WE3H-6

# Basic study of 79 GHz Band Resin Waffle-Iron Ridge Guide

Y. Aoki[1], H. Tanaka[1], K. Kamo[1], T. Shimizu[2]

[1]Taiyo Yuden Co., Ltd., Japan

[2]Utsunomiya Univ., Japan

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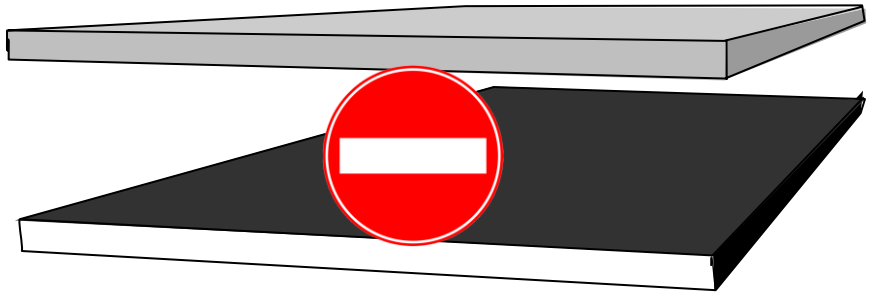
# What's the WRG

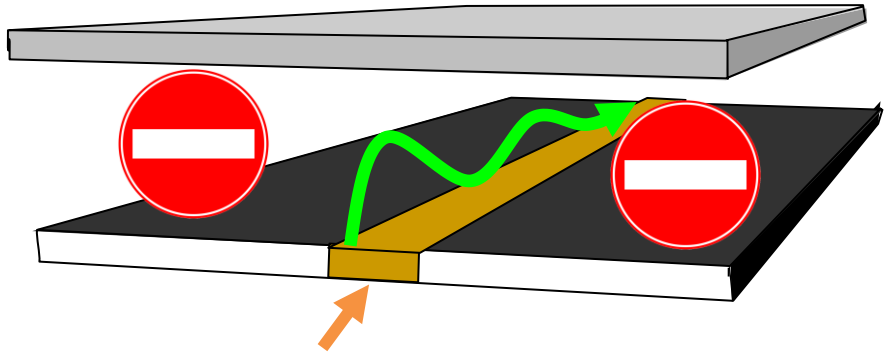
- "WRG" is an abbreviation for the Waffle-Iron Ridge Guide.
- It's also known as a "Gap waveguide".
- High performance RF transmission line.

Perfect Electrical Conductor (PEC)



Perfect Magnetic Conductor (PMC)

Perfect Electrical Conductor (PEC)



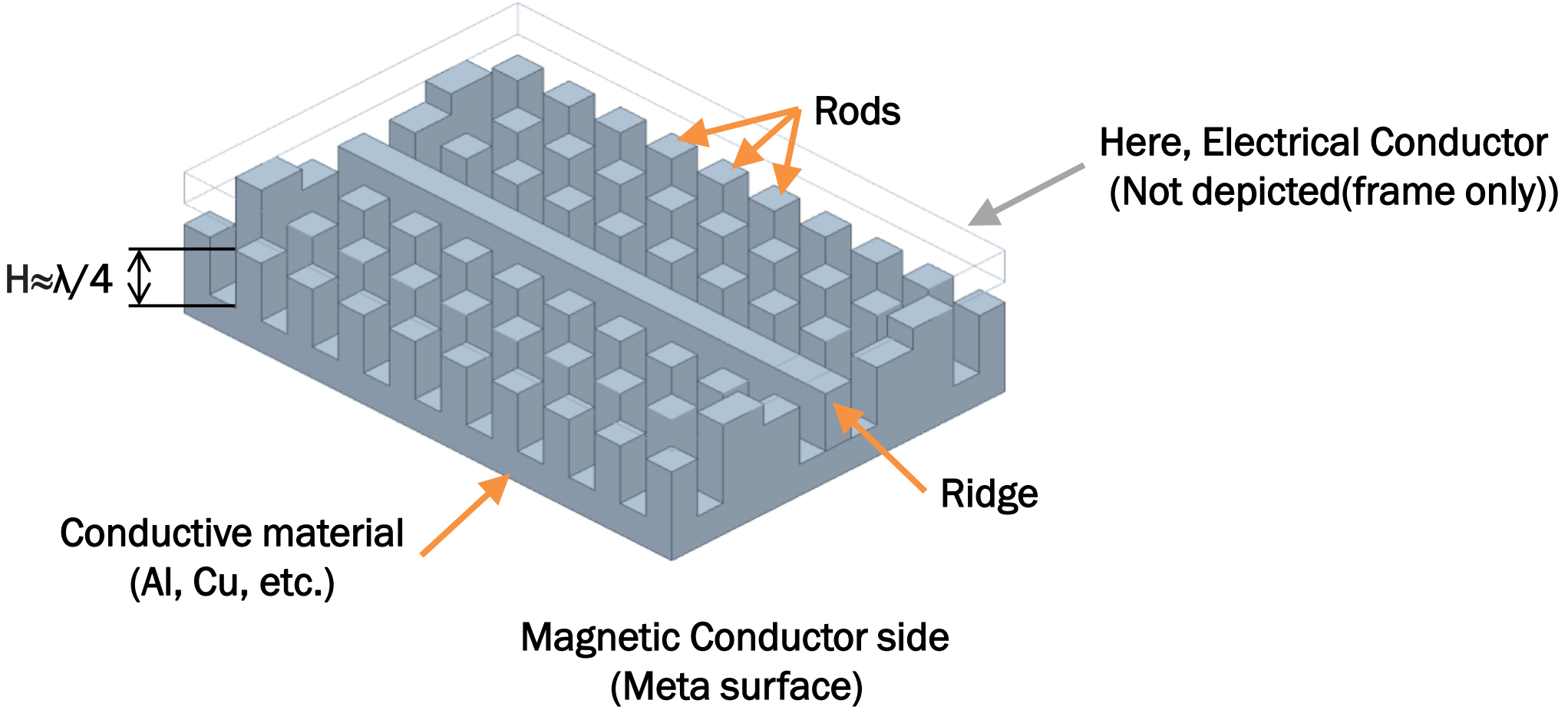
Ridge (Guide line)
Electrical Conductor

Perfect Magnetic Conductor (PMC)

# WRG basic structure

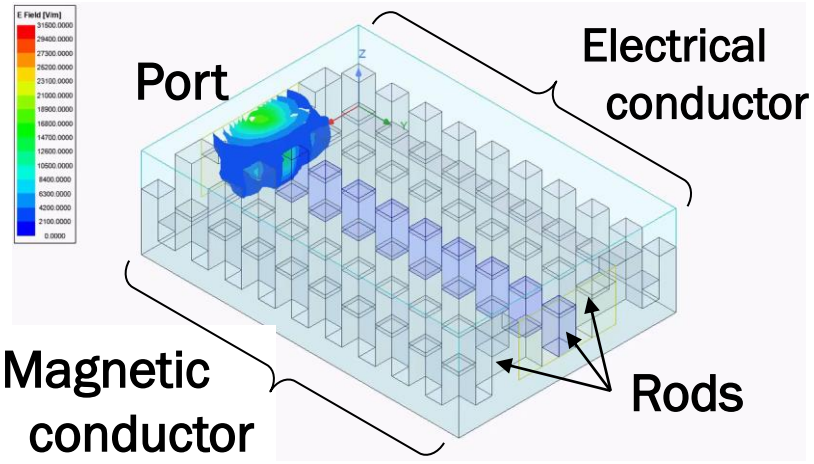


## WRG adopts PMC with meta-surface technology.



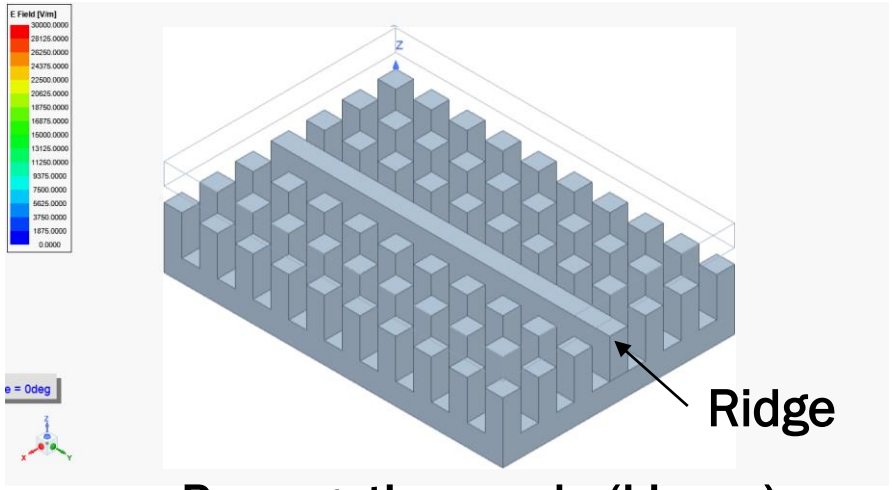
# Simulation analyzed

## E Field Animation

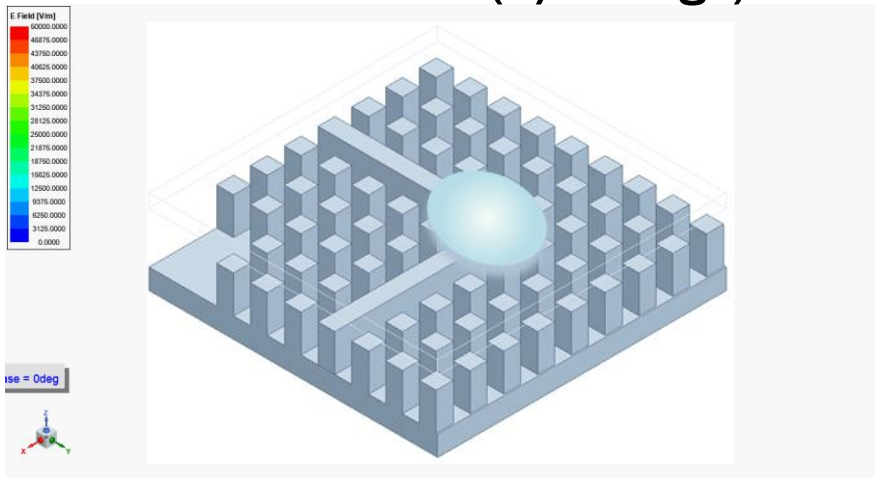



Cut-off mode (w/o Ridge)

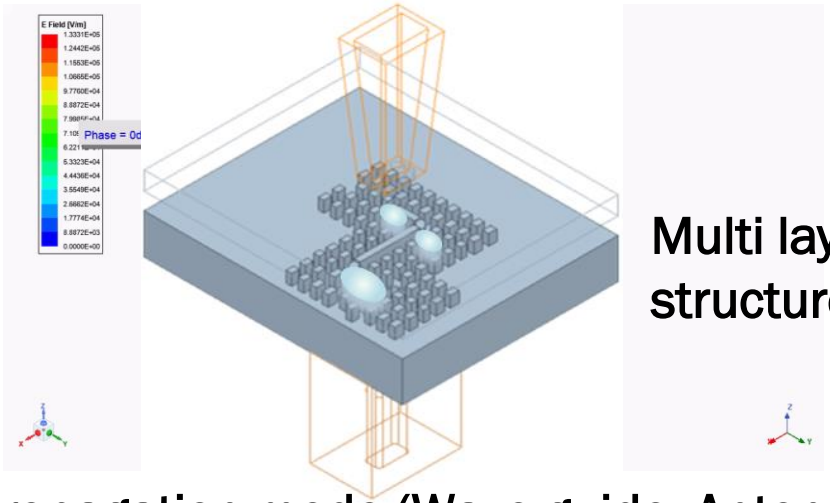
3D EM Simulator HFSS (Ansys)




Propagation mode (Linear)



Propagation mode (Bend)



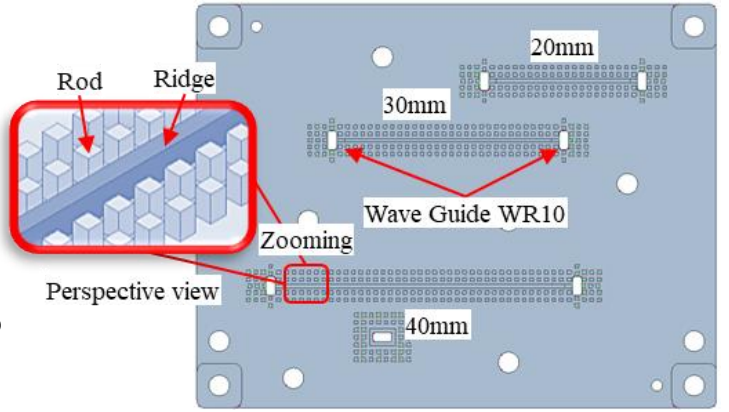
Multi layer structure

Propagation mode (Wave guide, Antenna)

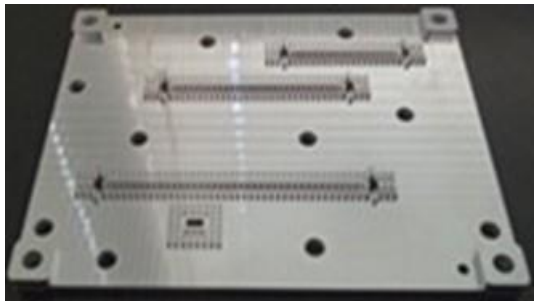
# Prototype of the WRG



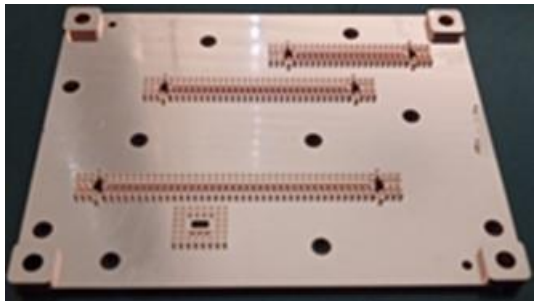
- Specification
  - –Material: ABS(+Cu plating), Aluminum
  - –Processing Method: Precise machining process
  - –Design Frequency: 79GHz
  - –Ridge length: 20mm, 30mm, 40mm
  - –Layer: 4 layers




Layer 3(Circuit layer)

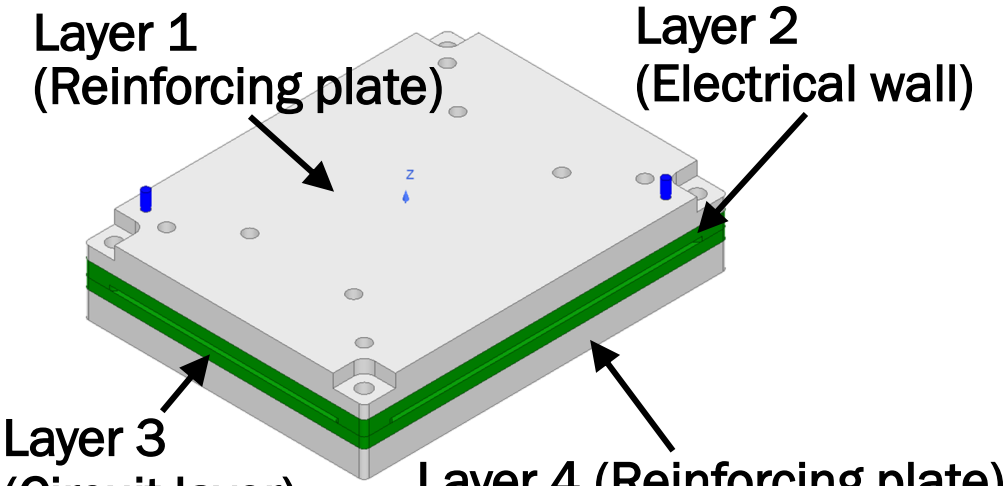


Made of aluminium



Made of ABS with Cu plating

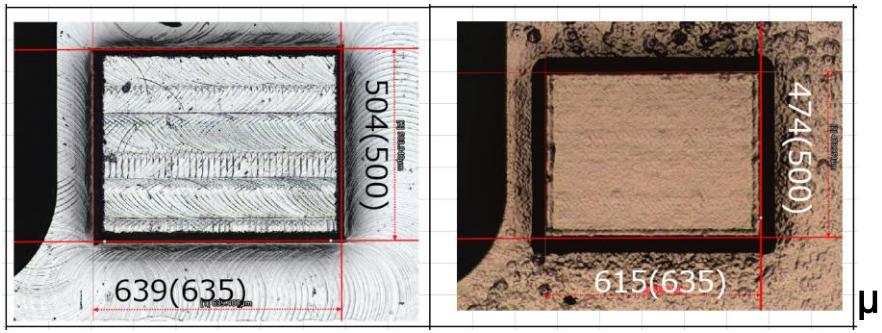
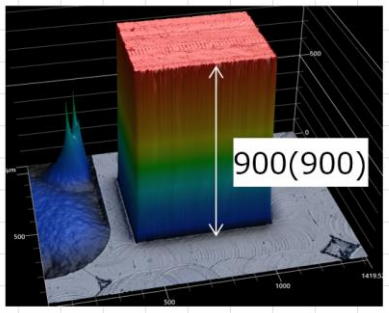
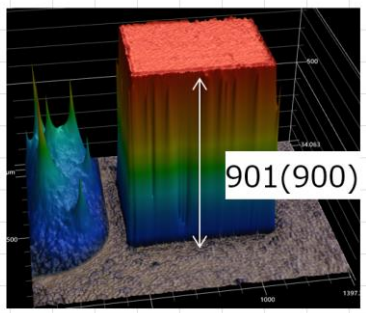
Layer 3(Pictures)




Outline View

# Accuracy of the Prototype

- Process: Precise machining process
  - Accuracy: ±5μm (aluminium), ±25μm (ABS)
  - Laser Microscope: VK-X3000, Keyence

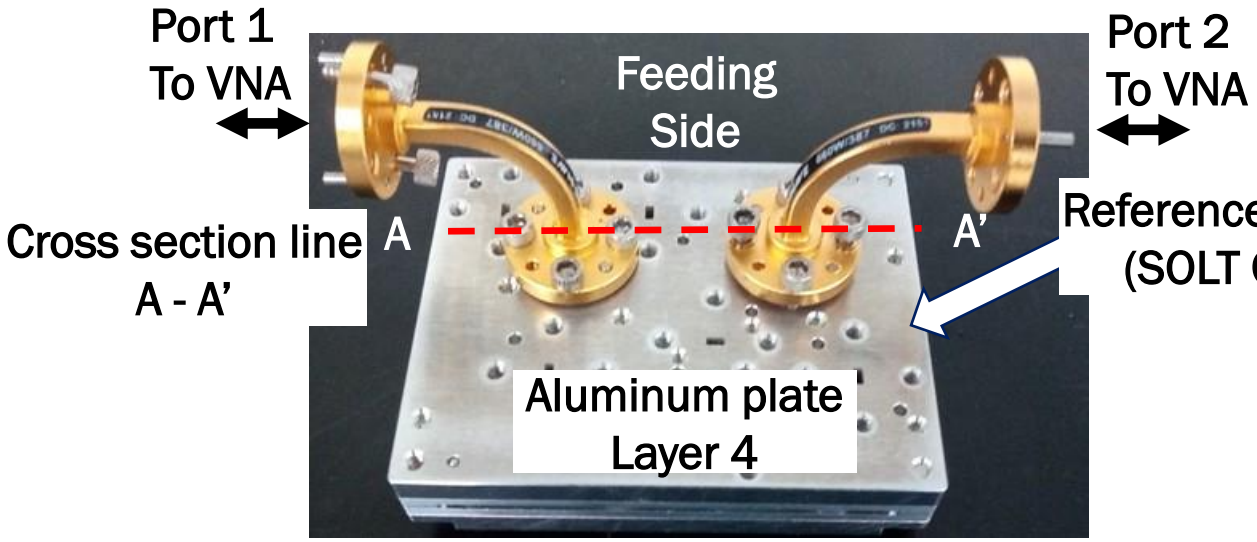
| | | |
|---|---|---|
| Picture |  |  μm |
| Laser Microscope |  |  μm |
| Roughness | 0.57μm_rms<br>Aluminum | 1.89 μm_rms<br>ABS+Cu plating |

VK-X3000, Keyence

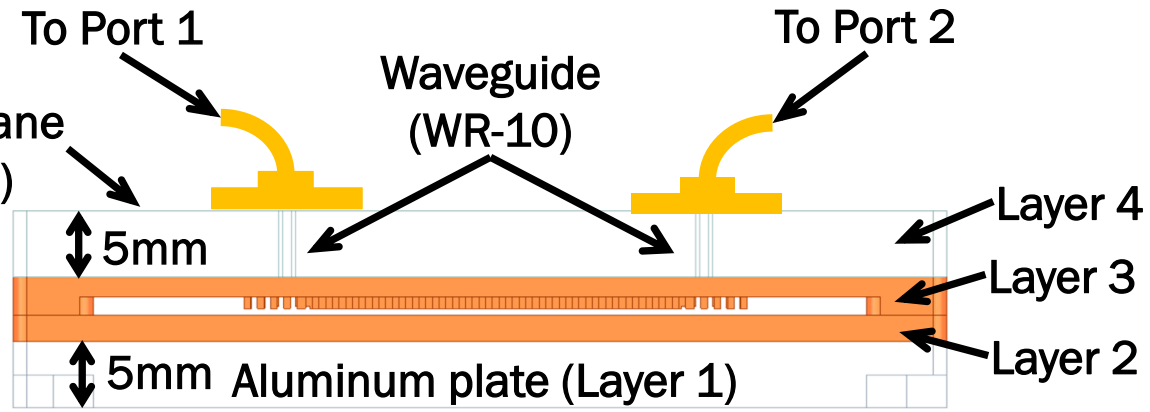
# S-parameters measuring system

## Equipment

- VNA: N5247B, Keysight Technology
- Frequency extension modules: N5262BW10 x2 (sets)




EUT

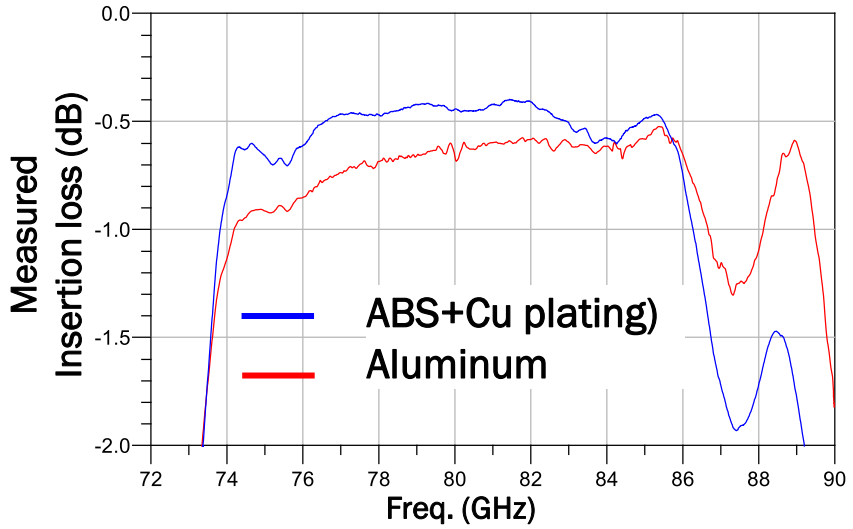


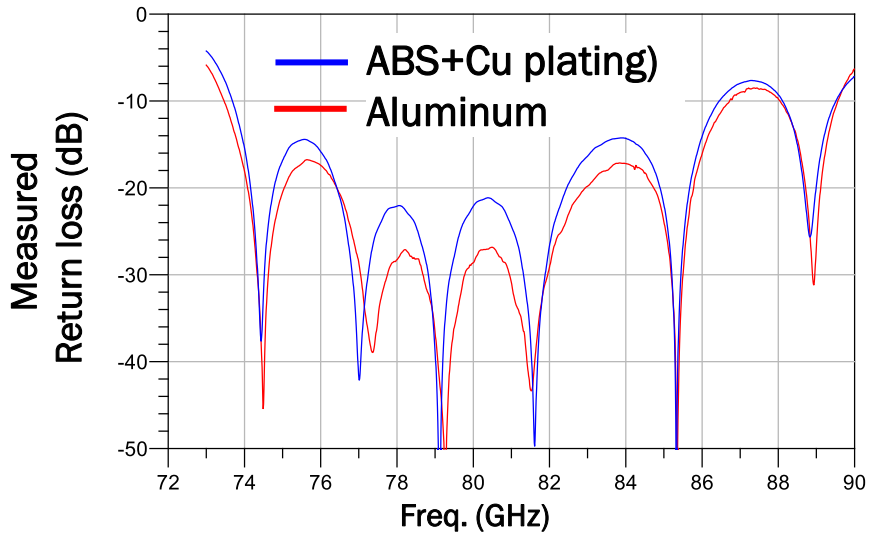

Cross sectional view (A - A')

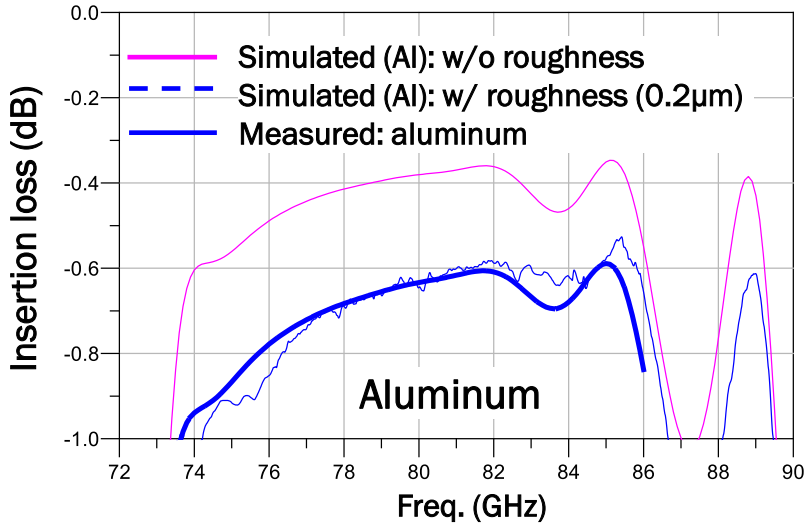
# Measurement results of S-parameters

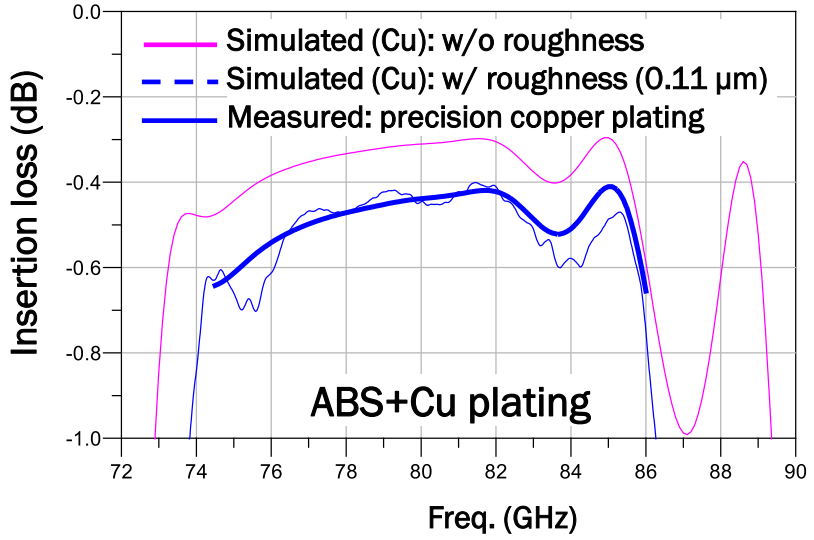


- These data include both waveguide parts(WR-10).




Simulator: 3D EM
HFSS by Ansys

Conductivity
Aluminum = 3.8e+7 (S/m)
Cu plating = 5.8e+7 (S/m)

Roughness(HFSS)
: Aluminum
0.2μm_rms

Roughness(HFSS)
: ABS+Cu plating
0.1μm_rms

Ridge length: 30mm

# Summary



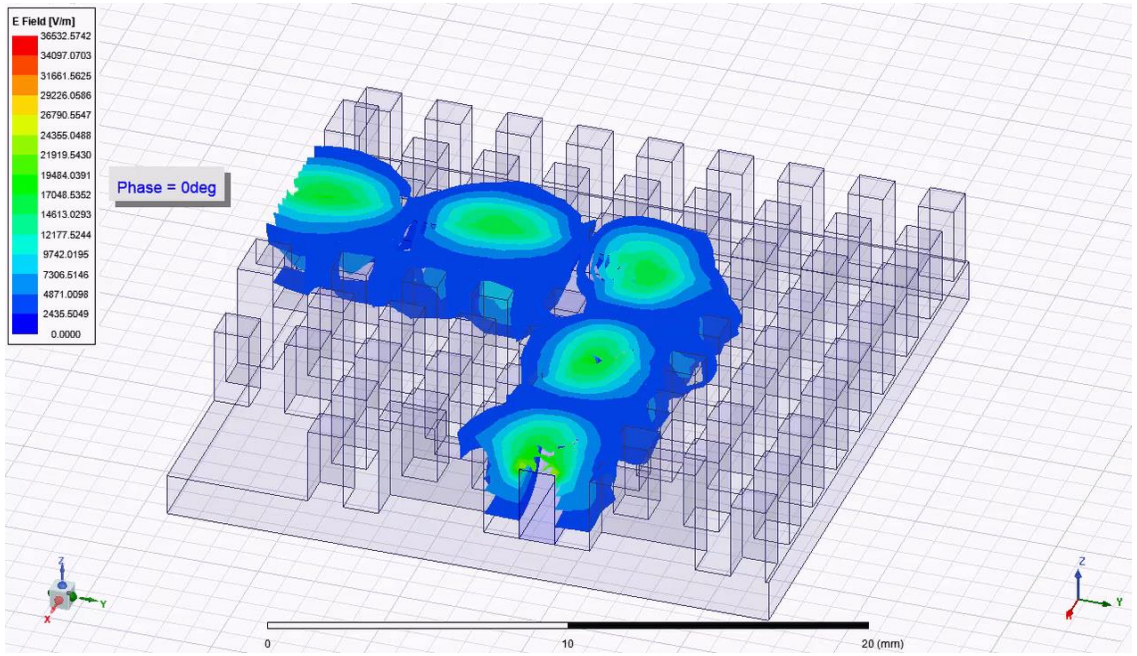
- The 79GHz transmission line using WRG has been evaluated.
- The circuit layer materials were ABS+Cu plating and aluminum.
- IL(@79GHz): approximately ABS+Cu 0.4dB, aluminum 0.6dB.
  Both data include 2 waveguide losses, Ridge length:30mm.
- Roughness:
  Measured: ABS+Cu 1.89μm_rms, aluminum 0.57 μm_rms,
  Simulated: ABS+Cu 0.11μm_rms, aluminum 0.2 μm_rms.

# Thank you for your attention.

# Appendix

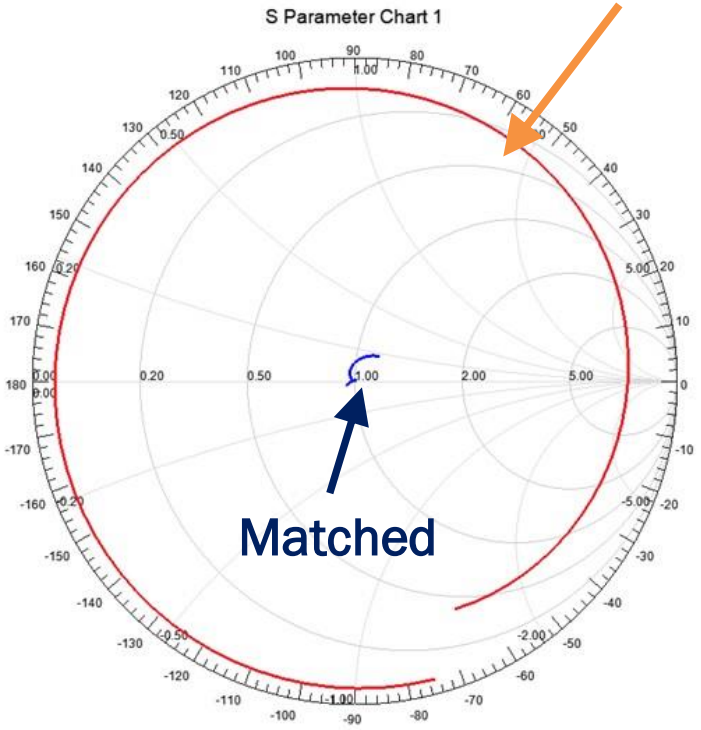


## Impedance Matching at Bend




Achieves smooth propagation even at bends

Before matching




S11

Optimal design of corners achieves appropriate impedance matching.