Supplementary Information

Transformation Optics for Antennas: Why limit the bandwidth with Metamaterials?

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The Supplementary Information includes:
Supplementary Figures S1 – S7, and Supplementary Table S1.

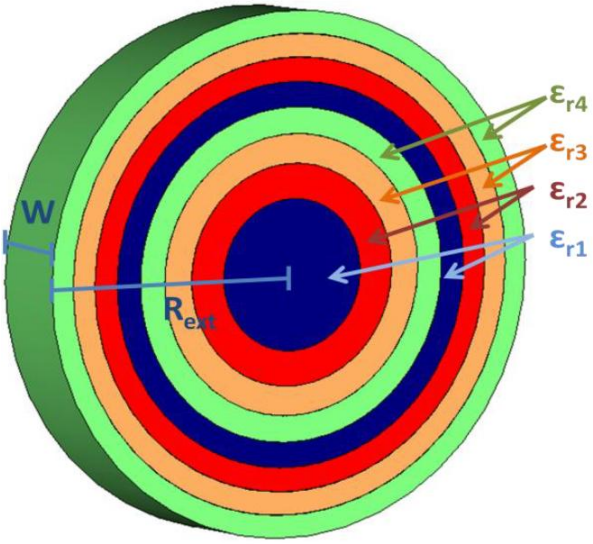


Figure S1 | Graphical configuration of a Fresnel lens. Dimensions were chosen for obtaining a comparable size to the transformed lens (following the guidelines in [27-29]) are: R_{ext} = 97mm and W = 30mm, ε_{r1} = 2.6, ε_{r2} = 5.6, ε_{r3} = 4.5 and ε_{r4} = 3.5.

a

b

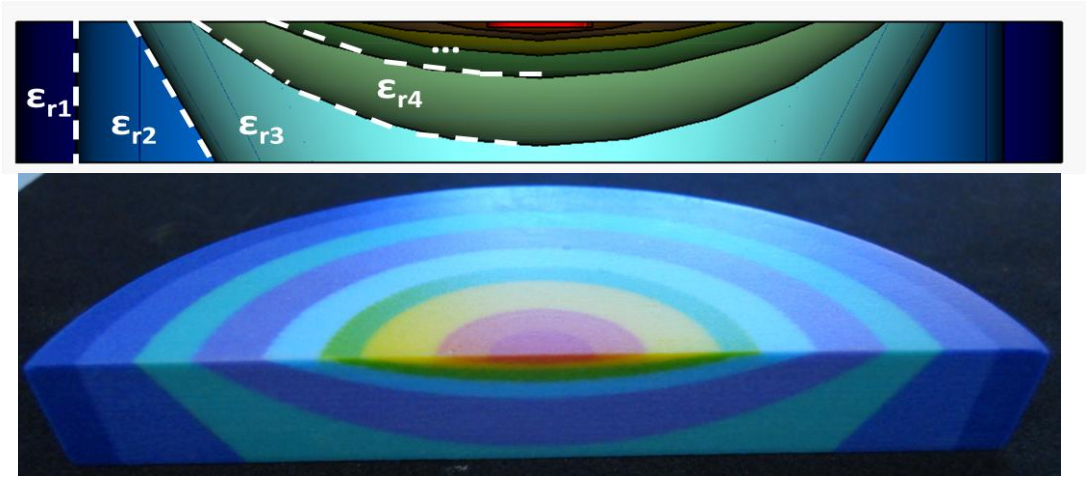


Figure S2 | Illustration of the discretization of the dielectric constant distribution for practical implementation. (**a**) Graphical illustration of the employed boundaries for different permittivity regions. (**b**) Photo of a section-cut of a preliminary prototype.

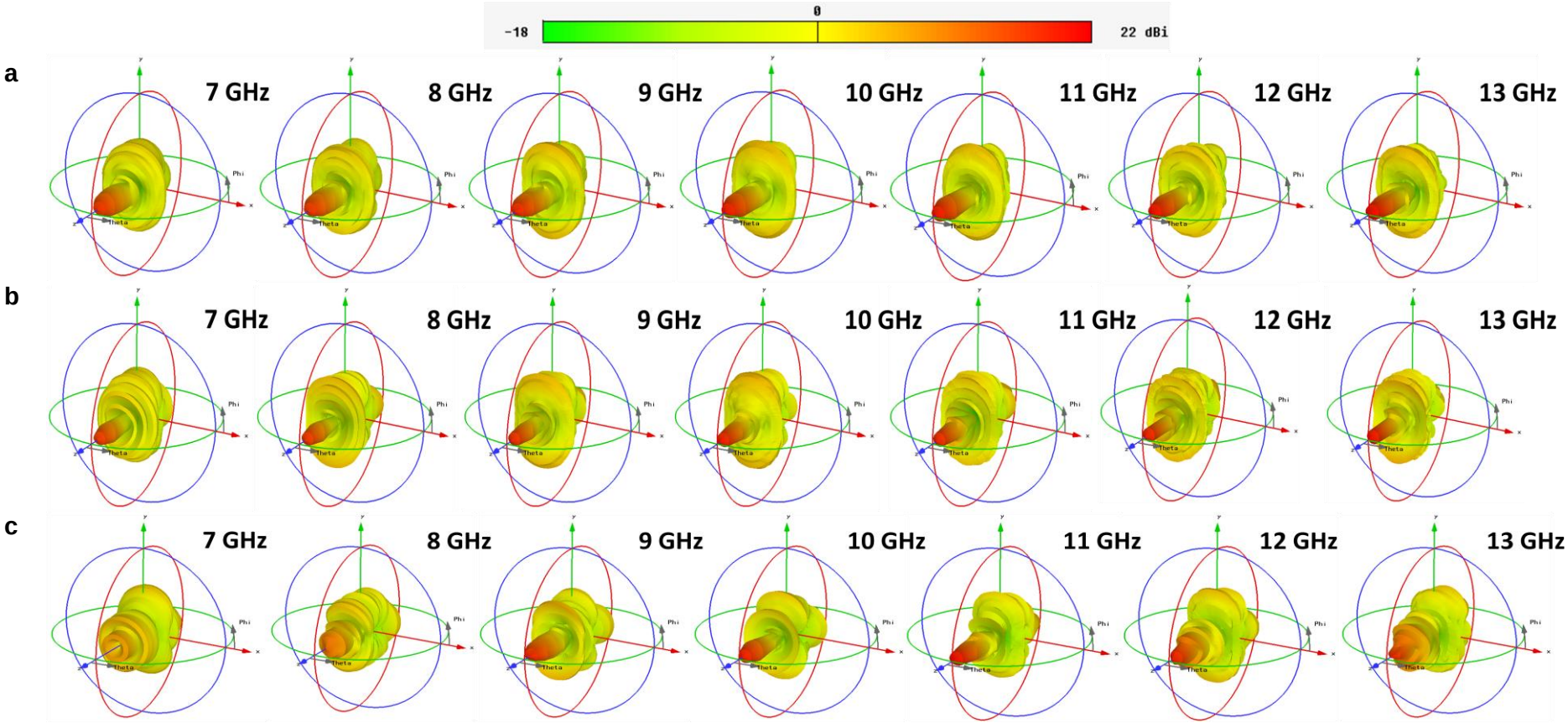


Figure S3 | Radiation patterns (Directivity in dB) of the lenses under study when they are fed with an X-band waveguide at their focal point. (**a**) Hyperbolic lens. (**b**) Electromagnetic transformed lens. (**c**) Fresnel lens as defined in Figure S1.

	Target ε_r	Manufactured ε_r
ε_{r1}	3	2.9
ε_{r2}	4.2	4.2
ε_{r3}	5.4	5.6
ε_{r4}	6.6	6.9
ε_{r5}	7.8	8.6
ε_{r6}	9.0	9.7
ε_{r7}	10.2	11.8
ε_{r8}	11.4	13.2
ε_{r9}	12.6	14.5

Table S1 | Target and manufactured dielectric constants. In the manufacturing process of the materials, some deviations from the original material requirement were observed.

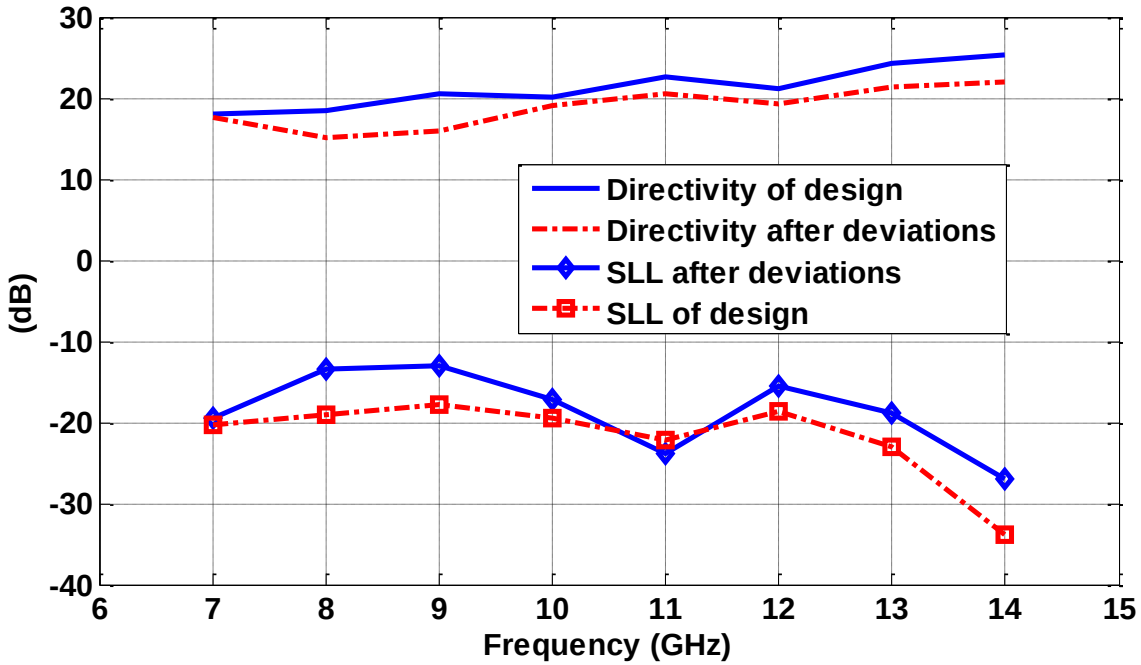
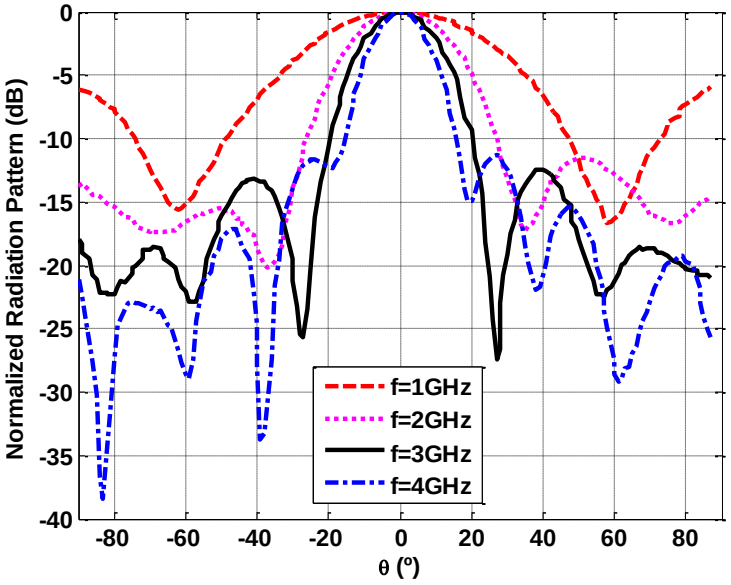
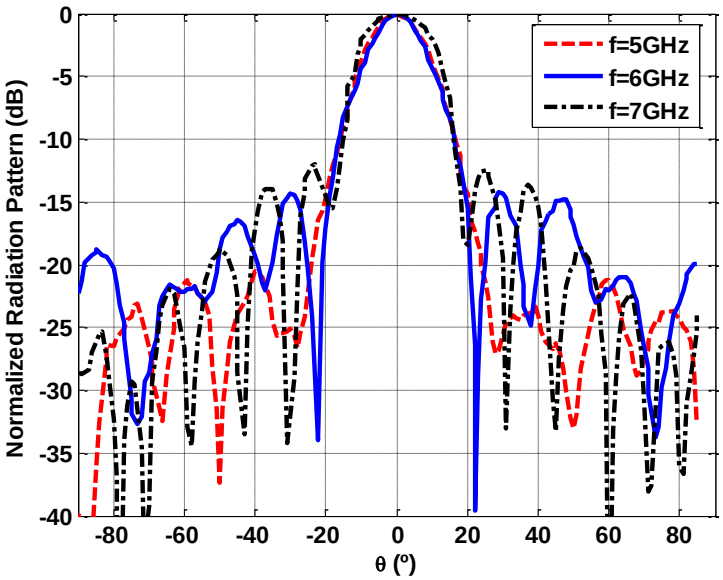


Figure S4 | Comparison (with simulated directivity and Side Lobe Level) between the initial design with the desired dielectric properties and the manufactured ones (material deviations) as indicated in Table S1. In order to obtain these results, a pyramidal X-band horn was employed as the transmitter positioned at the focal point of the lens.

a



b



c

Figure S5 | Measured direct ray radiation pattern in an anechoic chamber. (**a**) 1-4GHz. (**b**) 5-7GHz. (**c**) Configuration in the anechoic chamber.

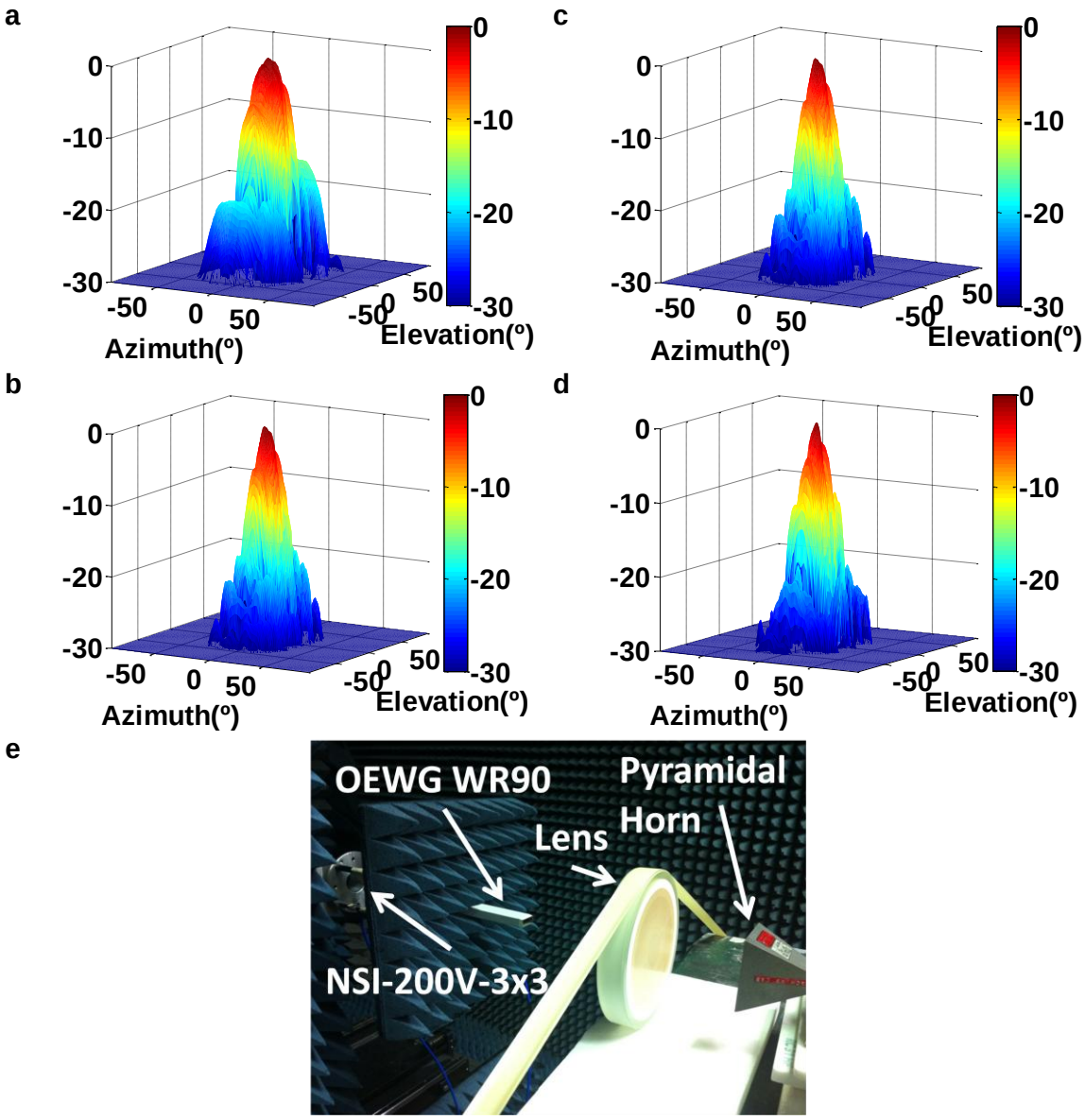


Figure S6 | Measured 2D normalized far-field distribution. Frequencies not shown in the paper for the sake of brevity**.** (**a**) 8 GHz. (**b**) 9 GHz. (**c**) 11 GHz. (**d**) 13 GHz. (**e**) Configuration for the measurements with the near field scanner.

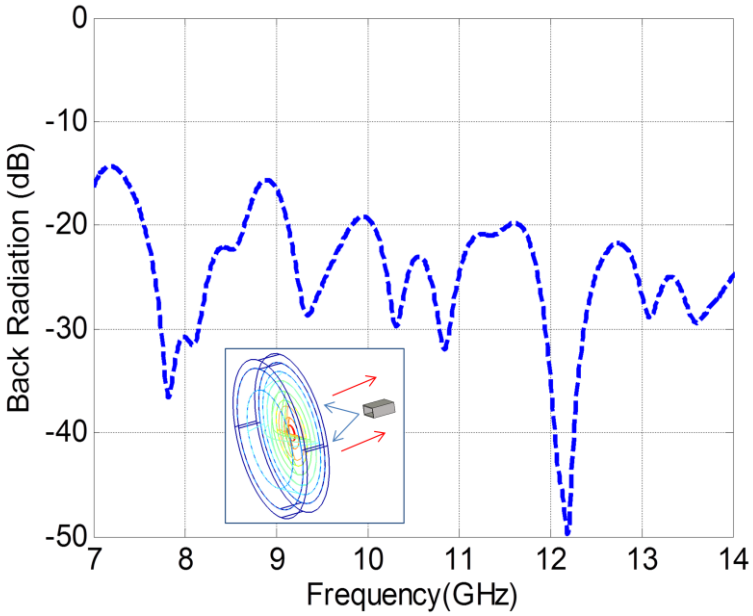


Figure S7 | Simulated back radiation. Reflected fields from the lens when it was fed with an X-band waveguide at the focal point (as indicated in the inset).