Impact of Tip-Shape in Water-Based Broadband THz Pyramidal Absorbers

Optoelectronic and Laser Technology Group

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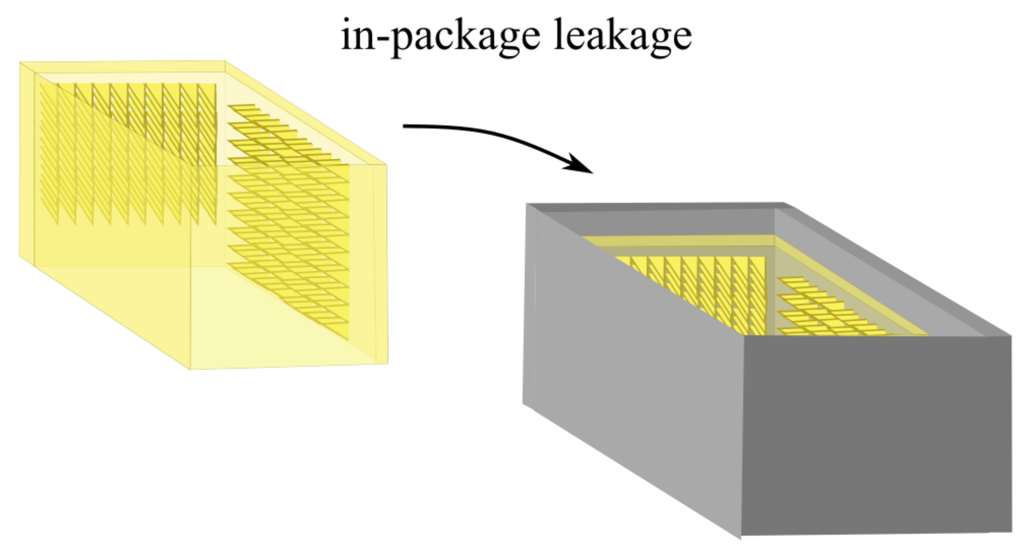
Motivation

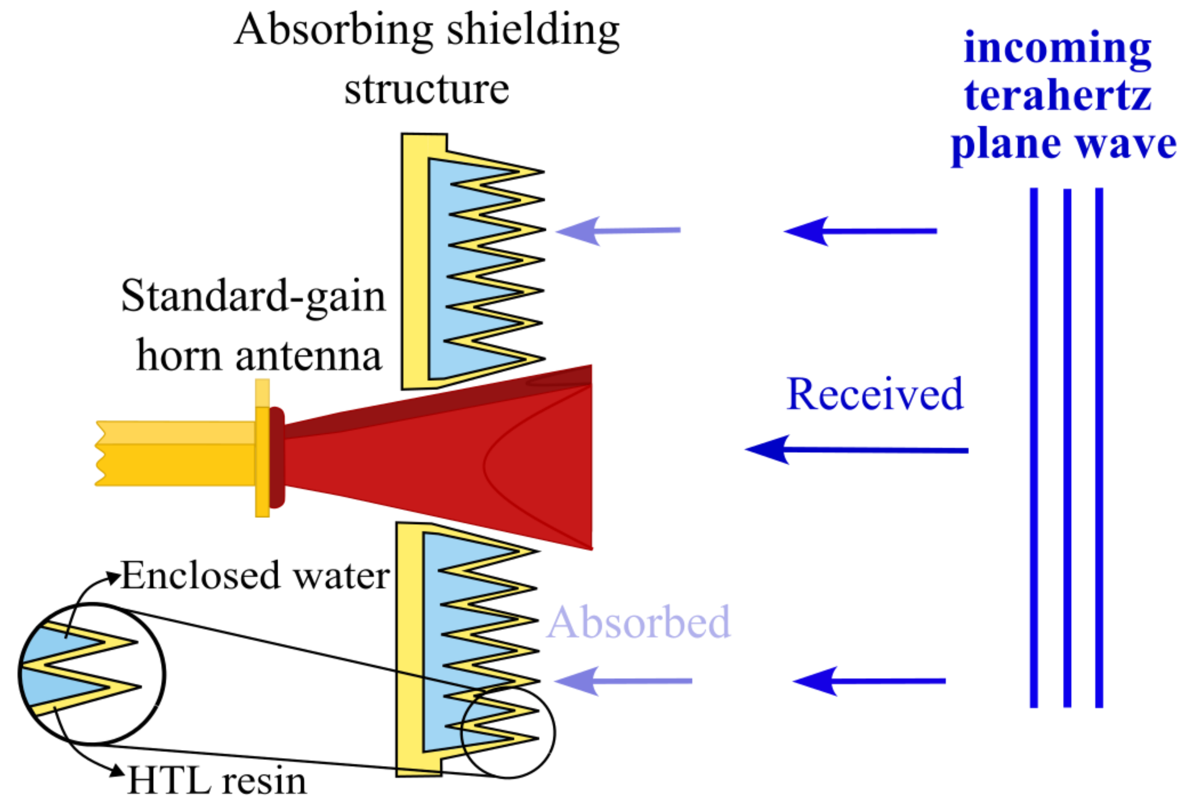
THz 5G/6G communication systems demands

- Broadband absorbers to mitigate multipath effects and signal degradation
- Device & package efficient shielding

Conventional absorbers & metamaterials

- Lack of micro-scale design flexibility[1]
- High costs, complexity[2]
- Narrowband performance





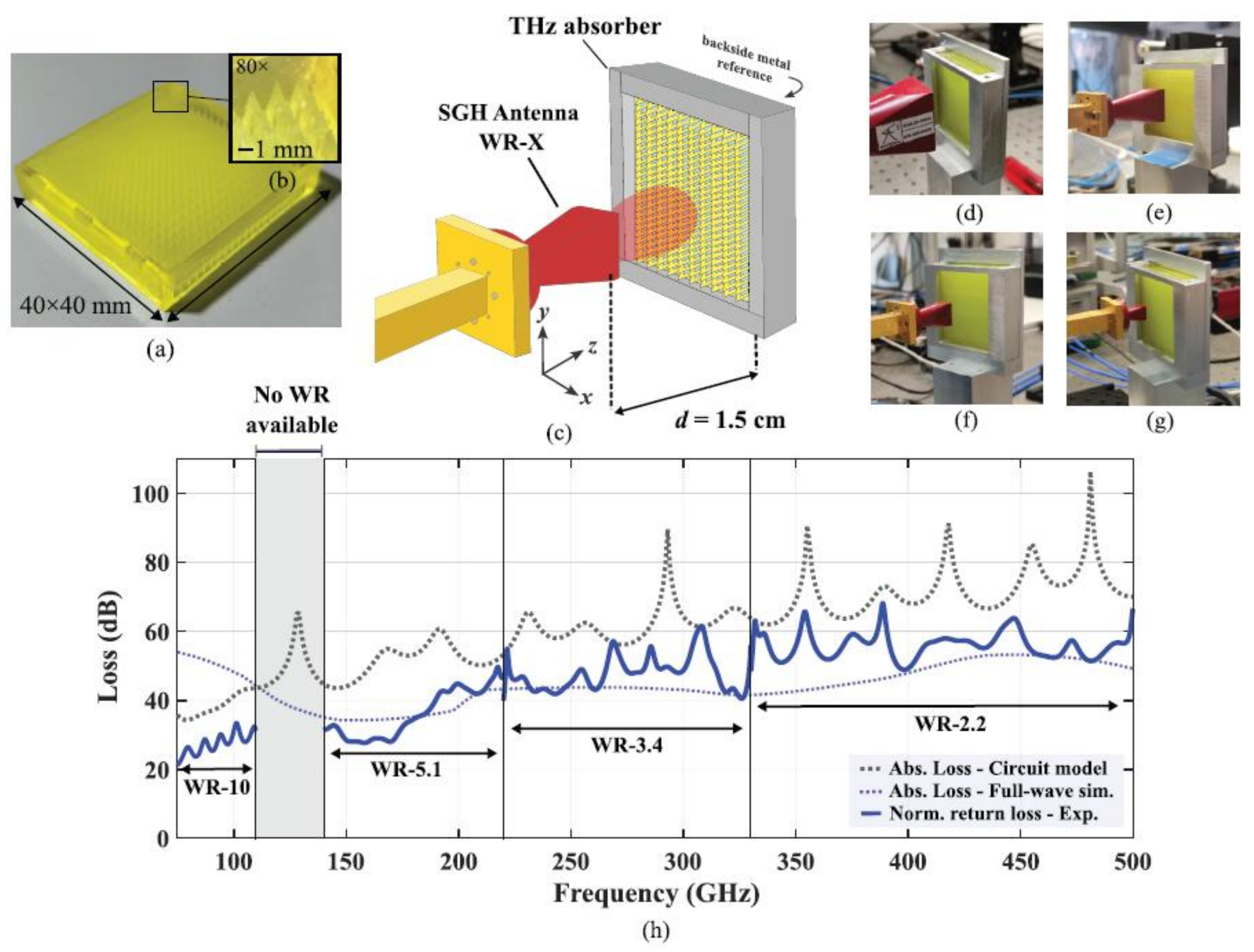
A water-filled, 3D-printed pyramidal absorber

- **>30 dB of absorption efficiency up to 500 GHz**
- **Practical manufacturability and assembly**

Read full paper here:
K. Spanidou et al., IEEE Trans. Microw. Theory Techn., doi:10.1109/TMTT.2025.3580219

Experimental Validation

- Assembly: Manual assembly, create a temporary hydraulic seal.
- Using a needle to bubbles at the tips due to surface tension.
- **Proof-of-concept demo** for normal incidence of THz radiation.

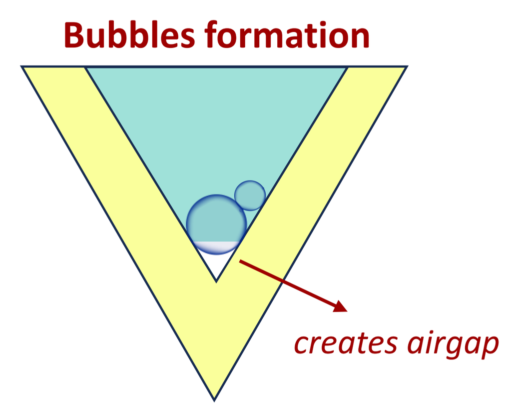


(a) Photograph of the proposed pyramidal absorber. (b) Micrograph of the tips. (c) Illustration of the experimental setup for absorber characterization. Photographs of the individual tests are presented for (d) WR-10, (e) WR-5.1, (f) WR-3.4, and (g) WR-2.2 frequency bands. (h) Measured absorption levels, derived from normalized reflection measurements, compared with simulated and theoretical results representing total absorption loss.

Technical Challenge

Unit-cell of pyramidal absorber

- Hollow **resin pyramids** fabricated via **micro 3D printing**
- **Filled with distilled water** as absorbing medium



Challenge

Water surface tension → prevents full filling of sharp tip, creation of air bubbles

Proposed solution

Truncating the tip improves water ingress during assembly

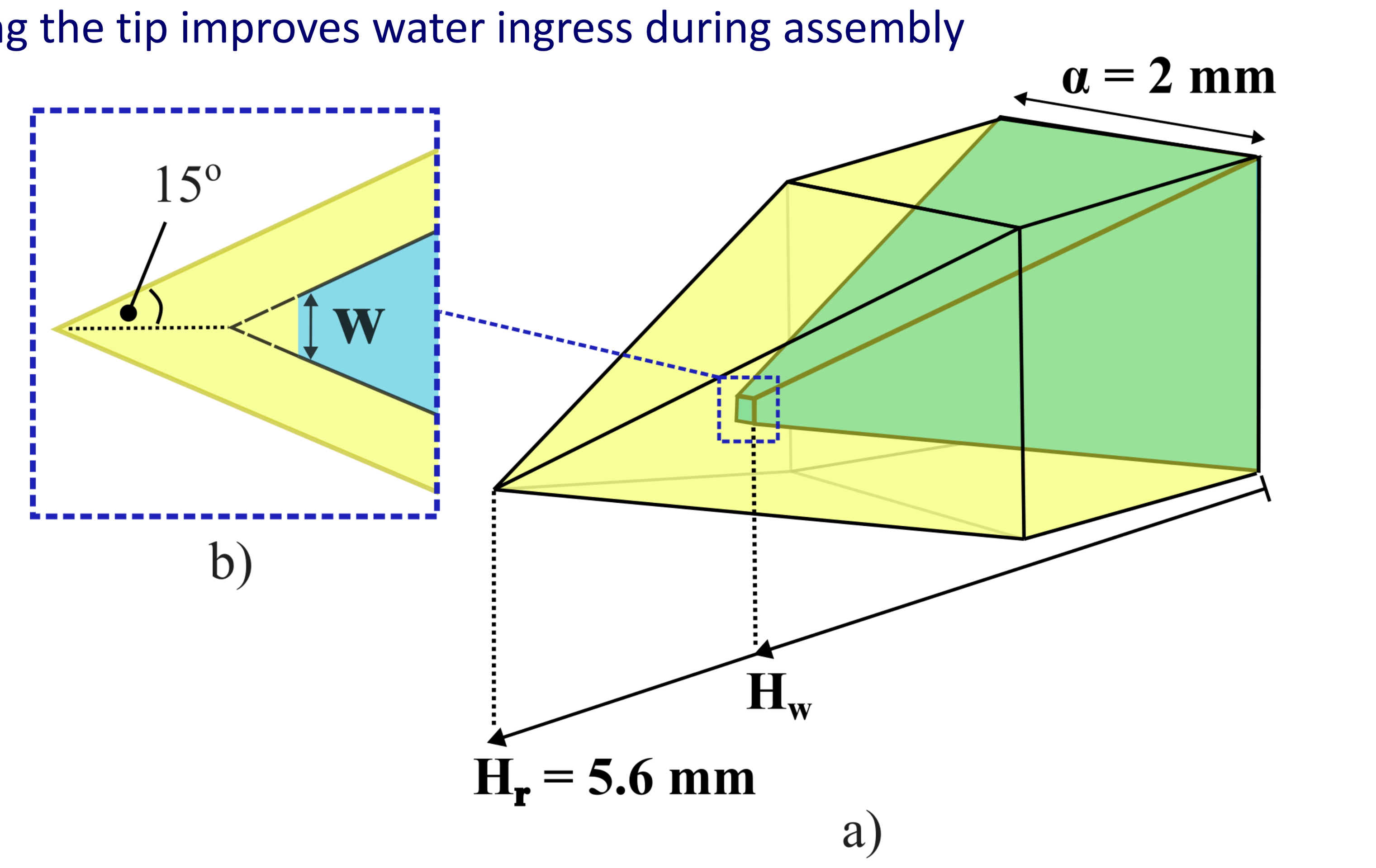


Fig. 1. a) The unit-cell of the optimized broadband absorber design encloses the water-based pyramid incorporating a snub-tip cavity of width *w*, b) the cross-sectional view of the modified tip.

Optimized Absorber Design

Design Variable:

- Snub-tip **terminal width w** varied from 0 to 200 µm.

Key tradeoff

- Tip truncation eases filling but may reduce impedance matching

Full-wave simulations from 75 GHz to 500 GHz

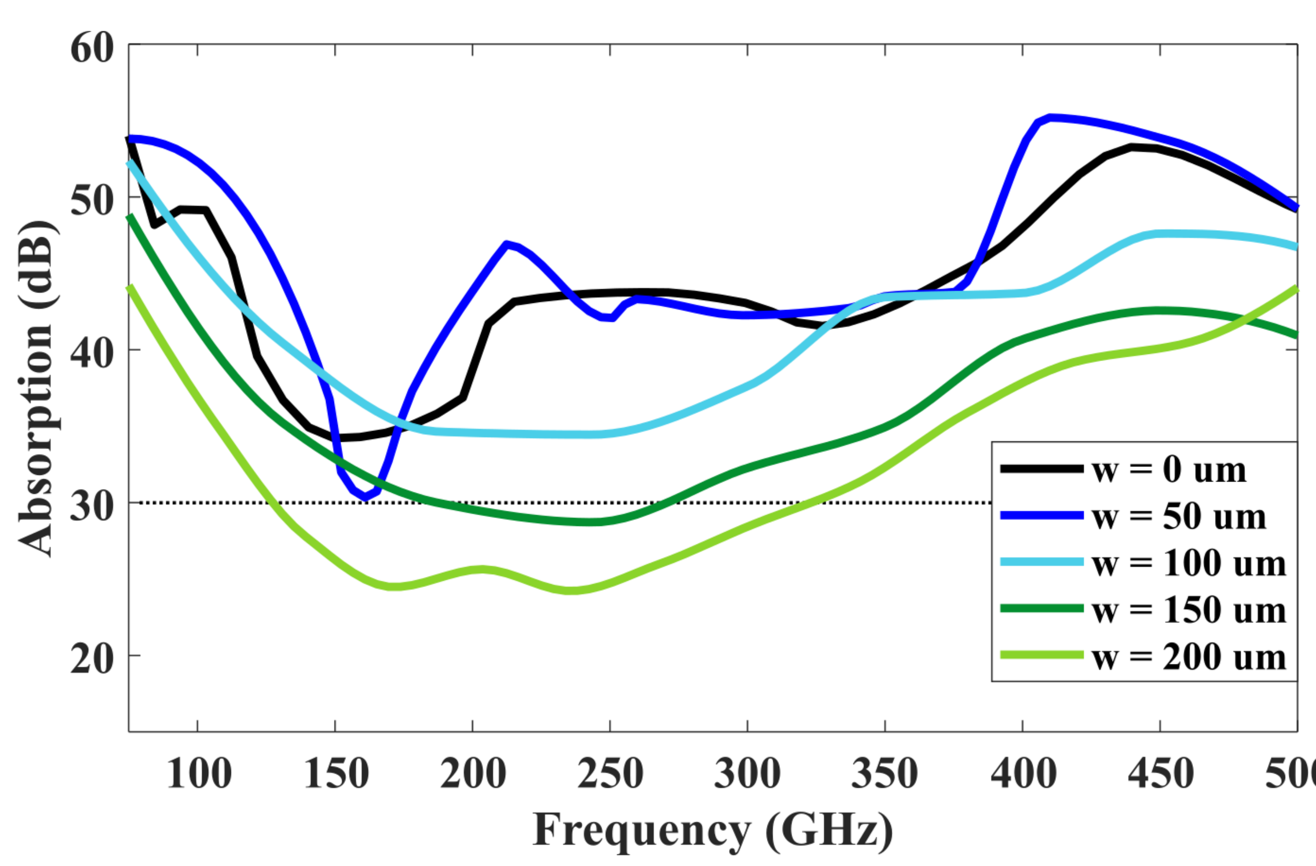


Fig. 2. Absorption spectra of the proposed THz absorber under normal incidence for different snub-tip widths ranging from 0 to 200 um, obtained from full-wave simulations.

Future Work

- **Width must be 50-100 µm:** best compromise for high THz absorption and fabrication ease
- Great potential of **resin micro 3D-printing** for **practical, low-cost, high-performance** water-based absorbers
- Opens a pathway to **low-profile THz anechoic environments**, packaging, and shielding up to 1 THz

References

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