MWP

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Compact and Robust Silicon Waveguide to Hollow Metallic Waveguide Coupling using a Quarter-Wave Dielectric Slot Waveguide for mmW and THz Waves

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Sessions 1

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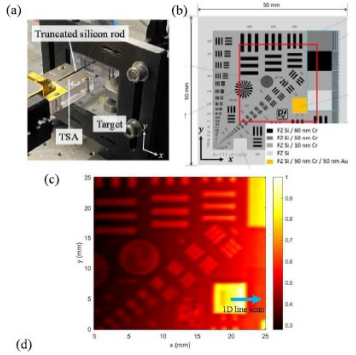
Silicon in Terahertz

- Intrinsic silicon supports:

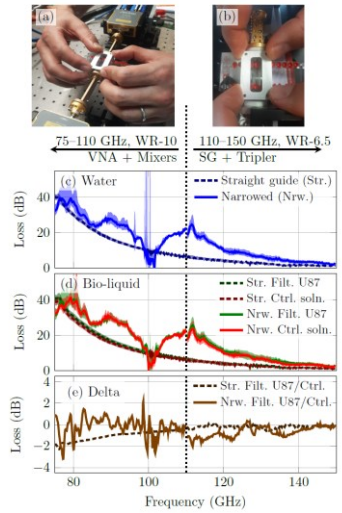
  low loss **Compactness** **Physical rigidity** **Cost-effective**

- Makes possible for various component for the application such as:

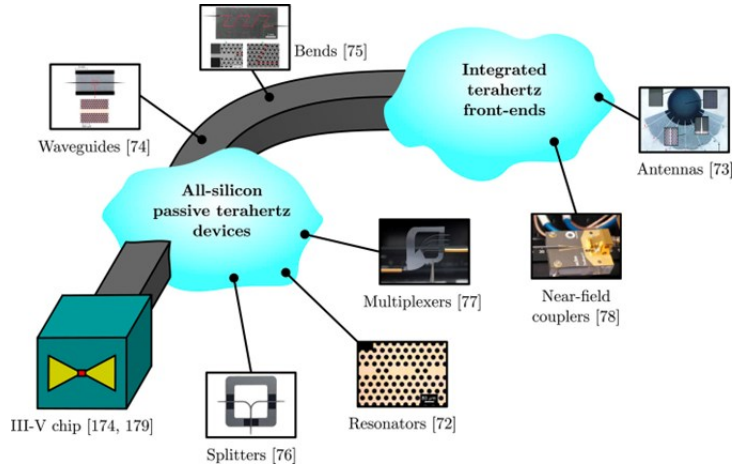
  - **THz imaging**
  - **THz sensing**
  - **THz spectroscopy**
  - **THz communication**



[Y. Kawamoto et.al, IRMMW 2023]



[D.Headland et.al, IRMMW 2023]



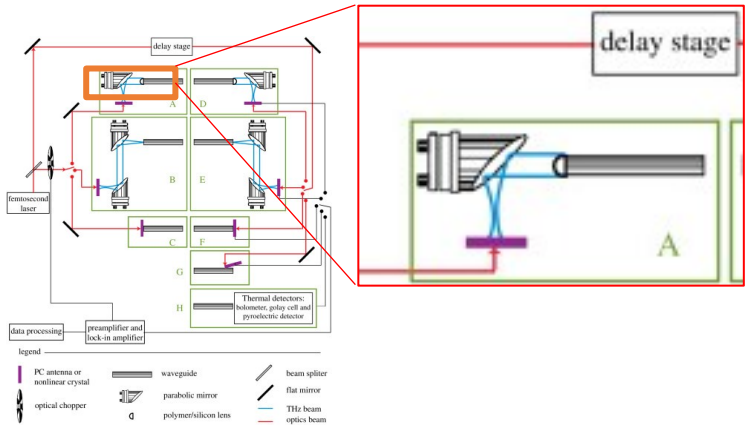
[D.Headland et.al, APL Photonics. 2023;8(9)]

All dielectric THz Feed

Main type of mmW and Terahertz couplers :

- Free-space beam

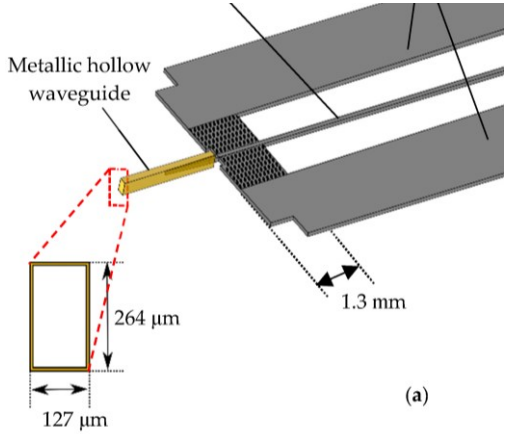
High feeding loss



[S. Atakaramians, et.al, Adv. Opt. Photonics, vol. 5, no. 2, 2013]

- Hollow waveguide

- **Compact and convenient port access**
- **Can be calibrated**



[R. Koala, R. Maru, et.al," *Photonics*, vol. 9, no. 8, 2022.]

Hollow waveguide-feed in THz

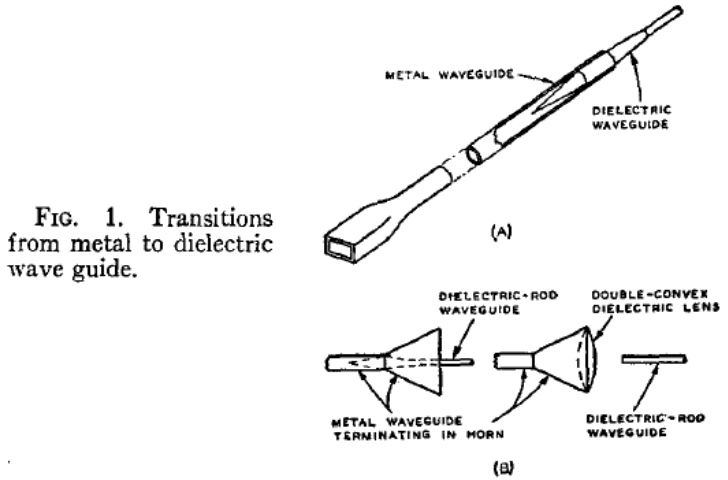
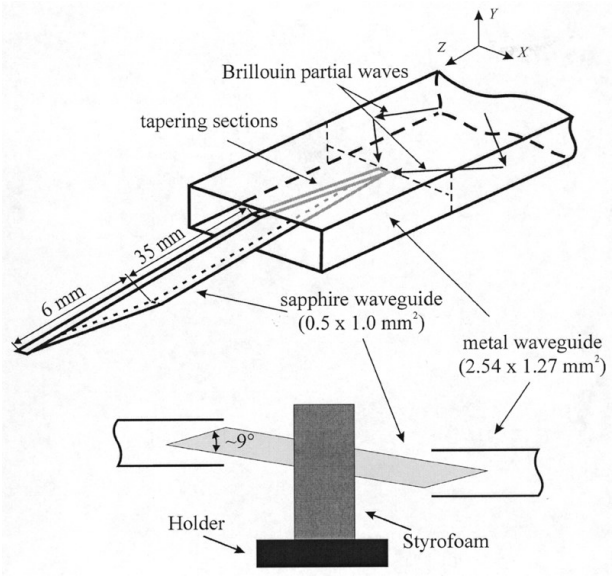


FIG. 1. Transitions from metal to dielectric wave guide.

1949

(a)

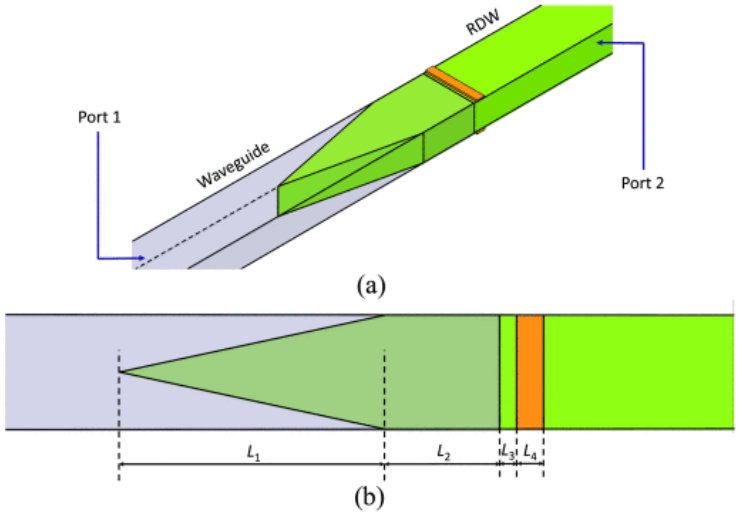
[C. H. Chandler, *J. Appl. Phys.*, vol. 20, 1949]



2001

(b)

[D. Lioubtchenko,et.al, *IEEE Microw. Wirel. Compon. Lett.*, vol. 11, 2001]



2020

(c)

[H. Zhu *et al.*, *IEEE Trans. Terahertz Sci. Technol.*, vol. 10, 2020]

Draw back

- **Major problems :**
  - Accidentally interfere with the internal structures
  - Can damage fragile components such as MMIC chips and monopole probes.
  - Can be left behind broken inside a hallow waveguide due to inserted part is a blind spot.

- **By avoiding the use of a taper**
  - Robustness
  - Reliability
  - Yield of integrated all-silicon terahertz devices and systems.

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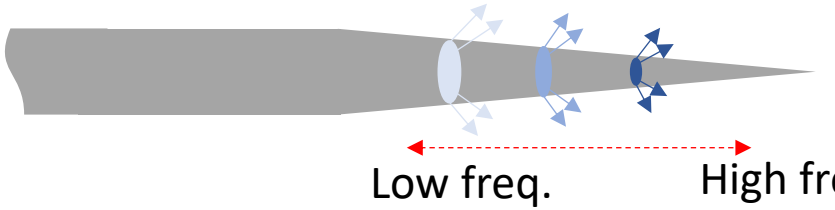
Feeding methods

Long rods rad center moves with freq.



Broadband

Low loss propagations

Long Tapered structure

Necessary for coupling from low ➔ High frequency

Short rods localization is well centered

Matching negatively impacted as no smooth index transition

Quarter-wave matched slot tip

Low reflection to matched frequency band (75-110 GHz)
smooth index transition

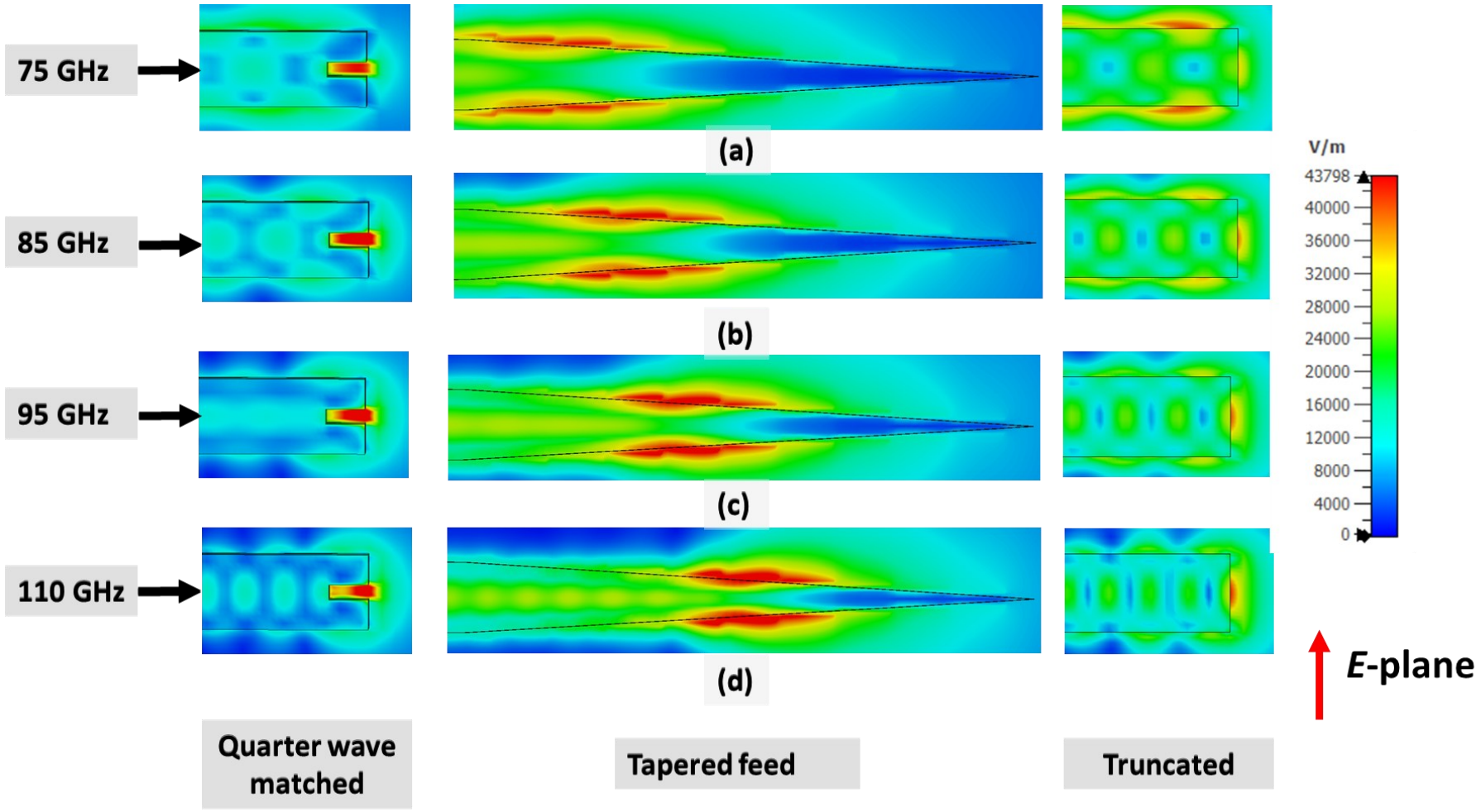
Operating principle

large discontinuity of electric field at a high-index-contrast interface to achieve a confine radiation center

free-space interface cancel with those from the input to the slot-guide section

Modal index of the dielectric slot waveguide is tailored with slot gap

E-field analysis



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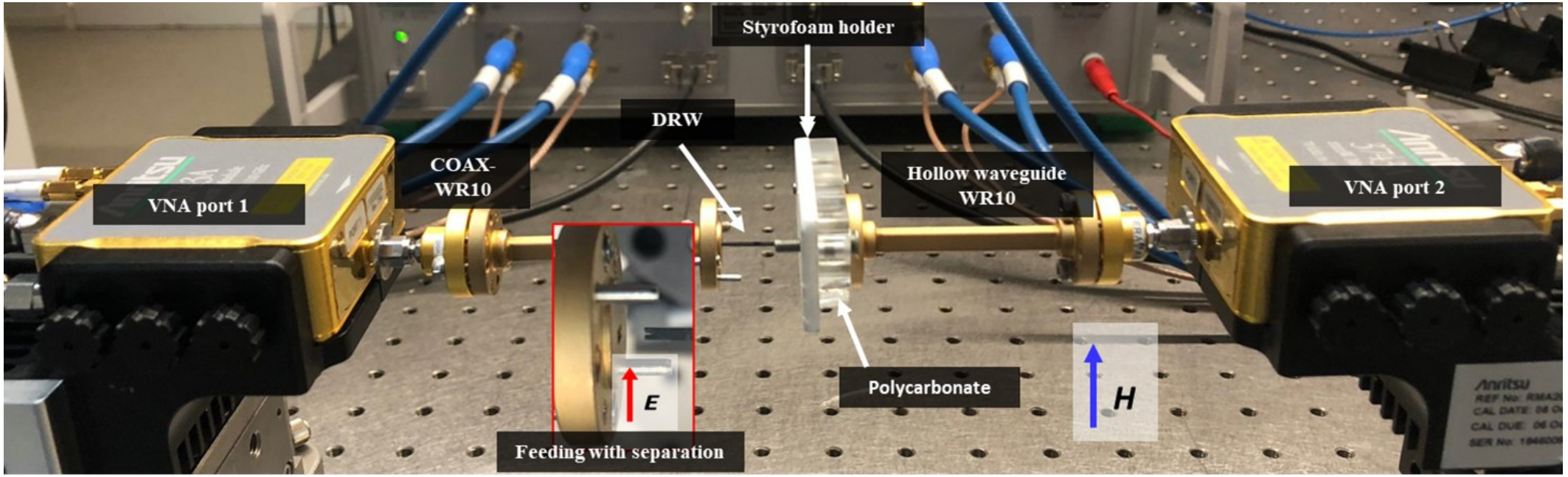
Experimental setup

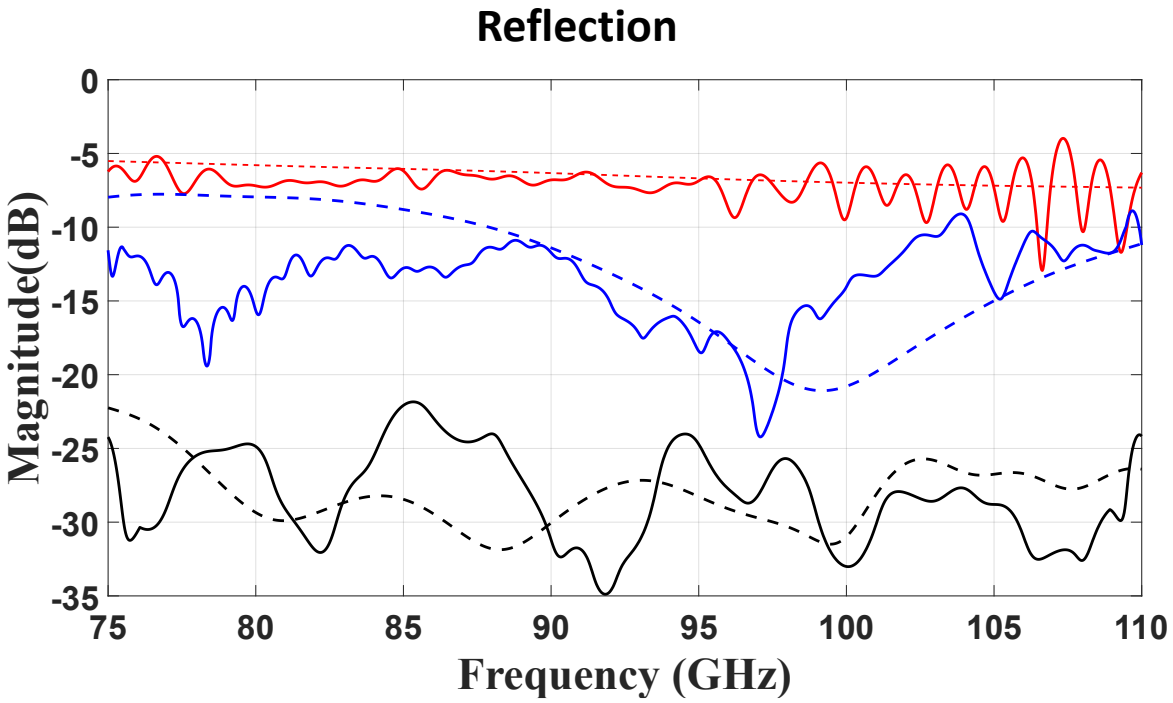
VNA (70 KHz – 110 GHz)

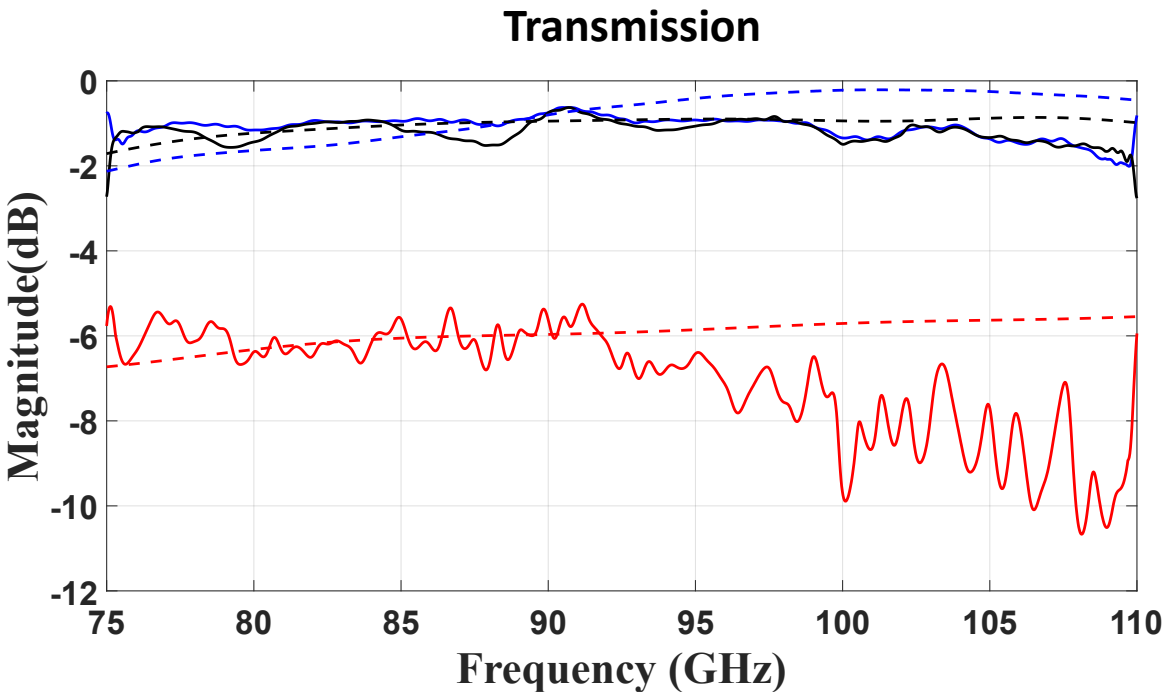


Hollow waveguide were excited with desired polarization

VNA port 1 → W1coax → WR10 → DRW → foam → WR12 → w1coax → VNA port 2

Results

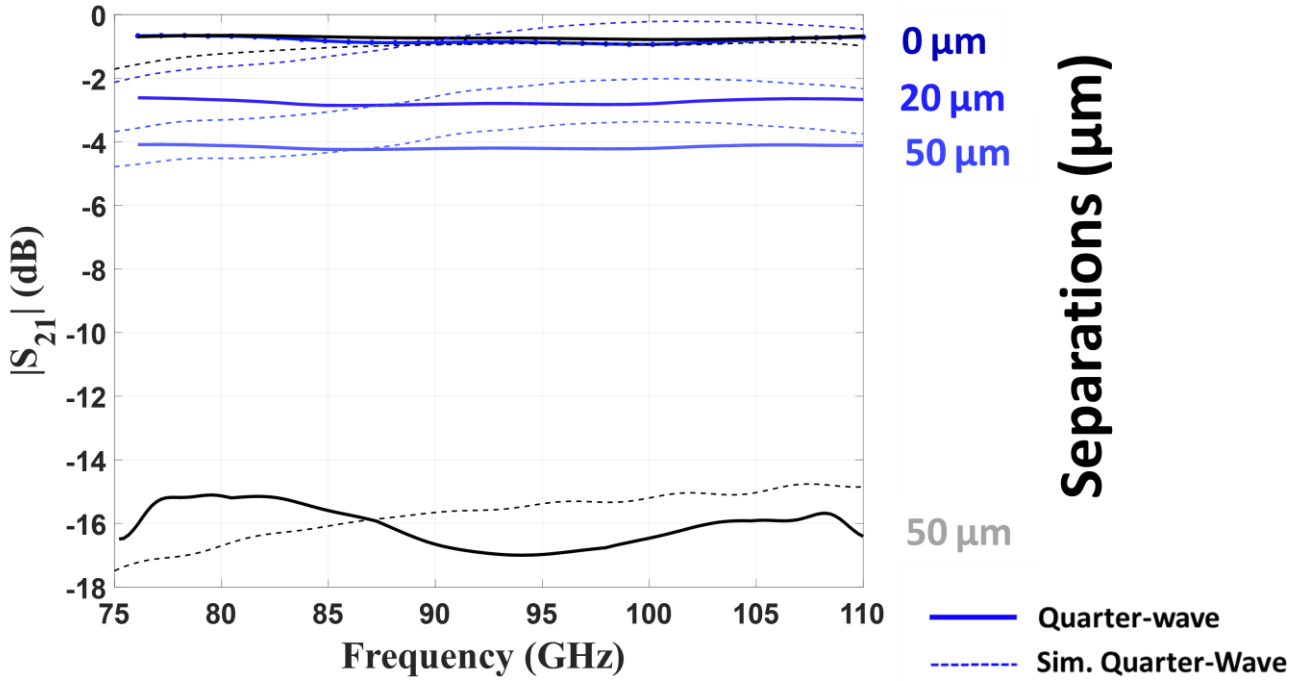




Quarter-wave Sim. Tapered Sim. Truncated Sim.

Measured Response

Feeding with separation



- **Measured reflection and transmission response with separations**

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Conclusion

- Demonstrates coupling between a hollow metallic waveguide and a DRW using a compact quarter-wave matched structure.
- Coupling is without insertion with stepped back with a modest efficiency penalty.
- Transmission loss over the 75-110 GHz is less than 2 dB.

Further work

- The extreme field localization in the slot-tip may also be useful for the application in high-frequency all-dielectric antennas

Acknowledgement

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That’s all for now!

Thank you for your attention

Question ?

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