

Supporting Information

Hollow ZnO/C Nanospheres with Defect Engineering for Enhanced Dielectric Loss and Broadband Electromagnetic Wave Absorption

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Table S1. Design composition of ZnO/C nanospheres

PS Microsphere Diameter (nm)	Precursor	Calcination Temperature (°C)	Sample Name After Calcination
200	PS@ZIF-8-2	700	ZnO/C-2-700
		800	ZnO/C-2-800
		900	ZnO/C-2-900
500	PS@ZIF-8-5	700	ZnO/C-5-700
		800	ZnO/C-5-800
		900	ZnO/C-5-900
1000	PS@ZIF-8-10	700	ZnO/C-10-700
		800	ZnO/C-10-800
		900	ZnO/C-10-900

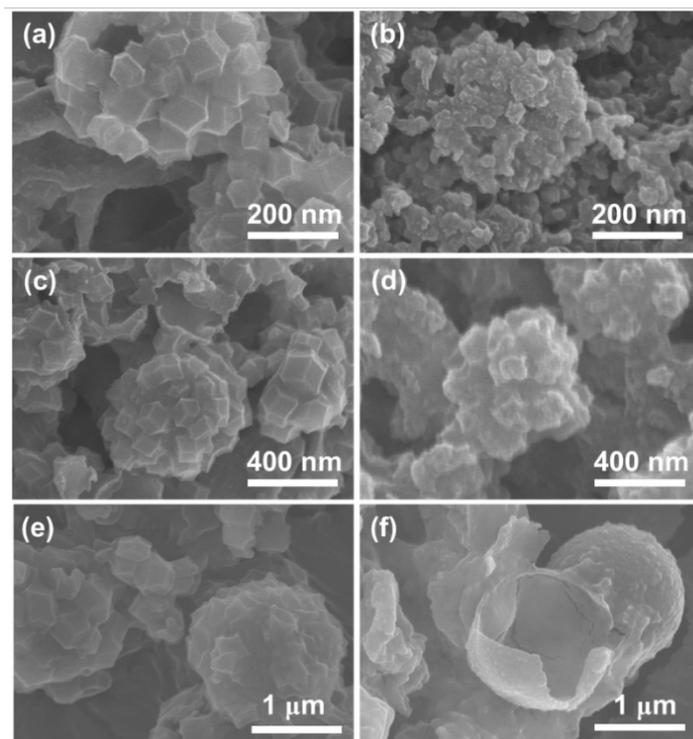


Fig. S1. SEM images of (a) ZnO/C-2-700, (b) ZnO/C-2-900, (c) ZnO/C-5-700, (d) ZnO/C-5-900, (e) ZnO/C-10-700 and (f) ZnO/C-10-800.

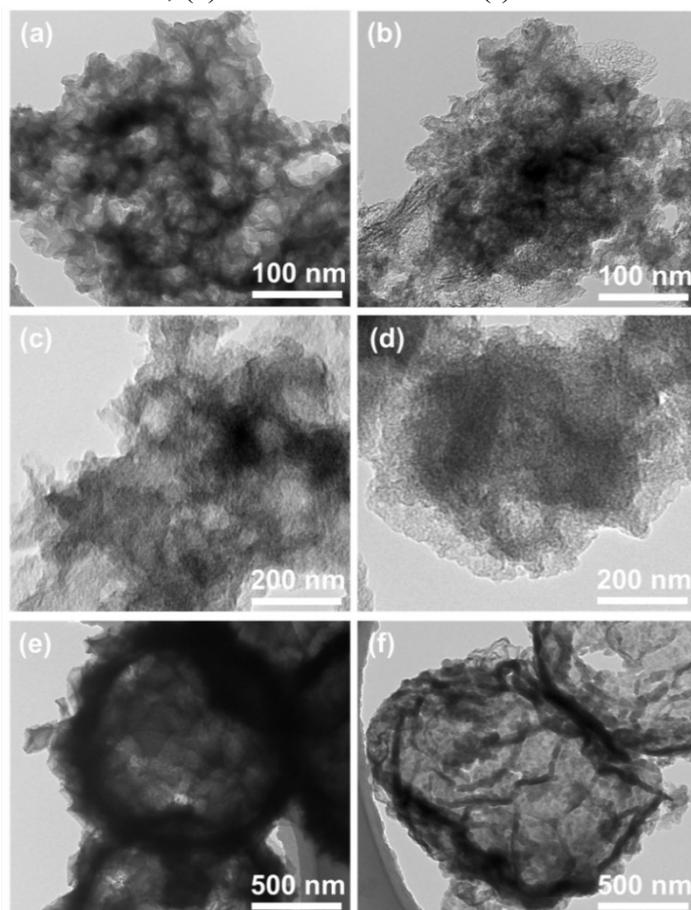


Fig. S2. TEM images of (a) ZnO/C-2-700, (b) ZnO/C-2-900, (c) ZnO/C-5-700, (d) ZnO/C-5-900, (e) ZnO/C-10-700 and (f) ZnO/C-10-800.

(a)					(b)					(c)				
Element	At. No.	Mass Norm. [%]	Atom [%]	abs. error [%] (1 sigma)	Element	At. No.	Mass Norm. [%]	Atom [%]	abs. error [%] (1 sigma)	Element	At. No.	Mass Norm. [%]	Atom [%]	abs. error [%] (1 sigma)
C	6	42.21	58.54	1.33	C	6	72.29	84.49	2.22	C	6	88.00	92.95	2.68
N	7	8.05	9.57	0.30	N	7	7.65	7.66	0.28	N	7	3.13	2.83	0.14
O	8	24.43	25.43	0.78	O	8	5.34	4.69	0.20	O	8	4.17	3.31	0.16
Zn	30	25.32	6.45	0.81	Zn	30	14.72	3.16	0.48	Zn	30	4.70	0.91	0.18
		100.00	100.00				100.00	100.00				100.00	100.00	

Fig. S3. EDS quantitative elemental analysis results of ZnO/C-2-800, ZnO/C-5-800 and ZnO/C-10-900 composites.

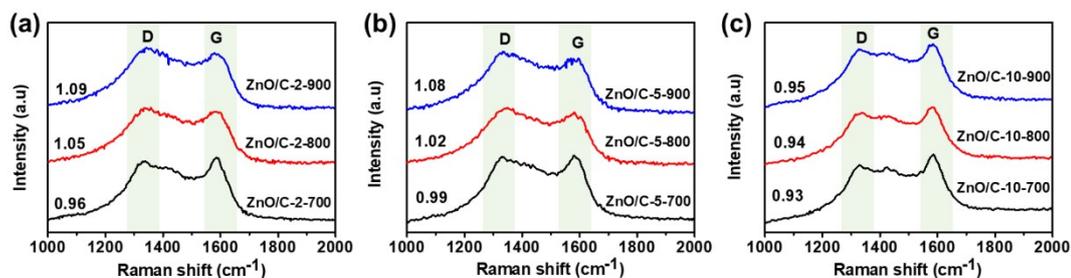


Fig. S4. Raman spectra of ZnO/C composites.

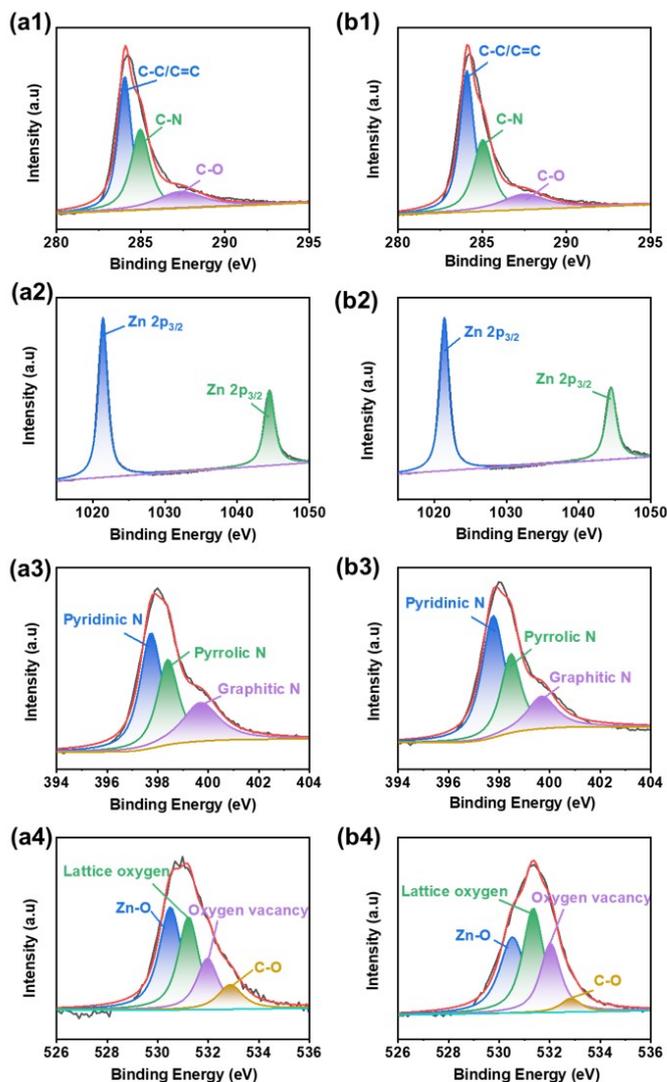


Fig. S5. XPS spectra of (a) ZnO/C-2-800 and (b) ZnO/C-10-900 composites.

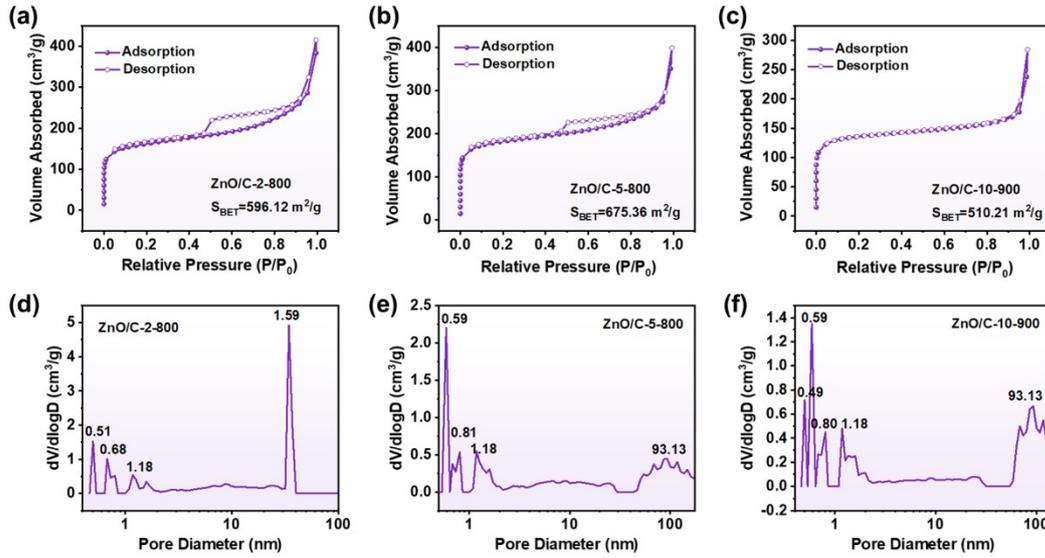


Fig. S6. N_2 adsorption–desorption isotherm and pore size distribution diagram of ZnO/C-2-800, ZnO/C-5-800 and ZnO/C-10-900 composites.

Table S2. Specific surface area, total pore volume, and average pore size of ZnO/C-2-800, ZnO/C-5-800, and ZnO/C-10-900 composites.

Sample	S_{BET} ($m^2 \cdot g^{-1}$)	V_{pore} ($cm^3 \cdot g^{-1}$)	Average pore size (nm)
ZnO/C-2-800	596.12	0.4662	9.03
ZnO/C-5-800	675.36	0.3975	9.34
ZnO/C-10-900	510.21	0.2637	12.57

Table S3. The dielectric loss of ZnO/C composites.

Sample	σ ($S \cdot m^{-1}$)	f (GHz)	ϵ''	ϵ_c''	ϵ_p''	$\epsilon_p''/\epsilon_c''$
ZnO/C-2-900	0.0117	/	/	/	/	/
ZnO/C-2-800	0.0143	16.9	2.3094	0.0152	2.2942	150.9
ZnO/C-2-700	0.0006	11.0	0.9774	0.0011	0.9763	887.5
ZnO/C-5-900	0.0371	/	/	/	/	/
ZnO/C-5-800	0.0202	8.0	2.4146	0.0454	2.3692	52.2
ZnO/C-5-700	0.0006	/	/	/	/	/
ZnO/C-10-900	0.0053	5.1	2.8465	0.0188	2.8277	150.4
ZnO/C-10-800	0.0043	/	/	/	/	/
ZnO/C-10-700	0.0006	/	/	/	/	/

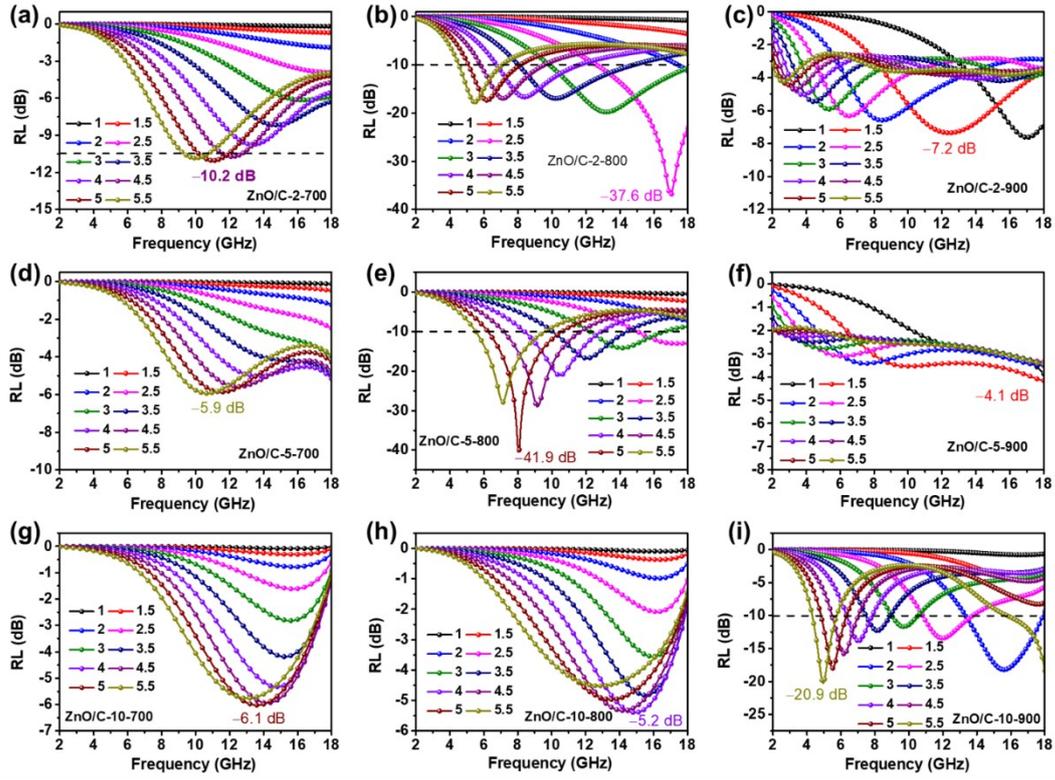


Fig. S7. Reflection loss (RL) curve of ZnO/C composites.

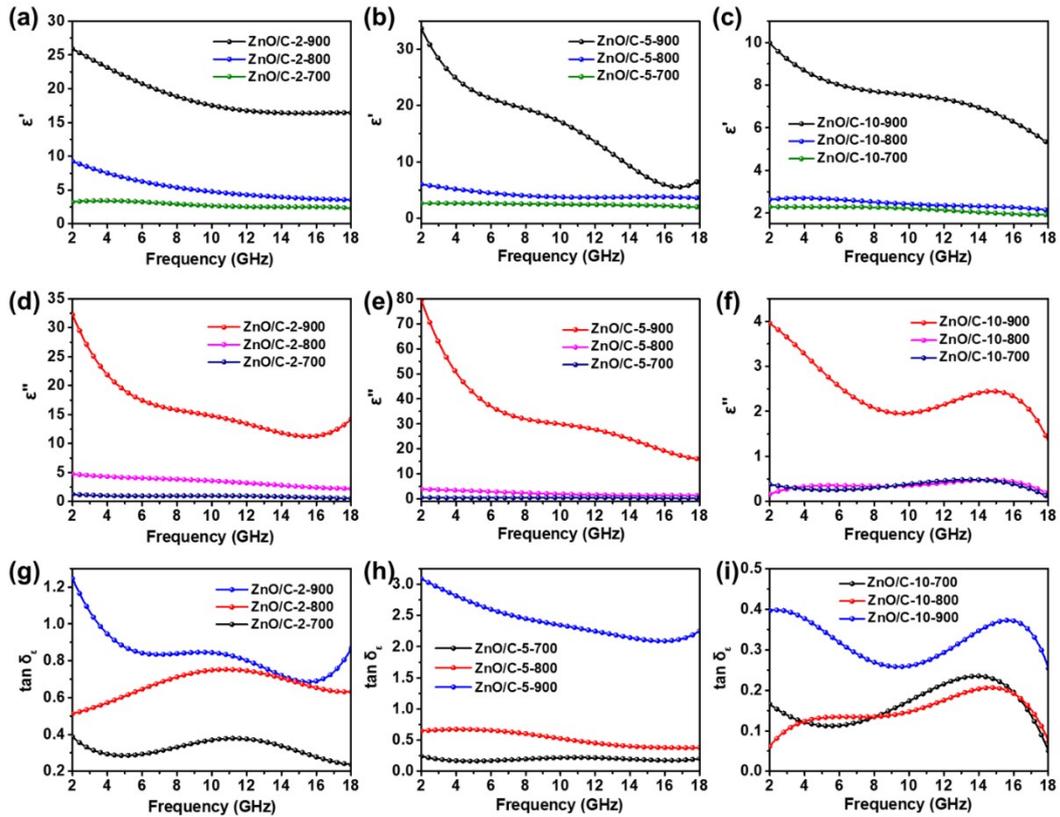


Fig. S8. The real and imaginary parts of complex permittivity and dielectric loss tangent of ZnO/C composites.

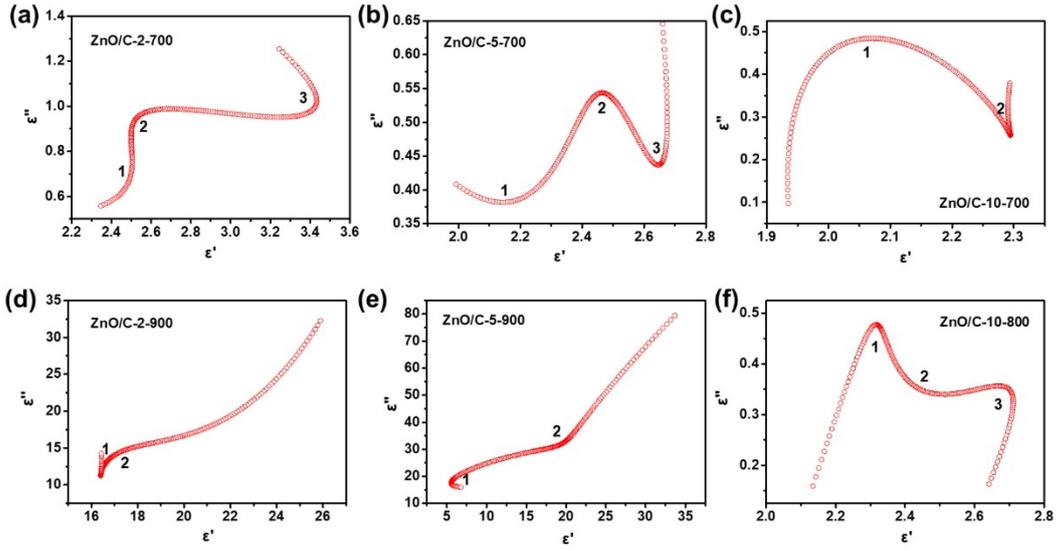


Fig. S9. The Cole–Cole curves of ZnO/C composites.

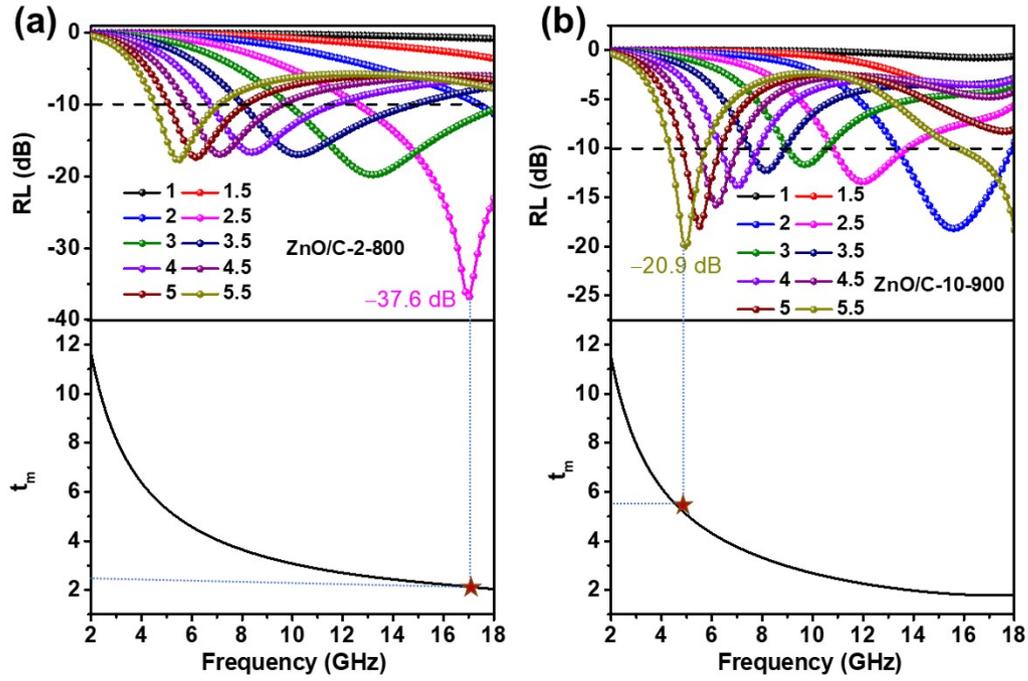


Fig. S10. Dependence of $1/4 \lambda$ matching thickness on RL peak frequency for (a) ZnO/C-2-800 and (b) ZnO/C-10-900