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A dual-polarized Fabry–Pérot antenna with high-gain and wide bandwidth for millimeter-wave applications

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Key words: Dual polarized; Fabry–Pérot cavity antenna; Partially reflective surface integrated with Fresnel zone lens; Millimeter-wave band; High-gain; Wideband

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Motivation

1. To compensate for the propagation loss with millimeter waves (mmWaves), antennas of low-cost and high-gain characteristics are always sought by the communication industry. Fabry-Pérot cavity (FPC) antenna is a promising way of obtaining a directive beam.
2. In the microwave band, chessboard-arranged metamaterial superstrate, sparse array excitation method, and 1D electromagnetic band gap (EBG) PRS are often used for high-gain FPC antenna designs. However, it is difficult for these designs to be scaled to the mmWave band because their complexity in structure makes high-frequency fabrication difficult.
3. For mm-Wave applications, up to now, several FPC antennas have been realized using a single-layer superstrate. However, these antennas suffer from narrow bandwidth and low gain, and the designs are realized with linear polarized radiation only.

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Main idea

1. In this study, a mmWave DP FPC antenna is introduced. The proposed antenna is composed of a DP feeding source, a Fresnel zone lens (FZL) integrated PRS, a quasi-curved reflector, and 3D printed supporters.
2. The proposed feeding source achieves DP radiation characteristics within a wide frequency range, which ensures wideband performance of the FPC antenna. At the same time, the proposed feeding source can achieve a high isolation level between the two polarizations.
3. The proposed PRS with integrated FZL provides wave reflection and phase correction in the FP cavity, contributing to a high antenna gain for the antenna.

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Method

1. An SIW-fed DP source antenna as shown in Fig. 2 is designed. It consists of three SIW layers. The radiator is a magnetic-electric dipole with symmetric structure along the *x* and *y* axes. The antenna is excited by feeding slots.

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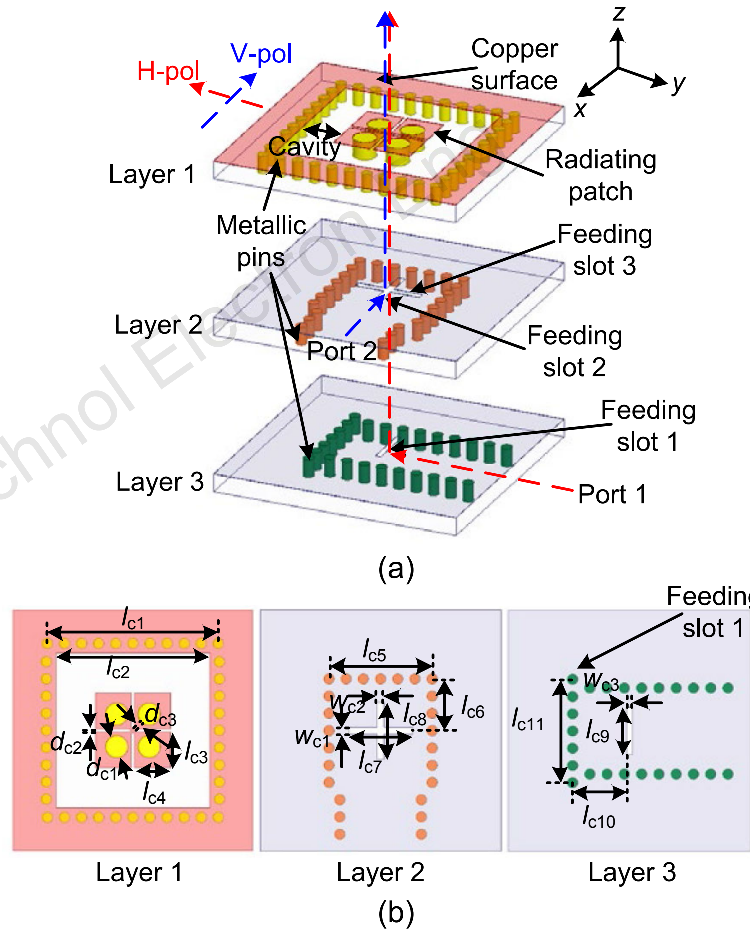

Fig. 2 Configuration of the proposed dual-polarized feeding source (a) and the layer-by-layer demonstration of the source antenna (b)

Method (Cont'd)

2. Based on the operating scheme of FPC and FZL antennas, we introduce an FZL-integrated PRS as shown in Fig. 8c for high-gain FPC antenna realization. FZL is printed on the bottom surface of a PRS, to an integrated structure.

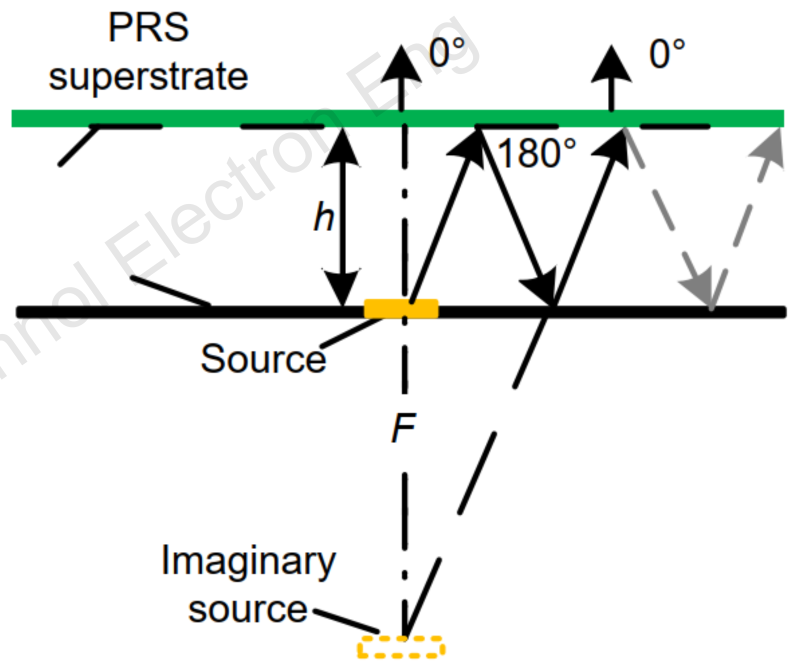

Fig. 8c Proposed FPC antenna using FZL-integrated PRS

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Method (Cont'd)

3. The four concentric strip rings in multilayer substrates make a quasi-parabolic plane, which is used to excite different Laguerre-Gaussian beam modes in the cavity. Hence, a wide gain bandwidth can be obtained.

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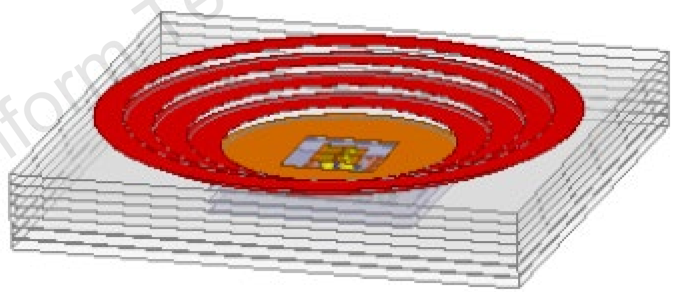
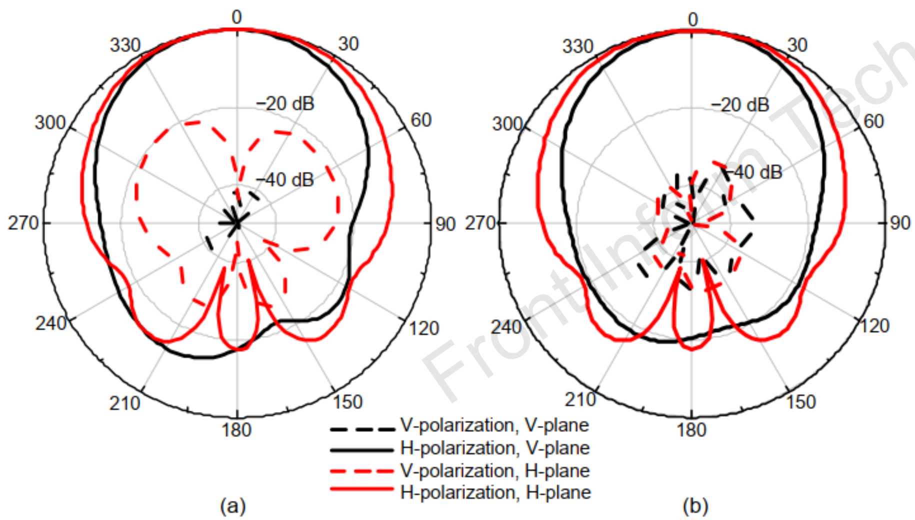


Fig. 6a Proposed quasi-parabolic plane

Major results

Performances of the dual-polarized feeding source



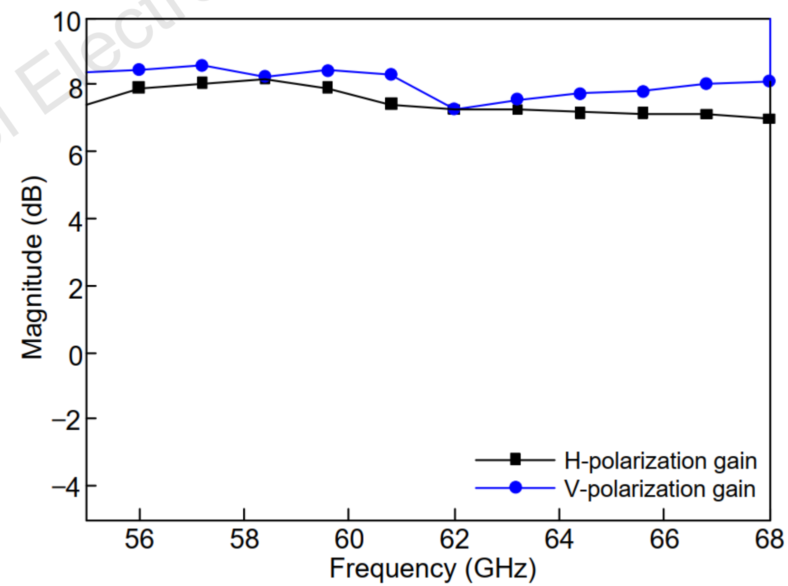


Fig. 5 Realized gain of the two polarizations

Fig. 3 Radiation patterns at 60 GHz of V-polarization (a) and H-polarization (b)

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Major results (Cont'd)

Performances of the total antenna structure

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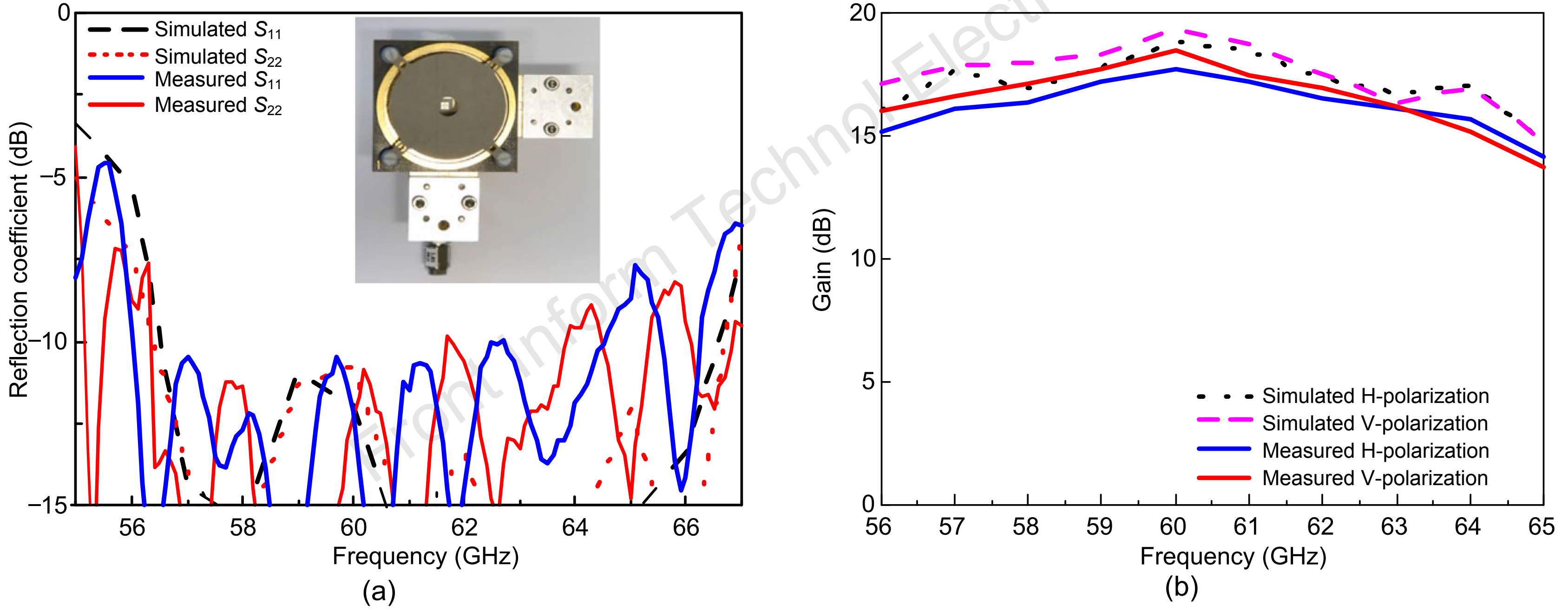

Fig. 11 Simulated and measured reflection coefficients (a) and antenna gains (b) (Insertion in (a) is the fabricated antenna prototype)

Major results (Cont'd)

Performances of the total antenna structure

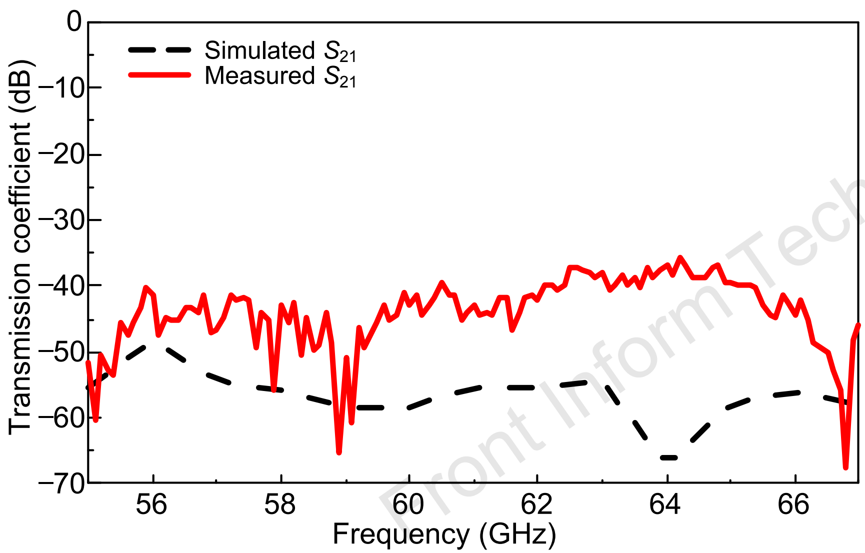

Fig. 12 Simulated and measured transmission coefficients between two polarizations

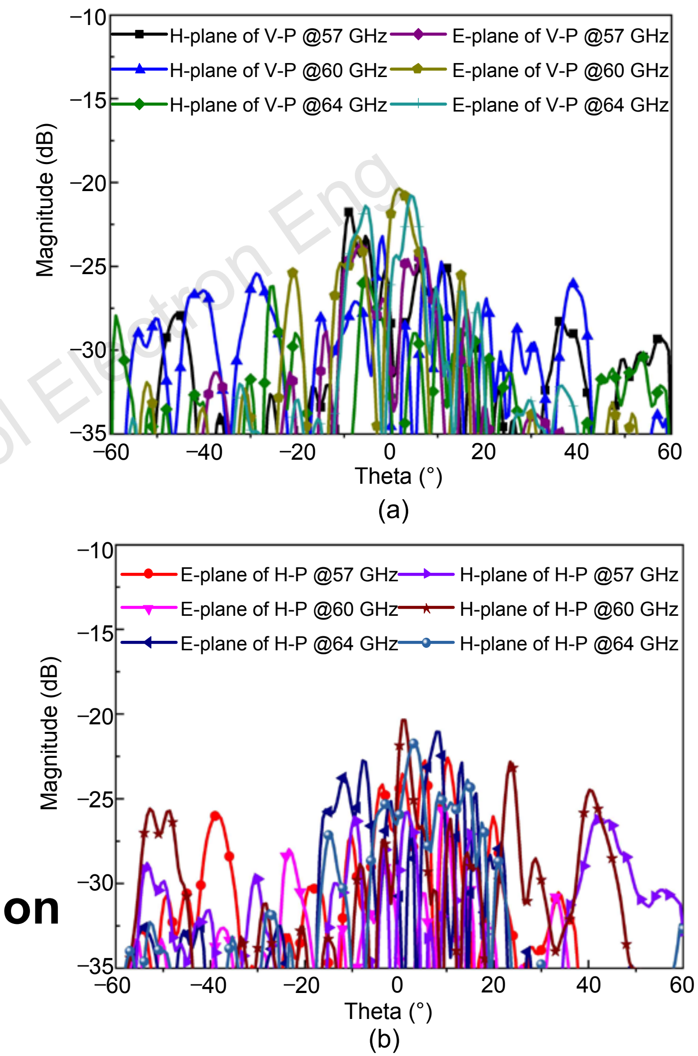

Fig. 15 Measured cross-polarizations of V-polarization (V-P) (a) and H-polarization (H-P) (b) at different frequency points

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Major results (Cont'd)

Performances of the total antenna structure

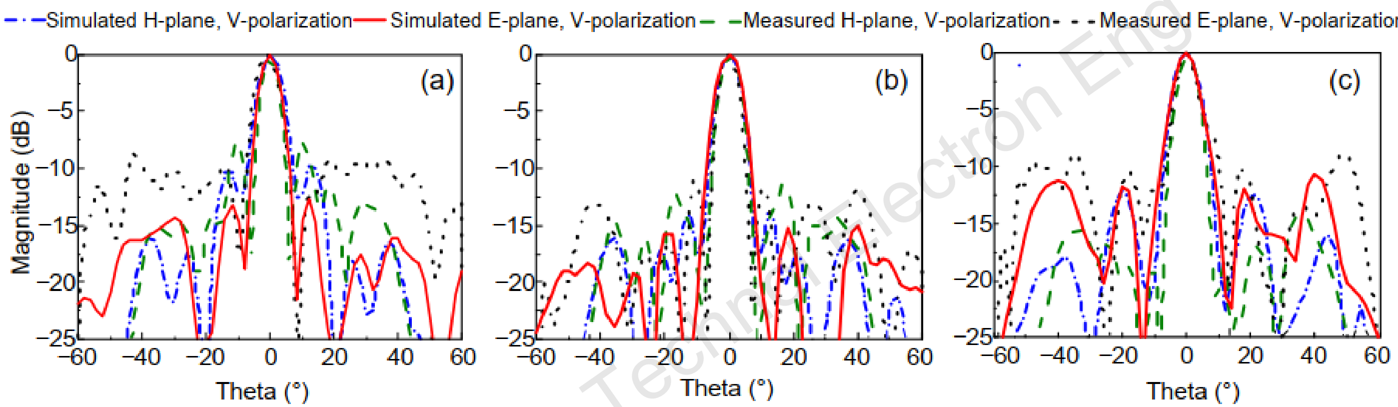

Fig. 13 Simulated and measured radiation patterns for antenna operating at *f*=57 GHz (a), 60 GHz (b), and 64 GHz (c) when port 1 is excited (V-polarization)

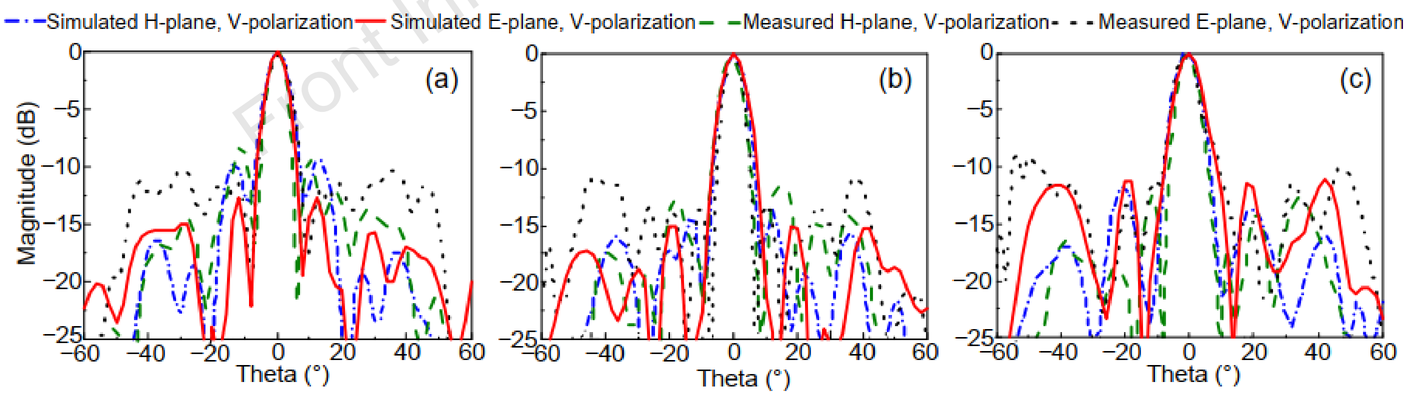

Fig. 14 Simulated and measured radiation patterns for antenna operating at *f*=57 GHz (a), 60 GHz (b), and 64 GHz (c) when port 2 is excited (H-polarization)

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Conclusions

1. A design of a high-gain mmWave FPC antenna has been presented. The proposed antenna demonstrates a directive beam for DP radiations. A DP feeding source and a PRS integrated with FZL were proposed.

2. This work demonstrates the implementation of a DP FPC antenna with a high gain and wideband performance while maintaining high isolation for two polarizations.

3. The antenna obtains the maximum gains of 18.4 and 17.6 dBi, for vertical and horizontal polarizations, respectively, and yields an impedance bandwidth of 14% with high isolation of 40 dB. This antenna will find potential applications in various wireless mmWave communication systems.

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