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Reduced Graphene Oxide-wrapped Fe-Fe_3O_4@$mSiO_2$ Hollow Core-shell Composites with Enhanced Electromagnetic Wave Absorption Properties

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Abstract

The Fe/Fe_3O_4 nanocomposite with mesoporous silica ($mSiO_2$ for short) shell was successfully prepared by solvothermal reaction combined with hydrogen-thermal annealing (550 ^oC). Further, reduced graphene oxide (RGO) was introduced to obtain Fe-Fe_3O_4@$mSiO_2$@RGO hollow core-shell composites with hollow structure by Aerogel method utilizing home-made equipment. The introduction of $mSiO_2$ on the surface of Fe_3O_4 constructed a ventilated framework, which thereafter maintained the dispersion of fine Fe particles emerging from the reduction process. The transformation from Fe_3O_4 to Fe nanoparticles enhanced the ferromagnetic loss, while the introduction of high conductivity RGO also enhanced the polarization relaxation and conductivity loss. Meanwhile, the unique hollow structure of the core-shell structure effectively reduces the density of the ferromagnetic composites (Fe-Fe_3O_4@$mSiO_2$) without sacrificing the contact between RGO and nanoparticles, adding more surfaces/interfaces. Fe-Fe_3O_4@$mSiO_2$@RGO exhibited excellent

electromagnetic wave absorbing performances. The coating using Fe-Fe_3O_4@mSiO_2@RGO as fillers exhibits a minimum reflection loss of -66.24 dB with an effective absorption bandwidth of 5.31 GHz with a sample thickness of only 1.79 mm. The hollow core-shell structure of RGO-wrapped Fe-Fe_3O_4@mSiO_2 demonstrates a promising approach for the design of lightweight and high-performance electromagnetic absorption materials.

Keywords

Electromagnetic absorption; Hollow core-shell structure; Reduced graphene oxide; Ferrites/ferromagnetic metal

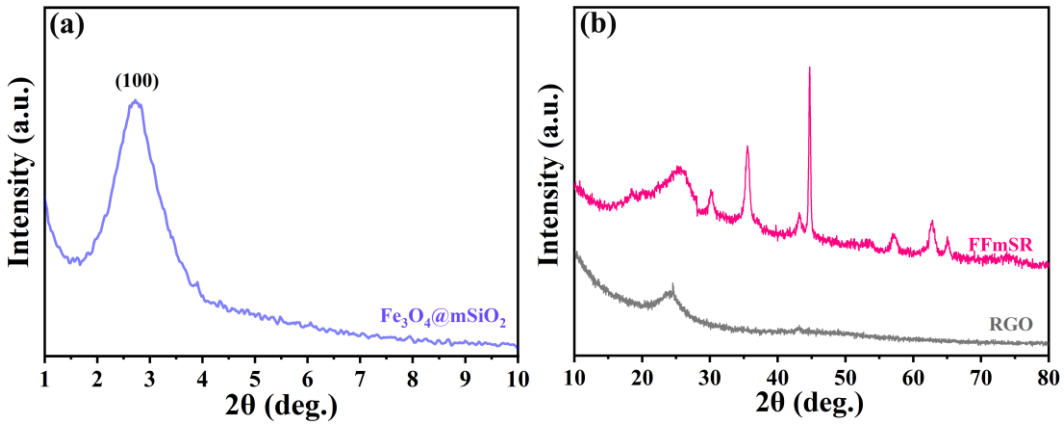

Fig. S1 (a) low-angle XRD patterns of Fe_3O_4@mSiO_2. (b) XRD patterns RGO and FFmSR.

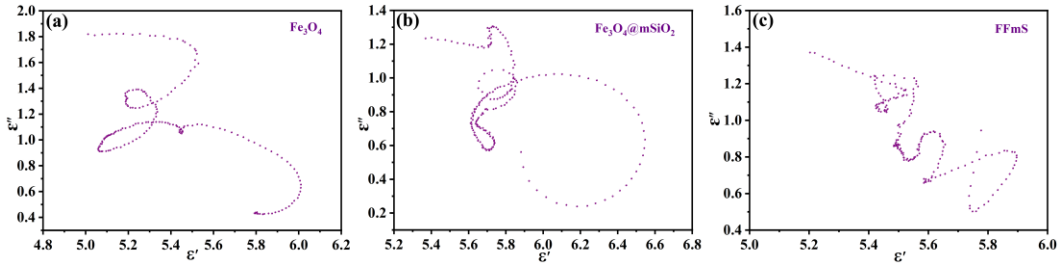

Fig. S2 The ε'' versus ε' of (a) Fe_3O_4, (b) Fe_3O_4@$mSiO_2$ and (c) FFmS.

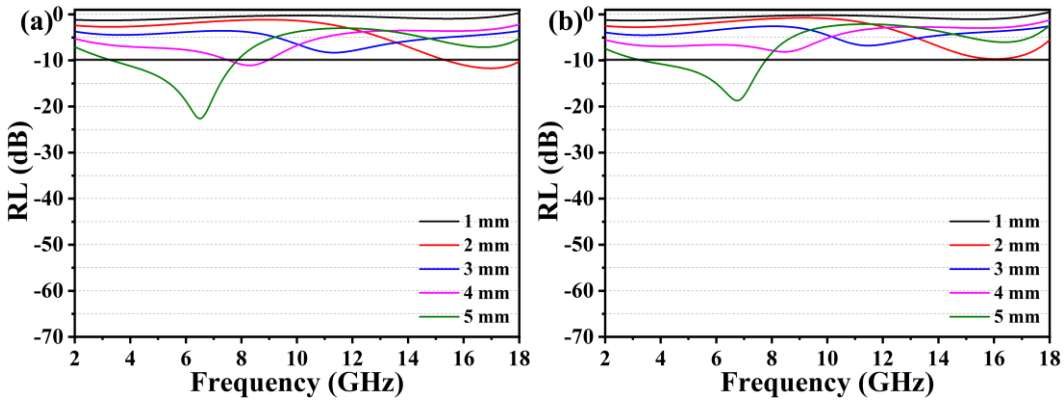

Fig. S3 Reflection loss versus frequency plot of (a) Fe_3O_4, (b) Fe_3O_4@mSiO_2 in the frequency range of 2-18 GHz.

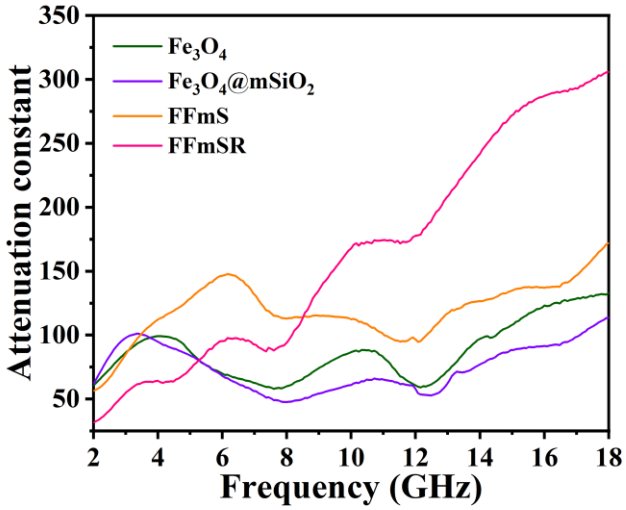

Fig. S4 Frequency-dependent attenuation constant of Fe_3O_4, Fe_3O_4@$mSiO_2$, FFmS and FFmSR.

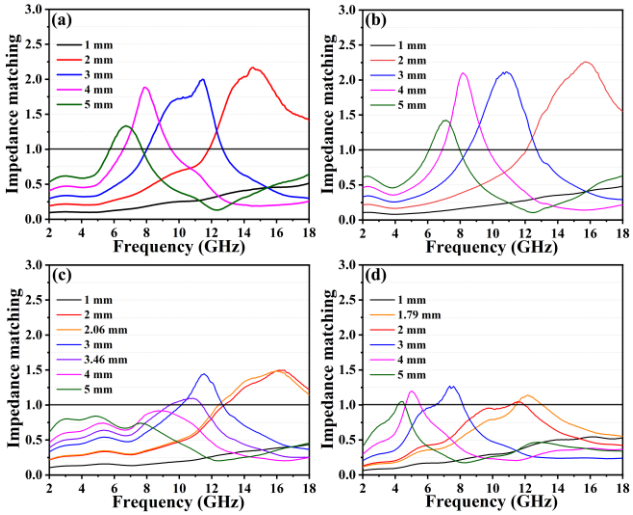

Fig. S5 Impedance matching of Fe_3O_4 (a), Fe_3O_4@mSiO_2 (b), FFmS (c) and FFmSR (d) with different thicknesses.

Table 1. Microwave Absorption Performance of Similar Composites.

Sample	RL_{min} (dB)	f_{EAB} (GHz)	Thickness (mm)	Filler loading (wt.%)	Refs.
Fe_3O_4@mSiO_2	-38.7	4.00	2.0	25	50
Fe_3O_4@SiO_2@ZnO	-24.4	~2.00	5.5	30	51
Fe_3O_4/SiO_2/graphene	-27.0	2.30	1.5	50	52
Fe_3O_4@MnO_2	-48.5	4.40	2.5	60	53
Fe_3O_4@Co	-20.7	2.90	4.0	60	54
Fe_3O_4@$CuSiO_3$	-34.8	5.10	1.5	70	55
Fe_3O_4@SnO_2	-27.38	2.1	4.0	80	56
FFmSR	-66.24	5.31	1.79	70	This work