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Low-cost high-order-mode cavity backed slot array antenna using empty substrate integrated waveguide for the 5G n260 band

Key words: Low cost; High-order mode; Empty substrate-integrated waveguide (ESIW); Printed circuit board (PCB); Millimeter wave

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Motivation

1. Dielectric loss in substrate-integrated waveguide (SIW) cannot be neglected in the mmWave regime. Low-loss materials are needed to achieve high efficiency, which will greatly increase the cost.
2. Empty SIW (ESIW) reduces the dielectric loss of SIW, which can be realized by any PCB material. Thus, the fabrication cost can be reduced.
3. High-order-mode technology is quite important for ESIW antennas in mmWave bands because fabrication precision cannot be achieved in complicated high-density feeding networks. Furthermore, simplified feeding networks can reduce much insertion loss, resulting in high-gain and high-efficiency antennas.

Subarray design

The proposed 3×4-slot subarray is excited by an empty substrate integrated waveguide cavity (Fig. 1). TE_{340} mode can be excited in the cavity through a coupling slot on the third layer.

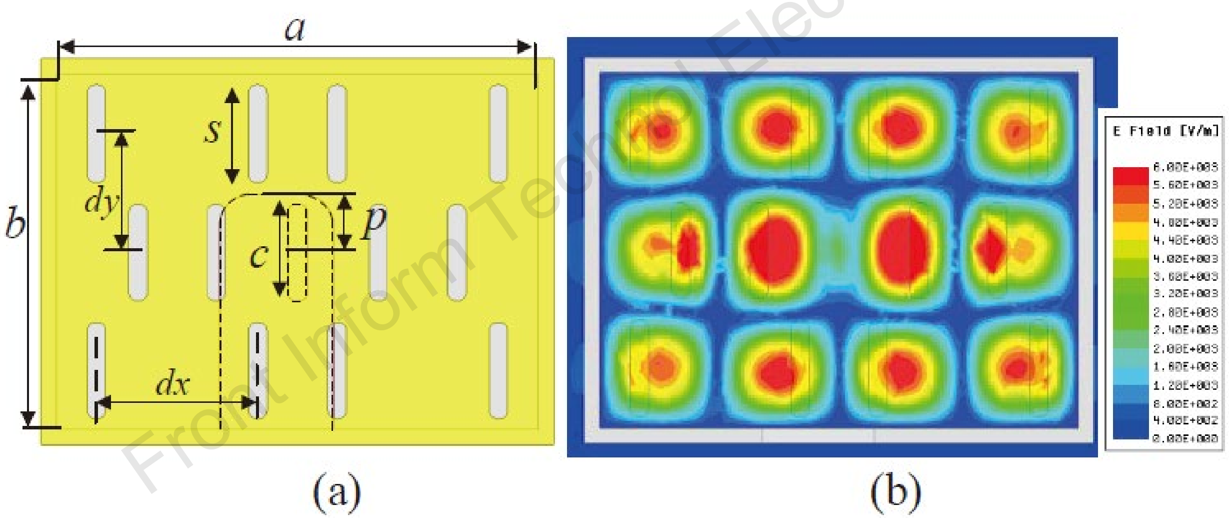

Fig. 1 The proposed 3×4 subarray: (a) dimensions of the subarray; (b) E-field distribution of the proposed subarray at 38 GHz

Subarray design

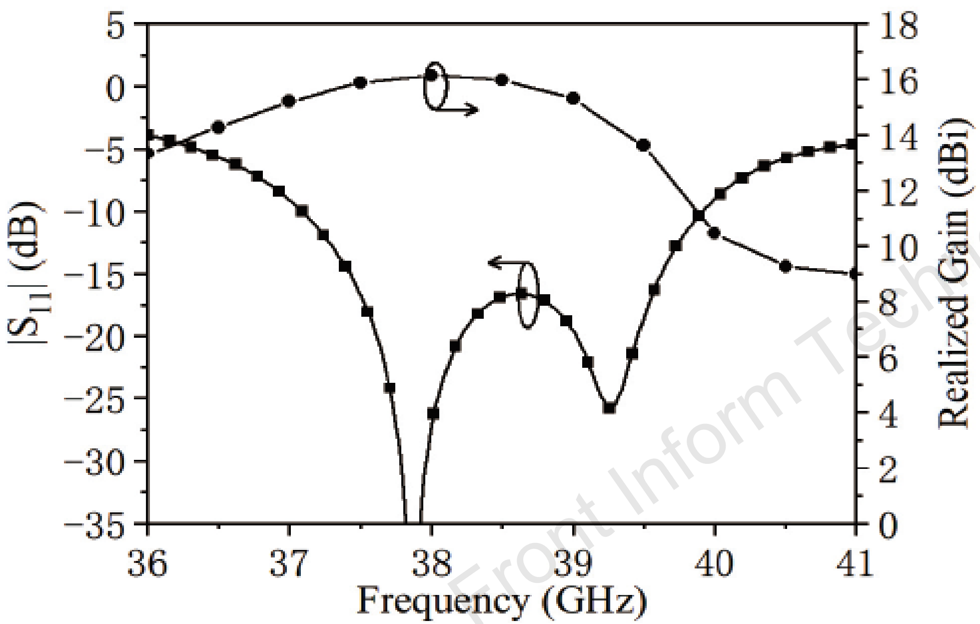

Fig. 2 Simulated $|S_{11}|$ and realized gain of the 3×4-slot subarray

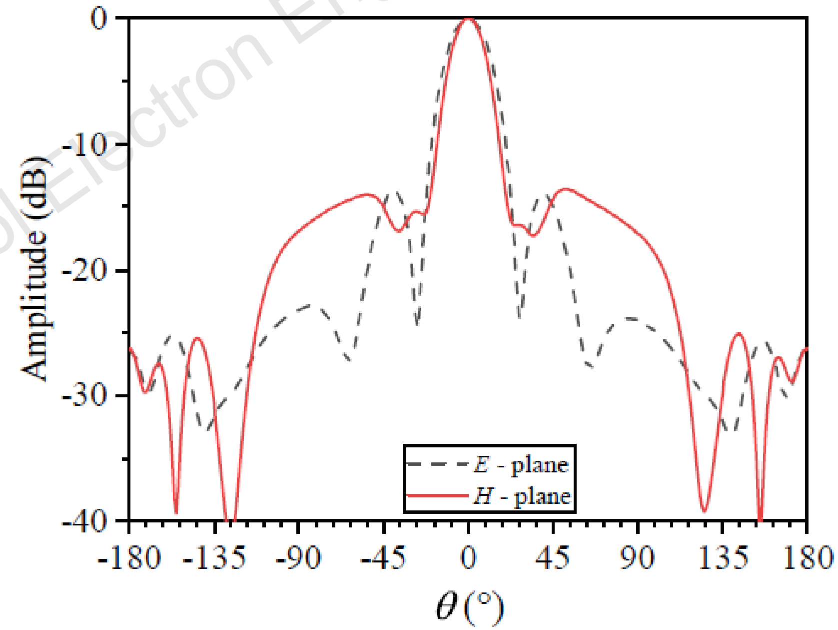

Fig. 3 Simulated radiation patterns at 38 GHz of the 3×4-slot subarray

12×16-slot array

The proposed 12×16-slot array is constructed with five PCB layers. All of the layers use the FR-4 substrate.

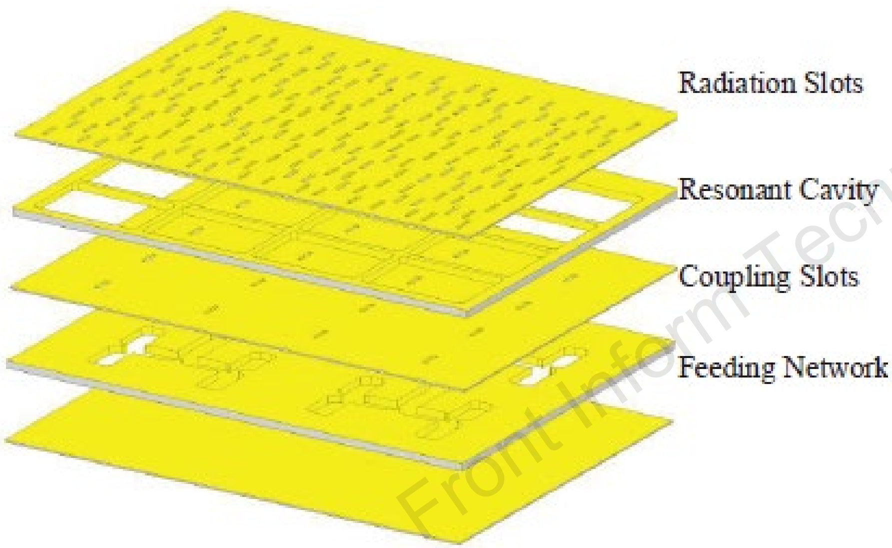

Fig. 4 Exploded view of the proposed slot array antenna

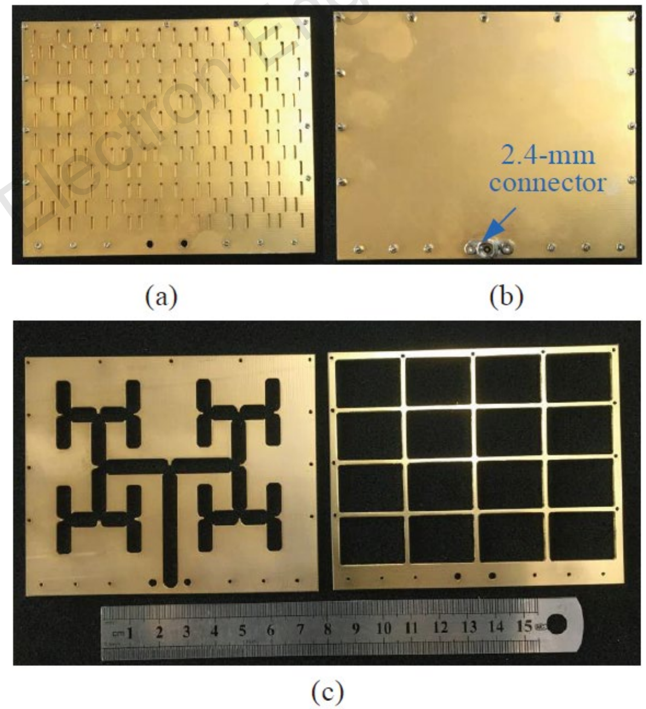

Fig. 7 Photographs of the fabricated slot array antenna: (a) top view of the assembled antenna; (b) bottom view of the assembled antenna; (c) feeding network layer and high-order-mode cavity layer

12×16-slot array

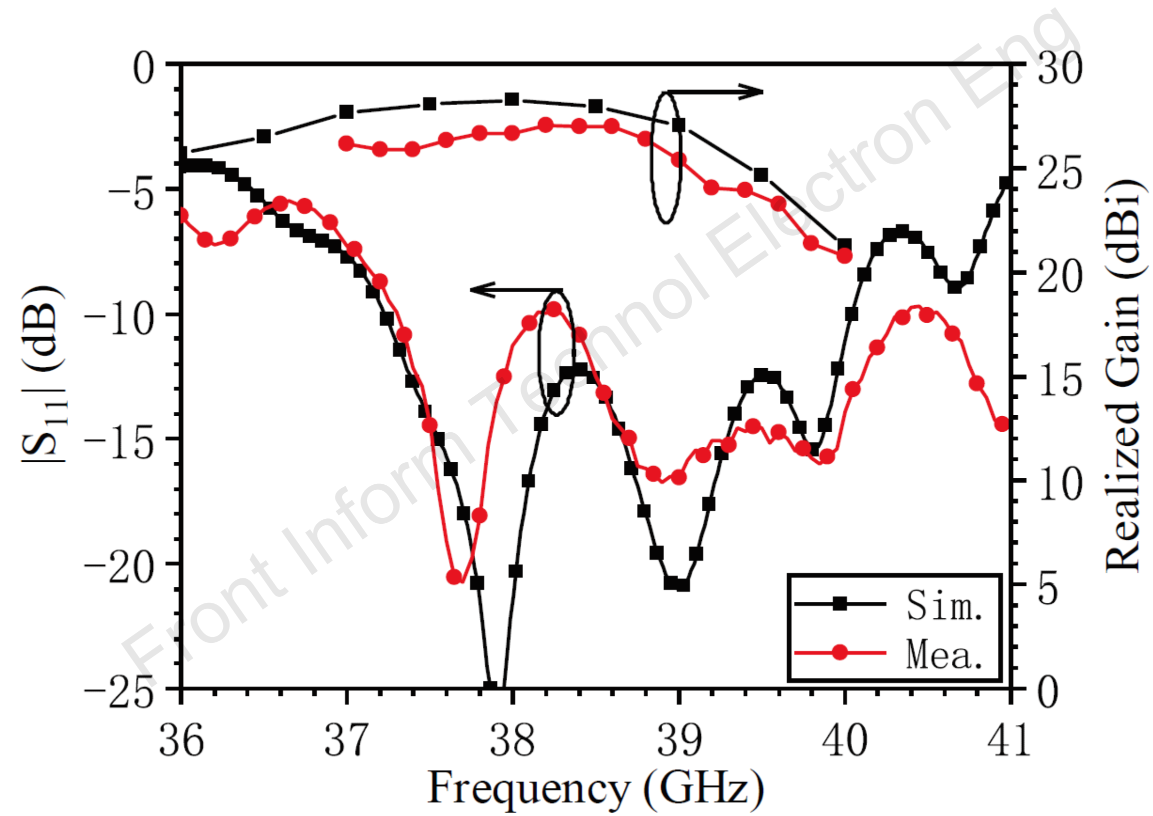

Fig. 8 Simulated and measured reflection coefficients and realized gains of the slot array antenna with a 2.4-mm connector

12×16-slot array

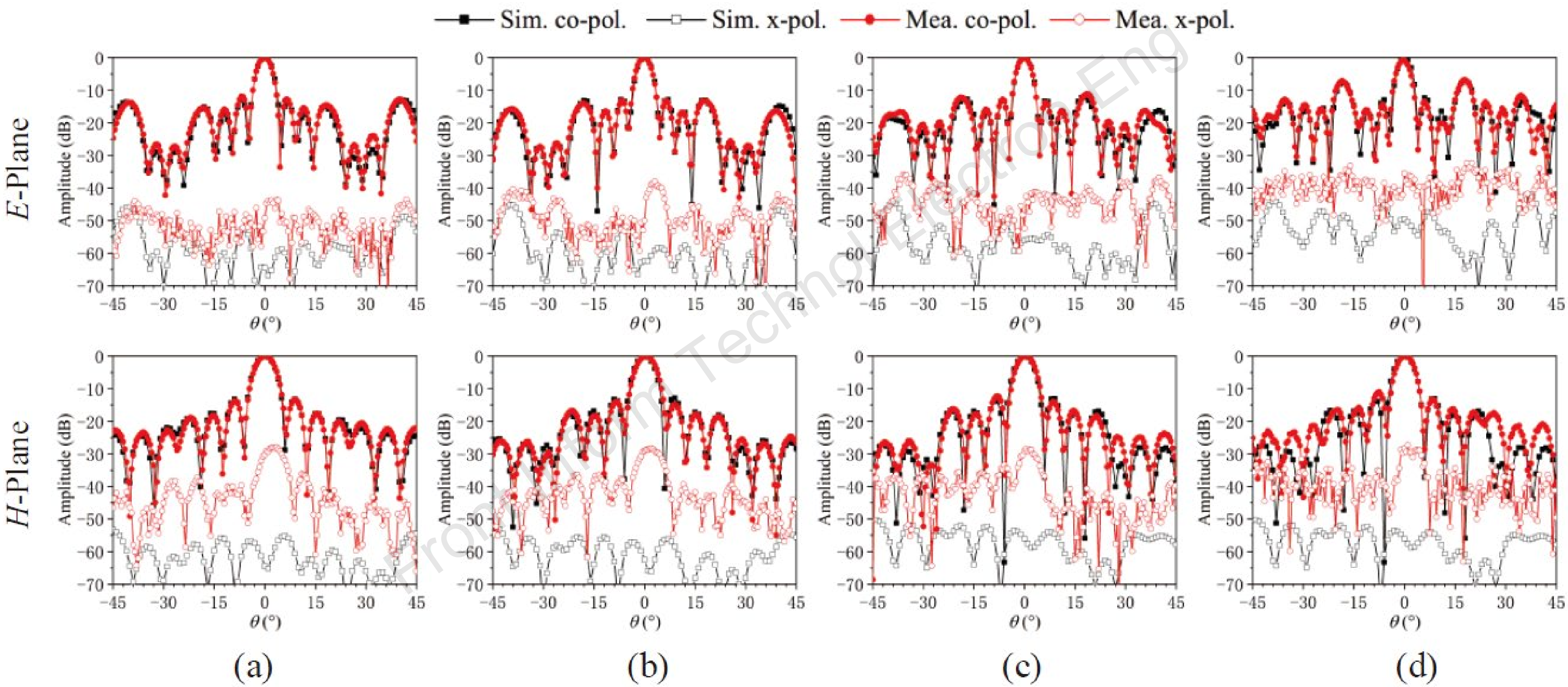

Fig. 9 Normalized radiation patterns of the slot array at 37 GHz (a), 38 GHz (b), 39 GHz (c), and 40 GHz (d)

Conclusions

1. This paper presented a low-cost, high-gain slot array antenna based on FR-4 PCB material for the 5G n260 band.
2. The proposed antenna shows a maximum realized gain of 27 dBi with a radiation efficiency of 72.4%.
3. The simplified feeding network implemented by high-order-mode cavities resulted in a high radiation efficiency.
4. The performance was verified experimentally using a practical structure. Measurement results show good agreement with simulation results.