Electronic Supplementary Material (ESI) for Materials Advances.

Supplementary Material

Enhancement on electromagnetic interference shielding from synergism between Cu@Ni nanorods and carbon materials in flexible composite films

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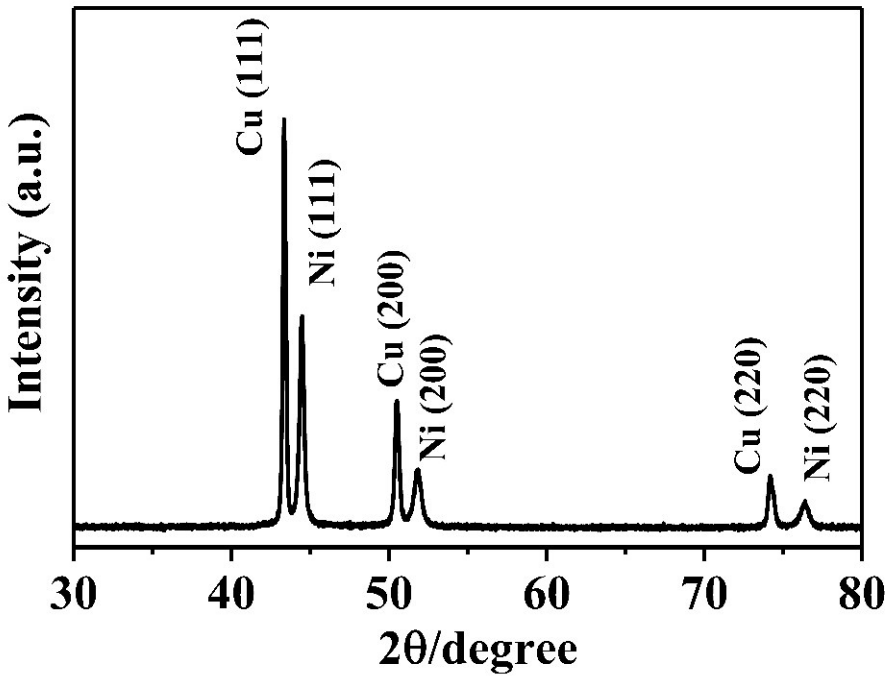
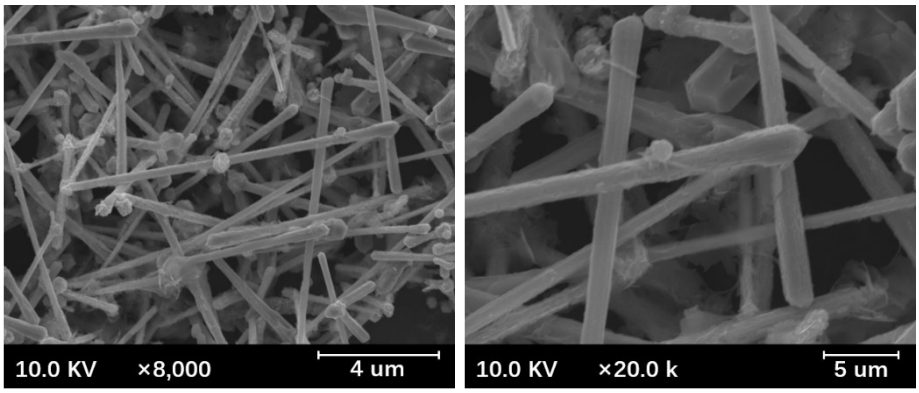
Table S1. The amount of the dissolved PVDF and Cu@Ni in DMF

Cu@Ni content in composite film (wt%)	0.6	1.2	2	4	6	8
PVDF (g)	8.54	8.48	8.60	8.20	8.00	7.80
Cu@Ni (g)	0.06	0.12	0.20	0.40	0.60	0.80



(a)



(b) (c)

Fig. S1. (a) XRD patterns (b-c) and SEM images of the Cu@Ni rods.

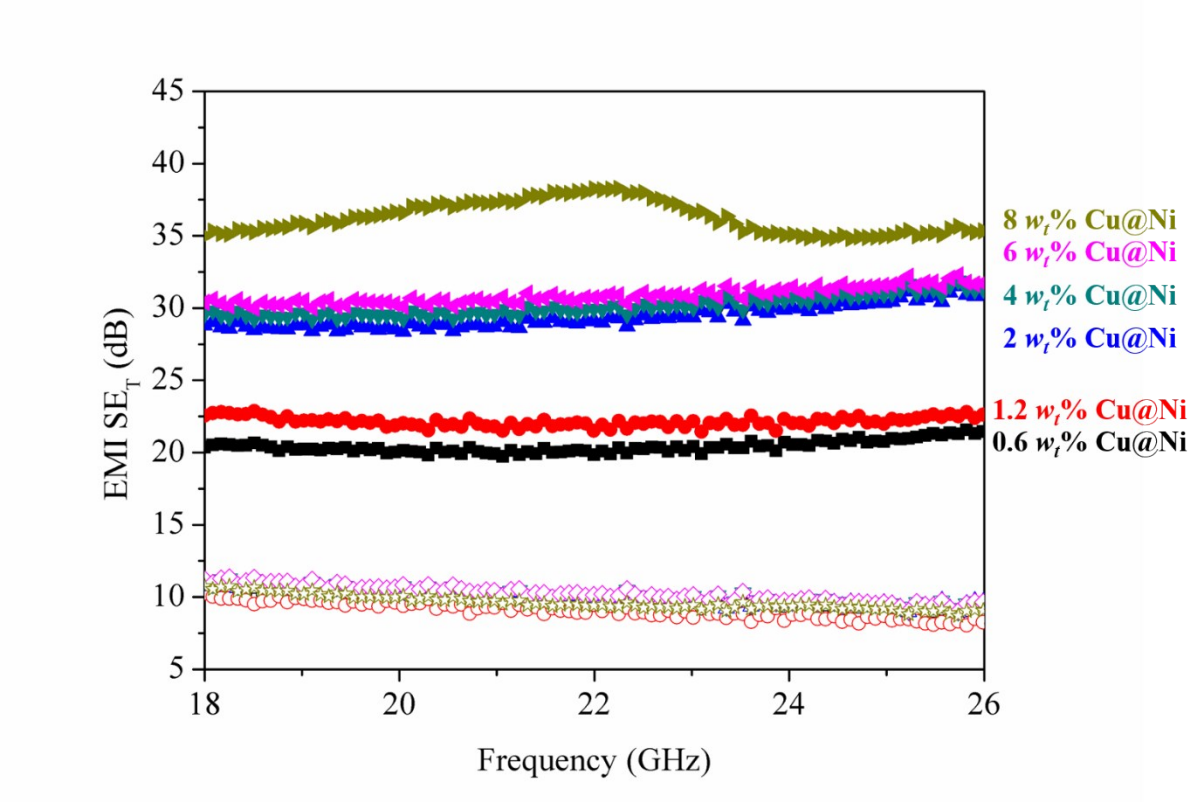


Fig. S2. SE_A (solid) and SE_R (hollow) of the composite films at the frequency from 18 GHz to 26 GHz;

Table S2. EMI Shielding Performance of Polymer Composites

Filler type	Filler	Matrix	Filler	SE (dB)	t (mm)	Ref.
Carbon-based filler/metal	**CNT/graphene/Cu@Ni**	**PVDF**	**6 w_t% CNT/8 w_t% graphene/8 w_t% Cu@Ni**	**47.6**	**0.3**	**This work**
	rGO/δ-Fe_2O_3	PVA	40 w_t%	20.3	0.36	[1]
	rGO/CF/γ-Fe_2O_3	Resin	50 w_t%	41.8	0.4	[2]
	rGO/Fe_3O_4	PVA	35 w_t%	15	0.36	[3]
	Ag/carbon filler	Epoxy	4.5 w_t%	38	2.5	[4]
CNT	CNT	PVDF	5 w_t%	35.4	0.4	[5]
	MWCNT	PMMA	40 w_t%	27	0.165	[6]
	SWCNT	EDOT	15 w_t%	58	2.8	[7]
	CNT	WPU	76.2 w_t%	50	2	[8]
	Cellulose/MXCNT	Cellulose	15 w_t%	35	0.15	[9]
	CNT	PP	7.5 w_t%	22.3	0.34	[10]
Graphene	Graphene	PI	16 w_t% graphene	21	0.8	[11]
	Graphene/CNT	PVDF	5 w_t%CNT 10 w_t% graphene	36.5	0.25	[5]
Graphite	Graphite	SEBS	15 w_t%	20	5	[12]
	Graphite	PA66	25 w_t%	12	3.2	[13]
	Graphite	Epoxy	2 w_t%	11	2	[14]
	Graphite	PE	18.7 w_t%	33	3	[15]
Metals	Ag Nanowires	PS	2.5 w_t%	33	0.8	[16]
	Cu Nanowires	PS	2.1 w_t%	35	0.2	[17]
	Ni-Co Fiber	WAX	30 w_t%	41.2	2.5	[18]
	Ni	PVDF	40 w_t%	23	1.95	[19]

Table S3. SE/t values of various PVDF-based shielding materials

Polymer matrix	Conductive filler	t (mm)	SE (dB)	SE/t ($dB \cdot mm^{-1}$)	Ref.
PVDF	**6 wt% CNT/8 wt% graphene/8 wt% Cu@Ni**	**0.3**	**47.6**	**158.8**	**This study**
	5 wt% Fe_3O_4/8 wt% graphene	1.1	35.6	32.4	[20]
	10 wt% Ni chain	2	21	10.5	[21]
	1 wt% CNT/6 wt% Ni chain	0.6	57.3	95.5	[22]
	5 wt% graphene nanoplatelets/8 wt% Ni chain	0.6	55.8	93	[22]
	5 wt% Fe_3O_4/ wt% 8 CNT	1.1	32.7	29.7	[23]
	6 wt% CNT/6 wt% Co chain	0.3	35.3	117.6	[24]
	3 wt% CNT/2.2 *vol* % Co nanowires	1	35	35	[25]
	50 wt% bulk $Ti_3C_2T_x$	1	34.49	34.49	[26]
	10 wt% MWCNT/12 wt% Ni@CNT	0.5	46.6	93.2	[27]
	50 vol% carbonyl iron powder	1.2	20	16.7	[28]
	2.7 vol.% MWCNT/22 vol.% ethylene-a-octene block copolymer	2.0	34	17	[29]
	1 wt% IL-MWCNT + 2 vol% BT–GO	5.0	26	5.2	[30]
	5 wt % CF/15 wt% CB	4.0	30	7.5	[30]
	9.5 wt% Graphene/silicon carbide nanowires (2:1),	1.2	32.5	27.1	[32]
PU	6.7 wt% MWCNT	3	60	20	[33]
PLLA	10 wt% MWCNT	2.5	23	9.2	[34]
UHMWPE	10 wt% MWCNT	1	50	50	[35]
Epoxy	0.66 wt% 3D CNT	2	33	15.5	[36]
PMMA	20 wt% SWCNT	4.5	30	6.7	[37]
PDMS	0.8 wt% graphene	1	21	21	[38]
PU foam	10 wt% graphene	60	57.7	0.96	[39]
PS	10 wt% functionalized graphene	2.8	18	6.4	[40]
Porous PS	30 wt% graphene	2.5	29	11.6	[41]

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