Supporting Information

Synchronously boosting microwave-absorbing and heat-conducting capabilities in $CeO_2/Ce(OH)_3$ core-shell nanorods/nanofibers via Fe-doping amount control

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Characterization

The morphology, size, elemental content, and mapping of Fe-doped $CeO_2/Ce(OH)_3$ CSNRs/NFs were examined on a scanning electron microscope (SEM, ZEISS, GeminiSEM 300, 10 kV) linked to an energy-dispersive X-ray spectrometer (EDS, Horiba EX-250, 15 kV). The core-shell structure and crystallinity were analyzed by a transmission electron microscope (TEM, JEM-2100F, 200 kV). XRD patterns were captured using a D/MAX-IIIA X-ray diffractometer (XRD) for the phase analysis. Cu Kα with λ = 0.15418 nm acts as the radiation source with a working voltage of 40.0 kV, a working current of 40.0 mA, and a scanning speed of 10°/min. A Fourier transform infrared spectrometer (FTIR, Nicolet 8700) was utilized to capture FTIR spectra to analyze the chemical structure of Fe-doped $CeO_2/Ce(OH)_3$ CSNRs/NFs. A Raman spectrometer (Renishaw, RM10000) was employed to obtain Raman spectra for the study of oxygen vacancy defects. The analysis of chemical states and oxygen vacancy defects was done on an ESCALAB250 X-ray photoelectron spectroscope (XPS). A WIC640 infrared thermal imager was used to capture infrared photos to investigate the process of heat transfer.

Measurements of magnetic properties, conductivity, and EM parameters

Measurements of static magnetic properties were performed using a vibrating specimen magnetometer (Model 7404, LakeShore, USA) at room temperature. The conductivity measurement was done by an RTS-9 model four-point probe. The measured disc pellets (diameter: 13.0 mm; thickness: 1.0 mm) were prepared by filling the powder specimens into a mold and then pressing them into disc pellets. The as-obtained powder specimens were mixed uniformly with molten paraffin at 45% loading and shaped into toroidal specimens (H =ca. 3.5 mm, ϕ_{out}=7.0 mm, and ϕ_{in}=3.04 mm) in a mold to determine the EMWACs. Permeability ($\mu_r = \mu^{'} - j\mu^{''}$) and permittivity ($\varepsilon_r = \varepsilon^{'} - j\varepsilon^{''}$) were measured by a Keysight N5230A vector network analyzer using the coaxial line method.

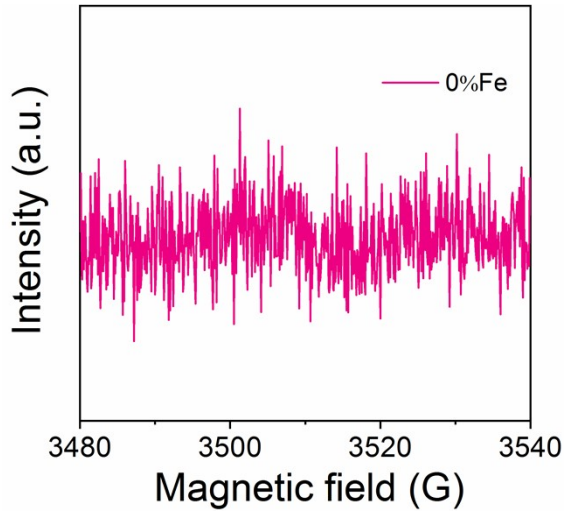

Fig. S1 EPR spectra of $Ce(OH)_3/CeO_2$ CSNFs/CSNRs.

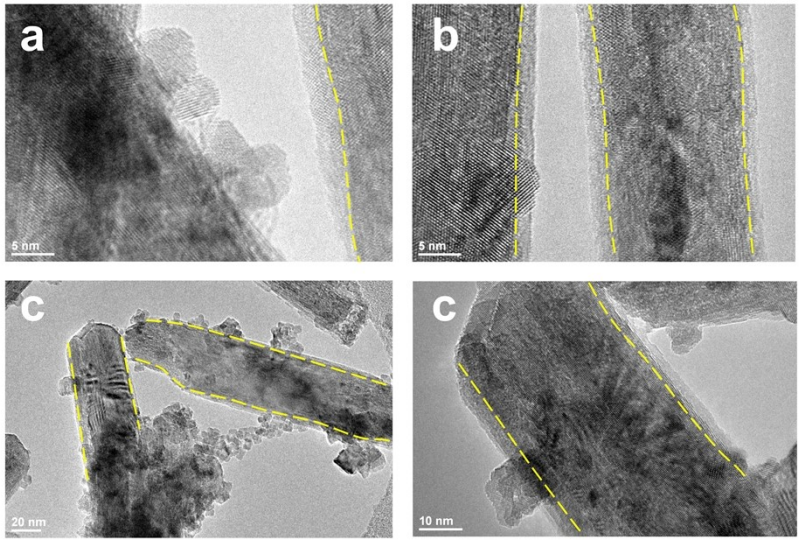

Fig. S2 TEM images of the specimens produced at (a–b) 20% Fe doping amount and (c–d) 50% Fe doping amount.

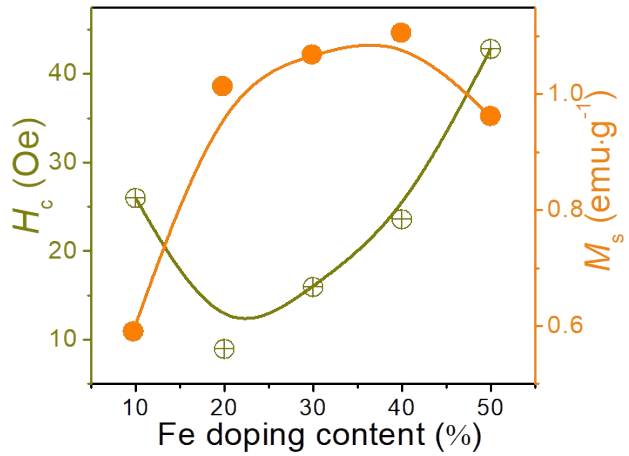

Fig. S3 M_s and H_c as a function of Fe-doping amount

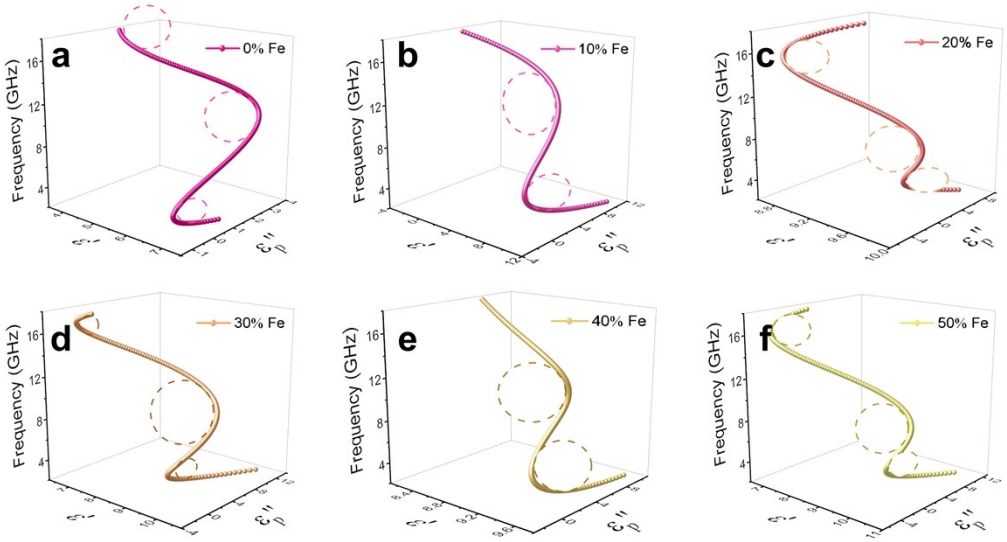

Fig. S4 Cole–Cole curves of Fe- doped $Ce(OH)_3/CeO_2$ CSNR/Fs.

Table S1 Comprehensive comparison of the EMWAPs with reported absorbers.[14–28, 43–45]

Absorbers	Filling mass fraction (%)	Optimal R_L value (dB)	f (GHz) (optimal R_L)	d (mm) ($R_L < -10$dB)	Bandwidth (GHz) ($R_L < -10$ dB)	EABW/d (GHz/mm)	Ref.
$Ba_{0.8}Ce_{0.2}Fe_{12}O_{19}$	70	−20.4	16.10	6.50	1.00	0.15	20
Nanostructured 3D CeO_2	>50	−19.3	15.80	2.00	<0.50	0.25	16
Zn modified CeO_2 microspheres	70	−35	14.00	2.00	Approx.0.5	0.25	18
$BaCe_{0.05}Fe_{11.95}O_{19}$ ferrite	70	−37.4	12.80	6.50	3.00	0.46	21
CeO_2/MWCNT	70	−34.64	16.25	5.00	2.88	0.58	23
Co-doped CeO_2/rGO nanocomposites	60	−53.66	6.40	3.50	4.00	1.14	19
PANI/CeO_2	50	−40	8.80	3.00	4.00	1.33	25
CNT/CeO_{2-x} yolk@shell hybrids	50	−52.4	6.15	4.00	5.50	1.38	24
MoS_2/CeO_2 composites	50	−56.3	10.70	3.00	<5.00	1.67	26
$BaCe_{0.2}Fe_{11.8}O_{19}$/CNTs nanocomposite	40	−49.61	9.00	2.50	4.20	1.68	22
$CeOHCO_3$(20% Fe)	50	−37.08	7.44 (4.9 mm)	3.40	7.04	1.90	17
CeO_2 (300 °C)	45	−34.49	13.28	2.00	4.00	2.00	14
CeO_2-rGO	50	−45.9	13.28	2.00	4.50	2.00	43
$CeOHCO_3$ (S4)	60	−42.71	9.12	2.90	6.40	2.21	44
yolk-shell CeO_2 microspheres	33.3	−71.3	14.50	2.00	5.40	2.70	15
Co_3O_4/CeO_2/CNTs composites	33.3	−59.82	11.92	1.73	5.20	3.01	27
core–shell CeO_2@Fe	80	−23.88	9.60	1.10	4.24	3.85	28
CeO_2/$Ce(OH)_3$ CSNFs	45	−50.28	9.76	2.40	5.12	2.13	This work
10%Fe-doped CeO_2/$Ce(OH)_3$ CSNFs	45	−42.33	3.76	1.70	9.26	5.45	
20%Fe-doped CeO_2/$Ce(OH)_3$ CSNFs	45	−45.42	4.00	1.70	6.64	3.91	
30%Fe-doped CeO_2/$Ce(OH)_3$ CSNFs	45	−54.64	3.60	1.50	6.64	4.43	
40%Fe-doped CeO_2/$Ce(OH)_3$ CSNRs	45	−43.92	3.76	1.60	7.12	4.45	
50%Fe-doped CeO_2/$Ce(OH)_3$ CSNRs	45	−39.27	13.04	1.80	8.24	4.58	

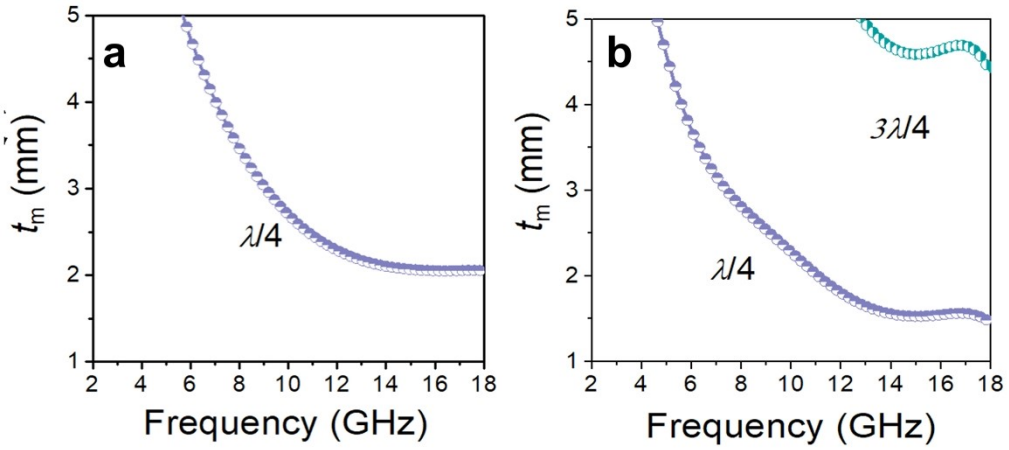

Fig. S5 Matching thickness as a function of frequency for a) $Ce(OH)_3/CeO_2$ CSNFs/CSNRs and b) 10%Fe-doped $Ce(OH)_3/CeO_2$ CSNFs/CSNRs.

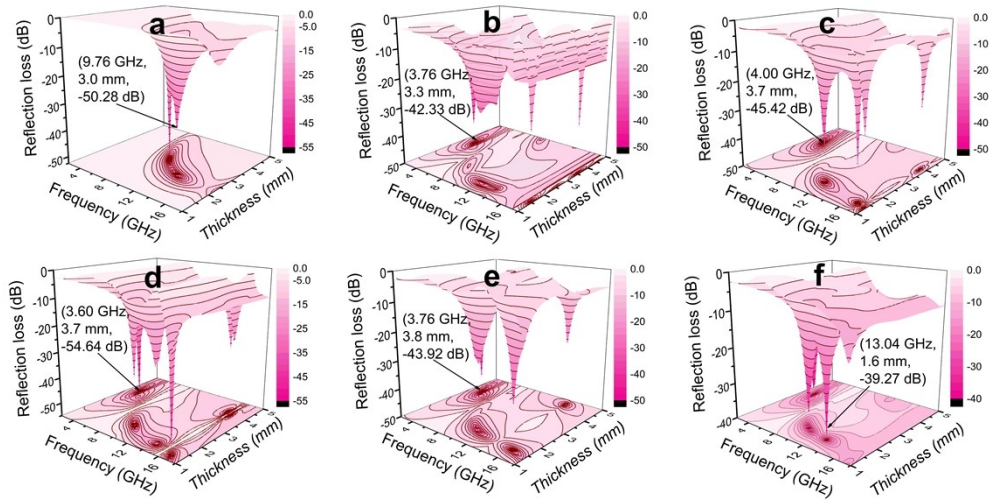

Fig. S6 Frequency characteristics: a)–f) 3D RL plots of the paraffin composites containing 45 wt.% specimens produced under various Fe doping amounts: (a) 0%, (b) 10%, (c) 20%, (d) 30%, (e) 40%, and (f) 50%.

Table S2 Heat conductance summarization of Fe- doped $Ce(OH)_3/CeO_2$ CSNR/Fs and other Ce-based fillers.[50–63,29,2,45,30,31]

Filler	Loading (%)	Heat conductance (W/m·k)	Ref.
SiC-SiO_2-Al_2O_3-TiO_2	80	0.122	50
$Y_{2.8}Ce_{0.2}A_{l5}O_{12}$	15	0.3796	51
$La_2(Zr_{0.7}Ce_{0.3})_2O_7$	/	0.541	52
Al_2O_3@AgNPs	70	0.67	53
Thiolene/TiO_2	90	0.76	54
$Ti_3C_2T_x$	50	0.767	55
Pt@TiO_2	100	0.998	56
$CoSb_3$+1% CeO_2	/	1.00	29
Al_2O_3/TiO_2	100	1.25	57
Si_3N_4/PTFE	70	1.3	58
PI/Al_2O_3 composite film	80	1.3	59
$CoSb_3$+5% CeO_2	/	1.7	29
BN/MWCNT/PPS	51	1.74	60
g-C_3N_4@Fe@C hollow micro-polyhedra	20	1.75	2
BN-GO	50	2.11	61
TiO_2/Fe/C nanocomposites	45	2.188	45
CeO_2+18 vol.% SiC	/	~2.2	30
CeO_2-Gd_2O_3	/	~2.2	31
$Ti_3C_2T_x$ MXene microflakes	50	2.746	62
GO/AlN	56	2.770	63
$CeO_2/Ce(OH)_3$ CSNFs	45	1.864	This work
10%Fe-doped $CeO_2/Ce(OH)_3$ CSNFs	45	2.518	
20%Fe-doped $CeO_2/Ce(OH)_3$ CSNFs	45	3.442	
30%Fe-doped $CeO_2/Ce(OH)_3$ CSNFs	45	2.240	
40%Fe-doped $CeO_2/Ce(OH)_3$ CSNRs	45	2.237	
50%Fe-doped $CeO_2/Ce(OH)_3$ CSNRs	45	2.143	