Heterogeneous Resonator Stacking for mm-Wave Probe Antennas with Enhanced Bandwidth

Optoelectronic and Laser Technology Group

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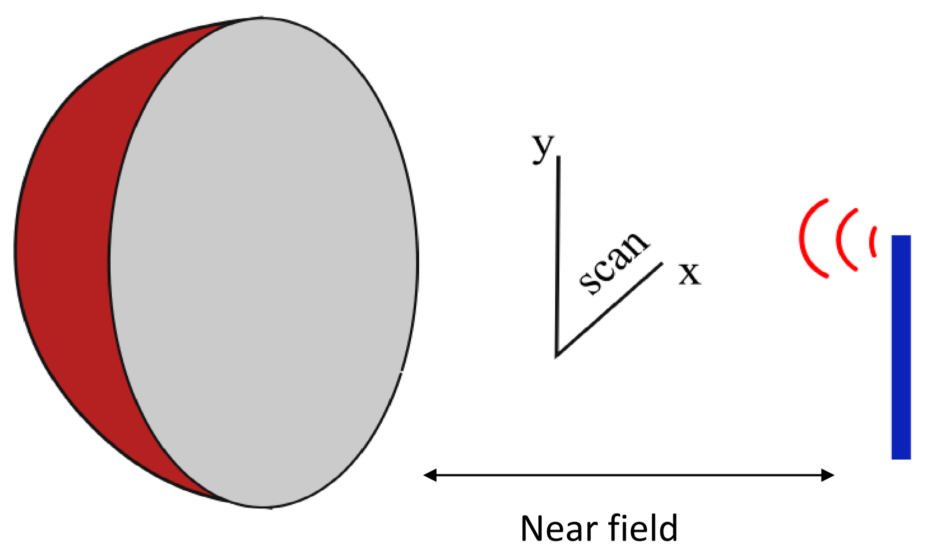
Motivation

Challenges in Testing Broadband, High-Frequency Antennas:

- Strong path loss necessitates high-gain antennas
- Far-field testing above 100 GHz requires large setups (e.g., Cassegrain)
- Conventional setups limited by cabling, size, and cost
- Microscale antennas add fabrication and assembly

Probe antennas for 5G/6G antenna testing

- Simple, cost-effective, widely accessible
- High frequency operation, accurate micro-assembly
- Compact in-door test ranges using NF-FF transformation



Proposed Solution

Coaxial-fed monopole antenna
- High radiation
- Compact form factor

Silicon micromachining
- High-frequency operation
- Reconfigurability
- Simple manual assembly

Broadband Operation
- By heterogeneous stacking of dielectric resonators

micro-scale accuracy!

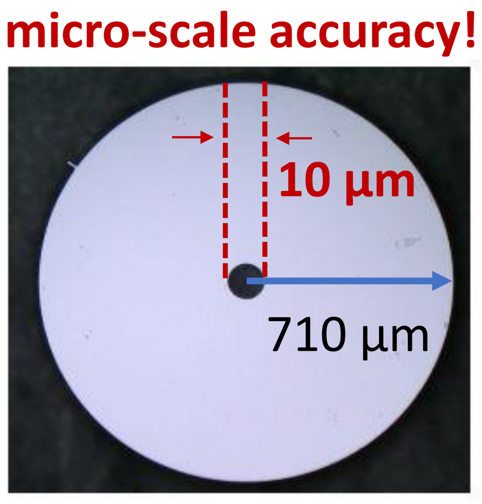


Fig. 1. Photograph of the cylindrical Si microcavity.

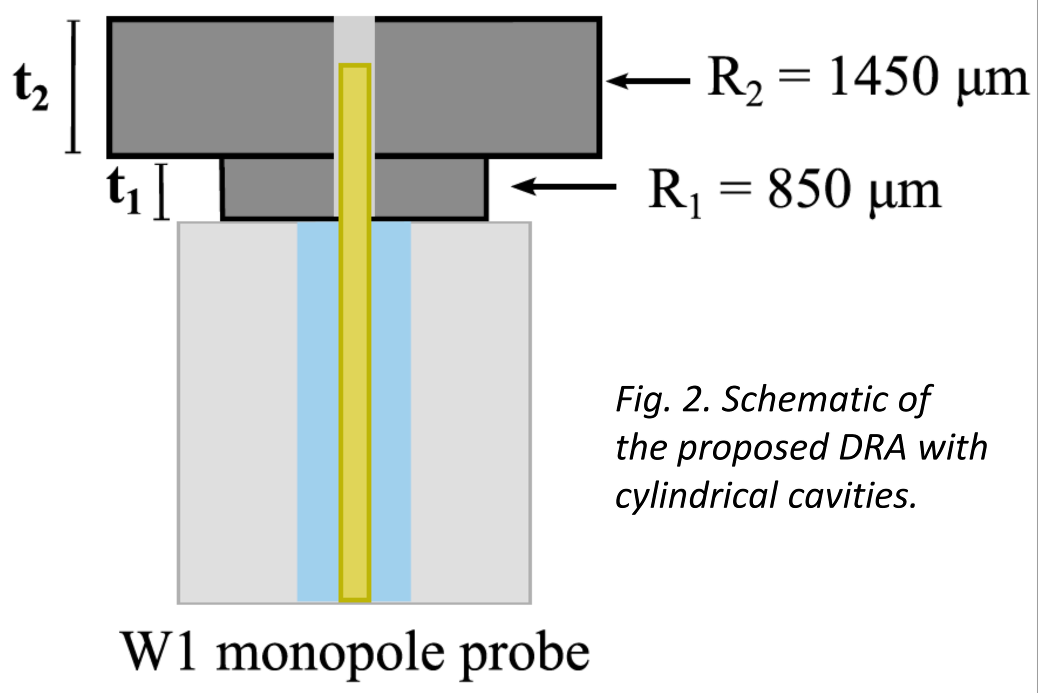
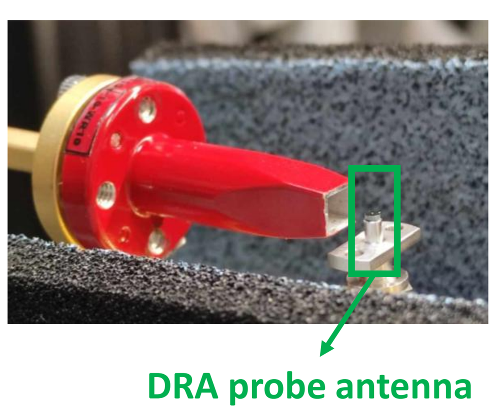


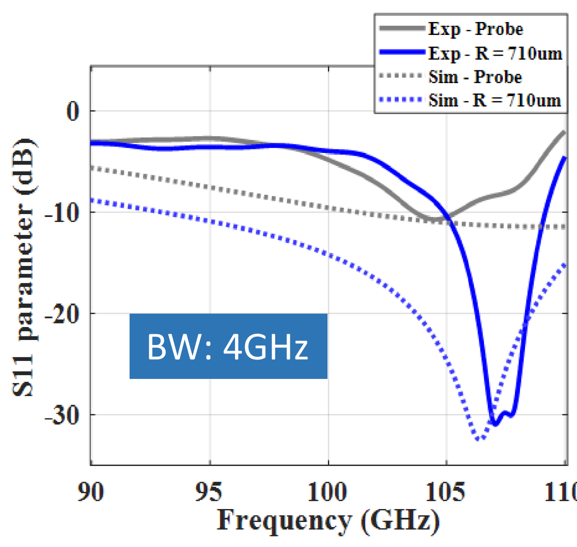
Fig. 2. Schematic of the proposed DRA with cylindrical cavities.

Single DRA: Near-field probing

Spanidou et al., Proc. SPIE 13365, 133650X (2025), doi:10.1117/12.3041244

- Single cavity enables narrowband operation
- Initial near-field AUT probing results.
- NF–FF transform reconstructs 3D radiation patterns in both planes.





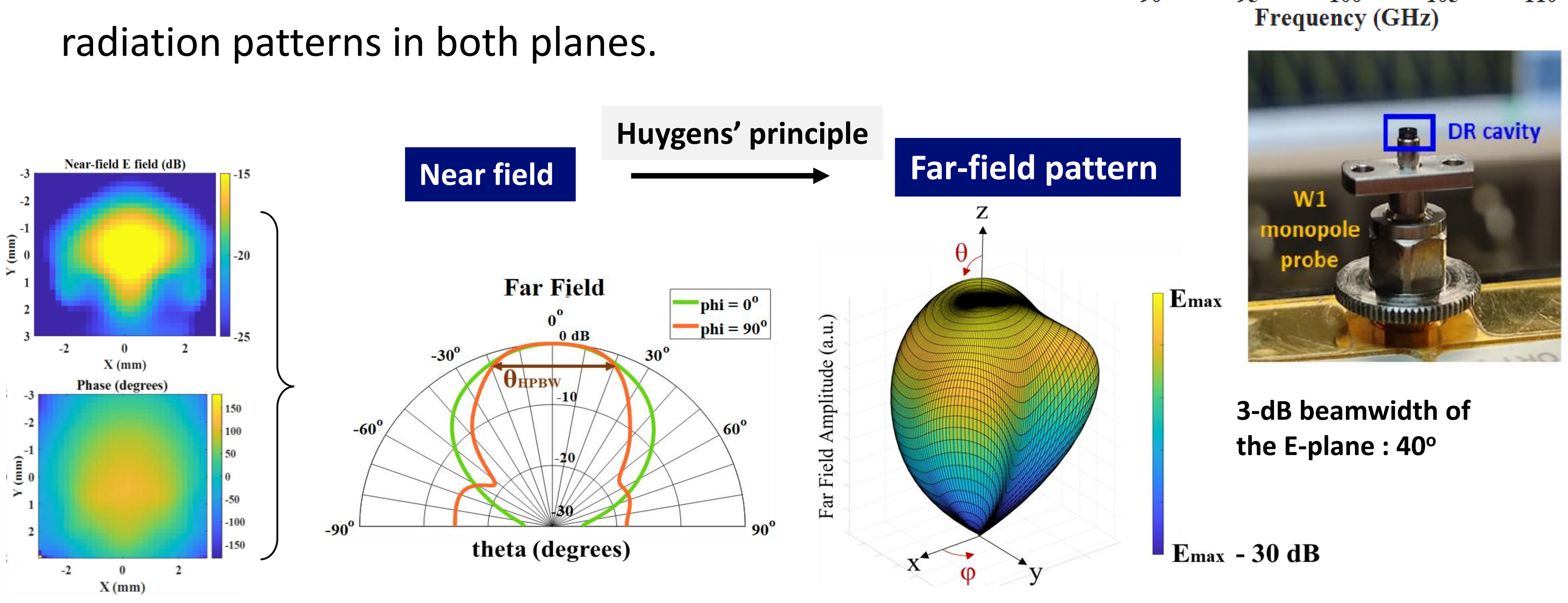


Fig. 5. Measured NF data of (a) amplitude and (b) phase of the E-field at the sample frequency of 107 GHz. The FF radiation patterns show the directivity in (a) polar coordinates and (b) in 3-dimensional view.

Broadband antenna validation

Experimental results:

- Manual assembly, no need for automated tools
- Interlocking concept offers micro-level accuracy
- Bandwidth enhancement by 7.5 times

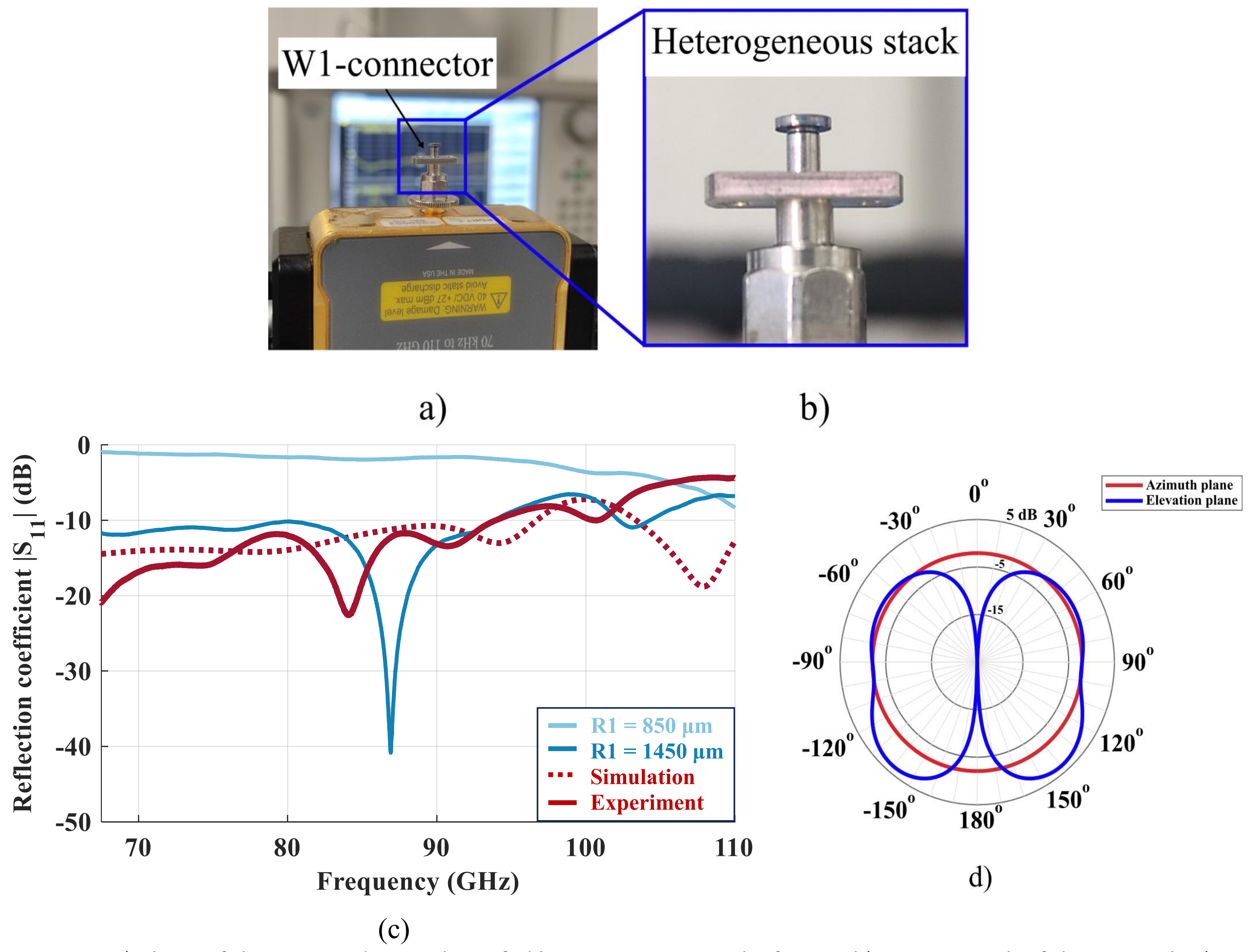


Fig. 4. a) Photo of the proposed coaxial-W1-fed heterogeneous stack of DRAs, b) a micrograph of the DR stack. c) Measured and simulated results of the reflection coefficient $|S_{11}|$ of the DR stack, along with the responses of the individual cavities. d) Simulated radiation patterns in the azimuth and elevation planes at the resonant frequency of 85 GHz.

Conclusions

- **Heterogenous stacking achieves BW enhancement**
- **Bandwidth increased from 4 GHz to 34 GHz (+750%).**
- **Silicon micromachining enables practical solutions with micro-level accuracy**
- **Debugging and evaluating advanced antenna systems, e.g. MIMO, phased arrays using Huygen's principle**

Acknowledgements

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