Impact of Multiple Lens Reflections on the Performance of Lens-Integrated THz Antennas

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Antennas placed on extended dielectric hemispherical lenses have been extremely beneficial for mmW and sub-mmW sensors. The extension length is pivotal in determining the directivity and Gaussicity of the lens-integrated planar antenna, where a high Gaussian beam-coupling efficiency along with a high directivity ensures the beam is transferred via the quasi-optical system without much signal loss. However, due to the extremely-large electrical size of the lens, such antennas are quite difficult to simulate using commercially available electromagnetic solvers. To estimate the radiation pattern of double-slot antennas on an extended hemispherical lens, ray-optics/field integration approach (D. F. Filipovic et al., IEEE Trans. Microwave Theory Tech., 41(10), 17381749, 1993) was used. However, this approximate analysis ignores the multiple reflections within the lens, which could significantly impact antenna performance, particularly when the lens is made from a high dielectric constant material, such as high-resistivity Silicon.

In this paper, we study the effects of multiple reflections within an extended hemispherical lens integrated with a double-slot antenna. Multiple internal reflections from the air-lens interface, as well as the cylindrical extension section and the ground plane are accounted for. The effects of these reflections on the radiation patterns and the directivity/Gaussicity values as well as the Gaussian beam properties (such as the near-field waist inside and outside the lens) are presented. In addition, the effects of a thin matching layer over the lens are illustrated. Consideration of such multiple reflections is required for a complete characterization of the lens-integrated antennas, particularly for novel applications in the THz-band.