

# A 325-500 GHz High Gain Antenna for Terahertz Applications

Kuikui Fan, Zhang-Cheng Hao and Wei Hong

School of Information Science and Engineering, Southeast University, Nanjing 210096, China

kkfan@seu.edu.cn, zchao@seu.edu.cn, weihong@seu.edu.cn

**Abstract** - This paper reports a 325-500 GHz antenna for terahertz applications. A novel highly integrated radiation structure including an E-plane flare and dual H-plane reflectors are proposed in the design for achieving high radiation gains. A terahertz horn antenna that is excited by using a standard WR2.2 waveguide is adopted as the primary feeder for the proposed antenna. To verify the design, a 325-500 GHz prototype is fabricated by using a low cost commercial milling technology. Experiment results show that the measured antenna has a maximum gain of 32.0 dBi at 500 GHz. In addition, in the 325-500 GHz frequency band, the measured prototype has a return loss larger than 20 dB, a gain higher than 26.5 dBi, and a high radiation efficiency over 43.75 %. The proposed antenna provides a low cost and high performance solution for developing terahertz antennas.

**Index Terms** - Terahertz antenna, high gain, wideband, high radiation efficiency, low cost.

## 1. Introduction

In recent years, the terahertz technology has been attracted many interests from researcher for its potential applications of space communications, astronomy and imaging systems. Specially, the 0.1-1 THz frequency band has been drawn much attention by radio communication researchers because it is possible to integrate the whole terahertz communication system of this frequency band on a single chip in the near future. However, the path loss of terahertz waves in free-space is much higher than that of the millimeter-wave. Therefore, very high gain terahertz antennas are required by the terahertz base-station to overcome the extra path loss for increasing the distance or performance of the terahertz communication system. To this end, a few high-gain terahertz antennas have been studied in recent years [1]-[5].

The horn antenna has been popularly used for high-gain terahertz antennas due to its simple structure, high performance with low cross polarizations and wide working bands. A multiple-flare angle horn at 1.9 THz is designed with a high gain of 31.7 dBi in [1] and the Potter horn has been investigated with good sidelobe suppression performance in [2], [3]. However, the conventional horn antenna usually needs long structures for obtaining a high radiation gain because the radiation gain is a function of the flare angle and the antenna length. Moreover, the above mentioned horn antennas consist of many sections. Then a high fabrication cost is required and a complicated and time consuming assembly process has to be taken in the experiments. Reflector antennas, including the parabolic

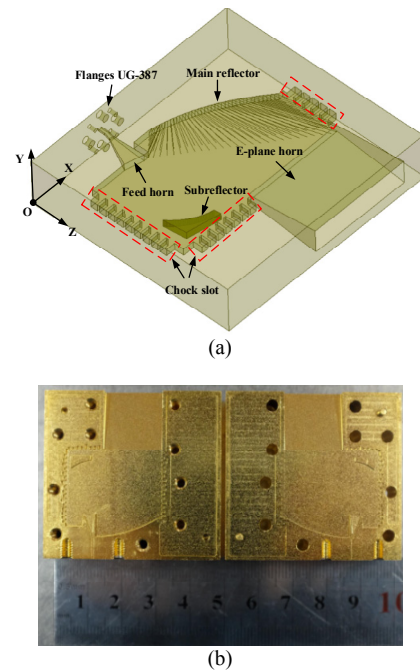


Fig. 1. (a) Configuration of the proposed offset dual-reflector antenna. (b) Photograph of the fabricated antenna prototype.

antenna, the Cassegrain reflector antenna and the Gregorian antenna, have been developed for achieving very high radiation gains [4], [5]. However, reflector antennas has a cubic volume, and the roughness of the reflector are critical to the antenna performance. As a result, very expensive fabrication cost has to be paid for a large aperture reflector antenna.

In this paper, a high gain terahertz antenna is proposed with an operating frequency of 325-500GHz. Highly integrated reflectors and an E-plane flare are adopted in the design for the proposed antenna. The design prototype is fabricated by using a low cost milling technology, and experiments are carried out to verify the design. Measured results show that the proposed terahertz antenna has a wide frequency band from 325-500 GHz with a return loss larger than 20 dB, and a high gain of 32.0 dBi at 500 GHz.

## 2. Antenna Structure, Design and Experiment

### (1) Terahertz Antenna Structure and Design

The schematic of the proposed terahertz antenna is shown in Fig. 1(a). The proposed antenna includes some integrated

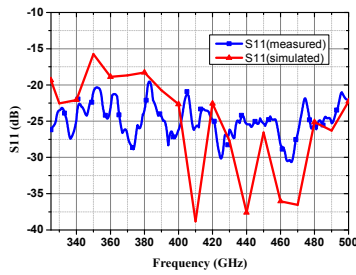


Fig. 2. The simulated and measured reflection coefficient of the proposed offset Gregorian dual-reflector antenna.

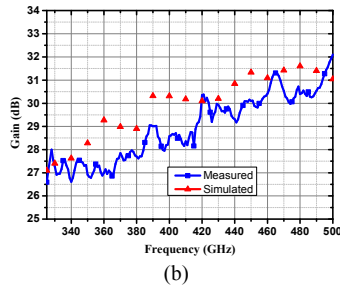


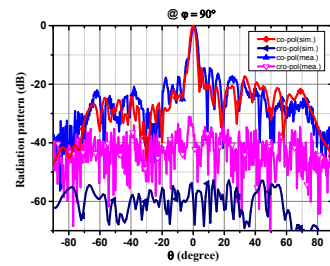
Fig. 3. Comparison of the measured and simulated Gain of the proposed antenna.

parts, i.e. dual reflectors, one E-plane flare, some chock slots, and one standard WR2.2 horn as primary feeder. The UG387 flange is adopted to install the proposed antenna with test instruments. The dual reflectors are used to increase the H-plane radiation aperture for obtaining a narrow H-plane radiation beam. They have a parabolic outline in horizontal direction, i.e. the XoY plane, while keep unchanged in vertical direction, i.e. the XoZ plane. As a consequence, the low cost commercial milling process can be used to fabricate the proposed terahertz antenna. To obtain a narrow beam in E-plane, i.e. the XoZ plane, a flare is adopted in vertical direction, as illustrate in Fig.1.

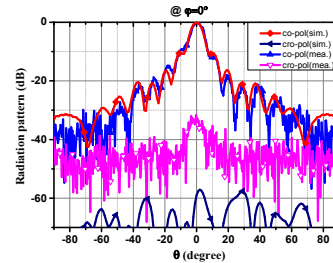
The proposed antenna is designed with the help of the full-wave simulator HFSS. The feeding position of the primary feeder is determined by the design principle of reflector antennas [4], [5]. To reduce the interferences from the multiple-path reflections, chock slots are etched at both sides of the reflectors.

## (2) Experiments

The designed prototype was fabricated by using a low cost milling process, and measured in a terahertz chamber. The photograph of the fabricated prototype is shown in Fig. 1(b). The Agilent vector network analyzer is used to measure the return loss, which is equipped with two OML terahertz extenders. The measured return loss is shown in Fig. 2. The proposed terahertz antenna has an excellent return loss performance which is larger than 20 dB in the whole operation frequency band. The measured 400 GHz radiation patterns are shown in Fig.4. It shows that the measured prototype has a good cross polarization pattern whose level is lower than -30 dB in both E- and H- planes. Generally, the measured radiation patterns agree well with the simulated results, which have a maximum sidelobe around -10 dB and -15 dB for E-plane and H-plane radiation patterns, respectively. The measured gain is shown in Fig.3, the antenna has a maximum gain of 32.0 dBi at 500 GHz. From



(a) H-plane at 400 GHz



(b) H-plane at 400 GHz

Fig. 4. Comparison of the measured and simulated Gain of the proposed antenna.

325-500 GHz, its measured radiation gain is higher than 26.5 dBi, and is increased monotonously along with the operating frequency.

## 3. Conclusion

This paper reports a novel compact terahertz antenna. By adopting high integrated reflectors with flares in the design, a compact footprints is obtained. Experiments are carried out to validate the design, and the measured results show that the proposed antenna has a good return loss higher than 20 dB from 325-500 GHz, a maximum radiation gain of 32.0 dBi at 500 GHz, and a good cross-polarization level than -30 dB in both E- and H- planes.

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