

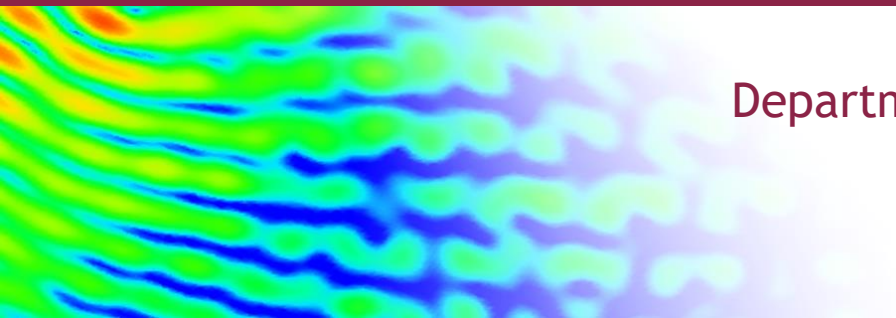
# High Performance Filters at 100 GHz: Ridge Gap Waveguide

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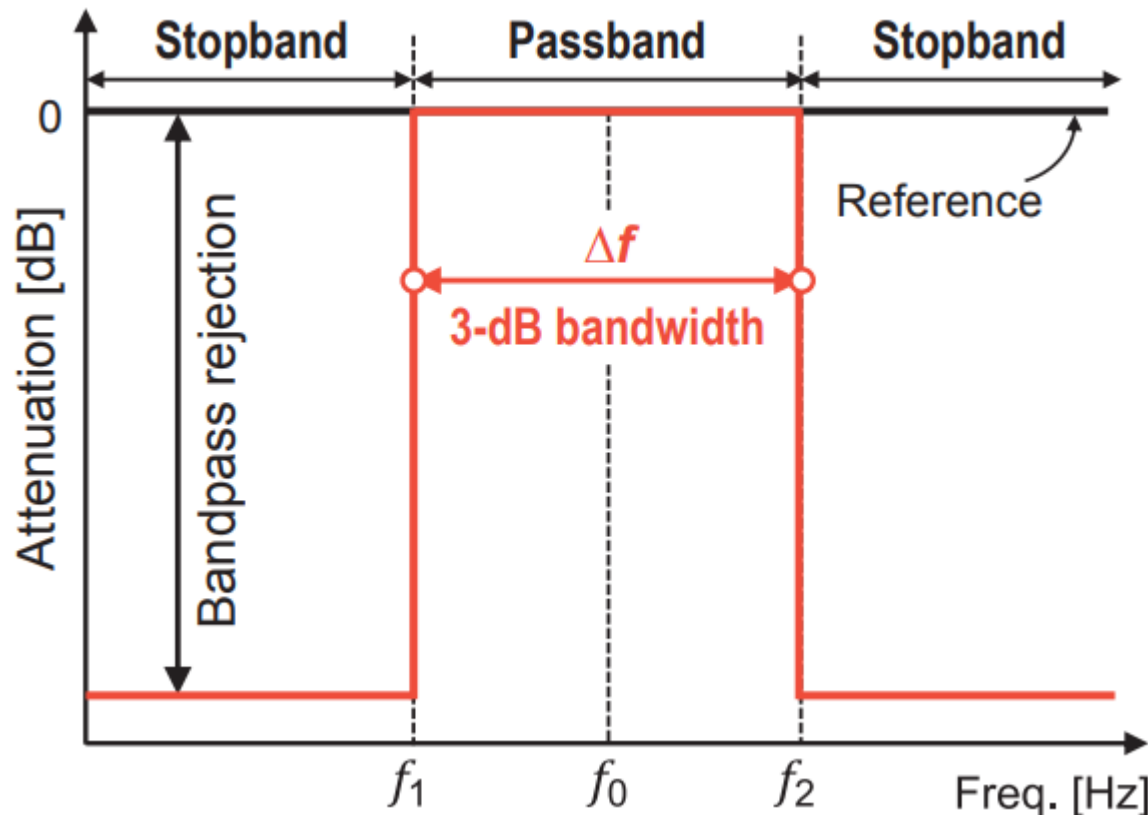
# Overview

- RF/Microwave Filters
- What is the problem at 100 GHz?
- Gap Waveguide
  - Design
  - Manufacture
  - Measured results
- Future

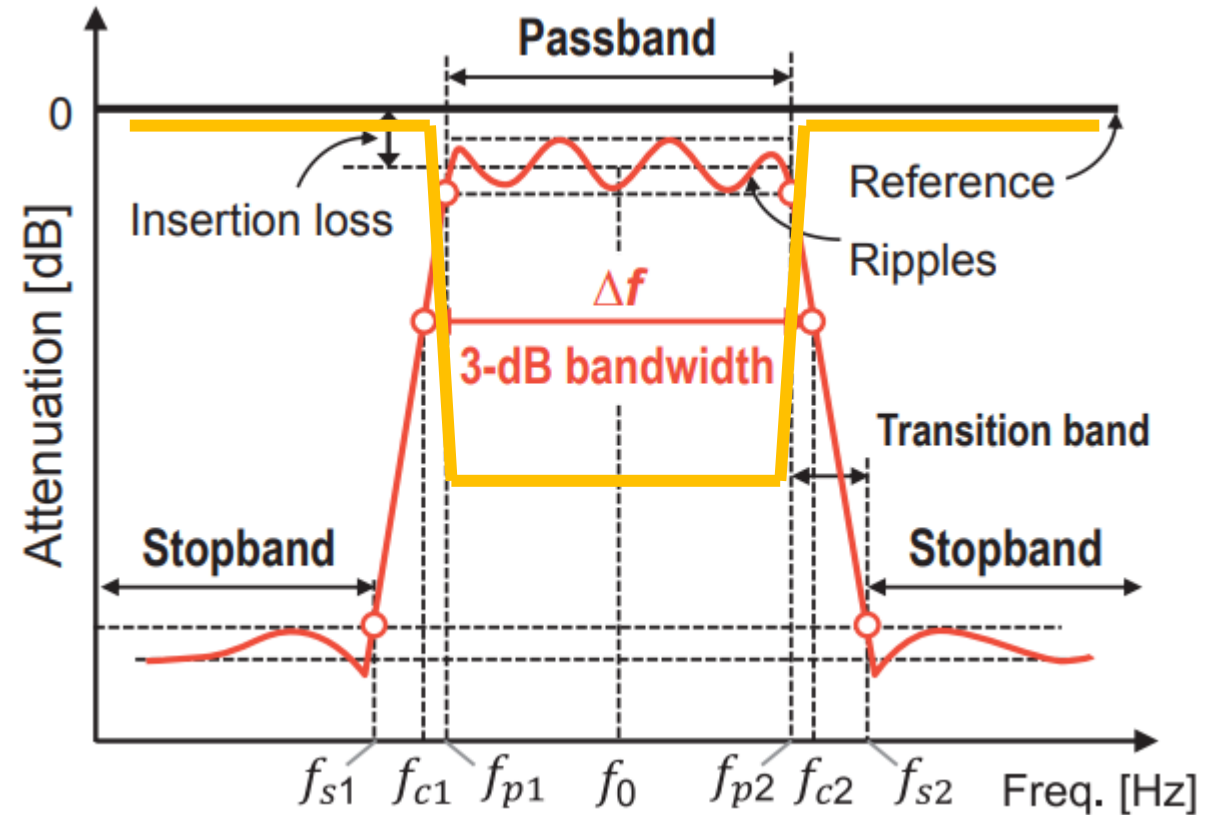
# RF/Microwave Filters

- Filters are used to pass signals at desired frequencies and reject signals at unwanted frequencies: Lowpass, highpass, bandpass

## Ideal Bandpass Filter

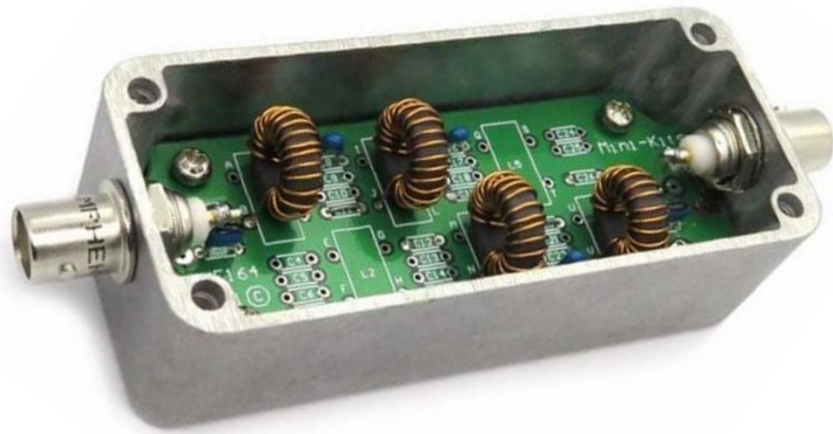


## Real Bandpass Filter

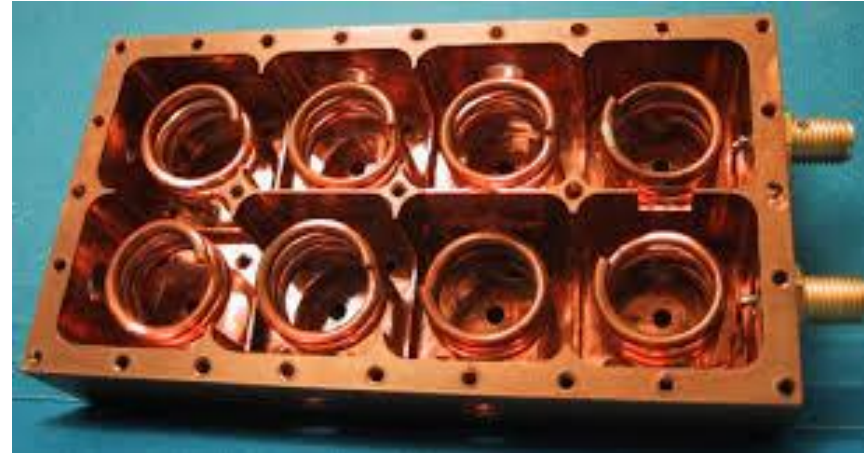


# RF/Microwave Filters

Discrete lumped elements (LC)



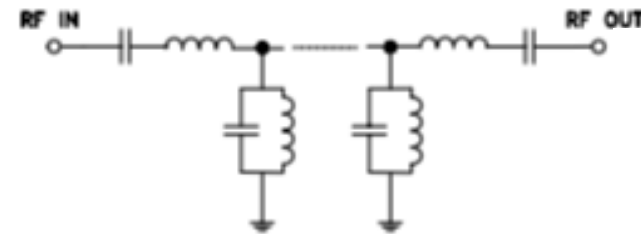
Helical resonators



High Q surface mount



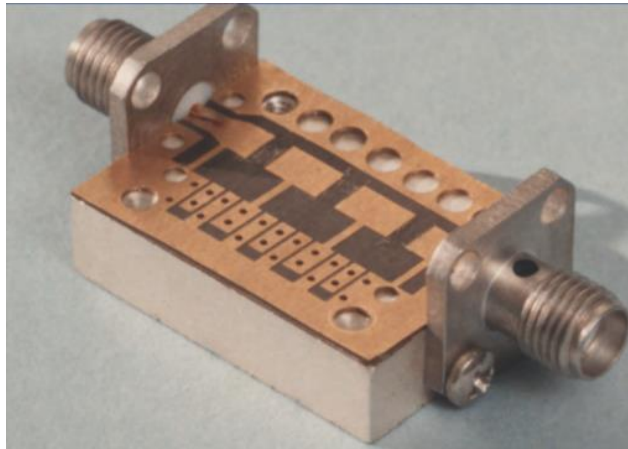
LTCC COTS



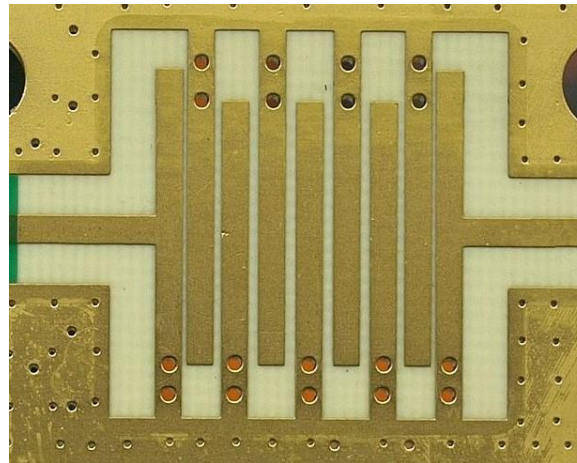
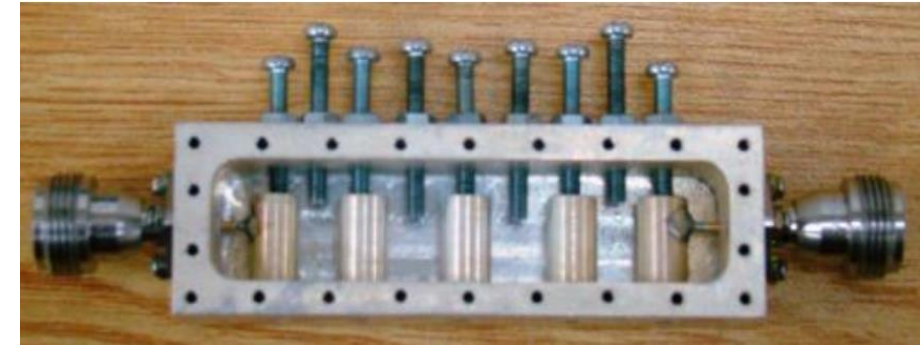
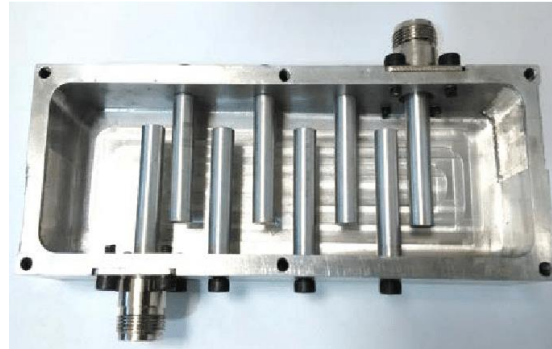
CASE STYLE: FV1206

# RF/Microwave Filters

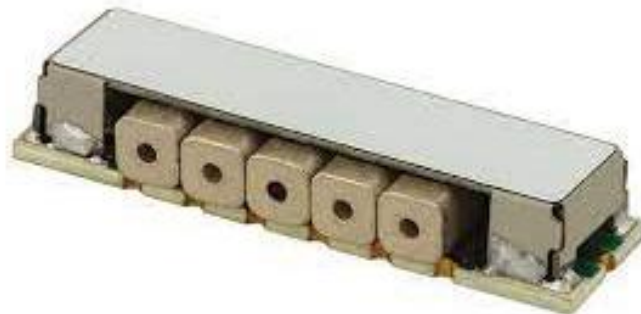
Suspended stripline



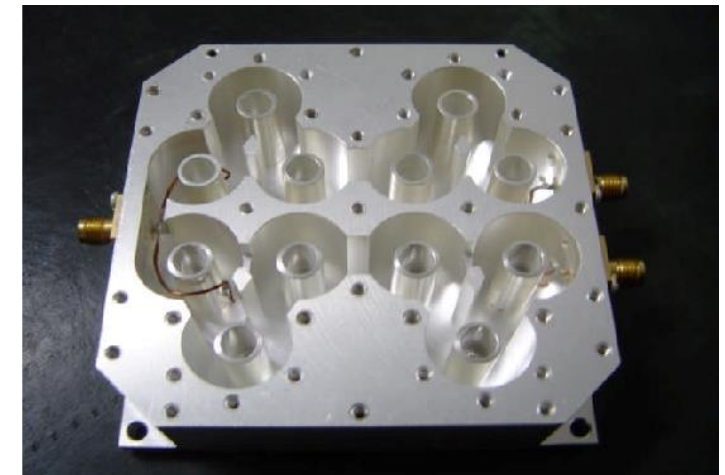
Cavity Filters: Comblines,  
Interdigital, Iris coupled



Ceramic coaxial resonator



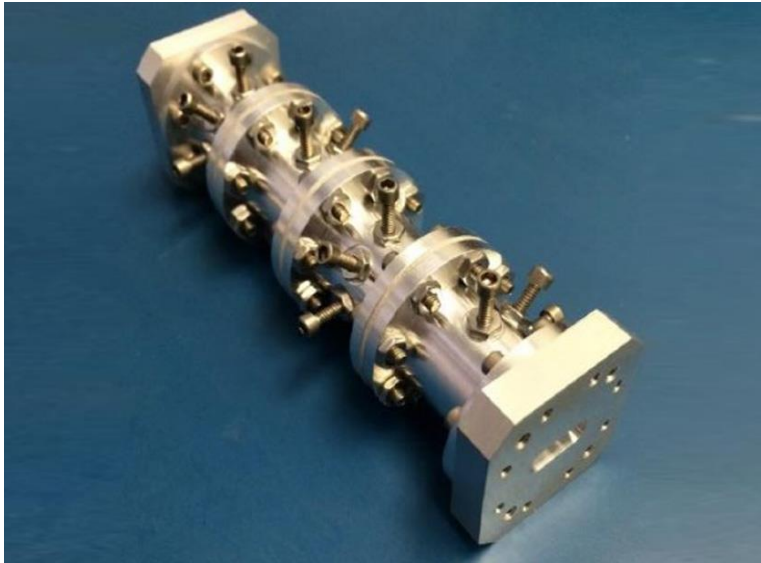
Coaxial resonator



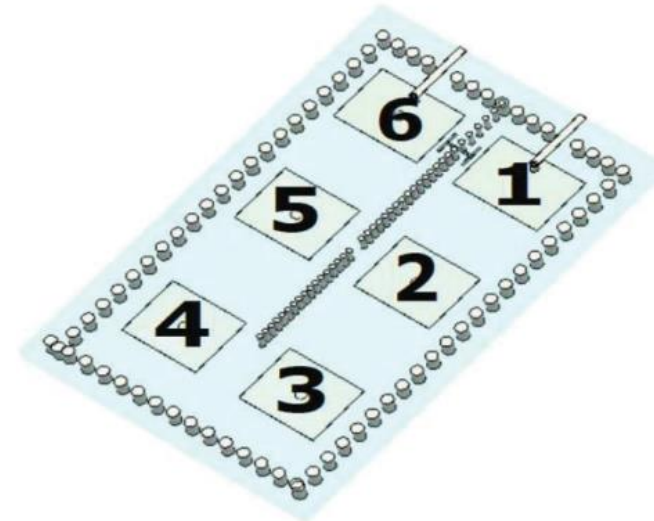
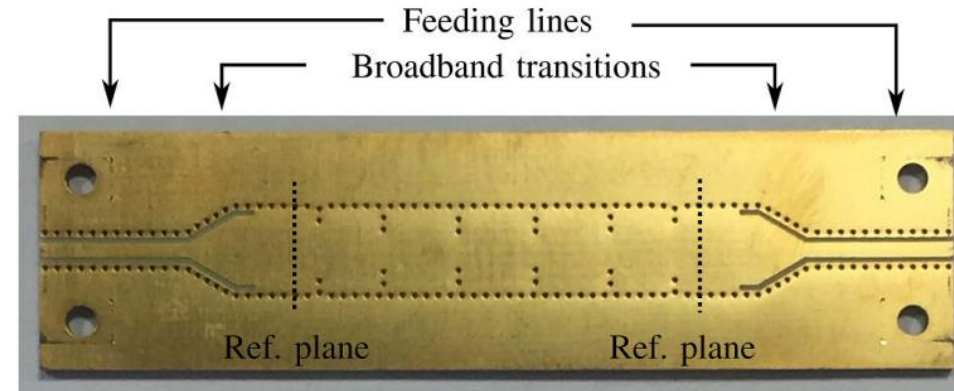


# RF/Microwave Filters

## Waveguide



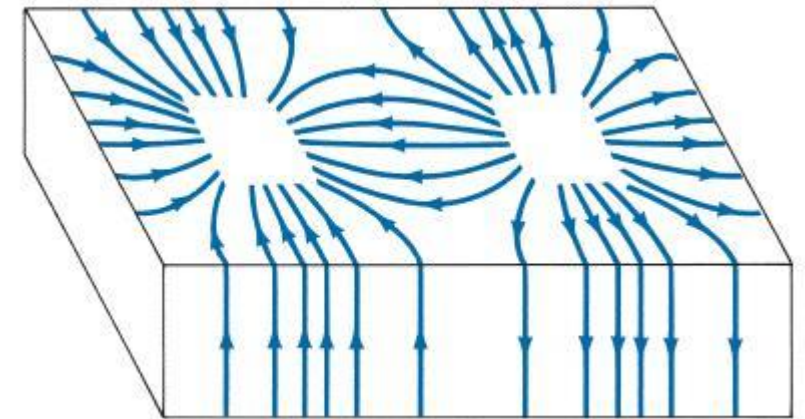
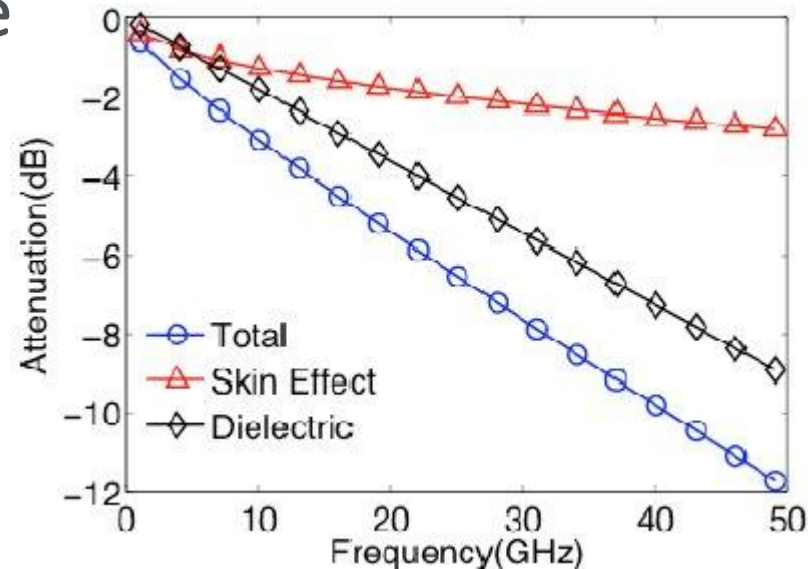
## Substrate Integrated Waveguide (SIW)



# What is the problem at 100 GHz?

- Dimensions are inversely proportional to frequency: **wavelength is now 3 mm!**
  - Manufacturing
  - Assembly
  - Integration with other components
- Losses increase

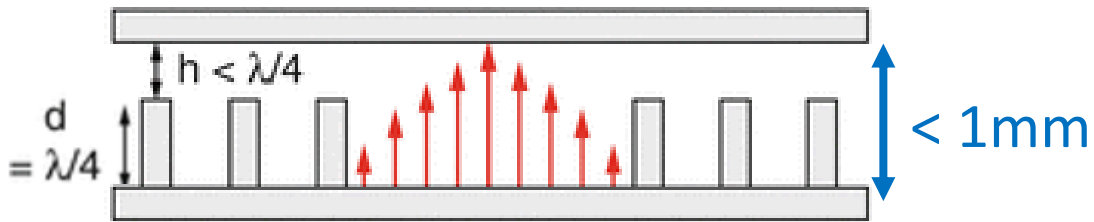
The solution is obviously waveguide, isn't it?



# Gap Waveguide

## Groove Gap Waveguide

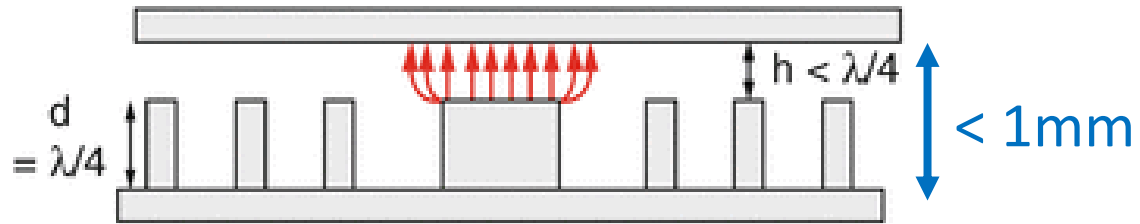
Metal Plate



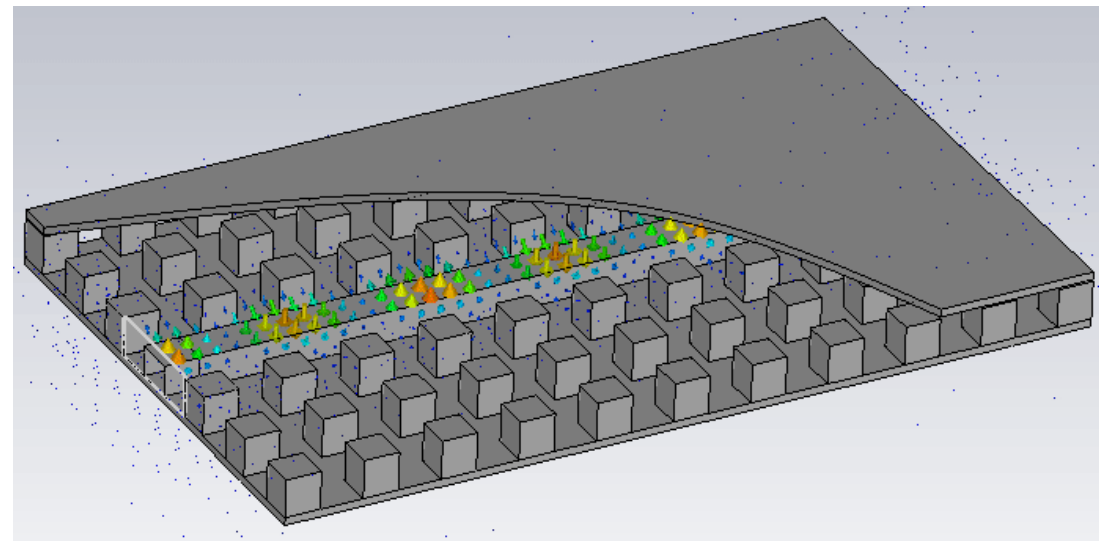
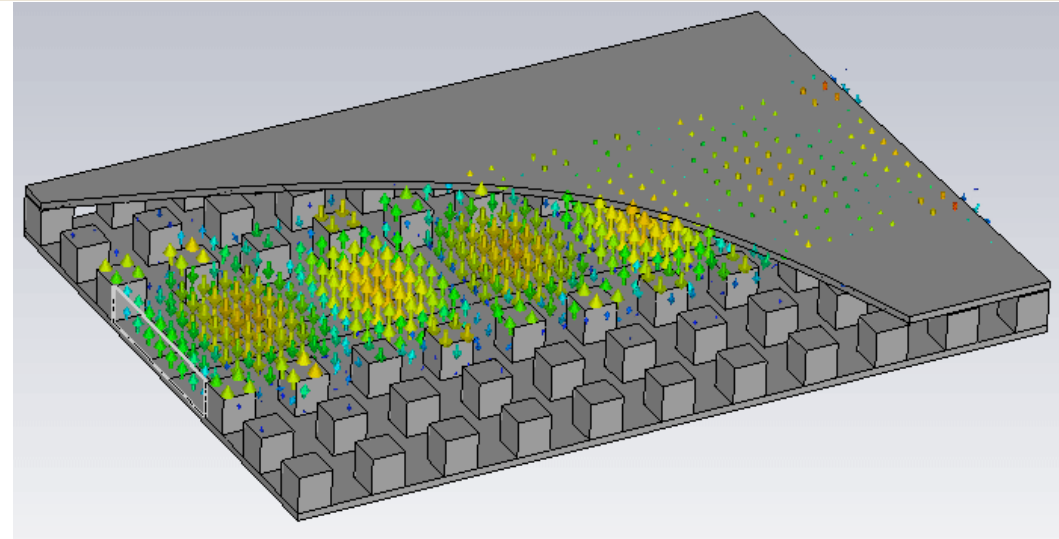
Metal Plate with periodic pins

## Ridge Gap Waveguide

Metal Plate

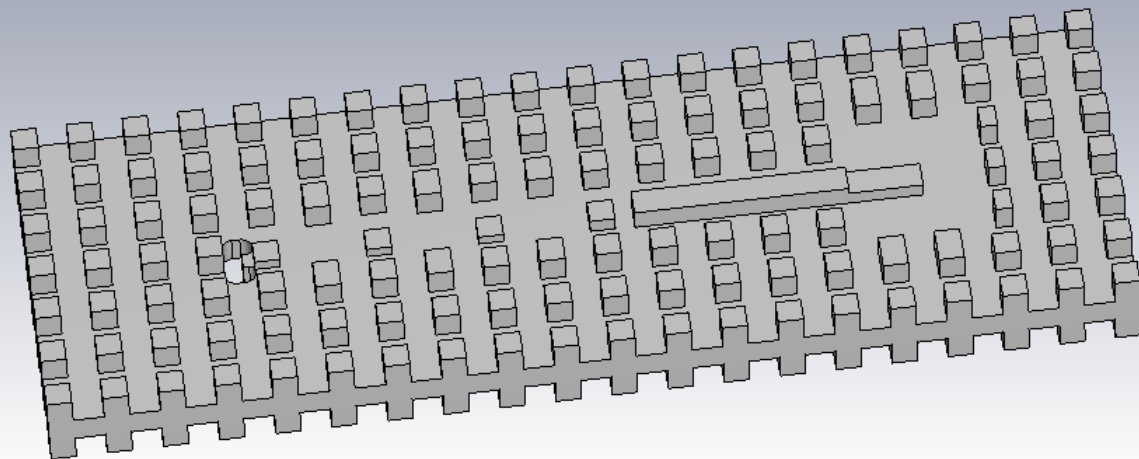
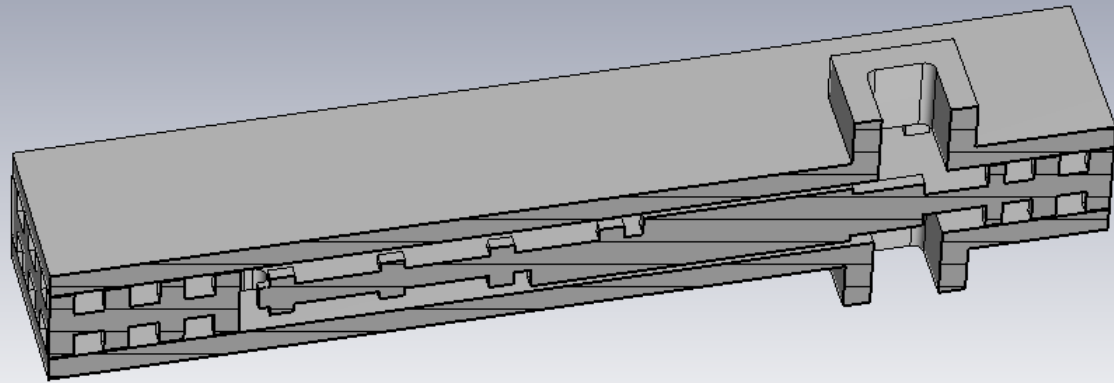


Metal Plate with periodic pins

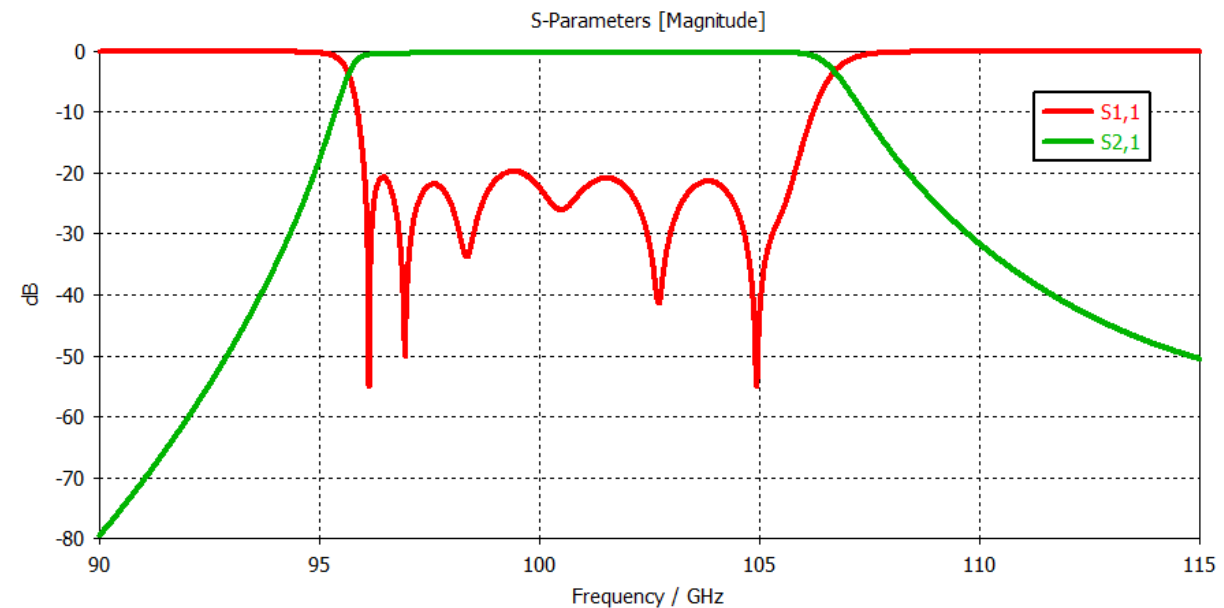




# Ridge Gap Waveguide 7<sup>th</sup> Order Folded Filter



Parameter	Dimension
Pin dimensions (w x l x h)	0.45 x 0.45 x 0.5 mm
Pin spacing	0.55 mm
Ridge dimensions (w x h)	0.5 x 0.4 mm
Gap width	1.5 mm
Gap height	25 $\mu$ m

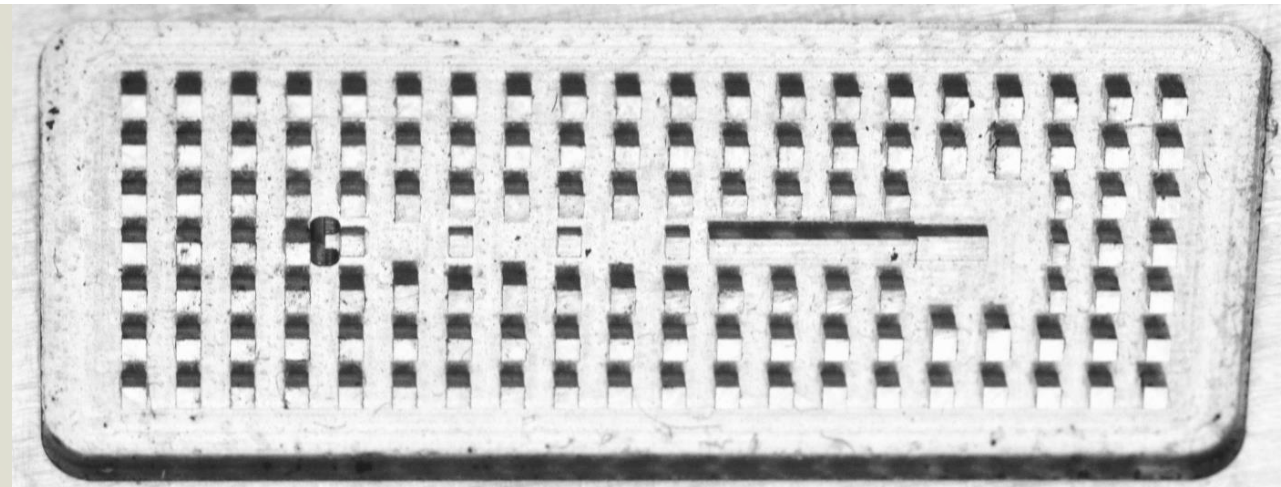
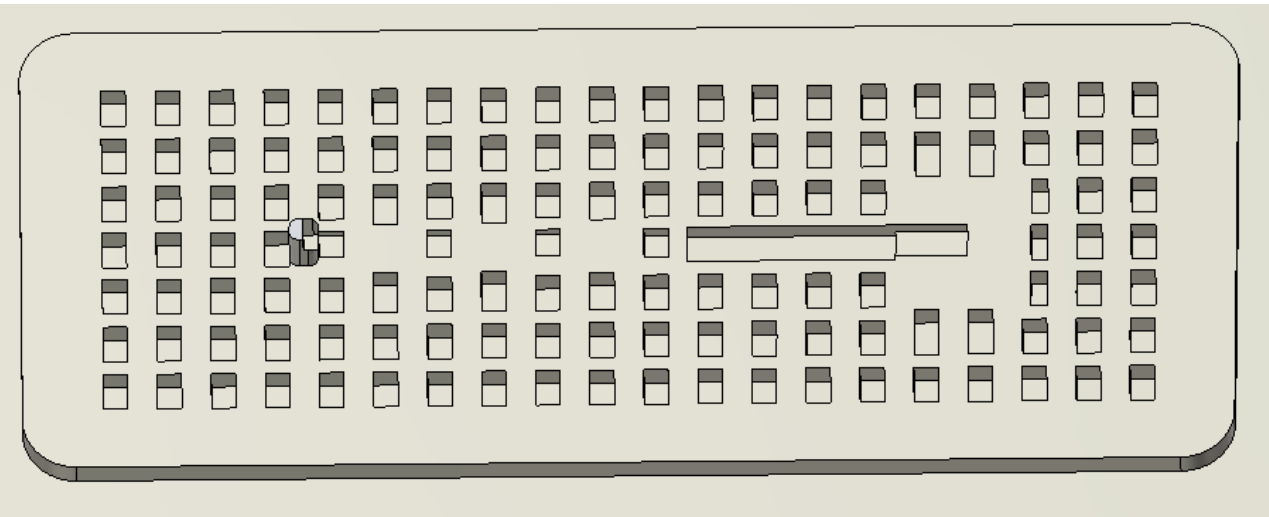


# Ridge Gap Waveguide Folded Filter

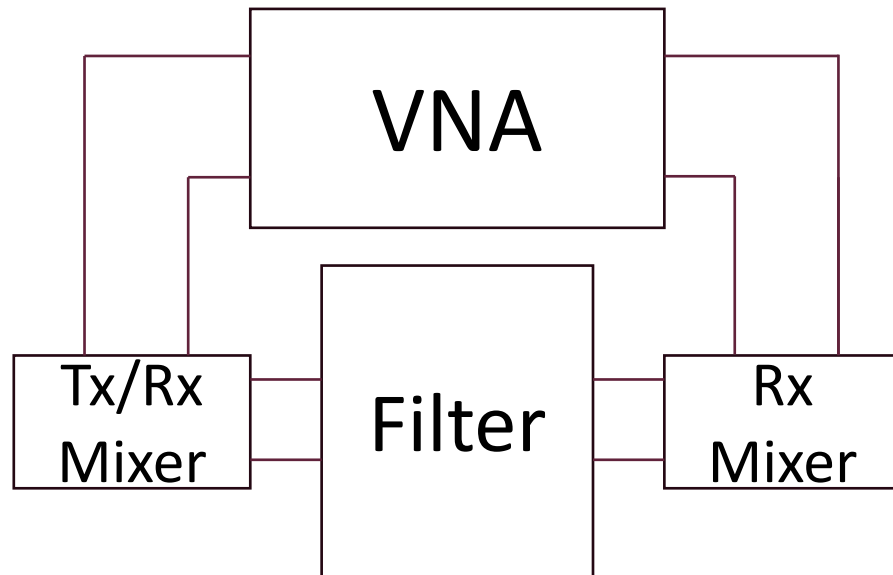
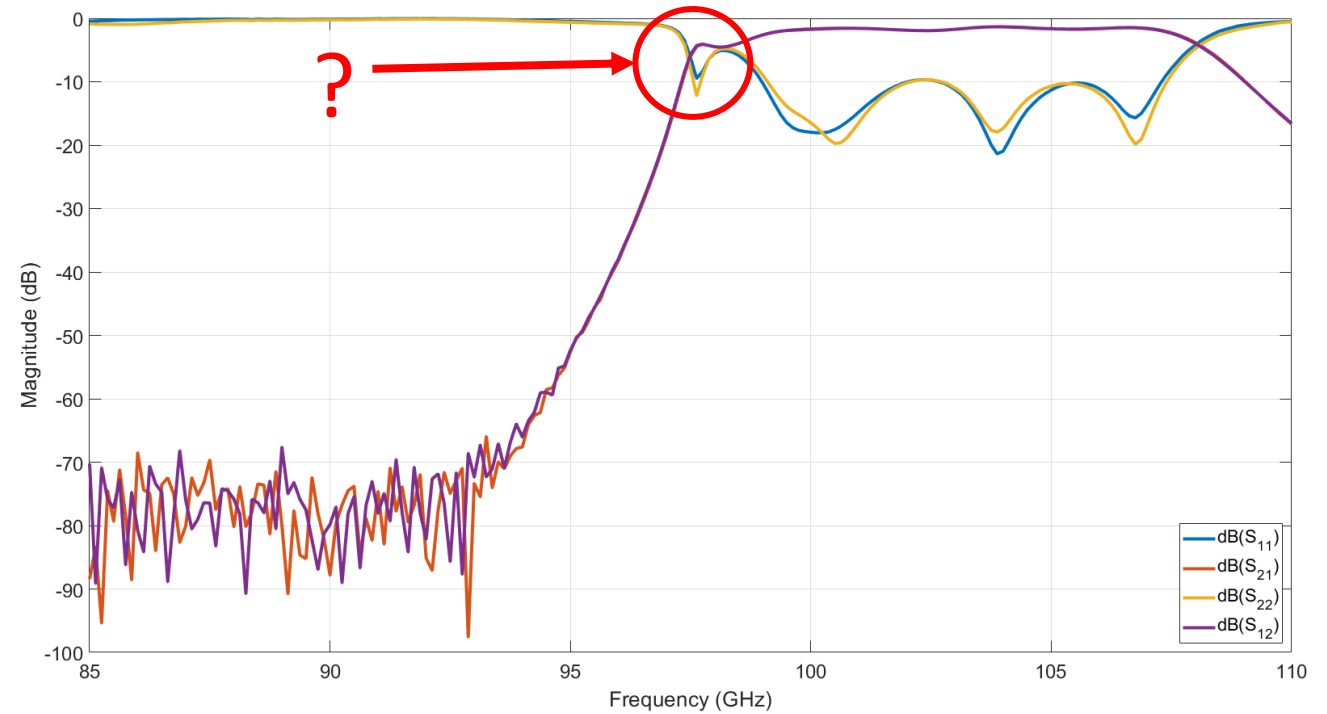
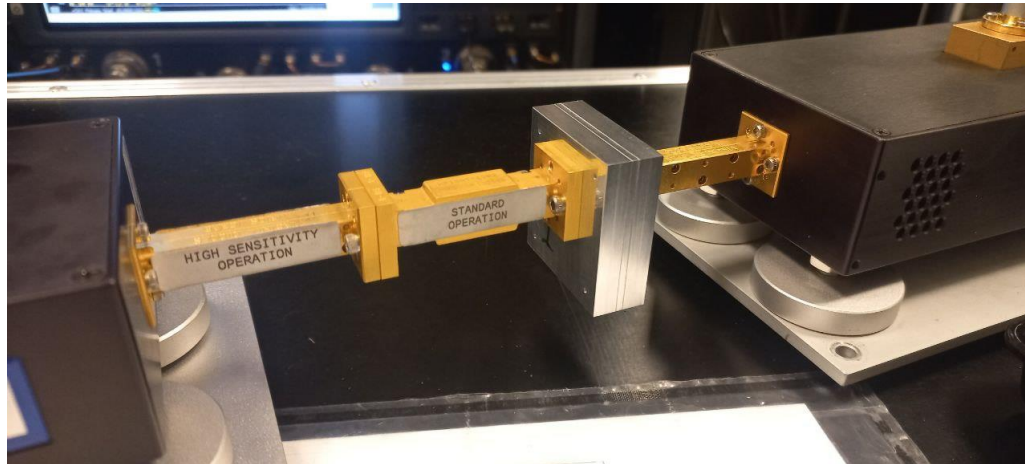


Micromachined in Sweden using  
a KERN MICRO HD

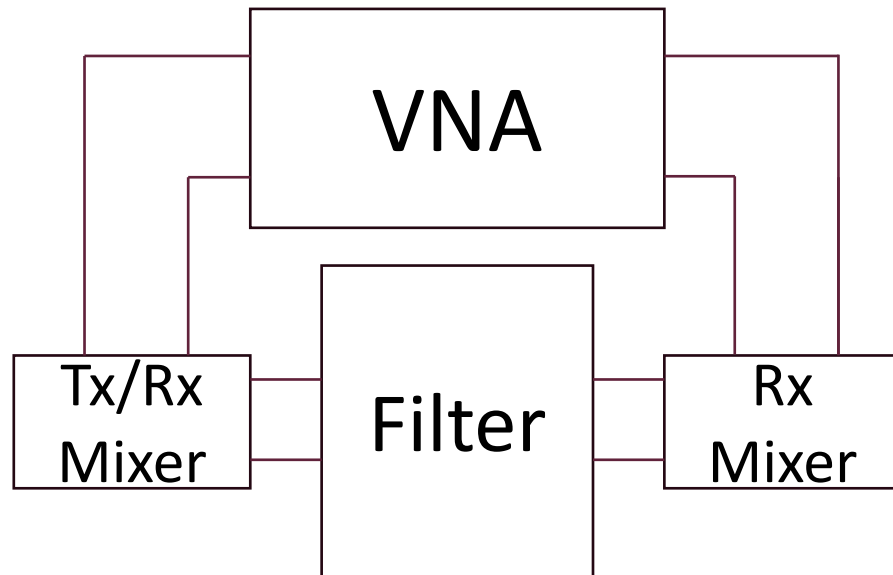
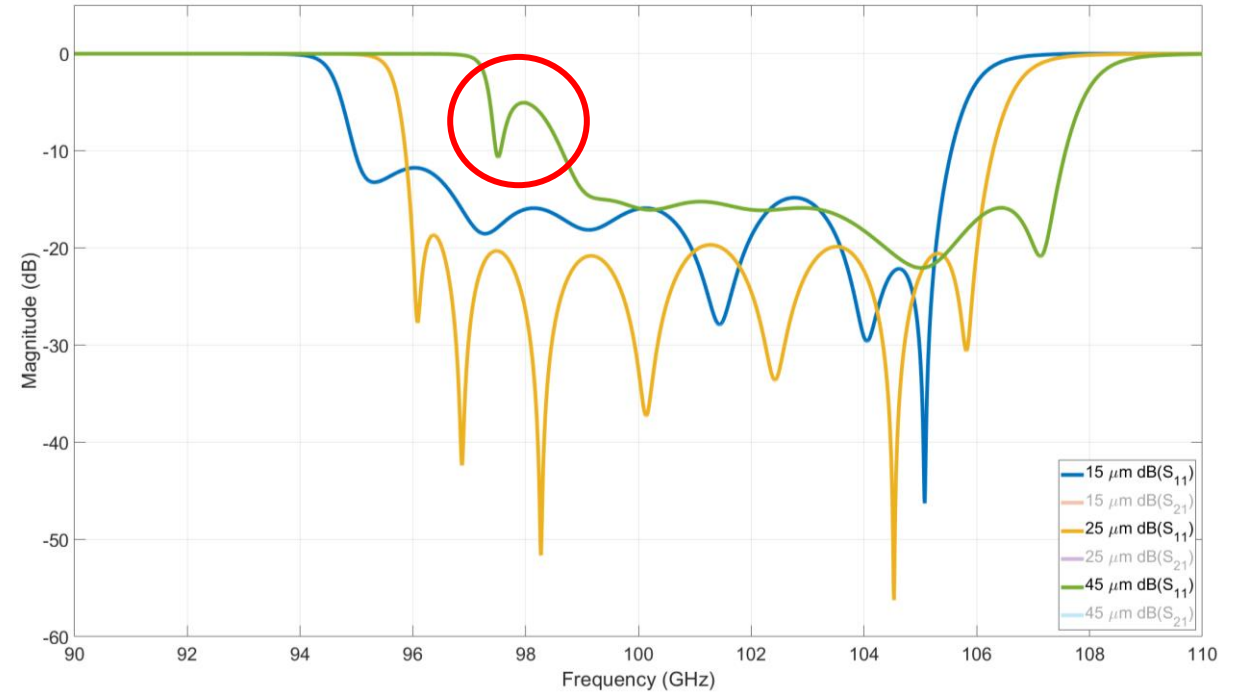
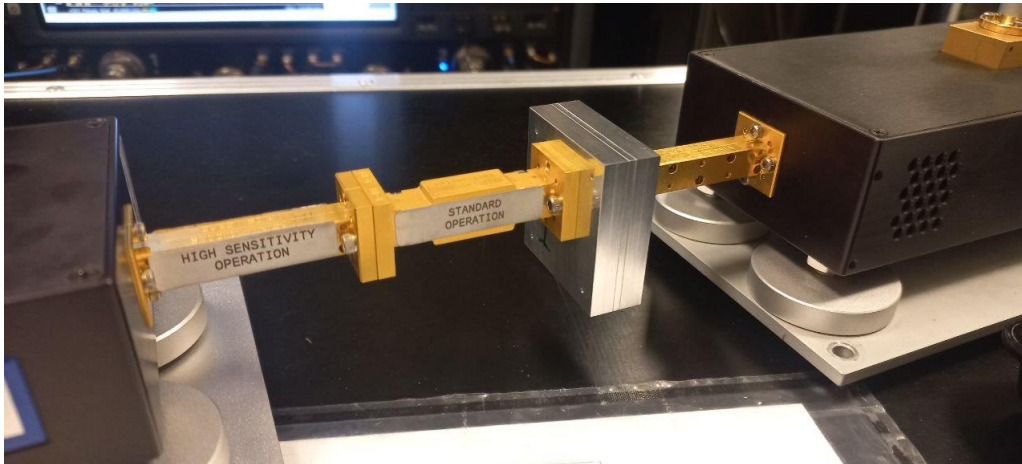
- 5-axis CNC machine
- 2  $\mu\text{m}$  tolerance
- 80 000 RPM low vibration spindle
- Temperature control:  $\pm 50\text{mK}$



# Ridge Gap Waveguide Folded Filter



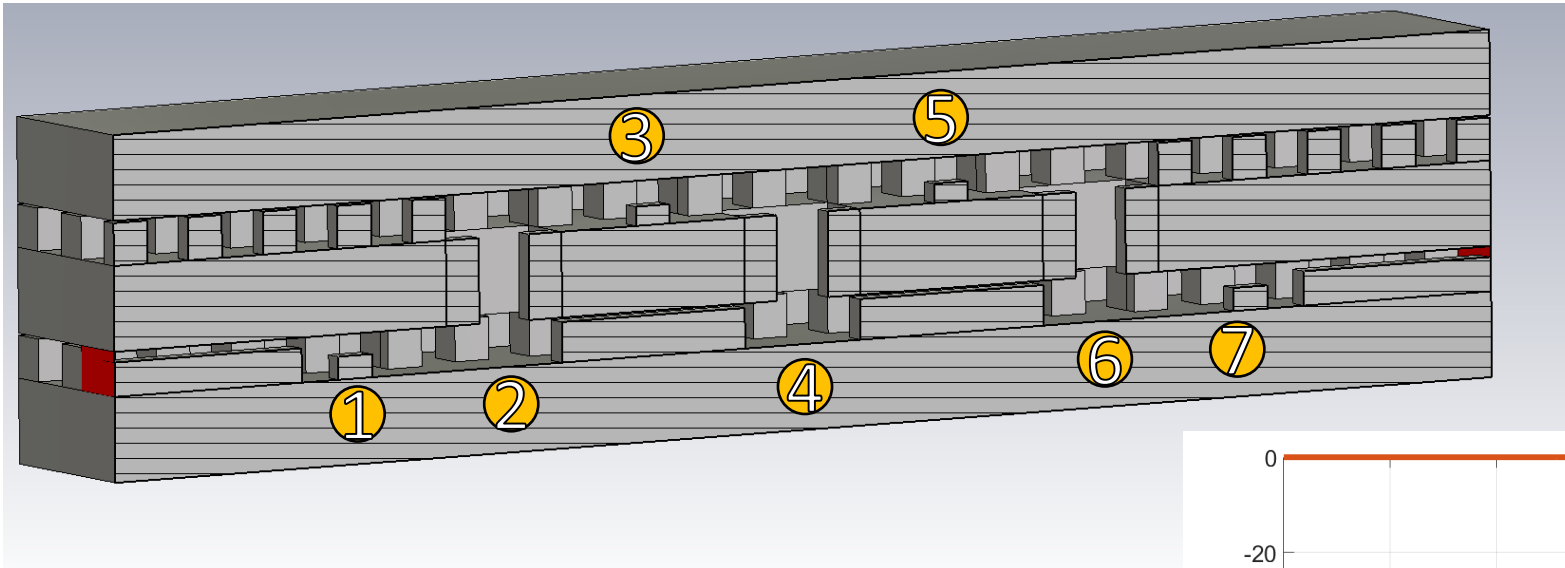
# Ridge Gap Waveguide Folded Filter



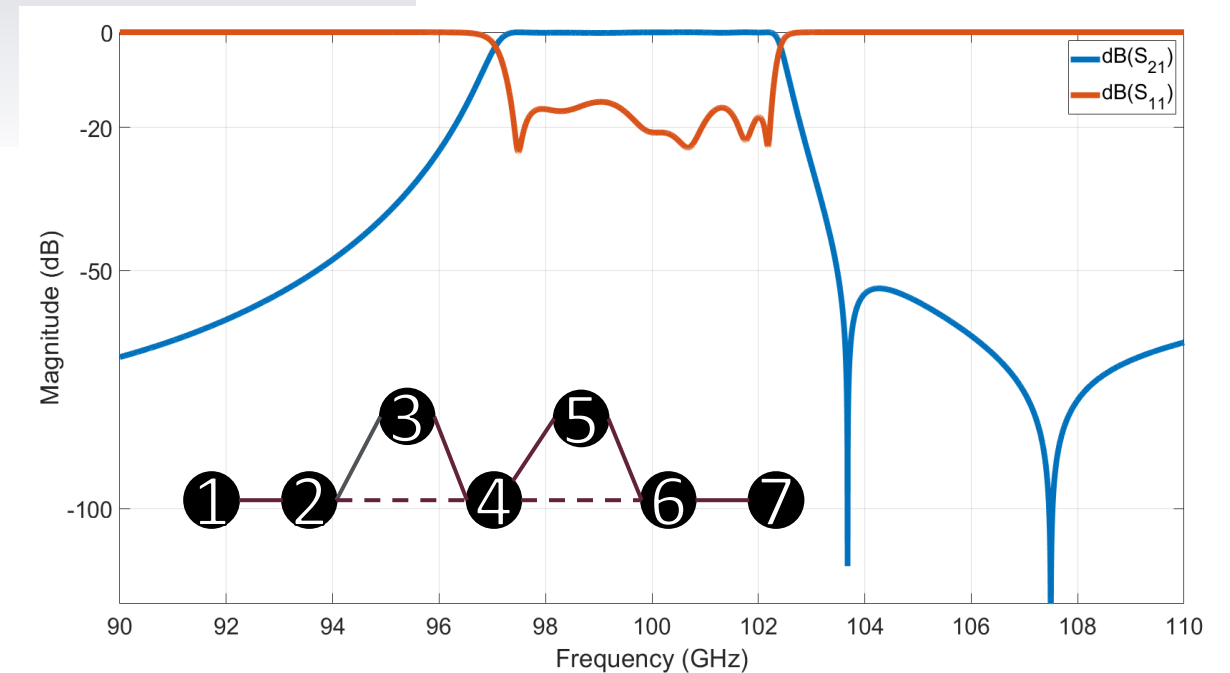
Gap height variation from 15  $\mu\text{m}$  to 45  $\mu\text{m}$  shows that the gap height is probably the main cause of the deviation



# Future: Transmission Zeros



- New “vertical” resonator between layers
- Cross-coupling between resonators on the same level to produce transmission zeros



# The End

**Thank you for your  
attention**