Supplementary Material

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

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| 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|
Fig. S1. (a) XRD patterns (b-c) and SEM images of the Cu@Ni rods.
Fig. S2. $S_{EA}$ (solid) and $S_{ER}$ (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. |
|-------------|--------|--------|--------|---------|--------|------|
| CNT/graphene/Cu@Ni | rGO/δ-Fe₂O₃ | PVDF | 6 w/\% CNT/8 w/\% graphene/8 w/\% Cu@Ni | 47.6 | 0.3 | This work |
| CNT | rGO/CF/γ-Fe₂O₃ | Resin | 50 w/\% | 41.8 | 0.4 | [2] |
| CNT | rGO/Fe₃O₄ | PVA | 35 w/\% | 15 | 0.36 | [3] |
| CNT | Ag/carbon filler | Epoxy | 4.5 w/\% | 38 | 2.5 | [4] |
| CNT | CNT | PVDF | 5 w/\% | 35.4 | 0.4 | [5] |
| CNT | MWCNT | PMMA | 40 w/\% | 27 | 0.165 | [6] |
| CNT | SWCNT | EDOT | 15 w/\% | 58 | 2.8 | [7] |
| CNT | CNT | WPU | 76.2 w/\% | 50 | 2 | [8] |
| CNT | Cellulose/MXCNT | Cellulose | 15 w/\% | 35 | 0.15 | [9] |
| CNT | CNT | PP | 7.5 w/\% | 22.3 | 0.34 | [10] |
| Graphene | Graphene | PI | 16 w/\% graphene | 21 | 0.8 | [11] |
| Graphene/CNT | Graphene/CNT | PVDF | 5 w/\% CNT | 36.5 | 0.25 | [5] |
| Graphite | Graphite | SEBS | 15 w/\% | 20 | 5 | [12] |
| Graphite | Graphite | PA66 | 25 w/\% | 12 | 3.2 | [13] |
| Graphite | Graphite | Epoxy | 2 w/\% | 11 | 2 | [14] |
| Graphite | Graphite | PE | 18.7 w/\% | 33 | 3 | [15] |
| Metals | Ag Nanowires | PS | 2.5 w/\% | 33 | 0.8 | [16] |
| Metals | Cu Nanowires | PS | 2.1 w/\% | 35 | 0.2 | [17] |
| Metals | Ni-Co Fiber | WAX | 30 w/\% | 41.2 | 2.5 | [18] |
| Metals | Ni | PVDF | 40 w/\% | 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·mm⁻¹) | Ref. |
|----------------|-------------------|--------|---------|-----------------|------|
| PVDF           | 6 wt% CNT/8 wt% graphene/8 wt% Cu@Ni | 0.3    | 47.6    | 158.8           | This study |
|                | 5 wt% Fe₂O₄/8 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% Fe₂O₄/ 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 Ti₃C₂Tx                   | 1      | 34.4    | 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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