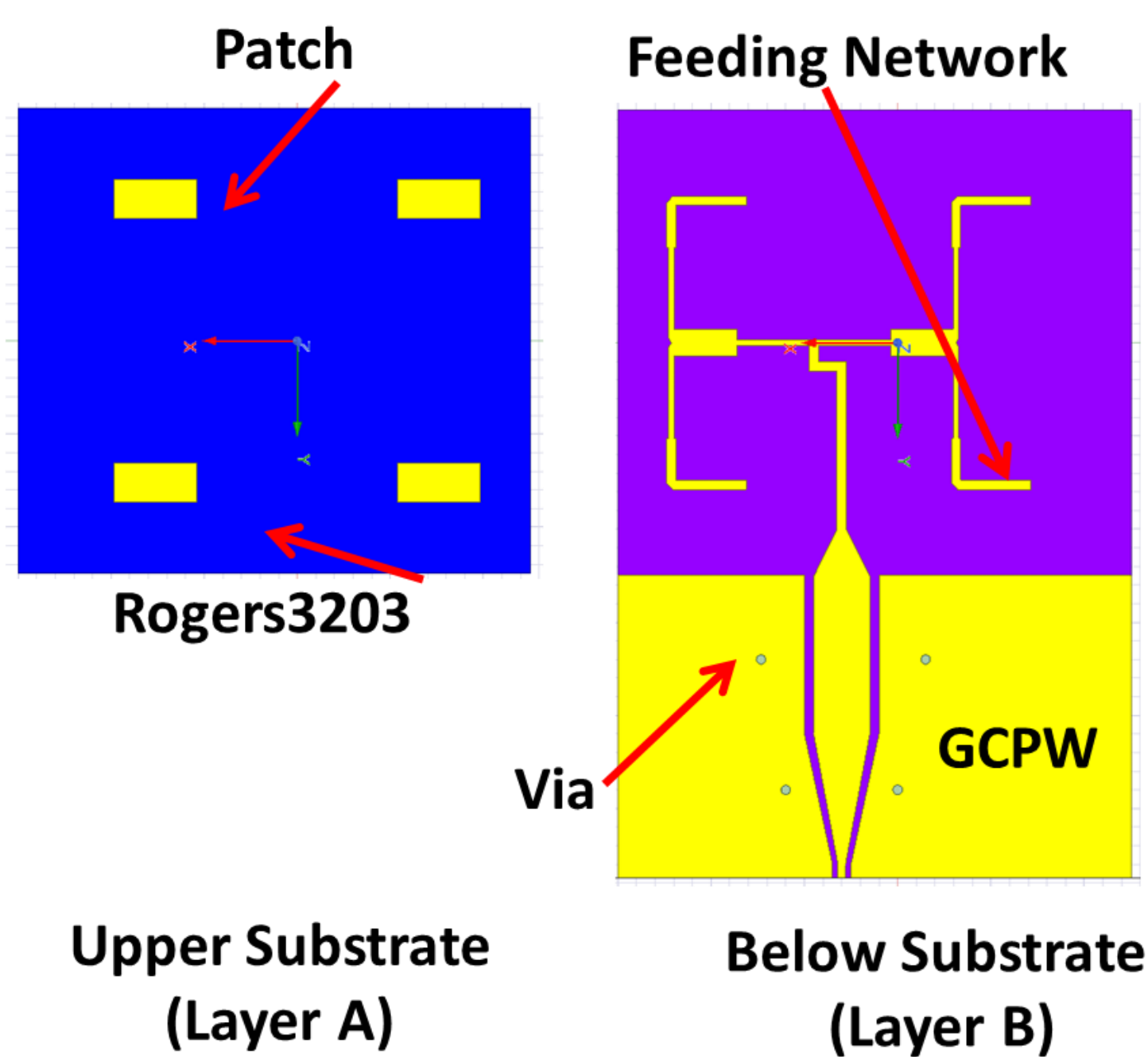


Abstract

Millimeter wave antennas suffer from high propagation losses, assembly challenges, fabrication tolerances, and cost. To overcome the losses, phased antenna arrays are considered, which can provide high gain.

A high-gain, 1x4 antenna array for millimeter-wave applications for frequency bandwidth of 70 GHz to 85 GHz (E-band), with a maximum gain of 17 dB at 73 GHz is designed on a two-layers of Rogers 3203 as the substrate. A proximity-coupled feeding technique is employed to excite the radiating patches, while the input interface consists of a grounded coplanar waveguide (GCPW), which can be ribbon-bonded to a signal source chip.

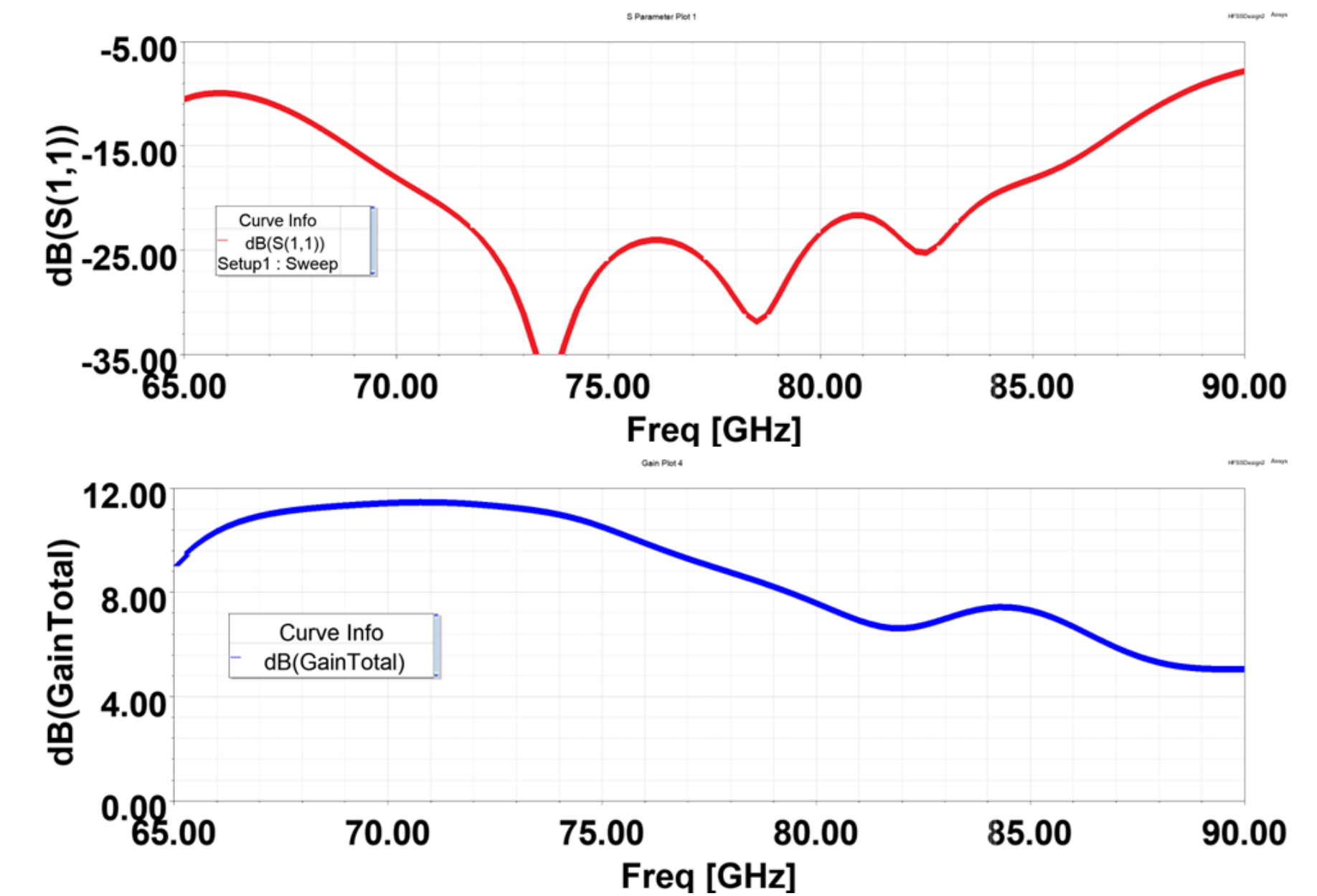
Subarray Element Antenna



➤ A 2x2 subarray element has been designed using a two-layer configuration that four rectangular-shaped patches on layer A, while the feeding network is placed on layer B.

➤ The antenna utilizes a proximity-coupled feed, with the feed line positioned beneath the radiating patch in a separate layer to enhance impedance bandwidth, making it ideal for mm-Wave antenna arrays.

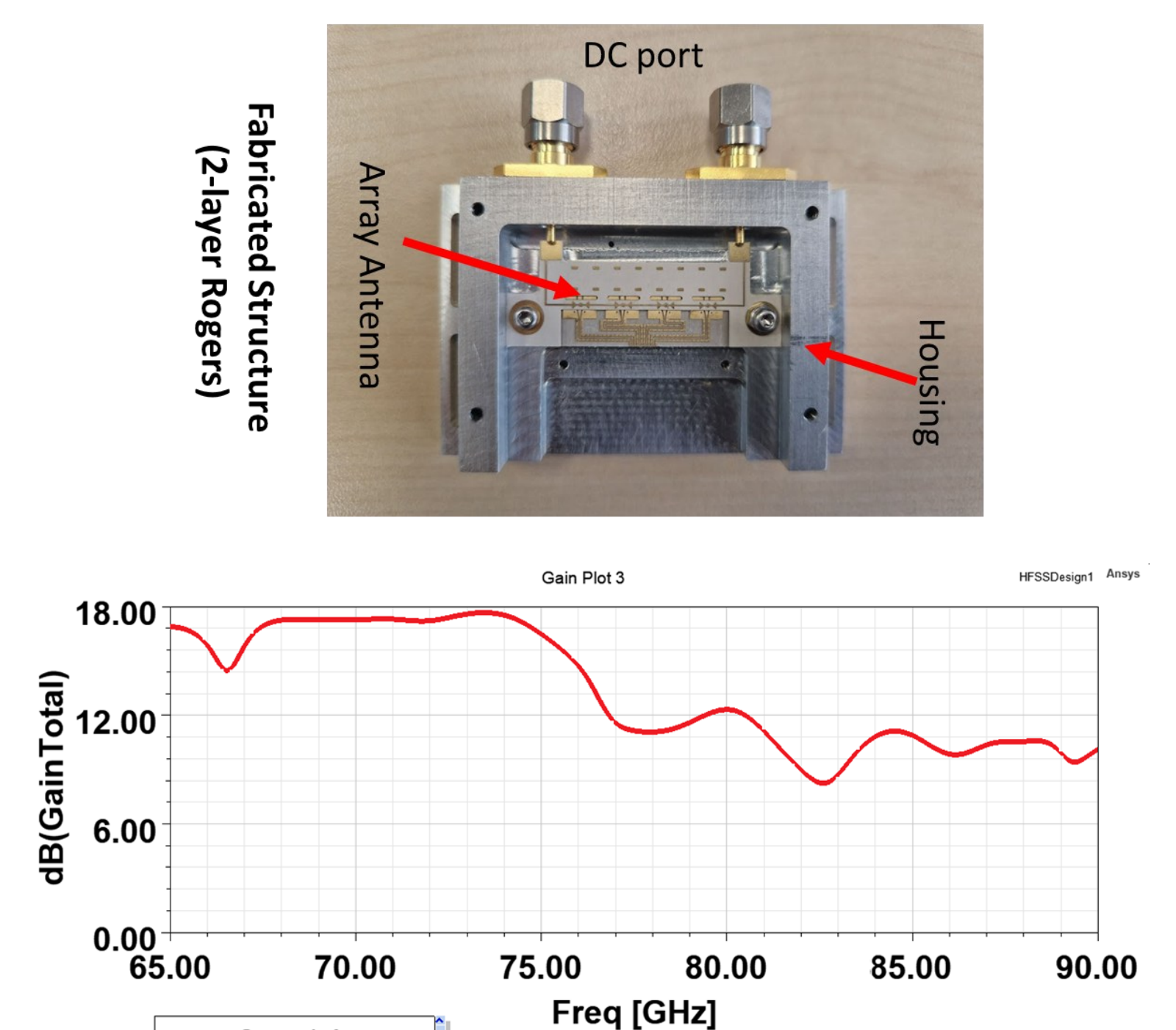
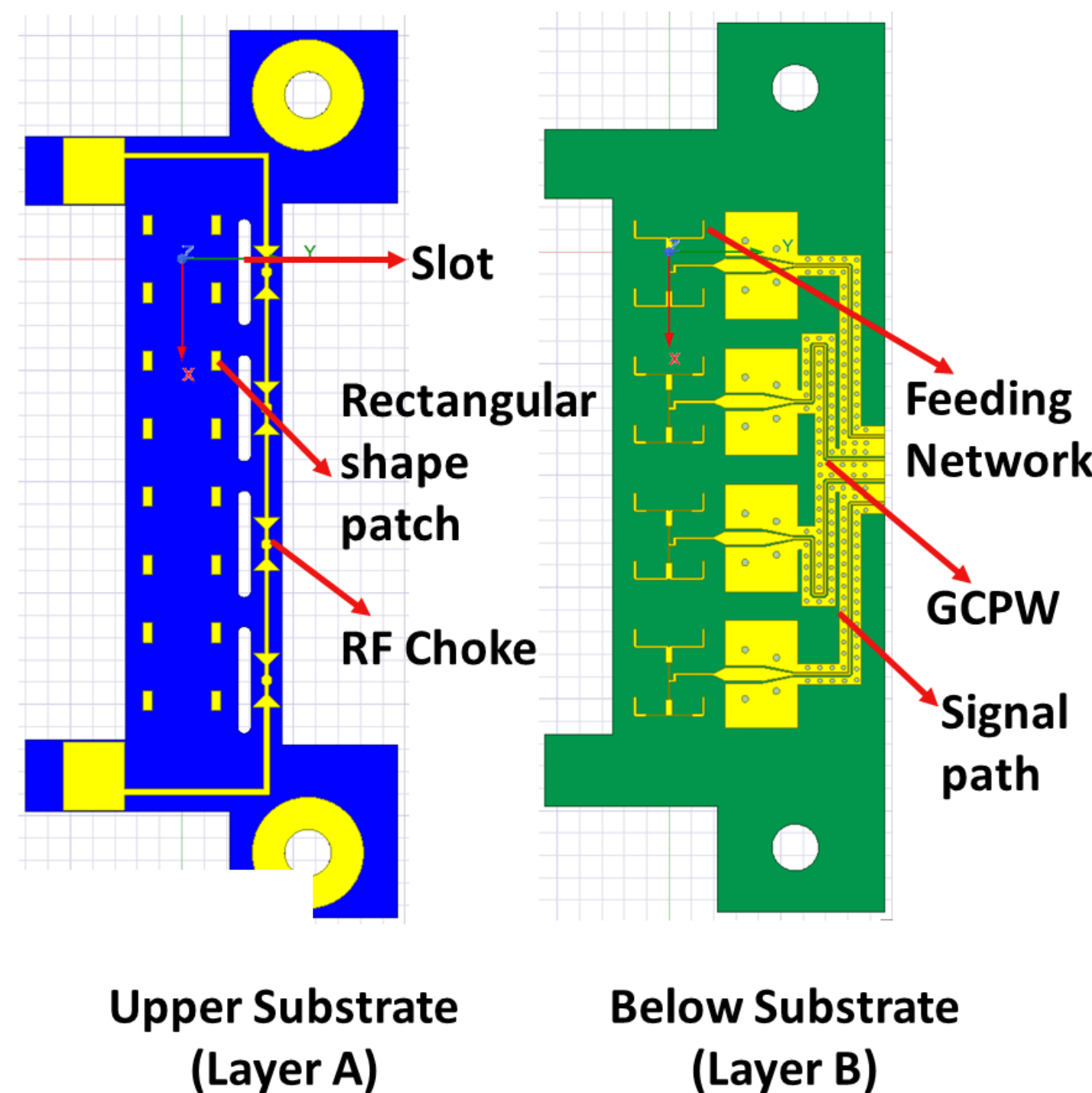
➤ The antenna operates between 65 GHz and 88 GHz, achieving a maximum gain of approximately 11.5 dB at 73 GHz, which declines to around 5 dB near 88 GHz due to increased dielectric and conductor losses and potential radiation efficiency degradation.



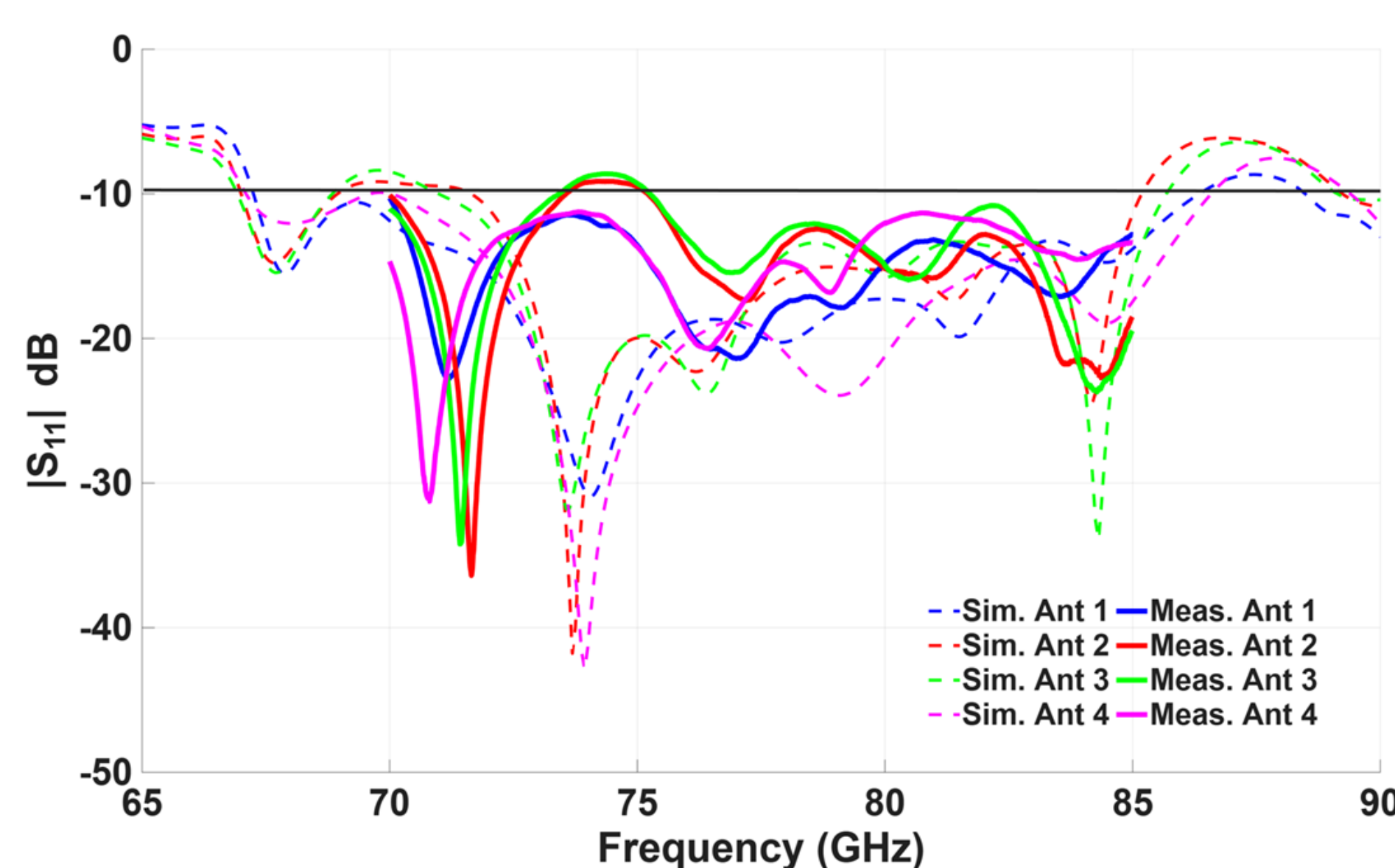
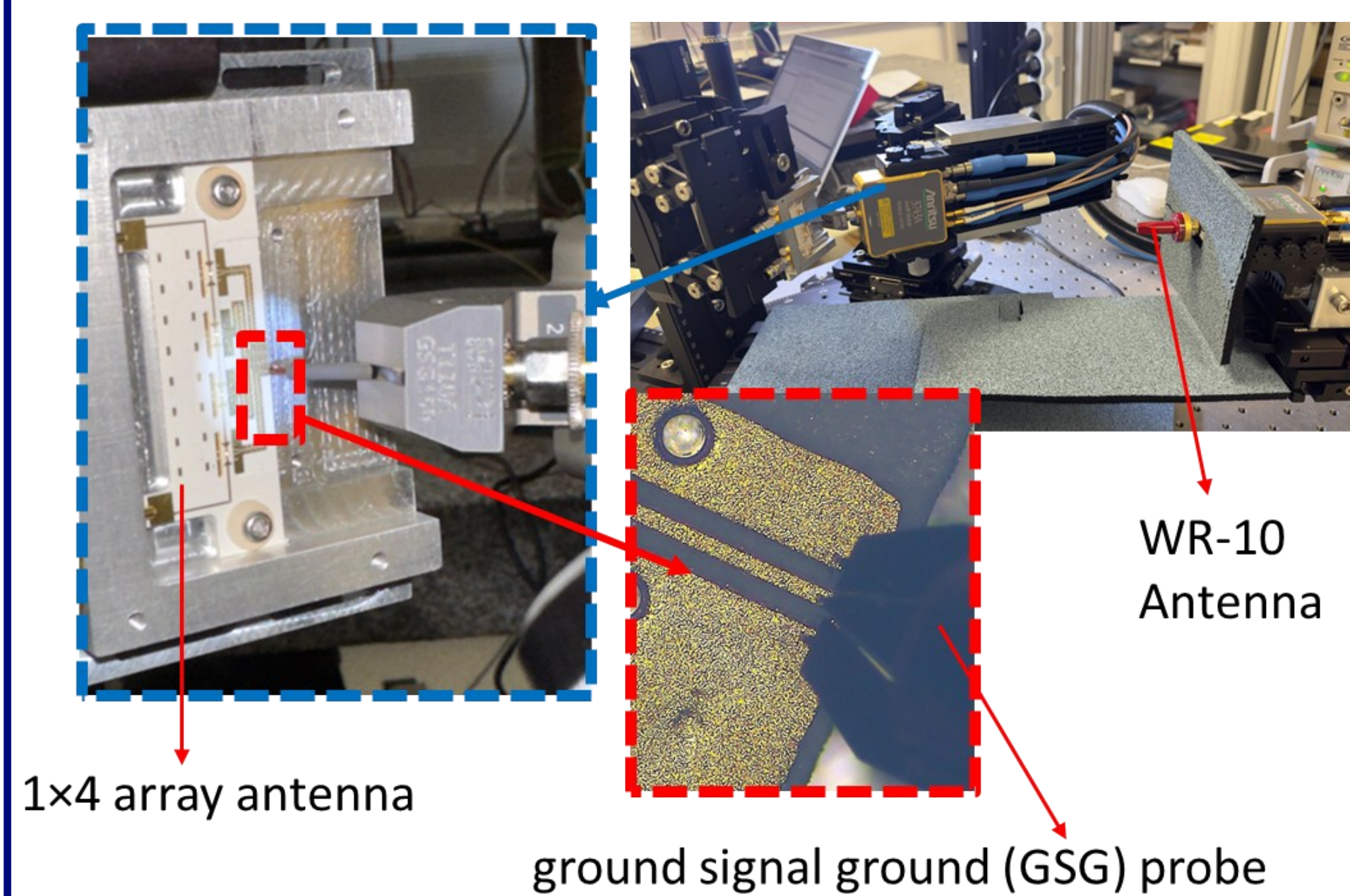
Antenna Array Design

➤ The antenna array like single element also consists of two layers. Layer A includes the patch of the antenna and the RF chokes, while in Layer B, the feeding network is implemented. In an antenna system that receives its power directly from active chips, the RF choke is essential for having appropriate isolation between the RF signal line and the DC biasing network.

➤ The maximum gain of the antenna is about 17.5 dB at 73 GHz. A significant gain reduction, around 10 dB, is evident at the upper operating bandwidth which is attributed to the inter-element spacing; as the frequency increases, the fixed physical distance between elements becomes electrically large, resulting in scattering and efficiency loss.



Single Element Characterization by Probing



➤ A probe with a pitch of 450 μm fed individual antenna elements, and their reflection coefficients (S11) were measured. Simulation and measurements results are presented.

➤ The observed frequency shift toward lower values was attributed to wider CPW gap sizes from fabrication variations, likely due to over-etching during lithography, which affected capacitive coupling and feed line impedance. Ultimately, the measured results confirm the antenna array's performance and functionality.

Conclusion & Future Work

➤ A high-gain 1x4 array antenna for mm-Wave applications has been designed, fabricated, and characterized. The antenna employs a two-layer structure with Rogers 3203 substrate and utilizes a proximity-coupled feeding technique to excite the radiating patches.

➤ Future work: investigating different PCB material and layer, contact pads and assembly can be done in future.

Acknowledgments

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References

- ❑ M. Ali et al., "mmW Photonic Emitter with PIN-PD and High Gain Antenna," *IWMTS*, 2020.
- ❑ A. Rivera-Lavado, "Diseño de un array de parches alimentado por aperturas," M.S. thesis, UC3M, 2020.
- ❑ G. Carpintero et al., "Photonic RF Phase Arrays for mmW/THz Range," *ICMMS*, 2025.
- ❑ S. Farhat et al., "Wideband, High Gain Antenna Array for mmW Band," *ICECCE*, 2019.
- ❑ J.-H. Lee et al., "Microstrip Comb-Line Array Antennas for mmW," *IEEE AWPL*, Aug. 2020.
- ❑ L. Wang et al., "CP-Patch Strain Sensor for Structural Health Monitoring," *ICEICT*, 2020.
- ❑ C. A. Balanis, *Antenna Theory*, New York: Wiley, 2002.