350 GHz Holographic Surface for Single- and Multi-focusing

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Reflectors are the preferred high-gain antenna for ground base stations and radar applications. However, they are bulky and heavy for airborne applications. Hence, planar arrays such as microstrip antenna arrays are favored in airborne use. Unfortunately, losses in the array feeding network are unacceptable at Terahertz (THz) frequencies due to the significant absorption of any material/substrate in this range (D. Grischkowsky et al., J. Opt. Soc. Am. B, 7, 2006, 1990). Therefore, high-gain reflectarrays are the preferred practical solution for high data rate THz airborne applications.

The spatial varying reflection of a reflectarray (also known as holographic surface) can be easily engineered to have specific radiation patterns. This is a powerful idea that can be also exploited to manipulate Gaussian beams. Here, we show at the atmospheric window of 350 GHz how to focus an incident Gaussian beam into a single or four different focal points using holographic surfaces (S.A. Kuznetsov et al., Sci. Rep., 5, 7738, 2015). The holographic surfaces consist of a patterned layer lying on a grounded dielectric slab. The dimension of each unit cell square-pixel is ~$\lambda_0/3$ to minimize grating lobes as well as phase errors while the required 360 degree phase variation is still achievable with simple pixel patterns. The 360 degree variation required in the surface is achieved via topological morphing of the surface pattern from metallic patches to U-shaped and split-ring resonators, making the design polarization dependent. The easy-to-code and robust Gerchberg-Saxton holographic algorithm is utilized in this work to synthesize the required reflection phase distribution. The holographic surface is illuminated by a Gaussian beam under an incidence angle of 45 degree to avoid blockage. The detection at the focal plane is done using a pyro-electric detector mounted on an *xy*-translation stage. A diffraction efficiency (i.e., ratio of the power diffracted into a chosen diffraction order to the power of the incoming wave beam) ~80% and a -3 dB bandwidth (i.e., -3dB fall relative to the peak magnitude) ~14% and ~9% for 1-spot and 4-spots designs, respectively, are achieved experimentally. We demonstrate then a high-performance solution for creating purely flat, thin, light-weight and relatively inexpensive passive beam-shaping and beam-focusing devices for the THz band.