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Wideband Dual-polarized Array Antenna on Dielectric-based Inverted Microstrip Gap Waveguide

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Abstract—A wideband dual-polarized planar array antenna is presented in this paper. The proposed array antenna consists of 8×8 bowtie antennas and dielectric-based inverted microstrip gap waveguide network. It is composed of multilayer substrate which can be fabricated by low cost PCB process. The simulated results show that the proposed array achieves a relative impedance bandwidth of 54.2% from 19.2GHz to 33.5 GHz for both polarizations with VSWR of 2.

Index Terms—dual-polarized, bowtie antenna, dielectric-based inverted microstrip gap waveguide.

I. INTRODUCTION

With the development of 5G wireless communication systems, many applications covering 20–40 GHz frequency range are needed. Ultra-wideband, high-gain and steerable dual-polarized array antennas are one of the key components in these systems.

Many high gain planar array antennas based on different transmission lines have been reported in the recent years [1–5]. Among these, antennas based on gap waveguide technology have high potentials due to its lower losses, surface wave suppression and self-packaging properties compared with conventional microstrip line and substrate integration waveguide (SIW) in millimeter-wave (mmWave) band. So far, mainly four gap waveguide versions have been proposed [6],[7], and the inverted microstrip gap waveguide (IMGW) may be the best choice when considering fabrication cost and flexibility in the feeding network design [8],[9]. Moreover, the fabrication cost can be further reduced when metal pins of the gap waveguides are replaced by metal vias in the substrate. Many IMGW antennas exhibit good performance, but it is still a challenging task to have a wide bandwidth and dual polarization performance with IMGW antennas.

In this paper, we present a wideband dual-polarized planar array antenna on dielectric-based IMGW for mmWave applications. The array antenna employs planar bowtie antennas as radiation elements which are similar to magneto-electric dipoles. The metal pins and air gap in IMGW are replaced by metal vias and dielectric gap, respectively. Thus the whole structure can be easily fabricated by multilayer PCB process and integrated with RF components.

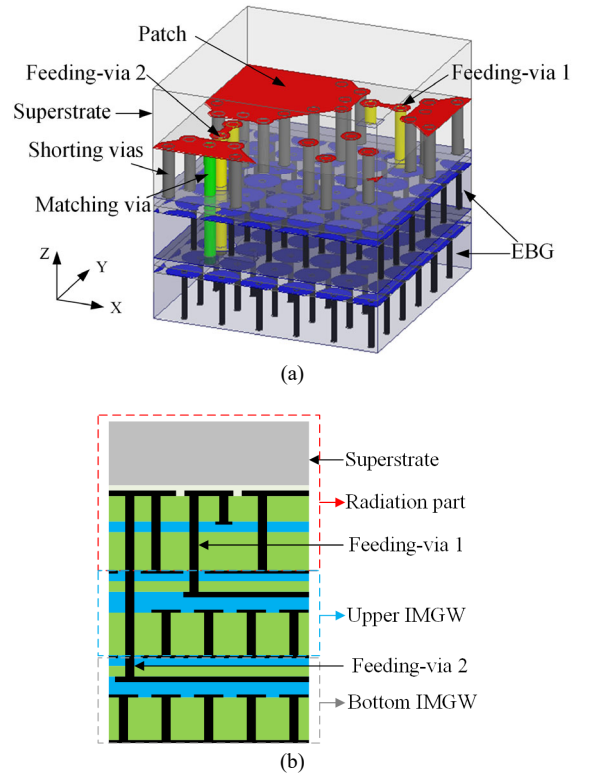


Fig. 1. Geometry of the proposed element with periodic boundary. (a) 3D view. (b) Side view.

II. ANTENNA CONFIGURATION

A. Radiation Element

The detailed structure of the proposed dual-polarized radiation element with periodic boundary is depicted in Fig. 1. The element consists three parts: a radiation part, an upper IMGW and a bottom IMGW, which can be fabricated by multilayer substrates. The radiating element is a bowtie antenna, resembling a magneto-electric dipole structure. To achieve dual linear polarization, the element is fed by feeding-via 1 and feeding-via 2, and these two vias are connected with the upper IMGW and the bottom IMGW, respectively. The excitation structure for the bowtie is r-shaped, which can obtain a good impedance matching over a

wide frequency range [10],[11]. Energy excited in bottom IMGW propagates a long path (longer than the path for the upper IMGW) from the bottom IMGW to the radiation element, and this makes the impedance matching a difficult task. To solve this problem, a matching via from top layer to bottom IMGW feeding layer is used.

The size of the radiation element is about $6 \times 6 \times 6.1 \text{ mm}^3$. Rogers RT5880 with dielectric constant of 2.2 is used as superstrate, and other substrate is Astra MT77 with dielectric constant of 3.0. The diameter of vias is chosen as 0.3 mm considering fabrication process feasibility.

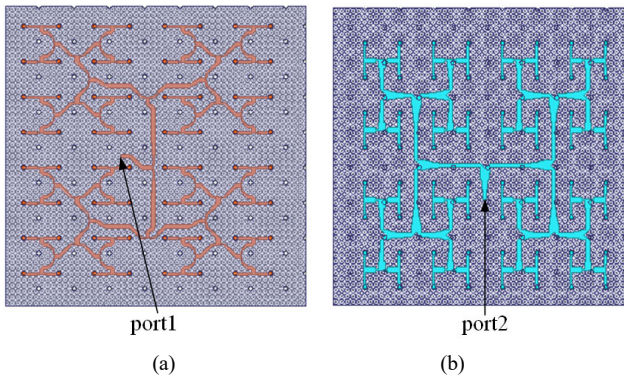


Fig. 2. IMGW Feeding networks: (a) the upper IMGW, (b) the bottom IMGW.

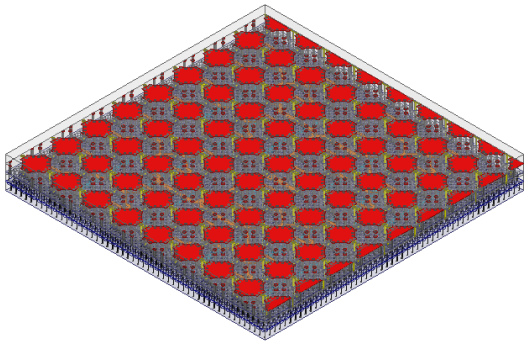


Fig. 3. Geometry of the proposed dual-polarized array antenna.

B. 8×8 dual-polarized array antenna

The proposed dual-polarized array antenna consists of 8×8 elements. To feed the elements, the feeding networks in the upper IMGW and the bottom IMGW are designed and shown in Fig. 2. Fig. 3 shows the overall structure of the proposed array. Its size is $51 \times 51 \times 6.1 \text{ mm}^3$. To obtain a good impedance matching, the parameters of the feeding networks are optimized.

III. SIMULATION RESULTS

The proposed array is simulated using CST Microwave Studio, by full wave simulations. The simulated reflection coefficient and mutual coupling for both ports is given in Fig. 4. It is seen that the relative impedance bandwidth is about 54.2% covering 19.2 – 33.5 GHz for both polarizations with the reflection coefficients less than -10 dB. The mutual

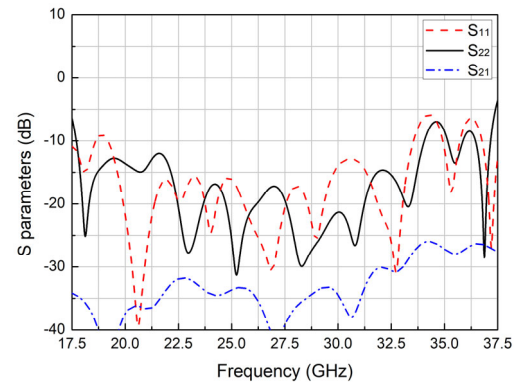


Fig. 4. Simulated S parameters of the proposed dual-polarized array antenna.

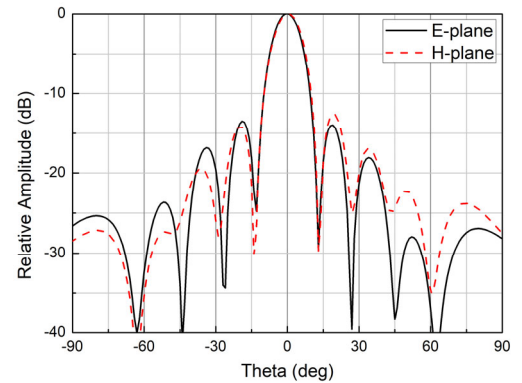


Fig. 5. Simulated radiation patterns of the proposed dual-polarized array antenna at 27.5 GHz when port 2 is excited.

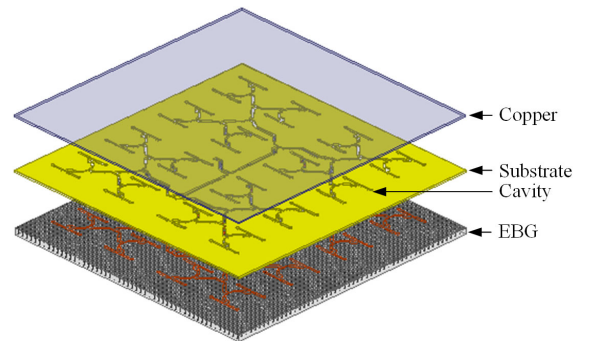


Fig. 6. The proposed partly air-filled IMGW.

coupling (S_{21}) between the two orthogonally polarized ports is less than -27 dB which is also an important feature while considering high gain amplifier integration. The simulated radiation patterns at 27.5 GHz when port 2 is excited are presented in Fig. 5. The sidelobe levels are about -13 dB below the main beam level. The simulated gain is within the range from 19.3 dBi to 24.9 dBi and the corresponding total efficiency is above 60% over the whole band.

As mentioned above, the proposed dual-polarized array antenna has good performance and can be fabricated by multilayer substrates PCB process. However, dielectric-based IMGW has its own drawbacks that the usage of full

dielectric structure will reduce antenna efficiency due to dielectric loss. To solve this problem, we can use partly air-filled IMGW shown in Fig. 6. We take away part of substrate to form a cavity having nearly the same shape of propagating path. So the dielectric loss can be reduced. The feasibility of the partly air-filled IMGW with PCB process will be discussed in future work.

IV. CONCLUSION

A wideband dual polarized planar array antenna based on dielectric-based inverted microstrip waveguide is proposed. Using planar bowtie antenna as element, the proposed 8×8 array antenna shows the reflection coefficient bandwidth ($|S_{11}| < -10$ dB) of 54.2% covering 19.2 -33.5 GHz frequency range. To the author's knowledge, it has the widest bandwidth among planar array antenna based on gap waveguide technology.

REFERENCES

- [1] Y. Zhao and Kwai-Man Luk, "Dual circular-polarized SIW-Fed high-gain scalable antenna array for 60 GHz applications," *IEEE Transactions on Antennas and Propagation*, vol. 66, no. 3, pp. 1288-1298, 2018.
- [2] H. F. Xu, J. Y. Zhou, K. Zhou, Q. Wu, Z. Q. Yu, and W. Hong, "Planar wideband circularly polarized cavity-backed stacked patch antenna array for millimeter-wave applications," *IEEE Transactions on Antennas and Propagation*, vol. 66, no. 10, pp. 5170-5179, 2018.
- [3] M. S. Sorkherizi, A. Dadgarpour, and A. A. Kishk, "Planar high-efficiency antenna array using new printed ridge gap waveguide technology," *IEEE Transactions on Antennas and Propagation*, vol. 65, no. 7, pp. 3772-3776, 2017.
- [4] A. Vosoogh, M. S. Sorkherizi, A. U. Zaman, J. Yang, and A. A. Kishk, "An integrated Ka-band diplexer-antenna array module based on gap waveguide technology with simple mechanical assembly and no electrical contact requirements," *IEEE Transactions on Microwave Theory and Techniques*, vol. 66, no. 2, pp. 962-972, 2018.
- [5] P. Taghikhani, J. Yang, and A. Vosoogh, "High gain V-band planar array antenna using half-height pin gap waveguide," in 2017 11th European Conference on Antennas and Propagation (EUCAP). IEEE, 2017, pp. 2758-2761.
- [6] J. Liu, A. Vosoogh, A. U. Zaman, and P. S. Kildal, "Design of a cavity-backed slot array unit cell on inverted microstrip gap waveguide," in International Symposium on Antennas and Propagation (ISAP). IEEE, 2015, pp. 1-4.
- [7] A. U. Zaman and P.-S. Kildal, "GAP Waveguides," *Handbook of Antenna Technologies*, Z. N. Chen et al. Eds., Springer, 2016, pp. 3273-47.
- [8] J. Liu, A. Vosoogh, A. U. Zaman, J. Yang, "Design and fabrication of a high-gain 60-GHz cavity-backed slot antenna array fed by inverted microstrip gap waveguide," *IEEE Transactions on Antennas and Propagation*, vol. 65, no. 4, pp. 2117-2122, 2017.
- [9] J. Liu, J. Yang and A. Zaman, "Analytical Solutions towards Inverted Microstrip Gap Waveguide for Characteristic Impedance and Losses Based on Variational Method," *IEEE Transactions on Antennas and Propagation*, vol. 66, 2018.
- [10] S. M. Moghaddam, J. Yang, and A. A. Glazunov, "Ultra-wideband millimeter-wave bowtie antenna," in International Symposium on Antennas and Propagation (ISAP). IEEE, 2017, pp. 1-2.
- [11] S. M. Moghaddam, J. Yang, A. A. Glazunov, "A planar dual-polarized ultra-wideband millimeter-wave array antenna," in 2018