

Supplementary Information

Electromagnetic Wave Shielding Flexible Films with Near-Zero Reflection in the 5G Frequency Band

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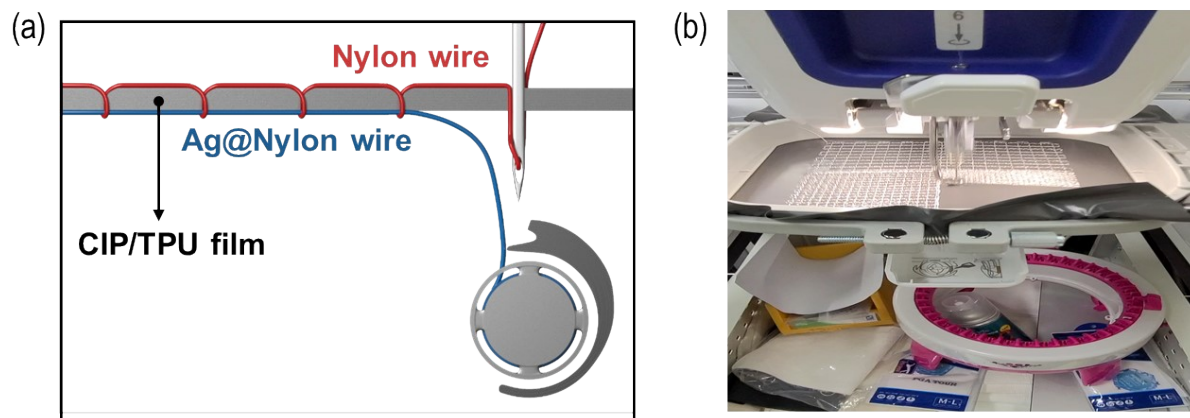


Figure S1. (a) Scheme of the experimental procedure of Ag@nylon wire stitching on the CIP/TPU composite and (b) captured image of sewing video.

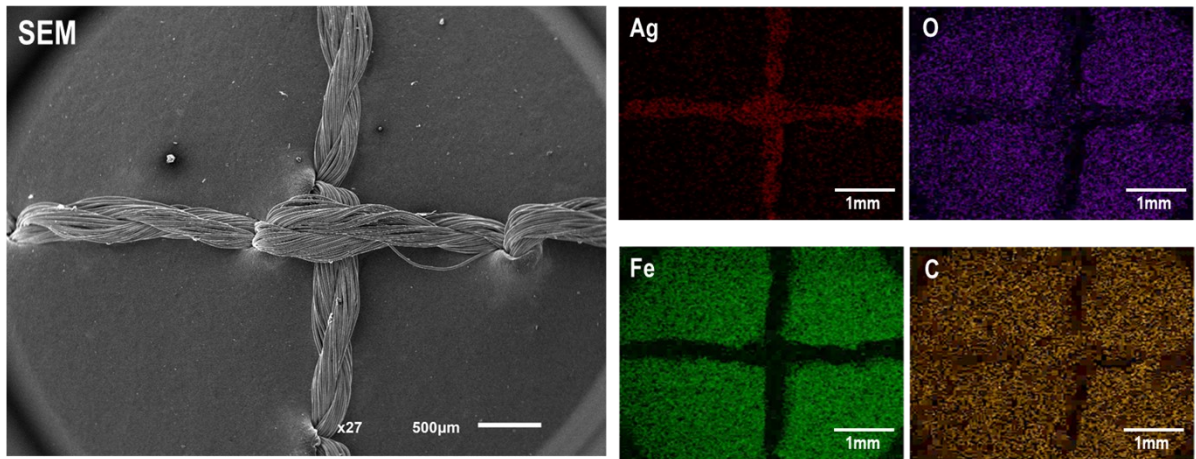
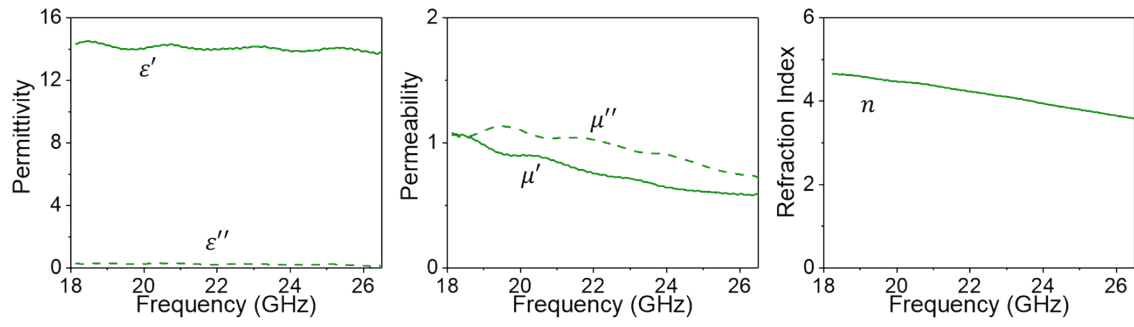


Figure S2. A scanning electron microscopic image (SEM image) of the proposed EMI shielding film and SEM-EDS mapping images of the film with spectra of Ag, O, Fe, and C.



$$n = \sqrt{\mu_r \epsilon_r} = \sqrt{(1.06 + 1.078i)(14.33 + 0.2926i)} = |4.277 + 1.843i| = 4.657 \text{ @ 18 GHz, Average (K-band) } \sim 4.2$$

Figure S3. Permittivity, permeability and refractive index of CIP/TPU composite layer.

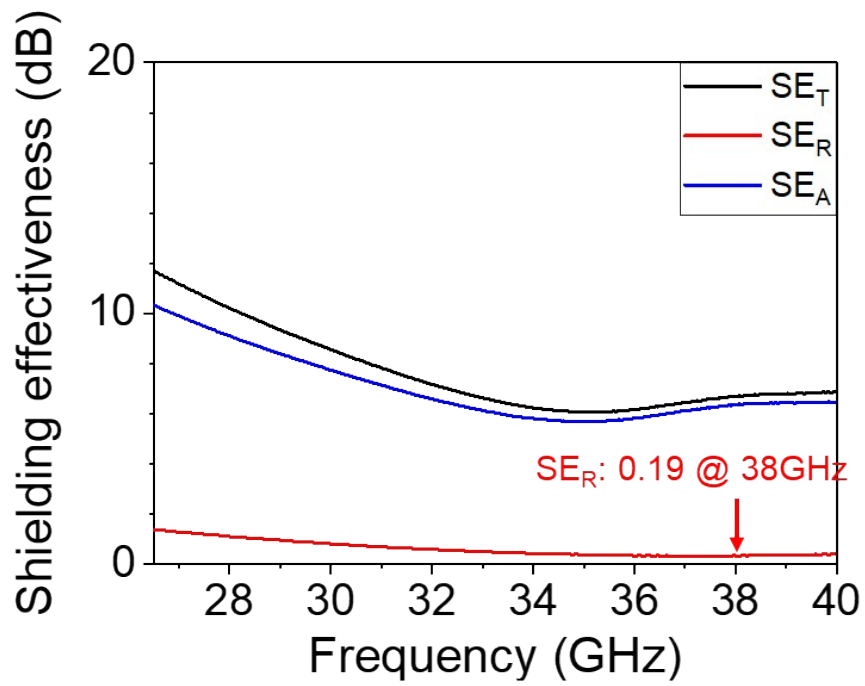


Figure S4. EMI shielding effectiveness of the shielding film with 1 mm grid period (Figure 3 (c)) in 26.5 – 40 GHz.

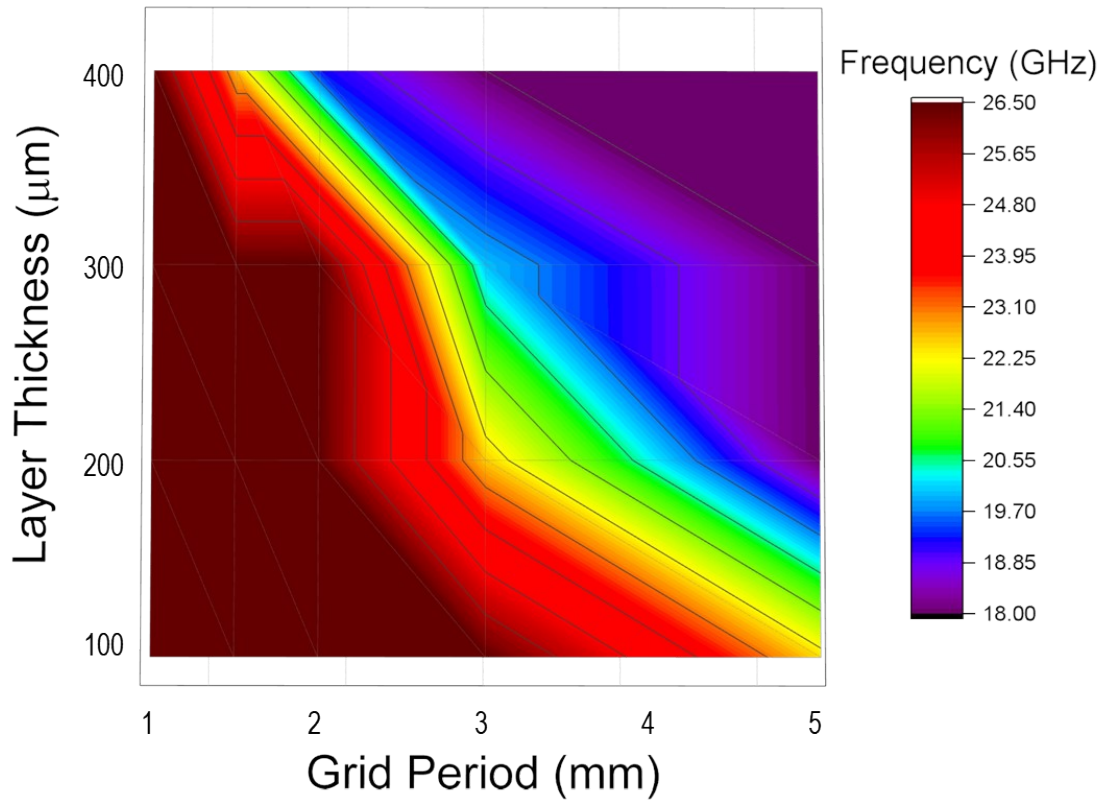


Figure S5. Visualized resonant frequencies of 16 different EMI shielding films with grid period from 1 to 5 mm and layer thickness from 100 to 400 μm .

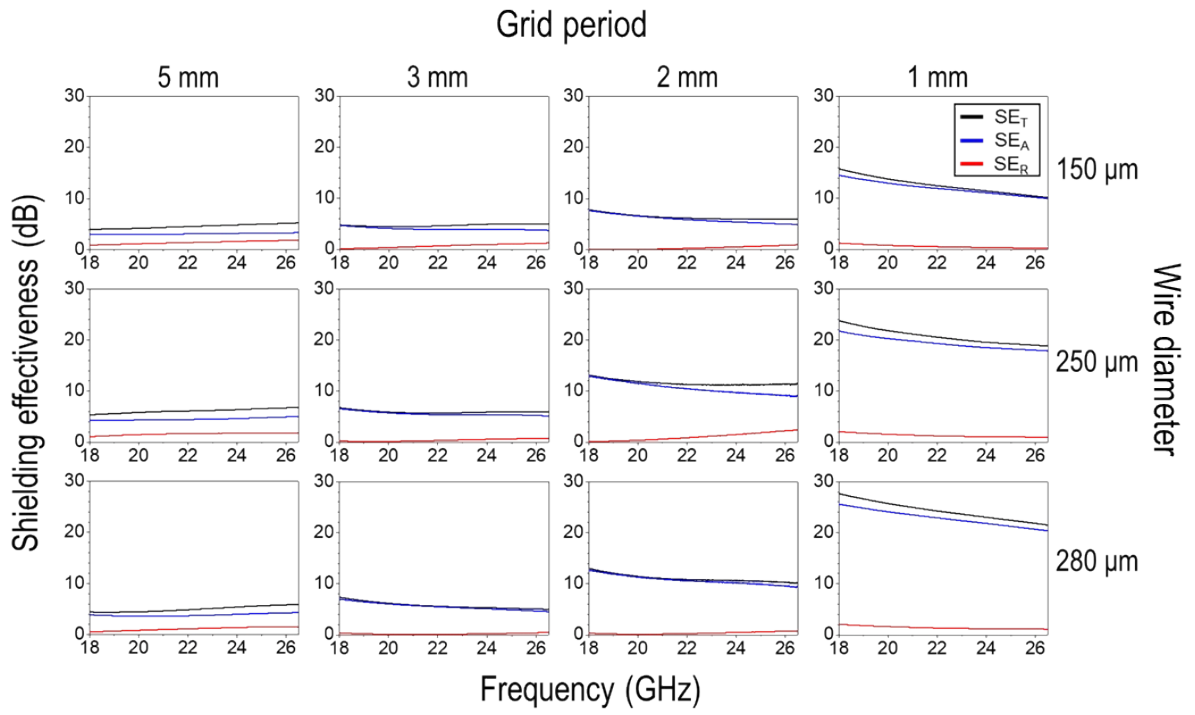


Figure S6. EMI shielding effectiveness of EMI shielding films with different grid geometries, grid periods (1-5 mm) and wire diameters (150-280 μm).

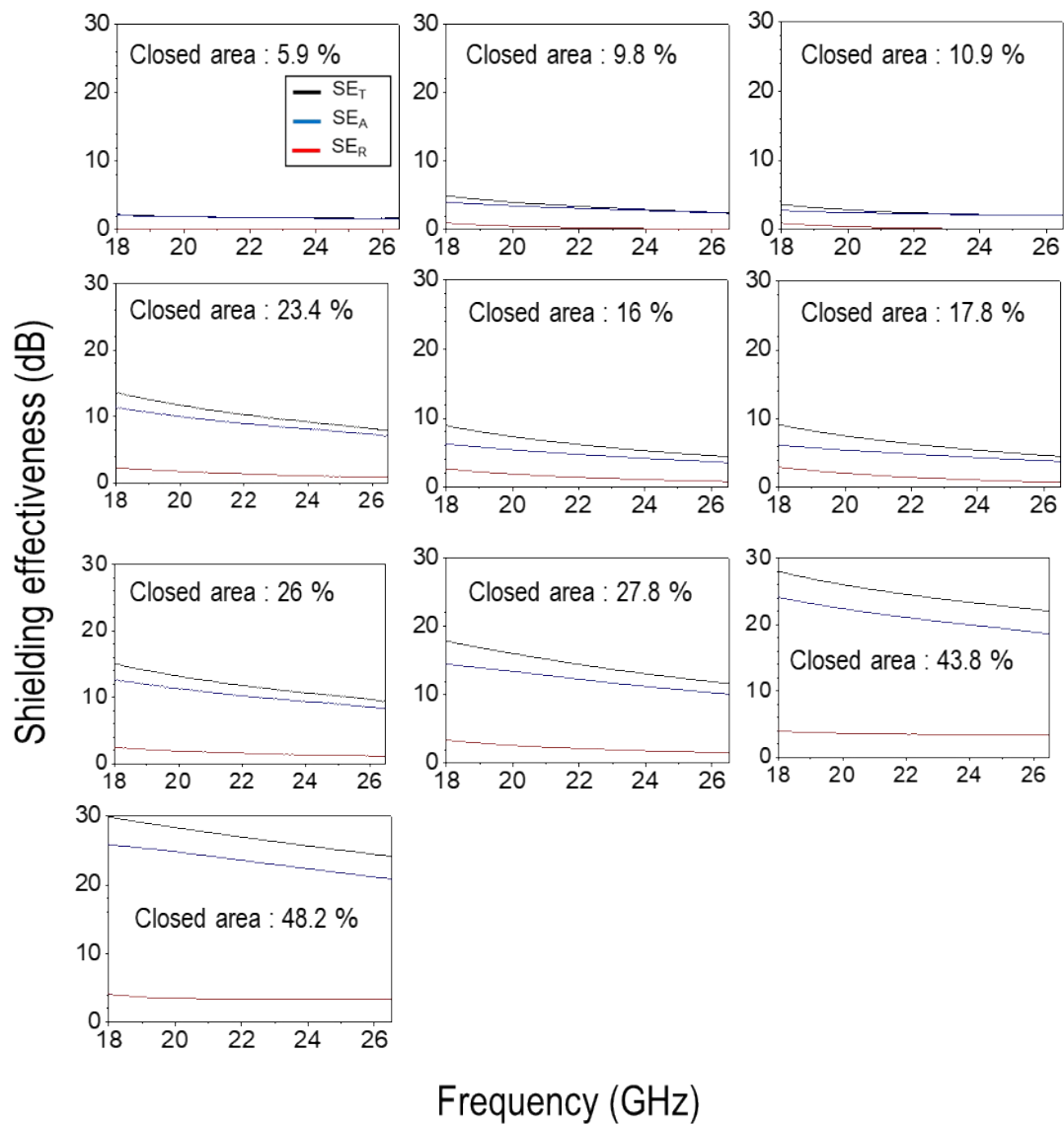


Figure S7. EMI shielding effectiveness of EMI shielding films with different closed areas (5.9-48.2%).

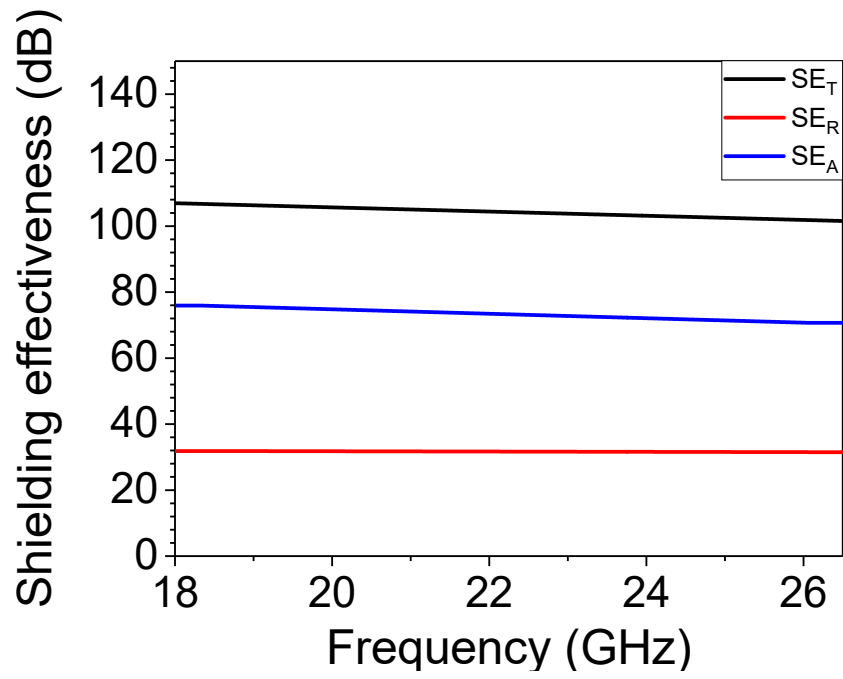


Figure S8. EMI shielding effectiveness of an aluminum foil.

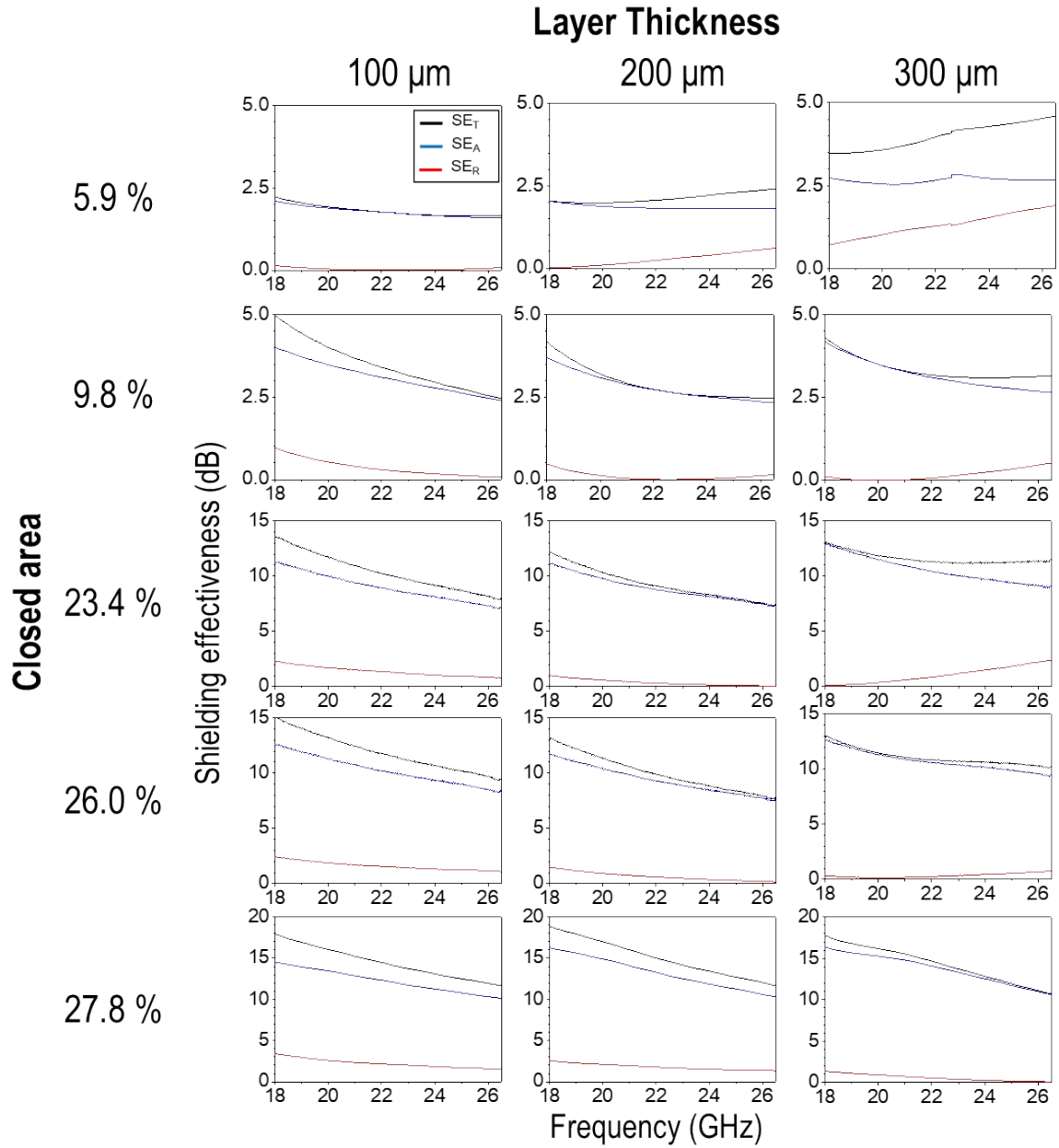


Figure S9. EMI shielding effectiveness of EMI shielding films with different film structures, composite layer thickness (100-300 μm) and closed areas (5.9-27.8%).

Table S1. Comparison with the previously reported EMI shielding materials at 26 GHz

Form	Main Materials	Thickness (mm)	SE_R (dB)	SE_A (dB)	R (%)	A (%)	Reference
Film	Metal	0.18	20	70	99.00	1.00	[6]
Film	Metal	0.01	10	15	90.00	9.68	[7]
Film	MXene	1	9.2	67.8	87.98	12.02	[9]
Composite	Graphene	2.5	3	24	49.88	49.92	[10]
Composite	Graphite	5	5	35	68.38	31.61	[11]
Composite	CNT	0.5	5.4	9.7	71.16	25.75	[12]
Composite	CNT	0.5	8.9	42.4	87.12	12.88	[12]
Composite	CNT	0.1	7.91	14.5	83.82	15.61	[13]
Composite	Graphene	0.1	8.76	13.82	86.70	12.75	[13]
Film	Graphene	0.02	11.3	23.8	92.59	7.38	[15]
Composite	CNT	0.4	9.3	29.3	88.25	11.74	[16]
Composite	Graphene	0.4	19.2	14.5	98.80	1.16	[16]
Bulk	Ferrite	3.5	0.5	9.5	10.87	79.13	[28]
Composite	Alloy	2	3.6	10.4	56.35	39.67	[29]
Composite	Alloy	2	2.1	6.8	38.34	48.78	[29]
Composite	Ferrite / CNT	0.7	6.3	16.2	76.56	22.88	[31]
Composite	Ferrite / Graphene	1.1	5.3	30.3	70.49	29.48	[31]
Foam	CNT	5	0.5	25.5	10.87	88.87	[32]
Foam	CNT	3	2.3	23.89	41.12	58.64	[33]
Foam	CNT	5	2.3	47.3	41.12	58.88	[33]
Composite	CIP / Ag@Nylon	0.4	0.01	11.2	0.23	92.20	This Work (NZR)
Composite	CIP / CNT Ag@Nylon	0.5	0.47	24.2	10.2	89.40	This Work (Nzt)