A Novel Circular Polarized SIW Square Ring-slot Antenna

Fang-fang Fan, Wei Wang, Ze-hong Yan
National Laboratory of Science and Technology on Antennas and Microwaves
Xidian University, Xi'an, Shaanxi, 710071, China

***Abstract-* A single-layer circularly polarized (CP) substrate integrated waveguide (SIW) square ring-slot antenna at X-band is proposed in this letter. By using two shorted square ring-slot in the top wall of SIW and two shorting vias, the CP wave is obtained. To verify the design method, the SIW antenna is fabricated and measured. The measure impedance bandwidth and AR bandwidth are 11% (9.62-10.74GHz) and 1.2% (10.08-10.2GHz), respectively. The antenna also has good radiation pattern and high gain than other similar SIW antennas.**

I. Introduction

Circularly polarized (CP) antennas are extensively used in space applications such as satellite communication, radar system and so on, because they can resolve problems in wireless channels such as polarization mismatch generated by Faraday effect and interference generated by multi-path effect.

Substrate integrated waveguide (SIW) technology, which is firstly proposed by Wu [1], has the advantage of easy integration with planar circuits by replacing the conventional microstrip and strip line. Also it has the merits of low loss, high power capacity, high Q-factor, low cost than conventional waveguide. SIW-based CP antennas have been reported by many researchers [2-7]. A 16-element top wall SIW slot antenna in Ref. 2 proposed two-compounded slot pairs to obtain CP wave centered at 16GHz, but the usable bandwidth is just 2.3%. In Ref. 3, the authors proposed an X-band cavity backed crossed-slot antenna fed by a single grounded coplanar waveguide. The antenna also met the same problem: a narrow impedance bandwidth of less than 3% and a narrow axial ratio (AR) bandwidth about 1% for AR less then 3 dB. In Ref. 4, a circular ring-slot antenna embedded in a single-layered SIW with a microstrip-to-SIW transition was presented. The antenna had a wider AR bandwidth 2.3% and a wide impedance bandwidth 18.74% than the cavity backed crossed-slot antenna [2-3], but its gain was less than 6 dBi, and the antenna had a high level of cross-polarization. In Ref. 5, the authors studied SIW cavity backed antennas using microstrip-to-SIW and coax-to-SIW transitions. A good level of cross-polarization was obtained with the coax-to-SIW transition; the antenna reached a gain about 7 dBi. The AR bandwidth and the impedance bandwidth were almost the same as for the circular ring-slot antenna [4]. However, the antenna occupies a relative large area, and its design is complex. In Ref.4-6, the authors employed shorting via to connect the metal area bounded by the ring-slot at the top wall and the bottom wall of SIW to obtain CP, so the location of the shorting via and fabrication errors affects the CP characteristic largely.

In this letter, two square ring-slots SIW CP antenna for X-band application is proposed. The shorted strips and shorting vias are used at the same time to obtain CP wave with good performance, the design is very simple.

II. Antenna Configuration

The geometrical configuration for the antenna (side view and top view) is shown in Fig.1. The overall size of the SIW antenna is 34mm×34mm, it is composed of three parts: SIW-based rectangular waveguide, two square ring-slot, two shorting vias and coax feeding probe. P and d are the distance between the two vias and their diameter of SIW structure. W and L are the width and length of the SIW structure. These values of SIW should certify that it operates in the fundamental mode TE_{10}. g1 and g2 is the length of the two shorted strips and its width is as long as the width of the ring-slot denoted as ws and ws1. Then the distance between the feeding probe and the bottom of square ring-slot is denoted as s2, and it is in the center of the SIW in the y-direction. s1 is the distance between the top of square ring-slot and the shorted end , the inner dimension of the square ring-slot is ls. And the other square ring-slot has the side length ls1 and width ws1. The distance between the two square ring-slot is d1. The two shorting vias are located in the middle of two square ring-slots. dy is the distance between the shorting via a-

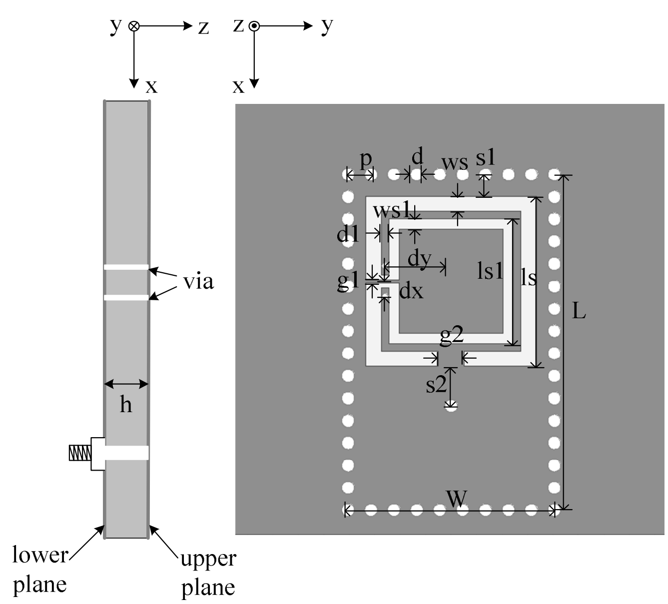


Figure 1 The SIW antenna geometry (side view and top view)

nd the y-direction, dx is the distance between the shorting via and the center of square ring-slot in the x-direction. The two shorting vias is at both side of the center of square ring-slot in the x-direction.

The side length of square ring-slot ls and ls1 mainly influence the resonating frequency of the SIW antenna, the location and the diameter of the two shorting vias and the parameters g1, g2 determine the CP wave performance. The antenna is simulated and analyzed in simulation software HFSS (High Frequency Simulation software). The final optimized parameter values are shown in Table1.

TABLE 1
The value of parameters for SIW antenna

Parameters	W	L	ls	ws	p	d	dx	dy
Value(mm)	16.2	26.4	13.4	1.2	1.8	1	1.2	5.2
Parameters	g1	g2	s1	s2	ls1	ws1	d	
Value(mm)	0.3	2	1.7	3.1	9.8	0.8	0.6	

III. Fabrication and The Measured Results

Taconic TLX-8 with relative permittivity of 2.55, height of 1.52mm is used for the antenna. The fabricated SIW antenna is shown in Fig.2. The simulated and measured VSWR is shown in Fig.3 with the help of the vector network analyzer E8363B from Agilent Technologies, it can be seen that the bandwidth with VSWR less than 2 is 11% (9.62GHz-10.74GHz), the simulated and measured impedance bandwidth are in good agreement.

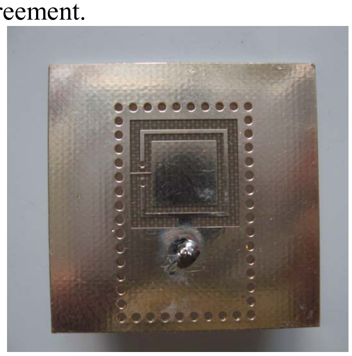


Figure 2 The photo of fabricated SIW antenna

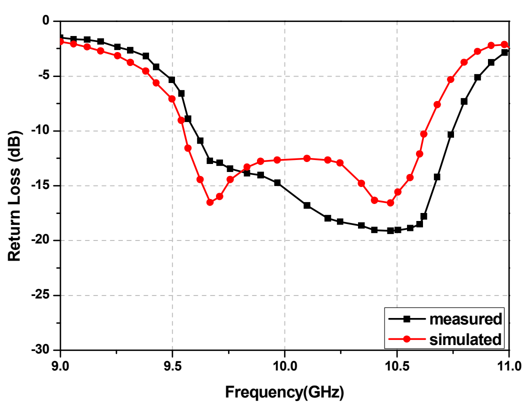


Figure 3 Simulated and measured VSWR versus frequency

The AR versus frequency is depicted in Fig. 4; the measured AR bandwidth below 3dB is 1.2% (10.08-10.2GHz). There is a discrepancy, which appears as a frequency shift to higher frequency for the measured AR, due to the tolerance error in the manufacturing process with the location and diameter of shorting via.

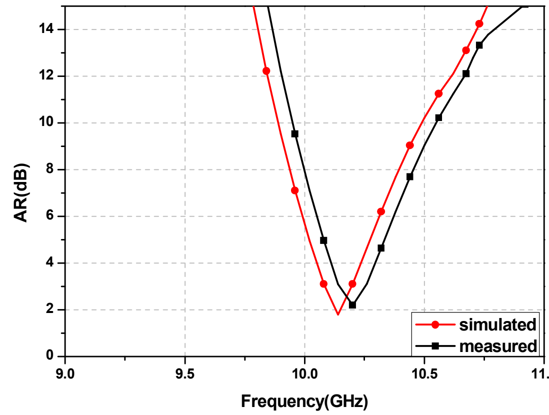
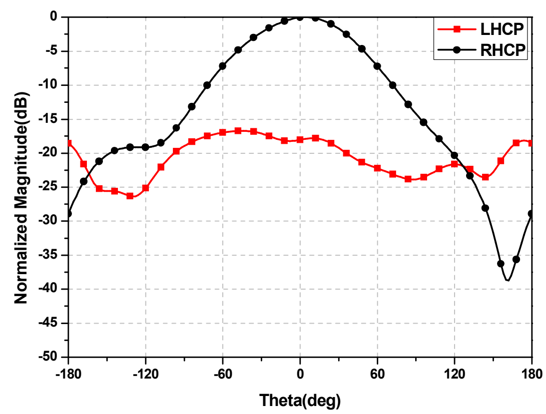
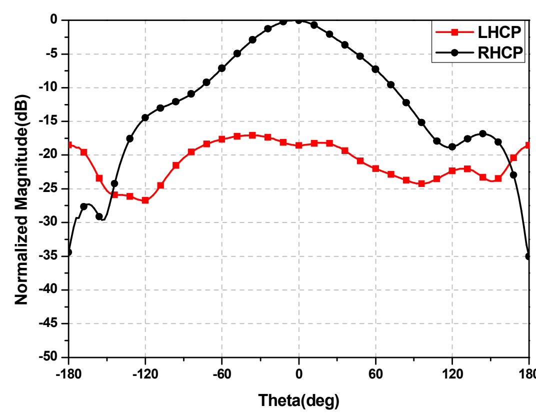


Figure 4 The simulated and measured AR versus frequency



(a)



(b)

Figure 5 The measured radiation pattern at 10.2GHz (xz plane, yz plane)

Fig.5 delineates simultaneously the RHCP and LHCP radiation pattern in xz- and yz-planes at 10.2GHz of the SIW antenna. It can be seen that the proposed antenna satisfies the RHCP generation with a lower cross-polarisation at the boresight direction. The maximum gain at the boresight direction is 8.0dBi at 10.2GHz.

IV. Conclusion

In short, a CP antenna based on SIW structure with high gain is presented here. Through the shorted strips and shorting vias, a RHCP wave is obtained; the design is simple and easy for fabrication. The SIW antenna achieves 11% impedance bandwidth and 1.2% AR bandwidth, respectively. The maximum gain at the boresight direction is 8.0dBi at 10.2GHz. The antenna can be used in satellite communication system.

Acknowledgment

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