3D Printed Flat Lenses Using Synthetic Artificial Dielectrics

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Flat lenses have the advantages of flat profiles, small volumes and ease of fabrication. The major challenge faced in fabricating these lenses, that are typically based on the Ray Optics (RO) design paradigm, is that the dielectric materials called for in these design are typically not available commercially. Artificial materials with the desired dielectric properties can be used to realize these flat lenses (R. K. Arya *et al*. APS/URSI, 2014). In this paper an alternative approach, namely the 3D printing technique is examined to fabricate dielectrics with three-dimensional control of local permittivity (J. Tribe *et al*. Electronics Letters, vol. 50, no. 10, 2014). Since the 3D printed dielectric materials are not only cost-efficient but are rapidly prototyped as well, they have become increasingly attractive for RF applications.

This paper investigates the problem of fabricating a 15 GHz RO lens by using the 3D printing technique. The RO lens is composed of a number of discrete dielectric rings with different relative permittivities. The 3D printing machine with fused depositing modelling (FDM) is used to fabricate the lens. The 3D geometry with internal structures is sliced into successive layers. The final shape of the object is created layer-by-layer by using thermoplastic printing material, enabling the fabrication of customized internal structures such as air voids in a single process without the need for mechanical machining. The effective relative permittivities and loss tangents of the non-solid dielectric materials with air-void inclusions can be changed by controlling of the infill patterns and air volume fractions.

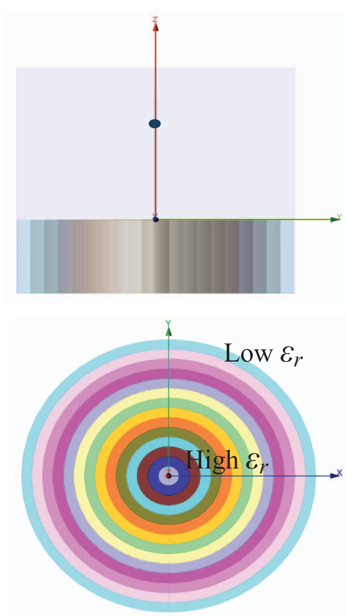

Fig. 1. Sketch of ray optic lens design

The lens is composed of fifteen 10 mm thick discrete dielectric rings. The outermost ring has the lowest relative permittivity of 1.2, while the center ring has the highest relative permittivity of 2.7. The center frequency of this lens is chosen to be 15 GHz while its focal length is 150 mm. All the rings have equal heights of 93.88 mm (see Fig.1).

Thermoplastic Polylactic acid (PLA) is used to print the RO lens. Measurement shows that this material has relative permittivity 2.72 and loss tangent 0.008. The rings of the lens are printed non-solid to reduce the effective permittivity. The air volume fraction is increased from the center to the outermost to vary the ε, and the infills of the dielectrics are designed to obtain the desired relative permittivity values.