Supporting information

Fusedly Deposited Frequency-Selective Composites Fabricated by a Dual-Nozzle 3D Printing as Microwave Filter

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In order to fabricate FD-FSCs transmitting and absorbing microwaves in the X-band (8.2~12.4 GHz) range, the resonance frequency was calculated according to the design parameters of a metallic FSS. The approximate admittance predicting the resonant frequency of a metallic FSS [19] is as follows.

$$Y_{ind} \approx (-\mathrm{j})(\beta - \beta^{-1}) \frac{\left[\left(\frac{A}{C}\right)+\frac{1}{2}\left(\frac{A}{\lambda}\right)^2\right]}{\ln \csc\left(\frac{\pi\delta}{2A}\right)} \quad \beta = \left(1 - 0.41\frac{\delta}{A}\right) \Big/ \left(A/\lambda\right) \tag{S1}$$

Design parameters A and B are the side lengths of periodic patterns and apertures, and λ is the wavelength. δ is defined as (A-C)/2. At the resonance frequency, $Y_{ind} = 0$ and in the case of a metallic FSS, microwaves are completely transmitted. Y_{ind} depends only on two parameters A/λ and C/A. When $\beta - \beta^{-1}$ is zero, Y_{ind} is zero.

β for $\beta - \beta^{-1} = 0$ is obtained as follows.

$$\beta = \left(1 - 0.41\frac{\delta}{A}\right) \Big/ \left(A/\lambda\right) = 1 \tag{S2}$$

$$\left(1 - 0.41\frac{\delta}{A}\right) = \frac{A}{\lambda} \tag{S3}$$

The resonance frequency is determined by the design parameters A and C of the inductive FSS, an aperture type of FSS with the conductive areas connected together. The resonance frequency (f_{res}) can be calculated from Equation (S3). Table S1 provides the calculated f_{res} according to the unit cell geometry of the FSS.

Table S1. Design parameters and resonant frequency of the metallic FSS.

A (mm)	C (mm)	δ (mm)	λ (mm)	f (GHz)
10.0	7.0	1.5	10.7	28.2
10.0	8.0	1.0	10.4	28.8
10.0	9.0	0.5	10.2	29.4
18.0	12.6	2.7	19.2	15.6
18.0	14.4	1.8	18.8	16.0
18.0	16.2	0.9	18.4	16.3
20.0	14.0	3.0	21.3	14.1
20.0	16.0	2.0	20.9	14.4
20.0	18.0	1.0	20.4	14.7
24.0	16.8	3.6	25.6	11.7
24.0	19.2	2.4	25.0	12.0
24.0	21.6	1.2	24.5	12.2
30.0	21.0	4.5	32.0	9.4
30.0	24.0	3.0	31.3	9.6
30.0	27.0	1.5	30.6	9.8

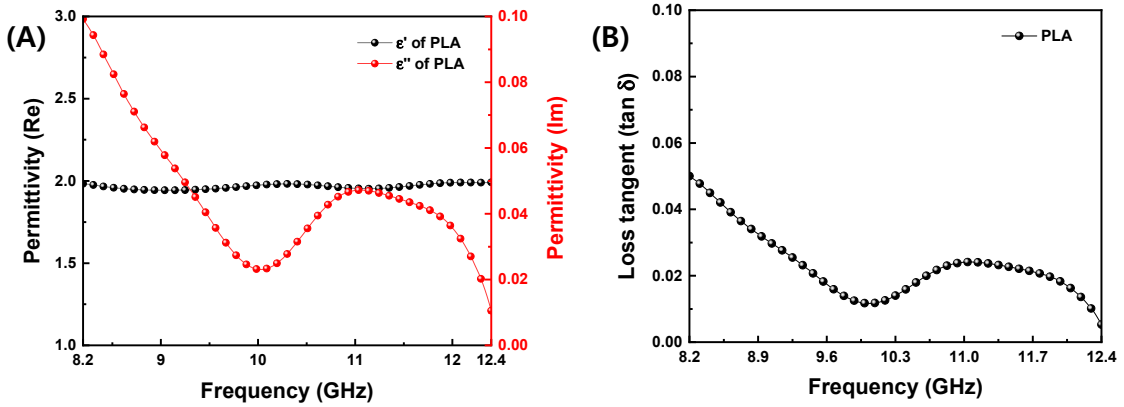

Figure S1. Measured permittivity of PLA. (A) Real and imaginary parts of permittivity, and (B) dielectric loss tangent.