# Design of W-band Substrate Integrated Waveguide Horn Antenna for Active Phased Array


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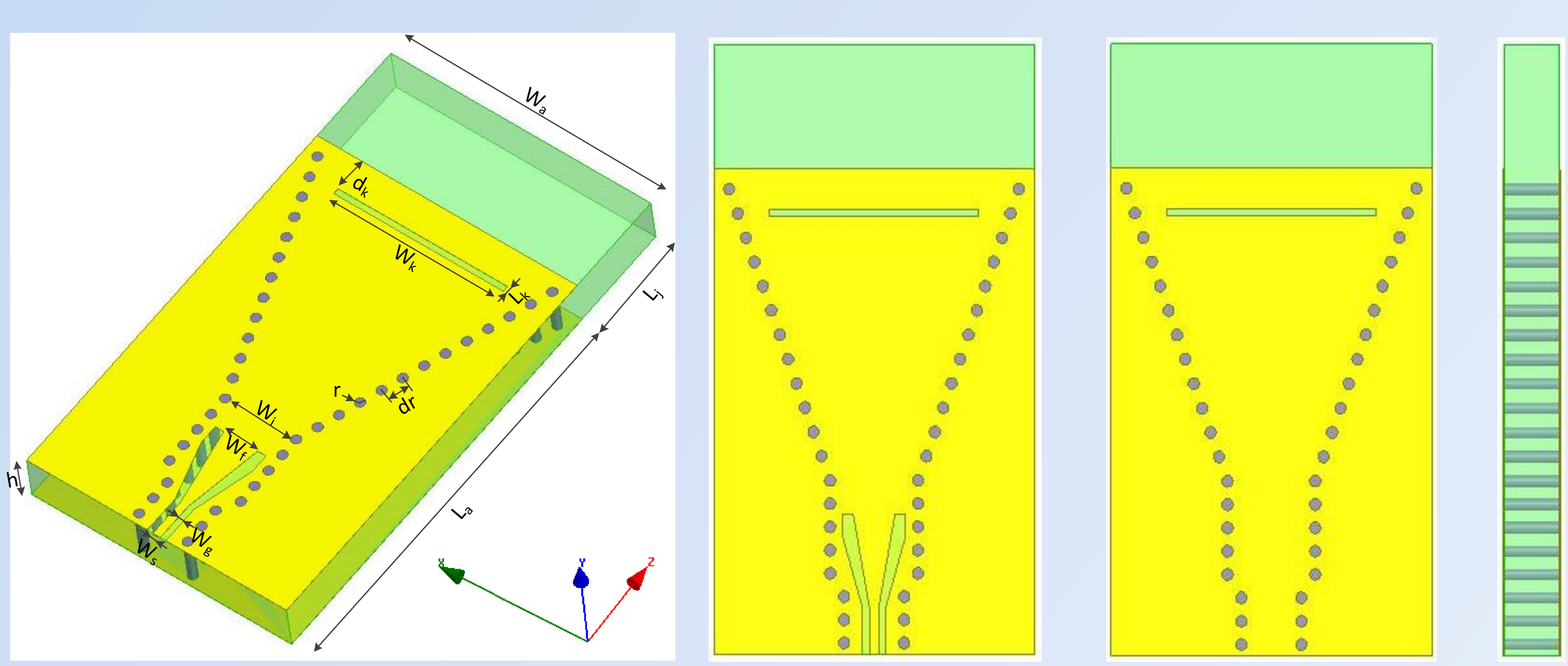
## Introduction

A novel W-band substrate integrated waveguide (SIW) horn antenna has been proposed in this paper. The proposed antenna is fabricated on a single layer of silicon substrate. In order to improve the antenna gain, a dielectric slab using the same silicon substrate is installed in front of the aperture of the horn. In order to improve the front-to-back ratio, two slots are symmetrically arranged in the top and bottom metal surface which are close to the radiating aperture. Moreover, since the width of the antenna is less than 75% wavelength and thus it is suitable for active phased array. The proposed SIW horn antenna and its 1×9 array have been investigated. A wide beam scanning range of ±20° in H-plane covering frequency form 91.5 to 96 GHz with respect to VSWR less than 2 is achieved and a high front-to-back radio of 21.3 dB is obtained.

## Antenna Design

The detailed configuration of the W-band SIW horn antenna is illustrated in Fig. 1. It is fabricated on a single silicon substrate with a thickness of 0.4 mm. Both the top side and bottom side are coated with 0.004 mm Au. The relative dielectric permittivity is 11.9 and the dielectric loss tangent is 0.001. The proposed antenna is constructed by three parts: 1) the loaded silicon slab, 2) the SIW H-plane horn, and 3) the grounded coplanar waveguide (GCPW) to SIW transition. The loaded silicon slab in front of the horn aperture functions as a dielectric guiding structure excited by the horn aperture which results in a narrow beamwidth in the E-plane and consequently increases the gain of the SIW horn antenna. Two same slots in the top and bottom metal surface close to the radiating aperture are used to enhance the front-to-back ratio. Since the performance of the mmW integrated device is usually tested on probe station which is adapted to GCPW feed structure, a GCPW to SIW transition structure with 50 Ω impedance is also designed.



(a) 3-D view (b) Planar layout

**Fig. 1. Structure of the proposed W-band SIW horn antenna.**

## Conclusion

In this paper, a compact W-band SIW horn antenna on a single silicon substrate has been proposed and demonstrated. Since the aperture width of the horn is less than 75% wavelength, the proposed SIW horn antenna is suit to be applied in active phased array. The proposed antenna and its application to arrays have been demonstrated. The simulated results show that a good beam-steering performance in H-plane has been achieved. To the best of our knowledge, this is the first time that a W-band SIW H-plane horn antenna with fine scanning performance is presented.

## Simulated Results

The simulated active VSWR for different scan angles are simulated and shown in Fig. 2. It can be observed that the active VSWR is less than 2.5 from 91.5 to 96 GHz when the scan angle varies from 0° to 20°. It means that the proposed antenna is suit to be applied in the active phased array.

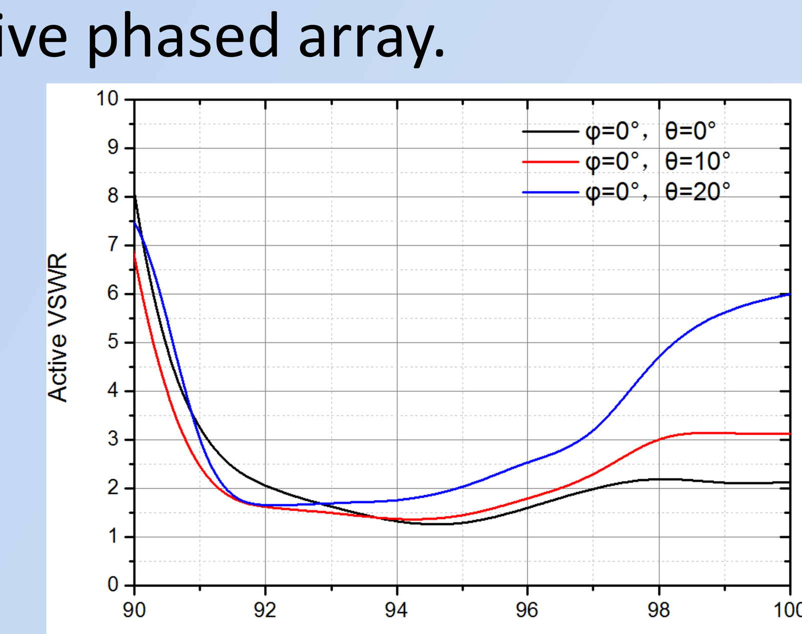
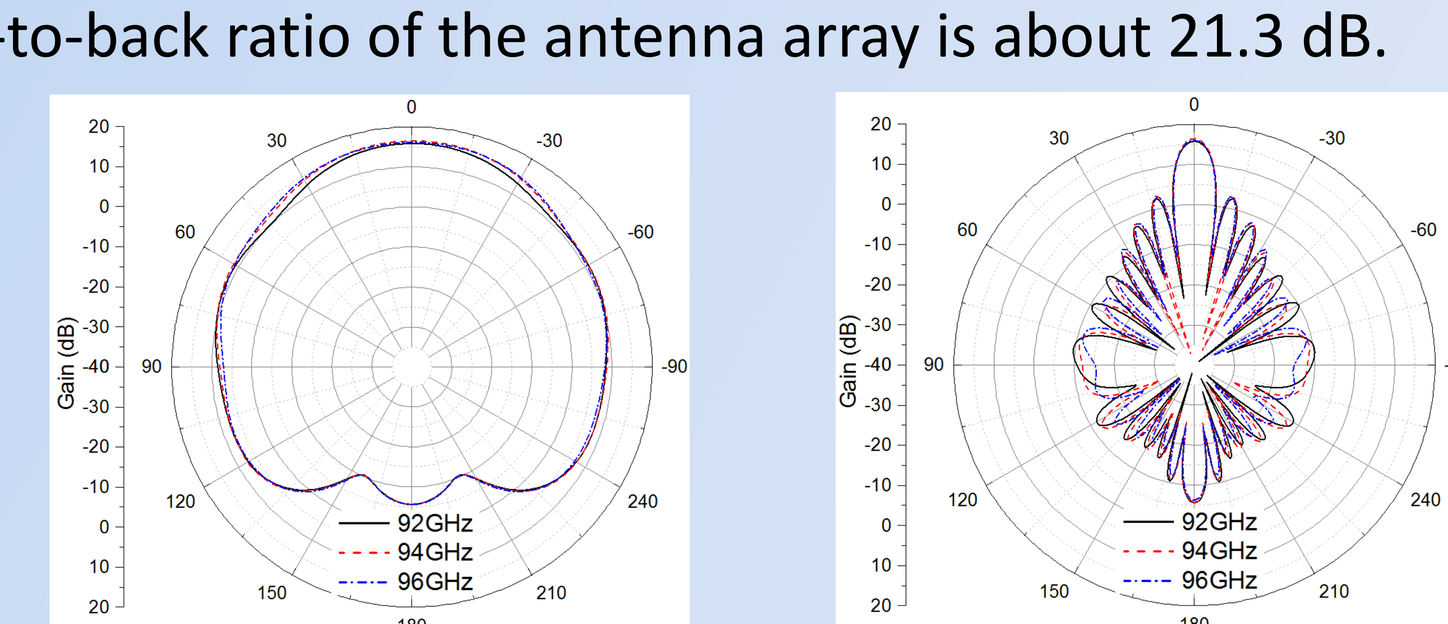



**Fig. 2. Simulated VSWR and gain of the proposed ME dipole antenna.**

A 1×9 antenna array in H-plane based on the proposed SIW horn antenna is also simulated. The distance of the neighboring antenna is 2.3 mm. The radiation patterns of this proposed SIW horn antenna in E-plane and H-plane are shown in Fig. 3. It can be observed that the side lobe level is less than -13.1 dB and the front-to-back ratio of the antenna array is about 21.3 dB.




(a) E-plane (b) H-plane

**Fig.3. Radiation patterns of the antenna array in (a) E-plane and (b) H-plane.**

The radiation patterns with different scan angles operating at 94 GHz are illustrated in Fig. 4. It can be clearly seen that a good beam-steering performance in H-plane is realized, agreeing well with the simulated active VSWR of the proposed SIW horn antenna.

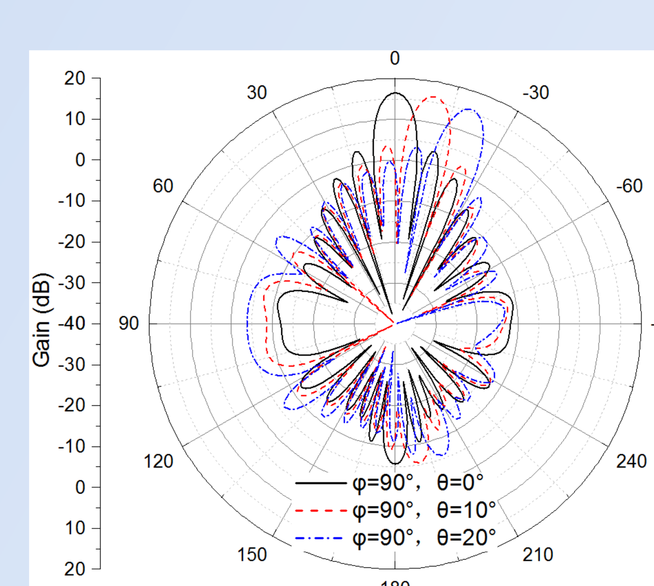



**Fig.4. Radiation patterns of the antenna array at 94 GHz with different scan angle in H-plane.**