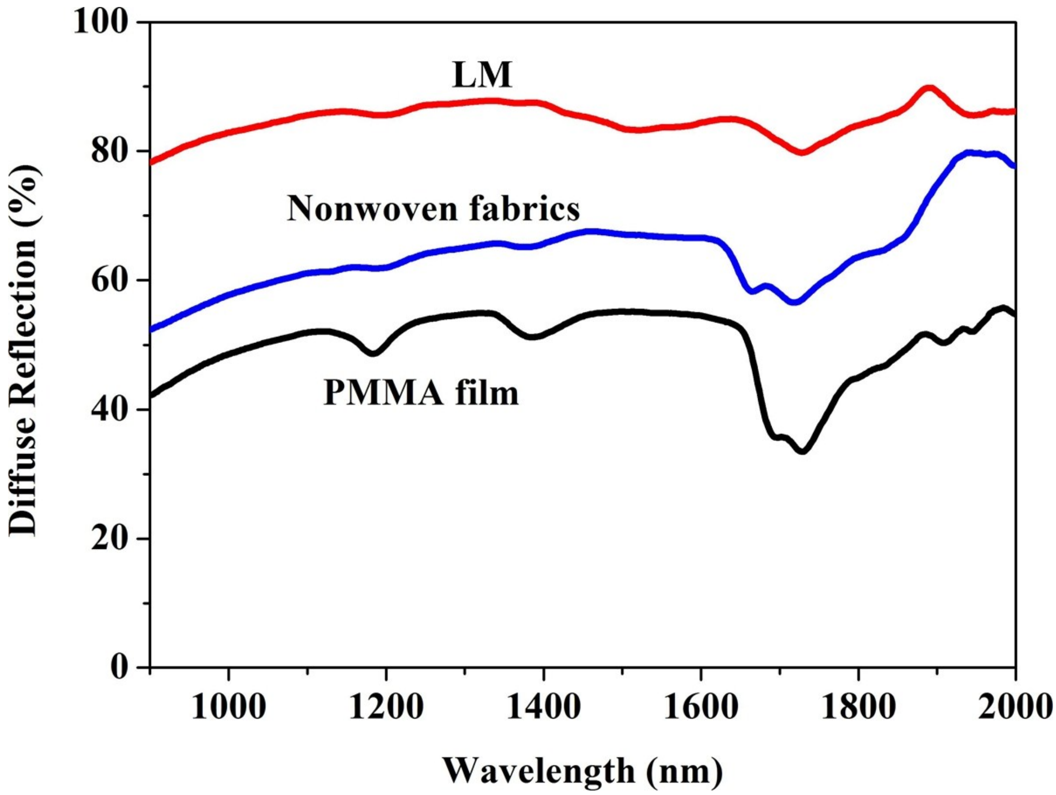

Fig. S5. NIR DR spectroscopy of LM, nonwoven fabrics and PMMA.

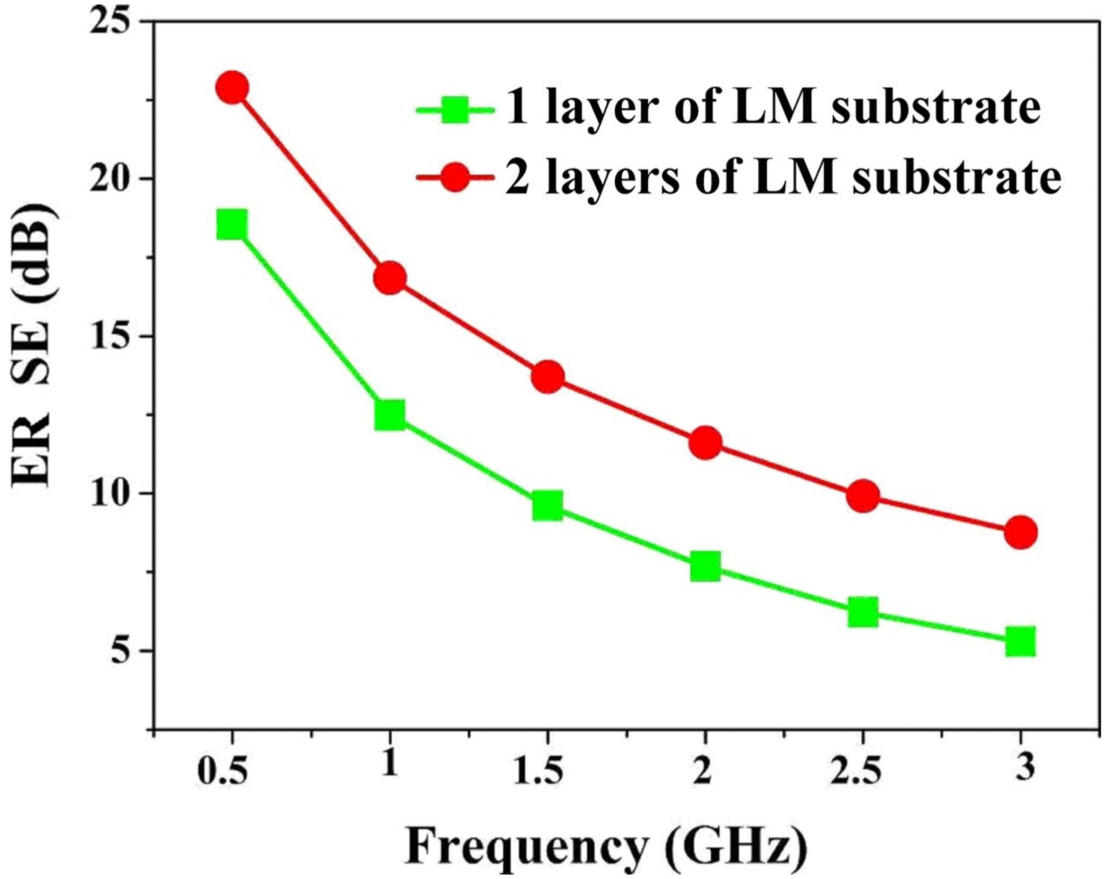

Fig. S6. The shielding effectiveness of LM substrate with different thickness (1 layer of LM = 0.6 mm, 2 layers of LM = 1.2 mm).

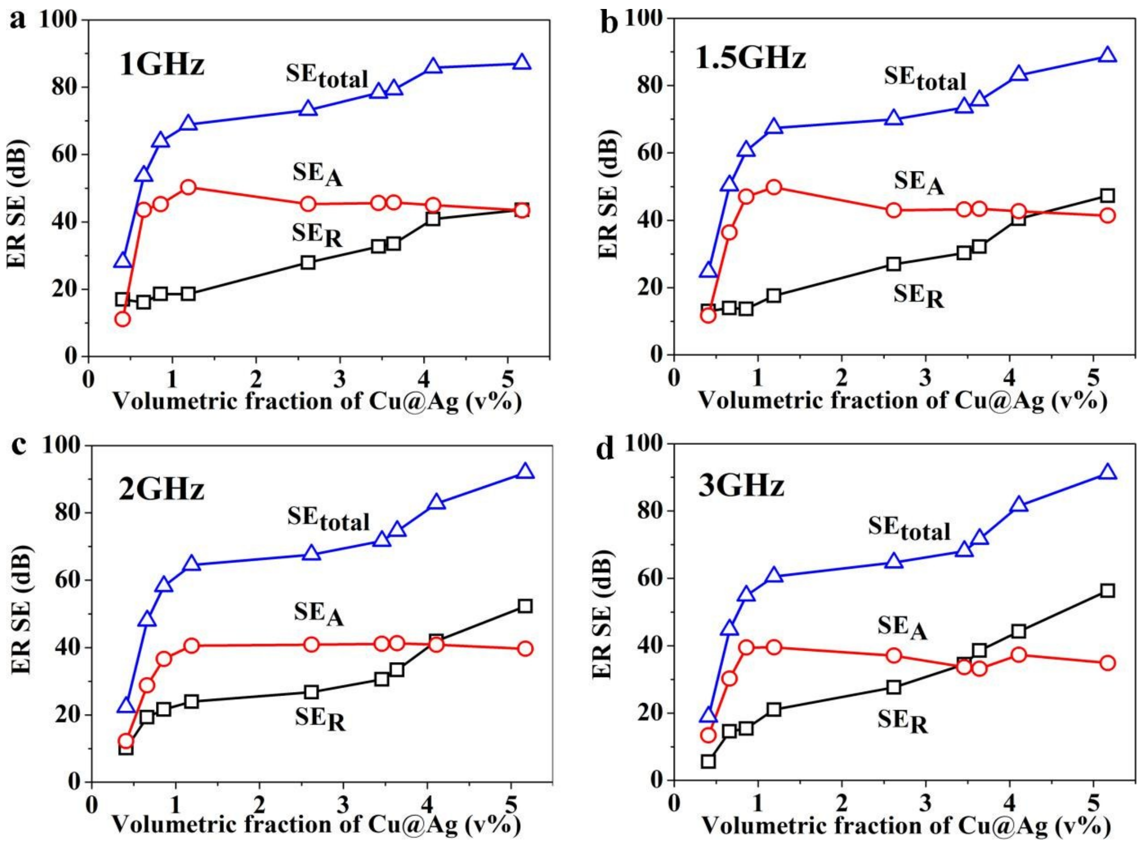

Fig. S7. SE_{total}, SE_A and SE_R of shielding leathers in the frequencies of 1.0, 1.5, 2.0, and 3.0 GHz respectively.

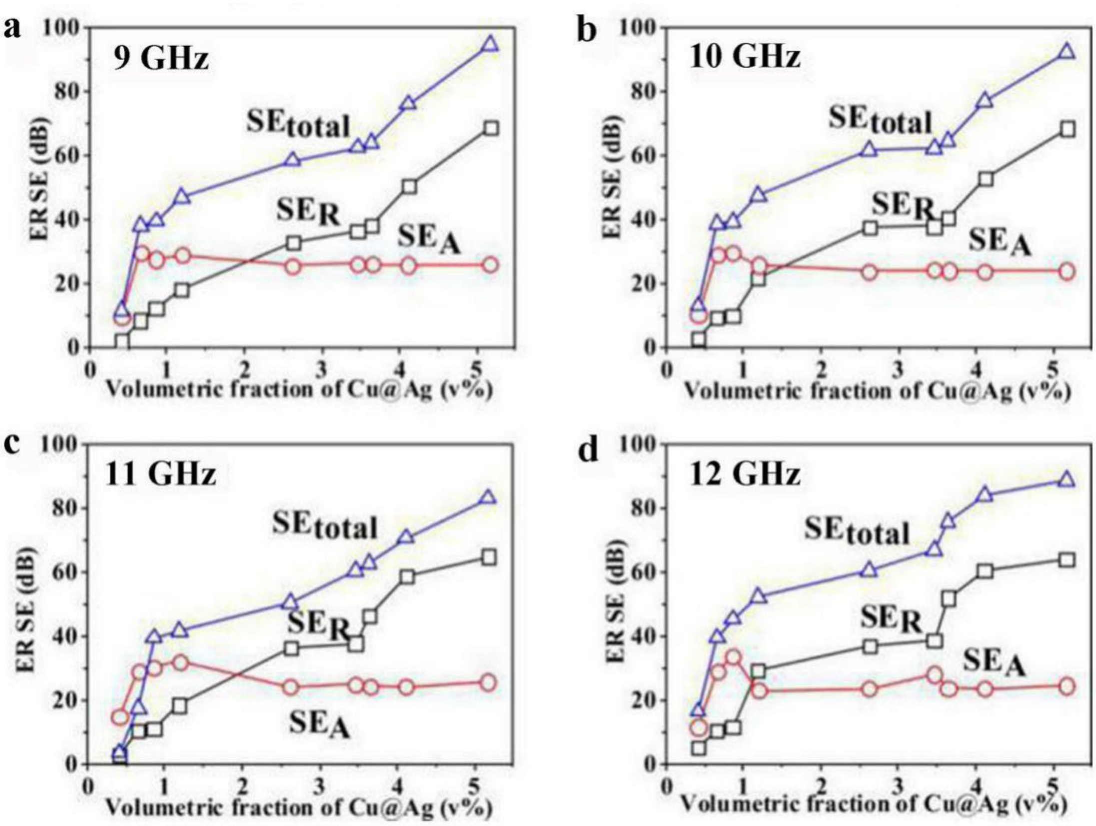

Fig. S8. SE_{total}, SE_A and SE_R of shielding leathers in the frequencies of 9, 10, 11, and 12 GHz respectively.

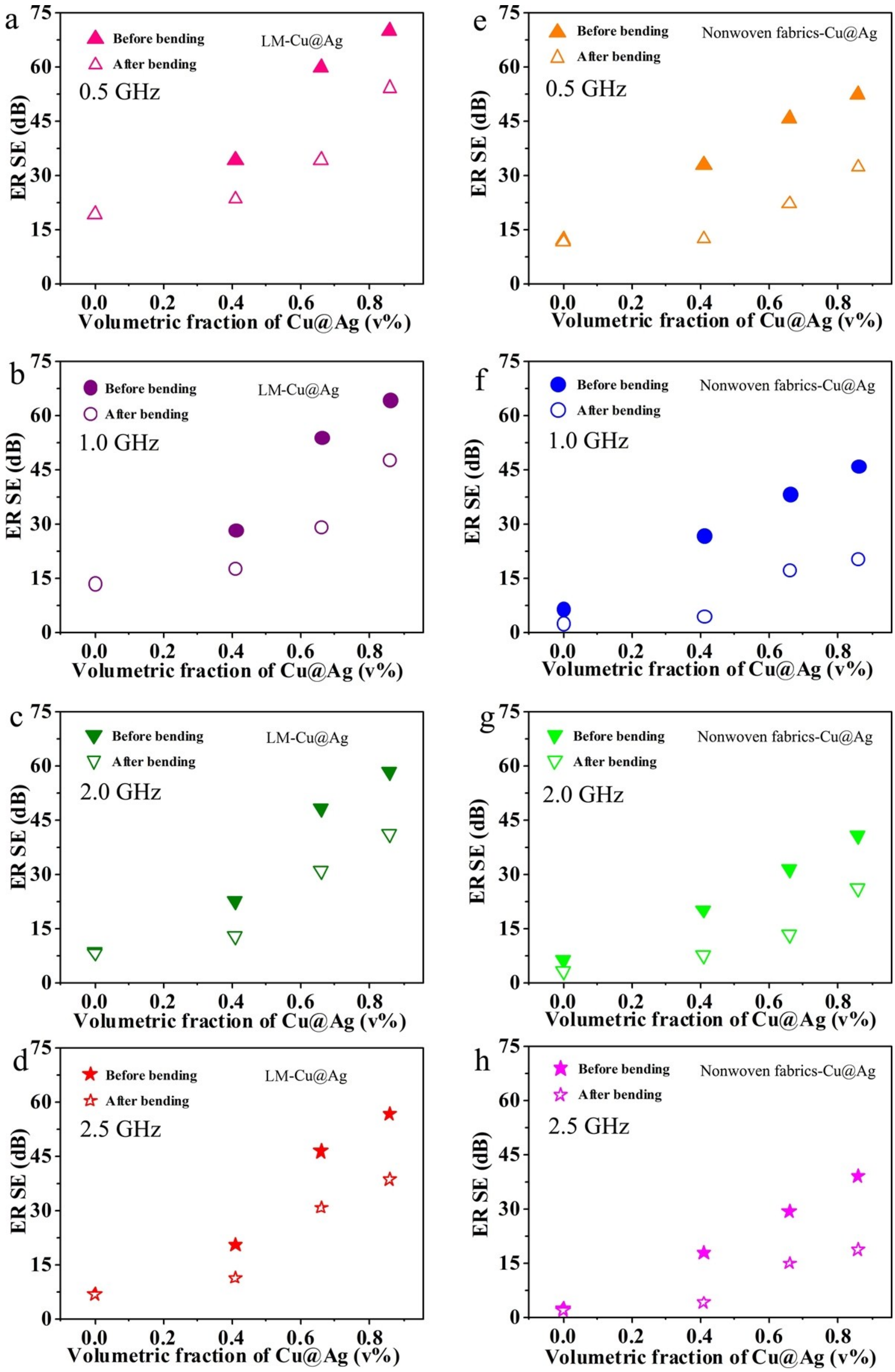

Fig. S9. The shielding performances of LM-Cu@Ag after bending 25,000 times. Shielding effectiveness of LM-Cu@Ag at the typical communication frequency (0.5, 1.0, 2.0 and 2.5 GHz) after bending 25,000 times (a-d). Shielding effectiveness of nonwoven fabrics-Cu@Ag at the typical communication frequency (0.5, 1.0, 2.0 and 2.5 GHz) after bending 25,000 times (e-h).

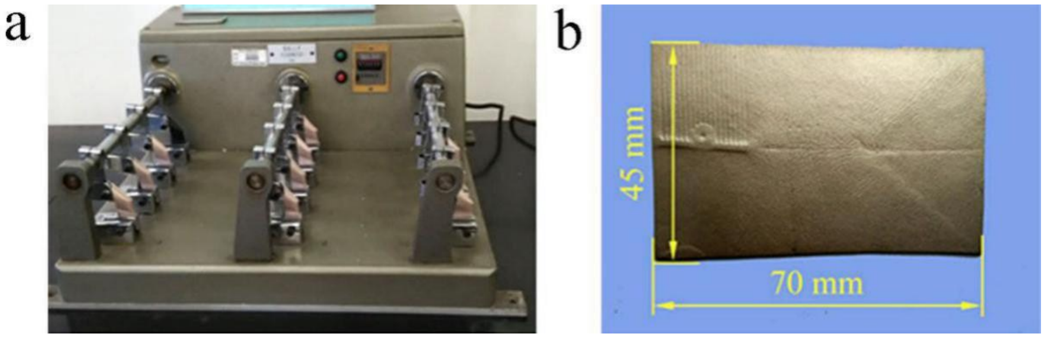

Fig. S10. The photos of (a) 2226 Bally Flexometer and (b) the LM-Cu@Ag (Cu@Ag 5.17 v%) after bending 25,000 times.

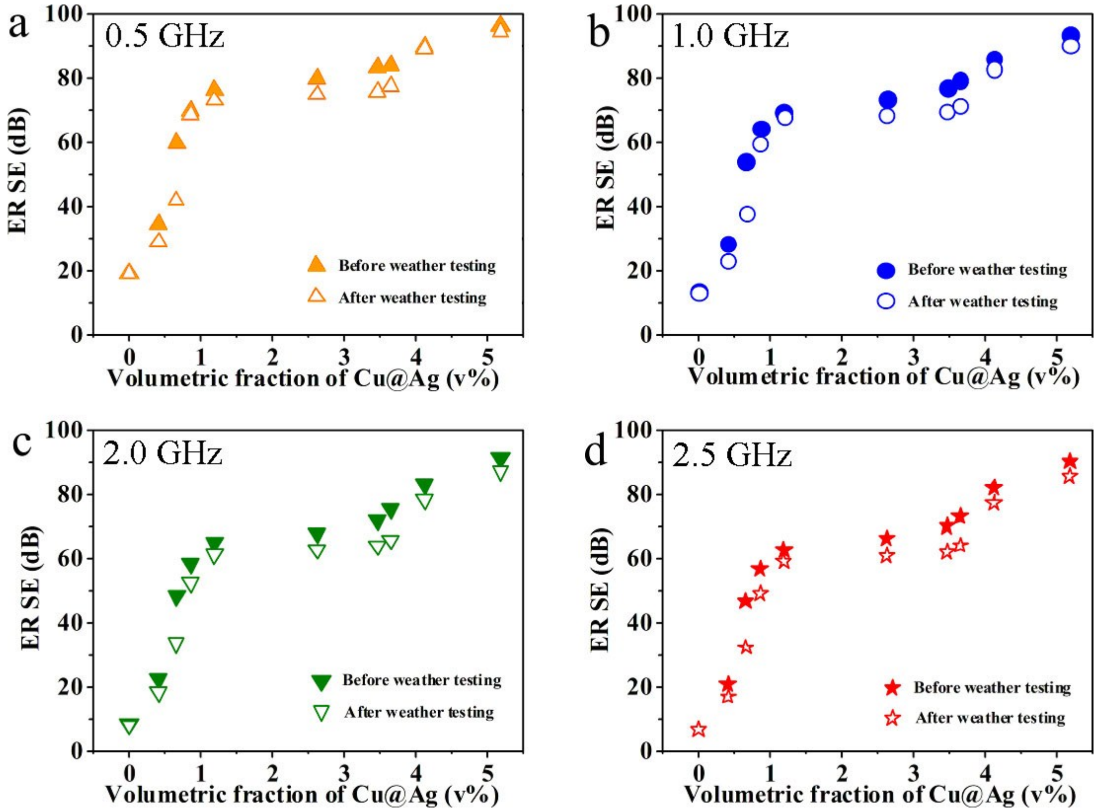

Fig. S11. Shielding effectiveness of LM-Cu@Ag at the typical communication frequency (0.5, 1.0, 2.0 and 2.5 GHz) before and after the weather testing.

Table S1. SE, SSE and thickness of LM-Cu@Ag and graphene-polymer based lightweight nanocomposites materials

Samples	SE [dB]	SSE [dB cm^3 g^{-1}]	Thickness [mm]	Ref.
LM-Cu@Ag	100	120	0.6	Present work
Graphene foam/PDMS	30	500	1	12
Graphene/PEI	11	44	2.3	33
Graphene/PMMA foam	19	17-25	2.4	34
Graphene@Fe_3O_4/PEI	18.2	41.5	2.5	35
Graphene/Wax	12	-	2.5	36
rGO/PS	18	-	2.8	37
rGO/Epoxy	21	-	-	38
rGO@CNTs/PS	20.2	-	5.6	39

Table S2. Conductivity (Con.), skin depth (δ) and adequate depth (*t*) of Cu@Ag layer with different volumetric fraction

			0.5 GHz		**1 GHz**		**1.5 GHz**		**2 GHz**		**2.5 GHz**		**3 GHz**	
Cu@Ag (v%)	Con. [S/m]	d [μm]	δ [μm]	t [μm]	δ [μm]	t [μm]	δ [μm]	t [μm]	δ [μm]	t [μm]	δ [μm]	t [μm]	δ [μm]	t [μm]
0.41	28.4	2.5	4223.5	40049.1	2986.5	29357.5	2438.5	24466.2	2111.8	21493.2	1888.8	19435.5	1724.3	17899.8
0.66	1646.1	4.0	554.8	4130.6	392.23	3057.2	320.3	2561.3	277.4	2258.2	248.1	2047.6	226.5	1889.9
0.86	3008.9	5.3	410.3	2931.0	290.2	2173.4	236.9	1822.8	205.2	1608.2	183.5	1459.0	167.5	1347.2
1.19	8955.0	7.4	237.9	1568.9	168.2	1167.8	137.3	981.5	118.9	867.1	106.4	787.5	97.1	727.8
2.62	11558.7	16.7	209.3	1354.1	148.0	1009.0	120.9	848.4	104.7	749.8	93.6	681.2	85.5	629.6
3.46	50194.5	22.5	100.5	575.8	71.0	431.8	58.0	364.4	50.2	322.8	44.9	293.8	41.0	271.9
3.64	80971.7	24.2	79.1	434.4	55.9	326.6	45.7	276.0	39.5	244.7	35.4	222.8	32.3	206.3
4.11	94214.0	27.6	73.3	397.1	51.9	298.8	42.3	252.6	36.7	224.0	32.8	204.1	29.9	189.0
5.17	120014.1	35.5	65.0	344.0	45.9	259.2	37.5	219.3	32.5	194.6	29.1	177.3	26.5	164.3

δ = Skin depth, *t* = Adequate depth with SE at 100 dB, Con. = Conductivity,
d = practical thickness of Cu@Ag layer

Table S3. SE_A contributed by the layer of Cu@Ag nanoflakes in different LM-Cu@Ag

Cu@Ag (v%)	SE_A* (dB)					
	0.5 GHz	1 GHz	1.5 GHz	2 GHz	2.5 GHz	3 GHz
0.41	0.0051	0.0071	0.0088	0.0101	0.0113	0.0124
0.66	0.063	0.0886	0.108	0.125	0.1400	0.153
0.86	0.110	0.158	0.193	0.223	0.249	0.273
1.19	0.271	0.383	0.469	0.541	0.605	0.663
2.62	0.692	0.978	1.198	1.383	1.546	1.694
3.46	1.945	2.751	3.369	3.891	4.350	4.765
3.64	2.662	3.765	4.611	5.324	5.953	6.521
4.11	3.276	4.633	5.674	6.551	7.325	8.024
5.17	4.740	6.703	8.210	9.480	10.599	11.610

* SE_A contributed by the layer of Cu@Ag nanoflakes.

Table S4. Tearing load (T_l) and tensile strength (Ts) of LM-Cu@Ag with different volumetric fractions of Cu@Ag nanoflakes

Cu@Ag [v %]	0.00	0.41	0.66	0.86	1.19	2.62	3.46	3.64	4.11	5.17
T_l [N/mm]	16.1	16.2	16.4	16.9	17.1	17.5	18.6	19.9	20.7	23.9
Ts [MPa]	6.5	7.3	7.7	9.0	9.4	10.8	11.6	13.4	14.2	14.7