Supplementary material

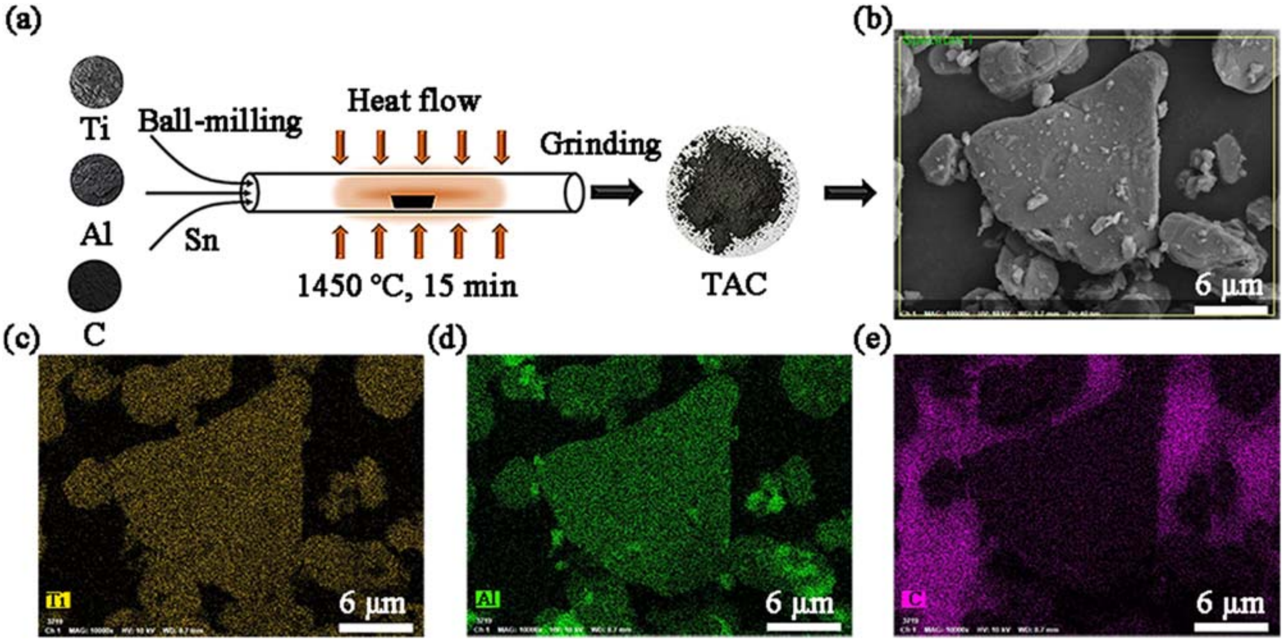

Figure S1: Preparation process and element analysis of TAC. (a) Schematic diagram of the preparation process of TAC. (b) SEM image of TAC and corresponding element distribution of (c) Ti, (d) Al, and (e) C. It can be seen from (a) that TAC was obtained by sintering the mixed powder at 1450°C for 15 min in an atmosphere tube furnace. The mixed powder was composed of Ti powder (Analytical reagent, AR = 99%), Al powder (AR = 99%), graphite powder (AR = 99%), and Sn powder (AR 99%) (sintering aid); It was milled and mixed for 8 h; The molar ratio of Ti, Al, C and Sn were 3:1:1.8:0.2. The sintering atmosphere was argon, and the flow rate was 80 ml/min. The heating rate was 10°C/min. After crushing and ball milling the products obtained from sintering, high-purity TAC required for the experiment was obtained, as shown in (b). Additionally, it was found that TAC is mainly composed of Ti, Al, and C, as shown in (c)–(e).

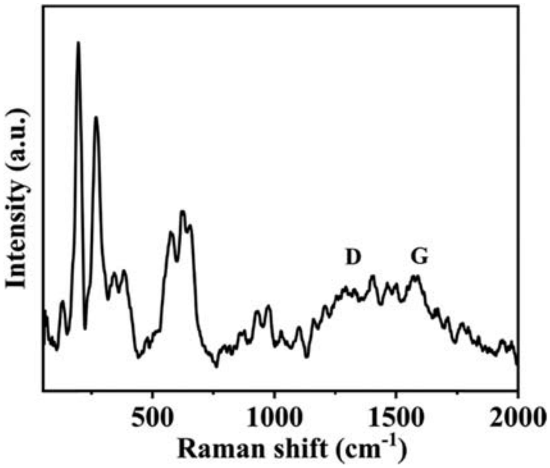

Figure S2: Raman spectrum of TAC@SiO_2.

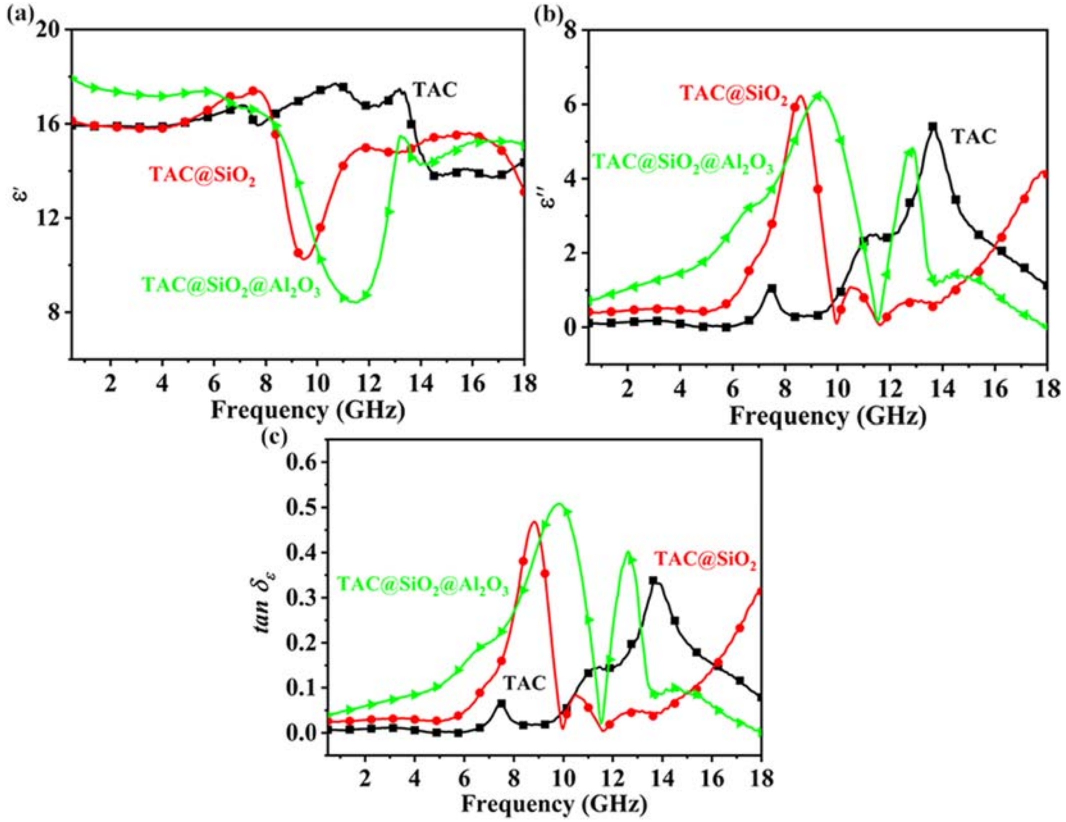

Figure S3: Complex permittivity of TAC, TAC@SiO$_2$, and TAC@SiO$_2$@Al$_2$O$_3$ in the range of 0.5–18 GHz: (a) real part (ε′), (b) imaginary part (ε″), and (c) dielectric loss tangent.

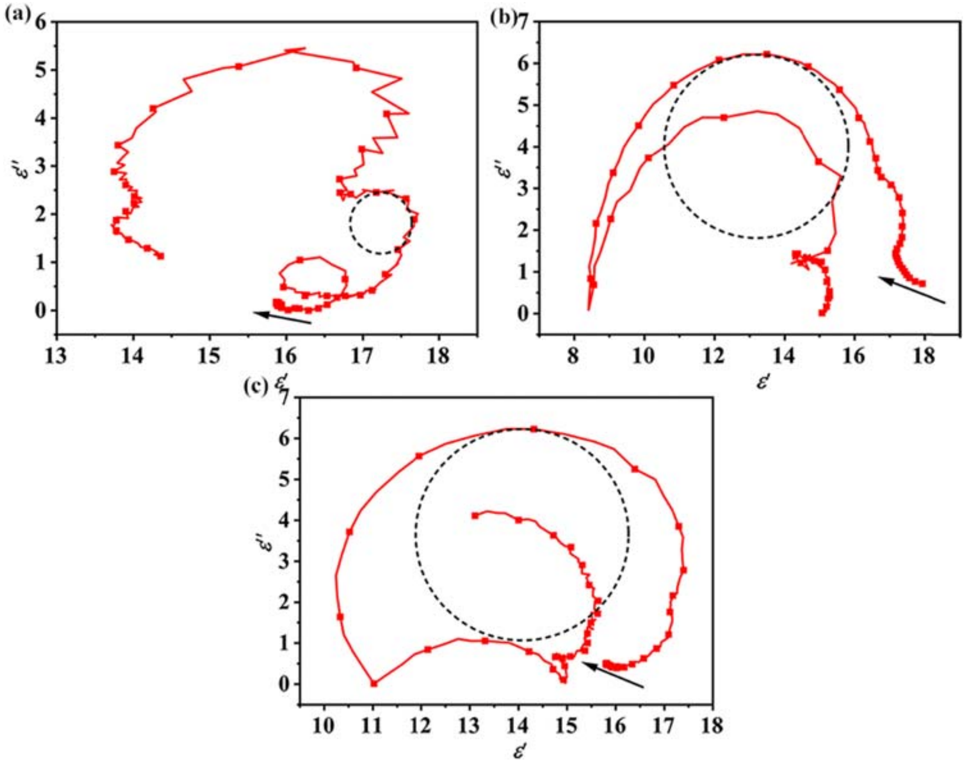

Figure S4: Cole–Cole plots of (a) TAC, (b) TAC@SiO$_2$, and (c) TAC@SiO$_2$@Al$_2$O$_3$ in the range of 0.5–18 GHz.

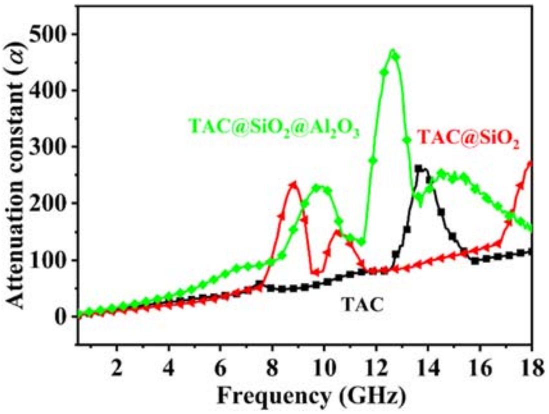

Figure S5: Attenuation constant of TAC, $TAC@SiO_2$, and $TAC@SiO_2@Al_2O_3$ in the range of 0.5–18 GHz.

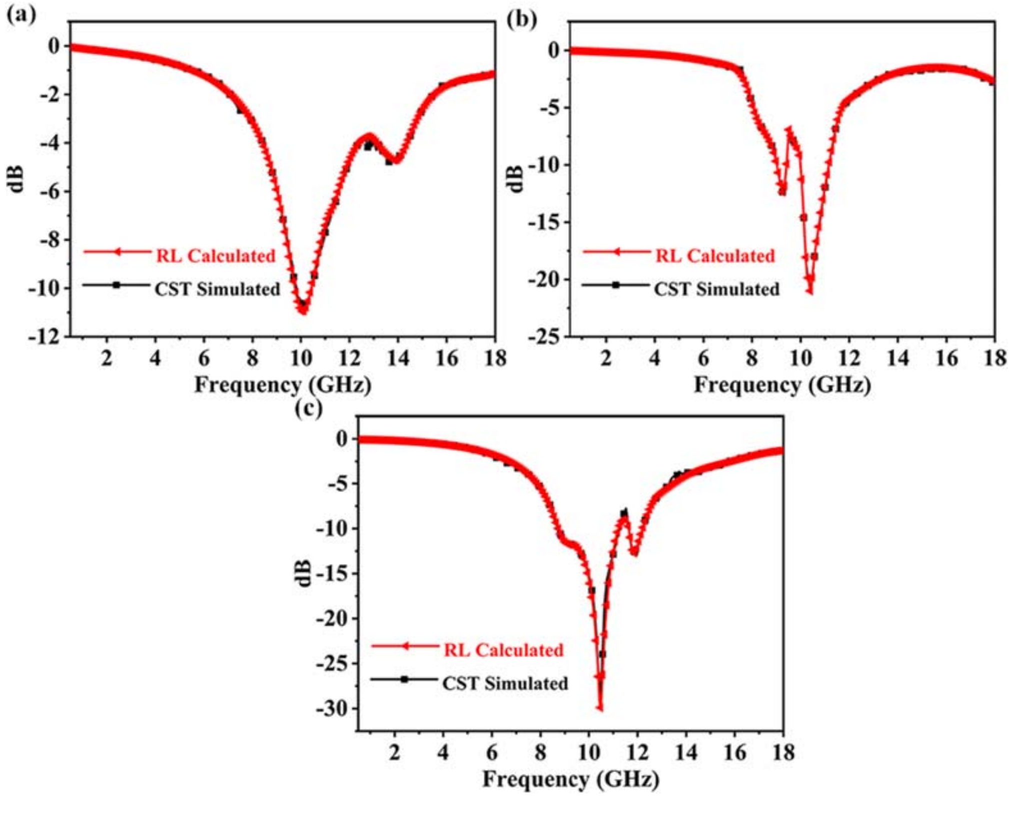

Figure S6: Simulated S11 and calculated RL curves of TAC, $TAC@SiO_2$, and $TAC@SiO_2@Al_2O_3$ with a thickness of 2.0 mm.