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# Planar dual-polarized millimeter-wave shared-aperture array antenna with high band isolation



**Key words:** Shared-aperture; Planar antenna; Millimeter-wave antenna; High isolation; Substrate integrated waveguide (SIW)

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# Motivation

- Modern wireless system usually adopts multiple antennas for the application of multiple polarization and multiple operating frequency bandwidth. These antennas usually occupied large space in the system.
- Miniaturized system requires the antenna have a very compact size and high integration performance.
- Millimeter-wave (mm-wave) wireless systems have become popular due to the wide available frequency bandwidth. When multiple mm-wave antennas integrated tightly together, it is hard to realize a high isolation in a wide frequency bandwidth for each antenna.
- Planar shared-aperture antennas have merits of very compact size and multiple-functions such as different polarizations and operating bandwidths. However, it is a challenge to design both the element and array in the mm-wave band, and only rare few works have been reported with good performance in recent years.

# Shared-aperture element antenna

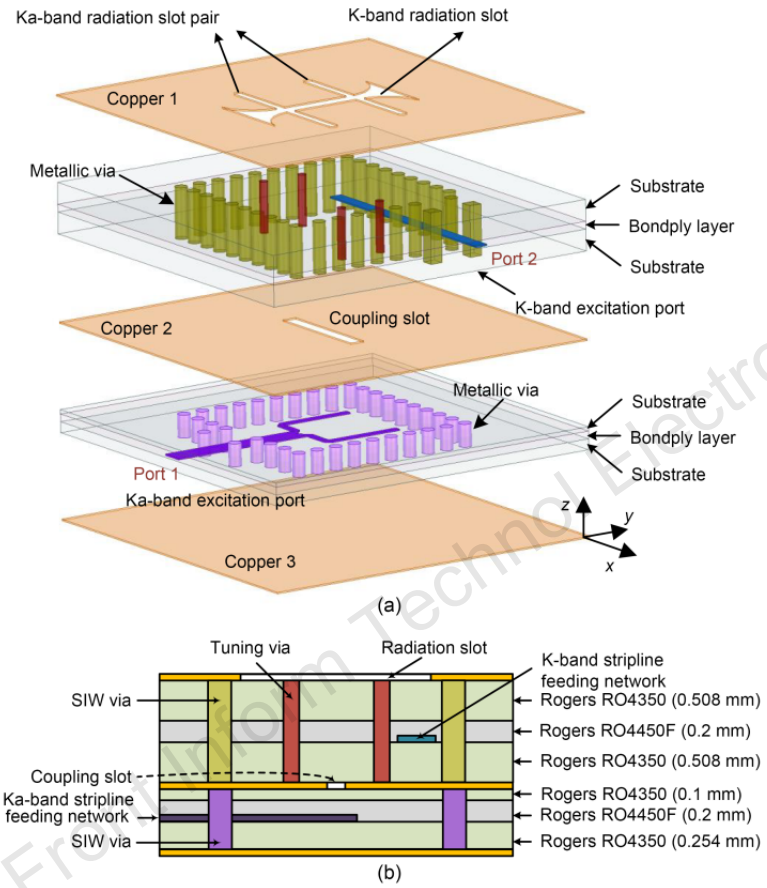


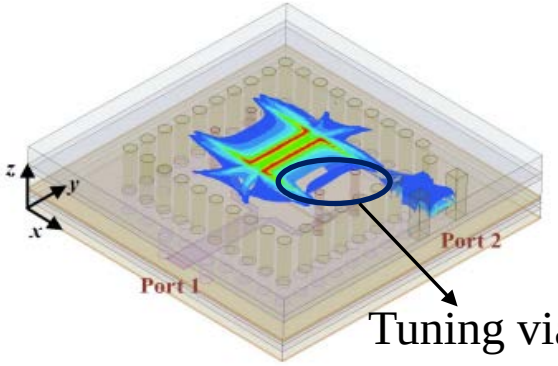

**Fig. 1 Configuration of the proposed K-/Ka-band shared-aperture antenna element: (a) three-dimensional view; (b) cross-sectional view**

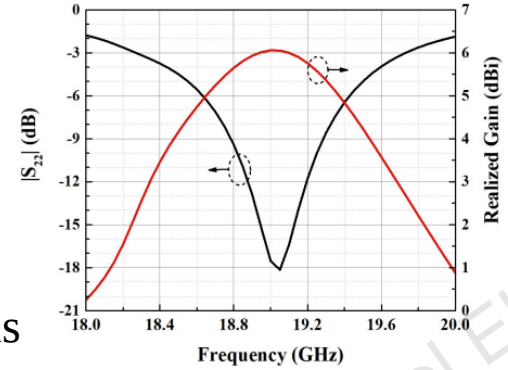


- the K- and Ka-band antennas are integrated and share the same radiation aperture on the top surface of the substrate integrated waveguide (SIW) cavity.
- **Ka-band antenna**: two rectangular slots, excited by the SIW cavity from port 1
- **K-band antenna**: a butterfly-shaped slot, excited by a stripline from port 2

# Shared-aperture element antenna

- K-band: the butterfly-shaped slot radiates the *x*-polarized wave



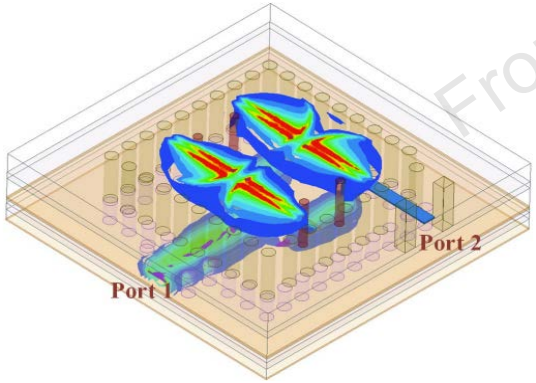



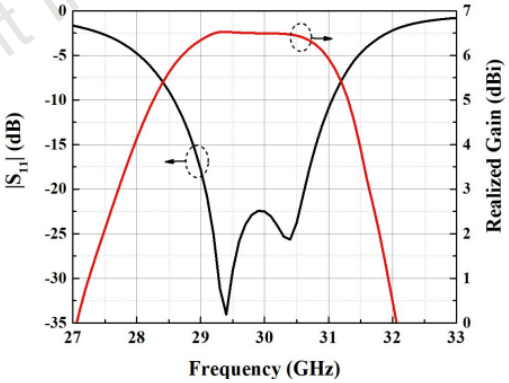

- A stripline in the upper substrate layers with an offset is adpoted (from port 2)
- Four metal vias are placed to obtain strong coupling and good impedance matching

Fractional bandwidth (FBW): 2.26% (18.82–19.25 GHz)

Realized gain: 6.06 dBi

- Ka-band: the slot pair radiates the *y*-polarized wave




- A forked stripline is adopted to excite the SIW cavity through coupling slot reducing unwanted radiation from the butterfly-shaped slot (from port 1)
- Double-point excitation help to generate two resonating peaks

FBW: 8.32% (28.58–31.06 GHz)

Realized gain: 6.53 dBi

# Shared-aperture element antenna

## ➢ Dual-band and dual-polarization performance

- The butterfly-shaped slot doesn't cut any surface current of SIW cavity when Ka-band element is operated
- The radiation fields are canceled because of opposite radiation phases in the slot pair when K-band element is operated

## ➢ High isolation due to weak coupling

- Two element support different modes, i.e., the quasi-$TE_{120}$ mode and the TEM-mode.
- Orthogonal polarization

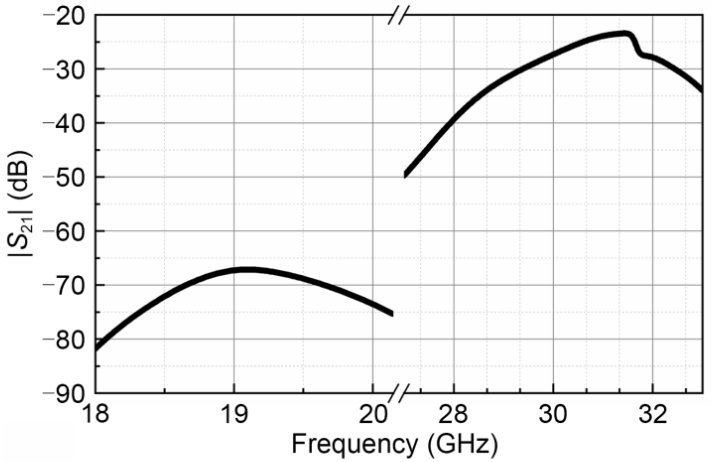
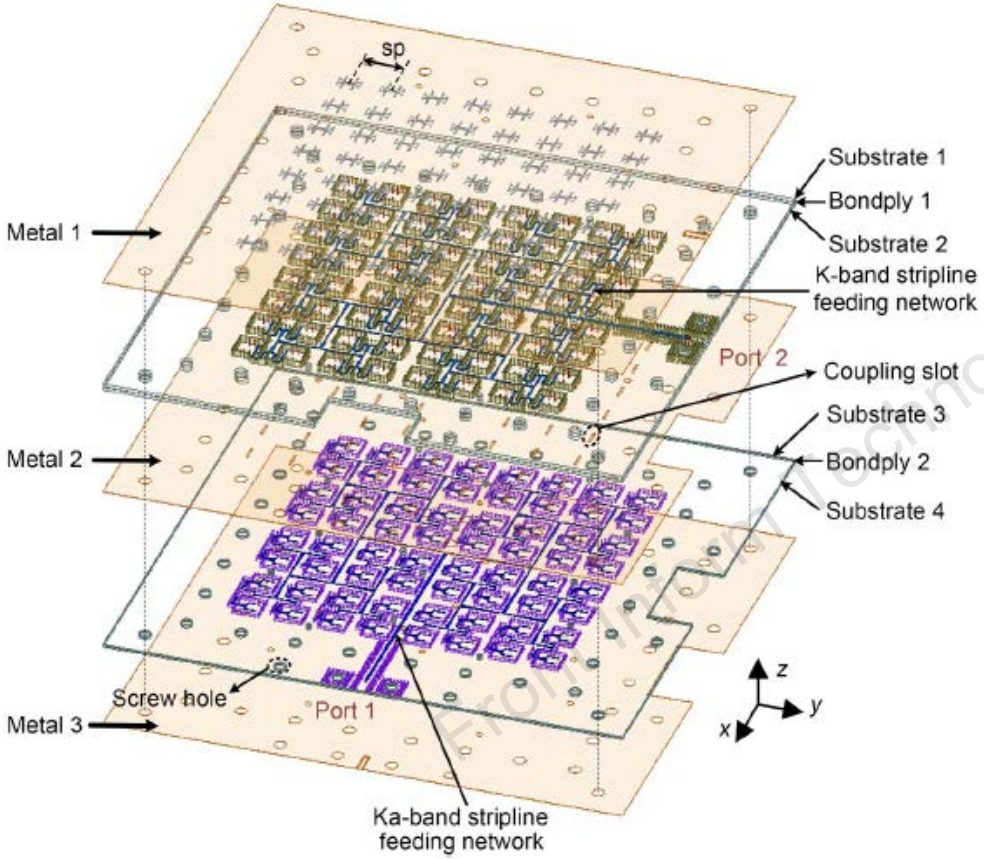


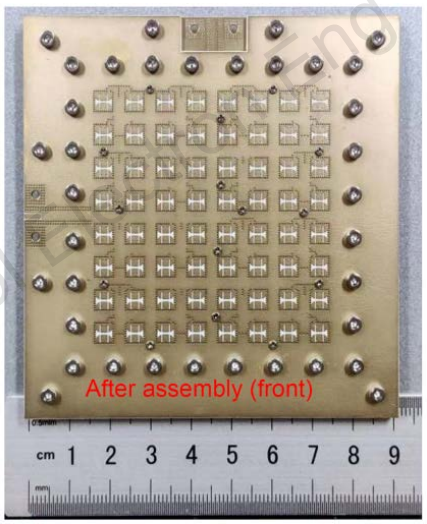

**Fig. 6 Simulated isolation between port 1 and port 2 of the antenna element**

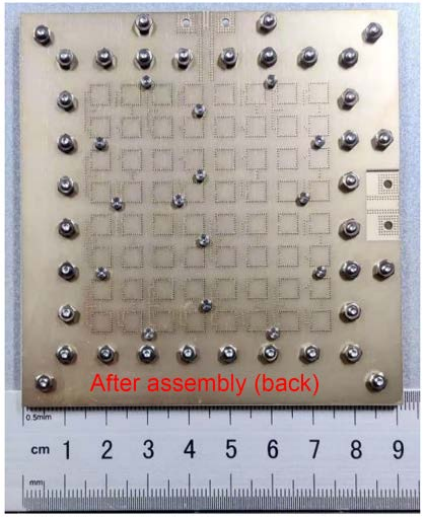
Isolation: > 65 dB in K-band
> 23 dB in Ka-band

# Shared-aperture array antenna

■ 8×8 array with parallel feeding networks




- Top two substrates and the bottom two substrates are fabricated separately and then aligned with screws

- The profile is only 1.91 mm

# Shared-aperture array antenna

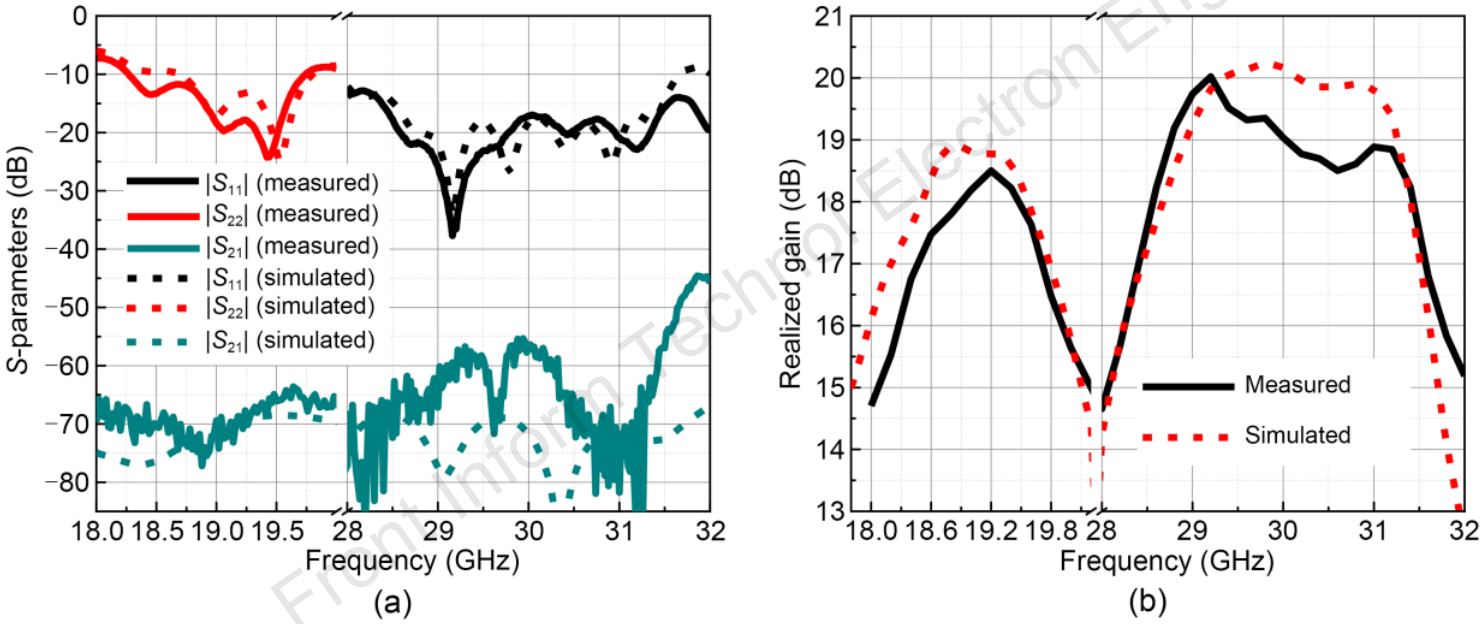
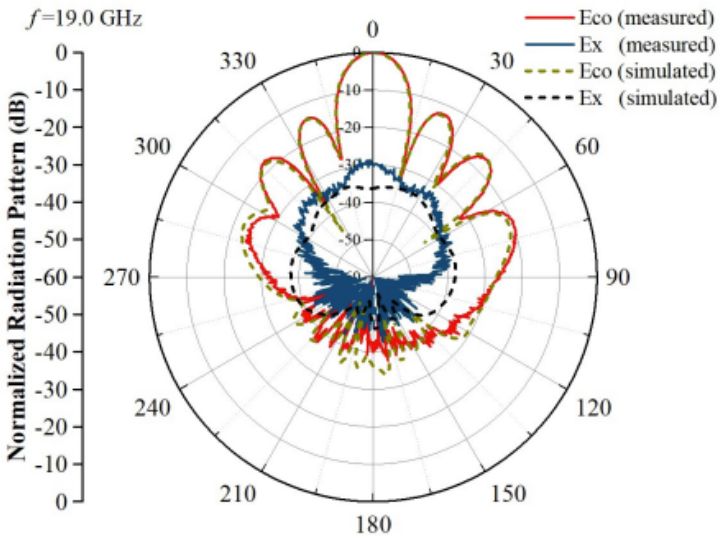


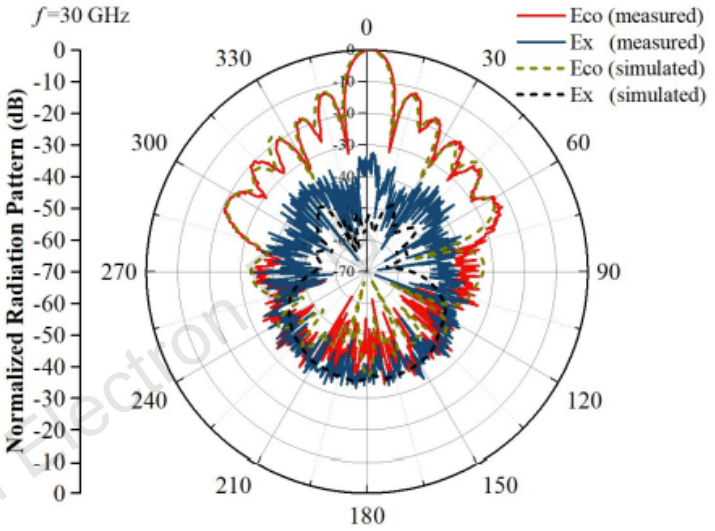



**Fig. 11 Simulation and measurement results of the shared-aperture array antenna: (a) magnitude responses for the *S*-parameters; (b) realized gain**

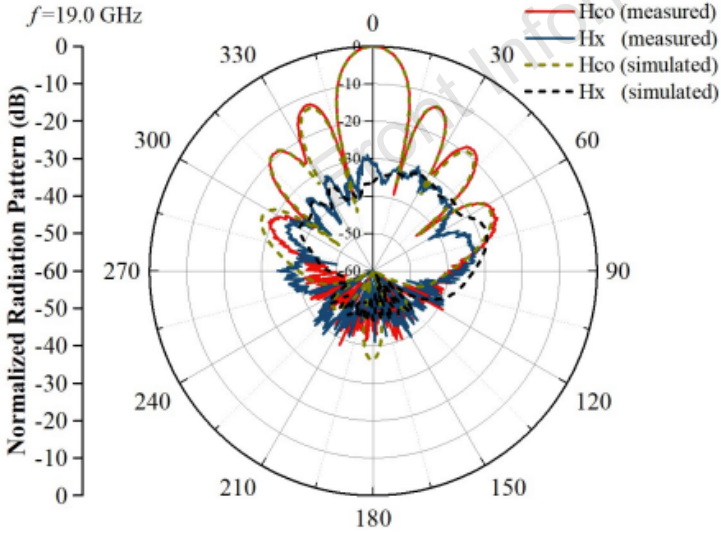
# Shared-aperture array antenna

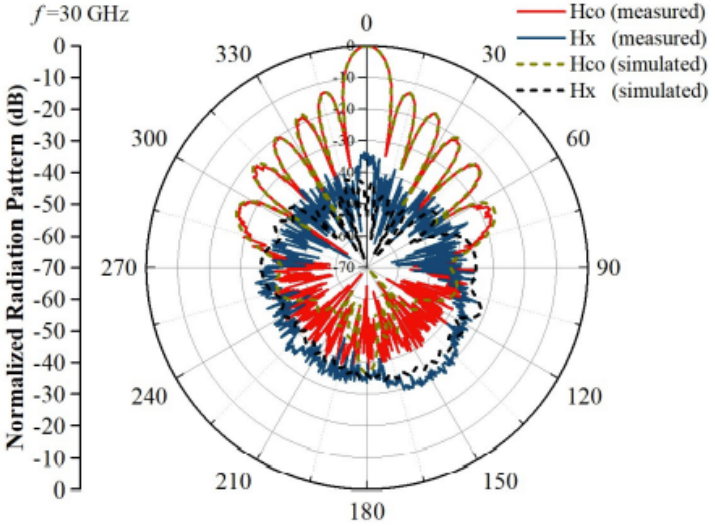



(b)




(b)



# Comparison & conclusions

**Table 1 Comparisons between the proposed and relative millimeter-wave shared-aperture array antennas**

| Reference | Array scale | Center frequency (GHz) | FBW (%) | Max gain (dBi) | Isolation (dB) | Size ($\lambda_u \times \lambda_u$) |
|---|---|---|---|---|---|---|
| Ferrando-Rocher et al. (2019) | 8×8 | 20/30 | 10/6 | 26/29.5 | 80/50 | 9.35×9.35 |
| Ding and Cheng (2019) | 4×4 | 16/34.7 | 12.5/4.1 | 13.2/17.2 | 70/28 | 3.2×1.7 |
| Guo et al. (2021) | 8×8 | 19/29 | 14.7/20.7 | 21.4/22 | 60/50 | 9.86×8.7 |
| This work | 8×8 | 19/30 | 7.73/20 | 18.5/20.02 | 60/44 | 5.8×5.8 |

$\lambda_u$ is the wavelength of the center frequency of the higher band. FBW is the fractional bandwidth. The numbers before and after "/" represent the corresponding performance of the two antennas with different center frequencies



- The proposed antenna has the advantages of dual-band operation capability, dual-polarization performance, high band isolation, planar form, and small size, and has great potential to reduce the size of wireless systems.
- The proposed antenna can also be used to support millimeter-wave satellite communication. A cross-radiation slot can be adopted instead of two types of radiation slots to generate circular polarization using a 90° phase feeding network.

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He has served as the TPC Chair/Co-Chair for many international conferences, such as iWat2018, ICMMT 2019. He has served as a Guest Editor for the IEEE T-MTT Special Issue on IWS 2018, an Associate Editor for the *IET Electronics Letters* and the *IET Microwaves, Antennas & Propagation*. He is a Member of the IEEE MTT-21 Terahertz Technology and Applications, Technical Committees.