A Comparison of the Gaussian Coupling Efficiency for Three Types of Terahertz Horn Antennas

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I. Introduction And Background

There is an increasing interest in developing technology for terahertz applications. This frequency band is rich in information for fields such as radio astronomy and spectroscopy of biological material. However the fabrication of components can be extremely difficult due to size and accuracy requirements. Therefore alternative fabrication techniques are currently under investigation to develop processes suitable for the realization of these components. Many of these applications rely on quasi-optics due to the excellent coupling of horn antennas to Gaussian beams [1]. Horn antennas can be designed into many shapes and sizes but are often limited by the fabrication method. For example the diagonal horn is relatively easy to fabricate in a block but the conical horn can be quite challenging. This research investigates the performance of a diagonal, conical, and octagonal horn antenna at 1.6 THz in terms of antenna patterns and Gaussian coupling efficiency.

Each of the horn antennas used in this research was fabricated using a different machining process. The conical horn was created by laser-machining, the diagonal horn by milling, and the octagonal horn by SU-8 based micromachining. One advantage of the milling and laser machining techniques is that the blocks are fabricated out of solid metal which is more robust and ideal for cryogenic applications. The SU-8 is an epoxy based photoresist that is deposited on a silicon wafer and thus de-lamination can be an issue at cryogenic temperatures. However, the SU-8 technique utilizes a batch fabrication process that allows for increased repeatability and easy modification to the block design with a change to the mask set. In addition as the frequency is increased above 2.5 THz the SU-8 process is relatively easy to scale up. In fact the fabrication of the blocks becomes simpler due to the smaller dimensions.

II. Measurement

The waveguide blocks presented in this paper were designed for 1.6 THz up-converters. Schottky diodes mounted in the blocks are biased in the square-law region and used as power detectors for the purpose of measuring antenna patterns. A 1.6 THz FIR laser is used as the source. Figure 1 displays the measurements for the conical, diagonal, and octagonal horn. In order to do an initial comparison of the Gaussian coupling efficiency for these antennas, an HFSS model is created for each design. With a good match between simulated and measured antenna patterns, as shown in Figure 1(c) for the octagonal horn antenna, the simulated data can be used to calculate the Gaussian coupling efficiency according to the following formula:

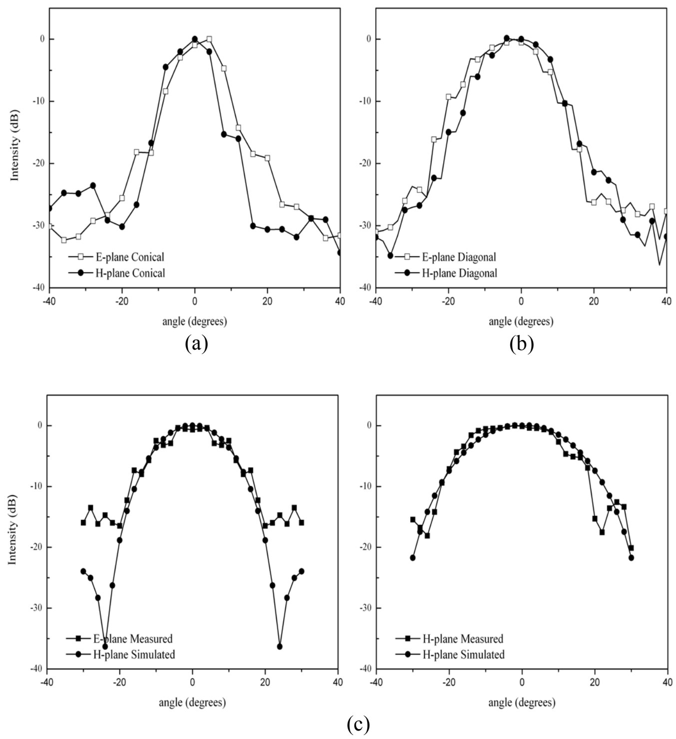

Figure 1: Measured antenna radiation patterns at 1.6 THz for (a) conical horn and (b) diagonal horn. Measured and simulated patterns for (c) octagonal horn.

$$\eta_{Gauss} = \frac{\left| \iint \left[\hat{\varepsilon}\, co \cdot F(\theta,\phi) \right] \exp^{-(\theta/\theta_0)^2} \exp^{-j\pi(\theta/\theta_1)^2} \sin\theta d\theta d\phi \right|^2}{\iint \left| F(\theta,\phi) \right|^2 \sin\theta d\theta d\phi \iint \exp^{-2(\theta/\theta_1)^2} \sin\theta d\theta d\phi} \qquad (1)$$

Applying equation (1) a Gaussian coupling efficiency value of 81% is calculated for the octagonal horn [1].

A model will be created for both the conical horn and diagonal. Following the simulations of the horn antennas, the Gaussian coupling efficiency will calculated for both the diagonal and conical horn and then compared to the octagonal horn.

References

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