# A D-band High-Gain Antenna for Terahertz Applications

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***Abstract* - A D-band high-gain antenna is proposed and investigated in this paper for terahertz applications. Metallic lens that uses ten symmetrical metallic waveguides has been adopted for the phase compensation, and an E-plane flared structure is used to improve the gain of the proposed antenna. A 110-170 GHz prototype has been designed and fabricated for demonstrations. Experiments show that the measured return loss is larger than 15 dB within 110-170 GHz frequency band, and the maximum measured gain is 27.2 dBi at 160 GHz. The measured cross polarization level is lower than -43 dB for both E-plane and H-plane radiation patterns.**

***Index Terms* —High-gain, wide-band, lens antenna, THz antenna.**

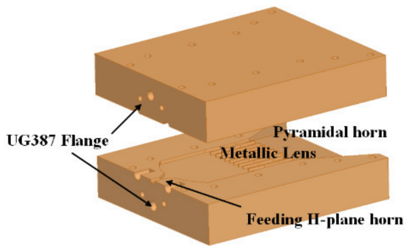
## 1. Introduction

The high gain terahertz antennas have been attracted many interests for their potential applications in high-speed communication, biomedical imaging and remote sensing. In the past years, a few terahertz antennas have been reported by using various techniques [1]-[6]. The terahertz lens antenna has been fabricated in a double SOI wafer in [1] with a compact size, and a measured gain of 22.0 dBi is obtained at 540 GHz. A micromachined 300 GHz slotted waveguide antenna is reported in [2] based on metal-coated SU-8 thick resist, which shows the possibility of developing planar terahertz antenna by using deep iron etching technology. A 3D printed reflector antenna has been reported in [3] with a gain of 22.5 dBi at 100 GHz and a bandwidth of 20.66%. A 340 GHz on-chip antenna is developed with a high radiation efficiency by using the SiGe BiCMOS technology in [4]. Horn antennas have been investigated as favorable terahertz antennas with a low cross polarization and a wide working band in [5][6]. By using the multiflare angle horn structure, a terahertz antenna is reported in [5] with a gain of 31.2 dBi within 1.7-2.1 THz.

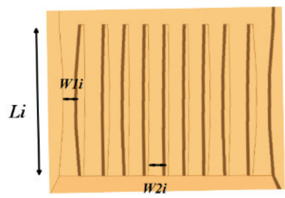
In this paper, a high-gain metallic lens antenna is proposed. As a demonstration, a 110-170 GHz prototype is designed with a metallic lens and a highly integrated E-plane flared structure. The metallic lens is designed by using ten metallic waveguides with varied width. The flared structure is integrated with the lens for improving the gain of the propose antenna. The designed prototype is fabricated inside an aluminum block by using conventional milling process. Experiments have been carried out to validate the design, and good measured performance is obtained. The detailed structure, design procedure and experiments are presented.

## 2. Antenna Structure and Design

The schematic of the proposed terahertz antenna is depicted in Fig. 1(a), where the UG387 flange is used as the interference of the antenna. A small conventional horn is used as the feeder. The feeding horn radiates electromagnetic waves to a cavity which is designed with a small height, and a planar wave is obtained at the aperture of the cavity. Then a narrow beam is obtained for the H-plane radiation pattern owing to the large H-plane radiation aperture of the cavity. Theoretically, the planar wave has the same phase at E-plane while there exists a phase difference in the H-plane. To achieve a uniform phase distribution in the H-plane, a metallic lens is adopted to adjust the phase of the planar waves. In order to obtain a narrow beam for the E-plane radiation pattern and improve the radiation gain of the proposed antenna, an E-plane flared structure is integrated with the metallic lens, as shown in Fig. 1(b).




(a)




(b)

Fig. 1. Schematic of the proposed terahertz antenna. (a) the proposed THz antenna, (b) the metallic lens.

Fig. 2. Photographs of the fabricated THz antenna.

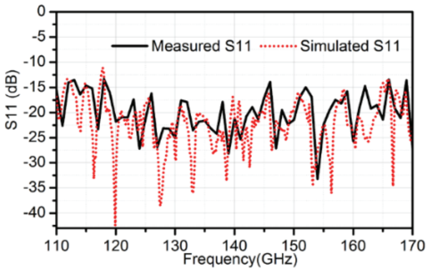
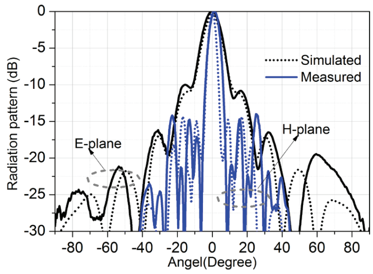
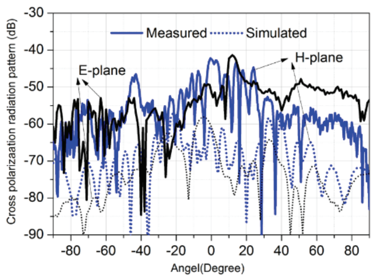



Fig.3. Simulated and measured S11 of the proposed THz antenna.




(a)




(b)

Fig. 4. Simulated and measured radiation patterns at 140GHz. (a) main polarization, (b) cross polarization.

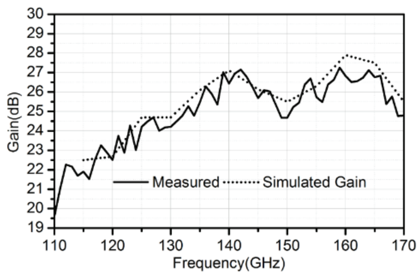



Fig. 5. Photographs of the fabricated THz antenna.

## 3. Experiments

A prototype has been designed with an operating frequency of 110-170 GHz, and fabricated by using the conventional milling process. Fig. 2 illustrates the photograph of the fabricated prototype, which has a size of 60mm*50mm*24mm. The prototype has been measured in a THz chamber. The measured and simulated return losses are illustrated in Fig. 3, where the return loss is larger than 15 dB over the whole D-band (110-170GHz). The 140 GHz radiation patterns are shown in Fig.4, where a small cross-polarization lower than -43 dB can be found for the H- and E- plane radiation patterns. The measured side-lobe levels are below -14 dB and -10 dB for H- and E- plane radiation pattern, respectively. The measured gain is presented in Fig. 5. It can be seen that maximum measured gain is 27.2 dBi at 160 GHz. Within the 125-170 GHz frequency band, the measured gain is higher than 24 dBi.

## 4. Conclusions

A compact high gain terahertz antenna is proposed in this paper. And a 110-170 GHz prototype is designed as a demonstration. The conventional milling process has been used to fabricate the designed prototype. Experiments are carried out to validate the design, which shows the measured antenna has a maximum gain of 27.2 dBi at 160 GHz, a good return loss larger than 15 dB within 110-170 GHz, and a small cross polarization level lower than -43 dB. The proposed antenna can be extended to design THz antennas with high operating frequency.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