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Dual-polarized geodesic lens antenna in the sub-THz regime

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Summary

For sub-Thz applications, a compact dual-polarized fully metallic geodesic lens antenna at 120 GHz is proposed. The prototype's size is 50 mm × 50 mm × 25 mm. The simulation results show that the dual-polarized lens can achieve an angular scanning range of ±60° with ±45° polarization. The aperture efficiency is around 90%. This proves that the geometric lens can work efficiently at higher frequencies, up to sub-THz, and dual-polarization can improve the channel capacity, which has a good potential application in the next-generation communication system.

1 Introduction

Starting from the 1970s till now, the wireless communication system has developed from analog communication to modern digital mobile communication. With the development of technology, a variety of new demands for mobile communication appear constantly. As time advances, new technologies, new functions, and new services will continue to bring us new growth momentum. For the next generation, 6G, the promising frequency range is from 100 GHz to 3 THz which has a massively abundant available spectrum of unused and unexplored. Among the most multi-beam techniques in this frequency band, the geodesic lens technique offers an opportunity in 5G and beyond due to its low losses, wide scan range, and low scan losses [1].

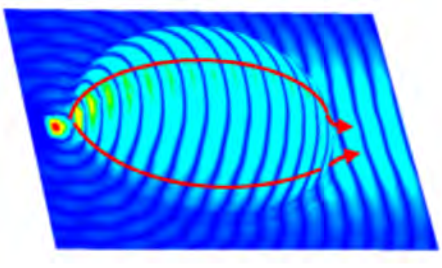
2 Geodesic Lens

The geodesic lens can be realized by a uniform parallel-plate waveguide (PPW) working in TEM mode with air/vacuum inside [2, 3] that can convert a spherical/cylindrical wavefront into a planar wavefront, shown in Figure 1(a). One of the latest advances in the research of geodesic lenses is the 'double-layer lenses' [5], offering more flexibility and functionalities. A concise expression of the geodesic curve is as follows, where z is the height and ρ is the radius.

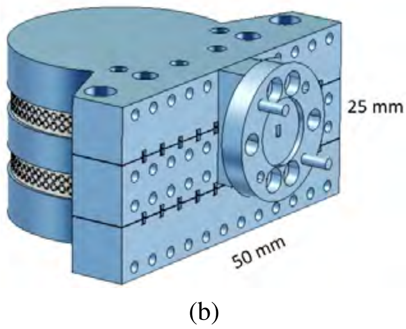
$$z(\rho) = h_0 (1-\rho^p)^{\frac{1}{q}} \tag{1}$$

In [4], h_0 is chosen as 0.56, $p = 2$ and $q = 1.6$. The prototype shown in Figure 1(b) that contains two layers of geodesic lens, and on the aperture of each layer is the polarization rotator. There are 22 ports in total and due to the semi-rotational symmetry of the structure, each port on the same layer has the same directivity with different angles of beam scanning. The scan loss from the center port to the edge port is around 0.6 dB, which is acceptable in such a high frequency.

Since in such a high frequency, the prototype needs to be plated in gold. The total efficiency of our prototype is shown in Figure 2. In the worst case, the total efficiency is -1.8 dB due to the losses in metal and surface roughness.



(a)



(b)

Figure 1. (a) Geodesic lens and its E-field inside PPW. (b) Geodesic lens prototype at sub-THz

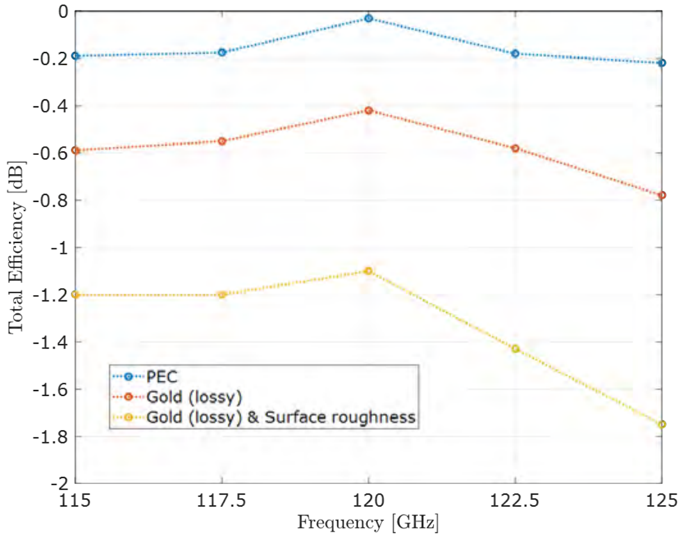


Figure 2. Total efficiency of different material settings.

3 Numerical results

With the operation frequency centered at 120 GHz, we propose a compact dual-polarized geodesic lens antenna. The simulation results show a good performance of dual-polarized geodesic lens antenna in sub-THz. The 15 dB return loss bandwidth is around 11 GHz and XPD is above 20 dB. The simulated realized gain for the middle port is 20.3 dBi and the side lobe level is -18.3 dB. The scan loss is 0.6 dB with an angular range $\pm 60°$. This compact design at sub-THz can achieve an aperture efficiency of about 90% and high total efficiency with a simulated lossy material and surface roughness.

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