Planar lenses by tailoring holey waveguides

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In recent years there has been an increased demand for directive antennas at high frequencies. There are different solutions to increase the directivity of those antennas such as reflectors, lenses or arrays. Nevertheless, reflectors are bulky, devices at those frequencies. Thus, lenses have become a suitable solution for the new generation of antennas.

One of the most classical example of lens antennas is the Luneburg lens. This lens makes use of graded refractive indexes to produce directive beams at different directions depending on the position of the excitation. The graded refractive indexes of those lenses can be obtained with a number of dielectric materials (O. Quevedo-Teruel, W. Tang, R. C. Mitchell-Thomas, A. Dyke, H. Dyke, L. Zhang, S. Haq, Y. Hao, Scientific Reports, vol. 3, no. 1903, 2013). However, at the present, the cost of this implementation can be significantly high if the employed materials have low losses. Therefore, in order to reduce the cost of those lenses, local periodic repetition of metallic and/or dielectric structures can be used. For example, holes can be drilled into a dielectric for the creation of 3D lenses (Hui Feng Ma, Tie Jun Cui, Nature Communications, vol. 1, no. 124, 2010). This technology can be also employed in slabs of parallel plate technology. A second alternative is the so-called bed of nails. These nails can tailor equivalent refractive indexes with different heights for the creation of planar lenses (S. Maci, G. Minatti, M. Casaletti, M. Bosiljevac, IEEE Antennas and Wireless Propagation Letters, vol.10, pp.1499-1502, 2011).

Here, we propose a solution based on a local periodicity of holes in a metallic slab. The configuration is topped with a second metallic slab which is separated from the first one by an air gap. In contrast to the bed of nails configuration, this separation is the parameter that mainly contributes to the modifications of the values of the equivalent refractive index. Therefore, the dimensions of the holes can remain constant and the manufacturing cost is reduced. Finally, a double structure, in which the top and bottom have a tailored metallic slab with holes, has been also studied. This configuration can provide higher refractive indexes and more frequency stability. The possibilities of this technology are demonstrated initially for a Luneburg lens, although other lens implementations are possible.