Signaling & Packaging for sub-THz Applications Microstrip, CPWs and SIWs

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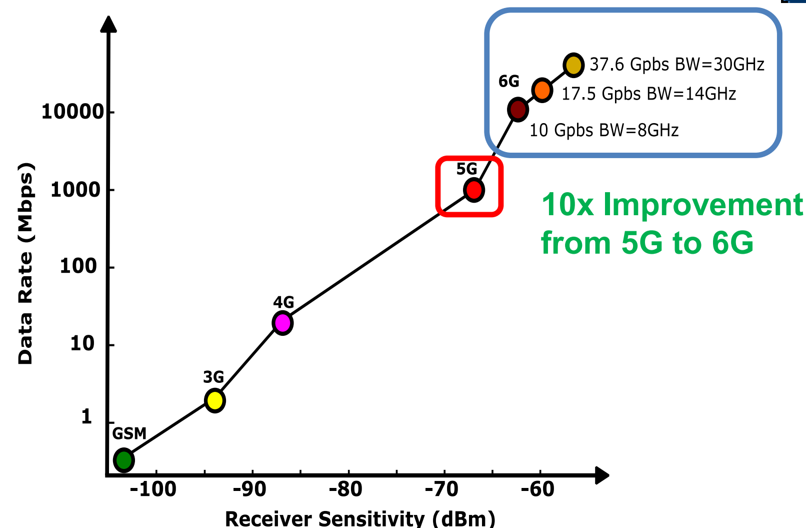
Outline

- Beyond 5G Region
- Sub-THz Module
- Challenges in sub-THz domain
- Material Characterization
- High Performance Interconnects and Passives → SIWs
- Schedule
- Summary

Next Generation Radio Architecture

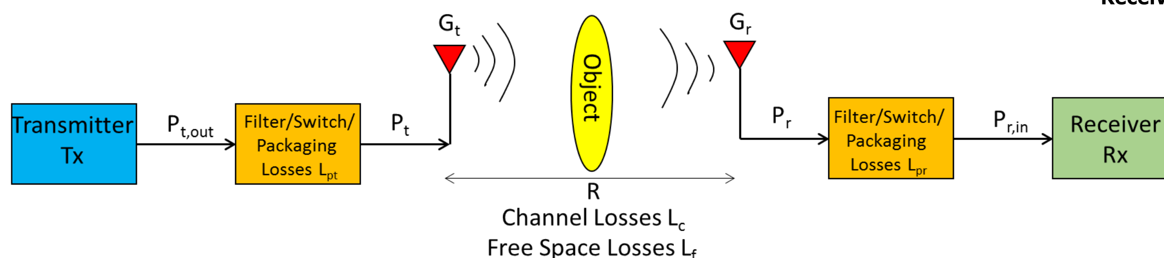
Next Generation Applications

- ❑ Multi-gigabit Communication
- ❑ High Resolution Imaging
- ❑ Wireless Virtual Reality



One demand→ Higher Data Rates

More physical bandwidth requirement
Solution→ Use of higher carrier frequencies



- ❑ Wireless communication @ THz (140GHz, 220GHz, 340GHz ….)
- ❑ High gain and low loss components (Antennas, Interconnects, Passives ….)
- ❑ Integrated Ultra-thin module
- ❑ <u>Our focus currently is on 140GHz RF module</u>

Parameters calculated based on ASCENT/ComSenTer, JUMP

Proposed Module @ Sub-THz

SIII Poster 2
Mutee Ur Rehman, "Substrate Integrated Waveguides for sub-THz Region"

SIII Poster 1
Kai-Qi Huang, "mm-Wave and sub-Terahertz Antennas for 5G and 6G Applications"

SIII Poster 3
Serhat Erdogan, "Design of D-Band Glass-based Vivaldi Antennas for 6G Applications"

SIII Poster 10
Nithin Nedumthakady - Thermomechanical analysis of GPE packages: integrated heat spreader design for high heat flux densities & reliability

SIII Poster 7
Nahid Aslani Amoli, "Thermal Management for 6G Module Using Vapor Chamber"

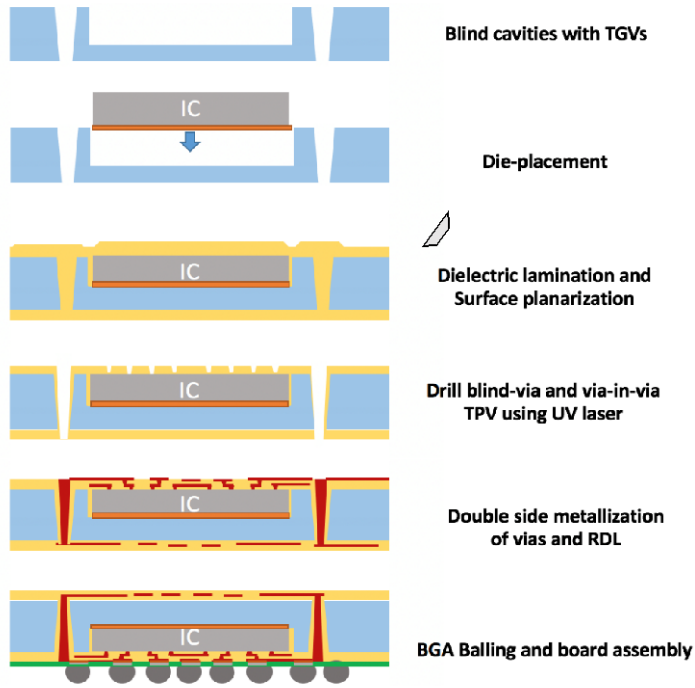
Challenges

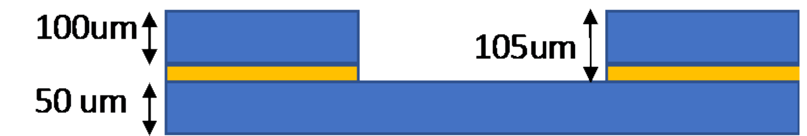
- ❑ Material Characterization
  - Extract electrical properties of materials in sub-THz region
- ❑ Design Innovation
  - To reduce interconnect loss in comparison to traditional structures (MS,CPWs)
- ❑ Process Development
  - Capability of fabricating fine features with good dimensional control and smooth surface finish
- ❑ Antenna Integration
  - 10% bandwidth @ 140GHz
- ❑ Thermal Management Solution
  - To manage heat flux greater than 100W/cm^2

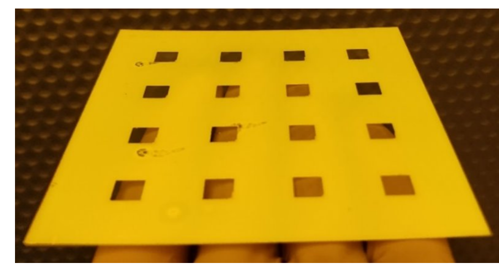
Fan Out Panel Level Packaging (FOPLP) for Sub-THz Module Fabrication Process Flow

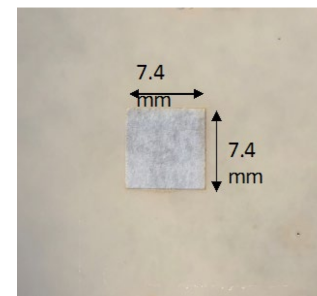
FOPLP for Sub-THz Module

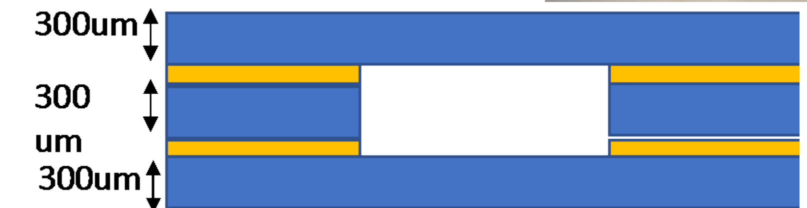
Cavities for die-embedding

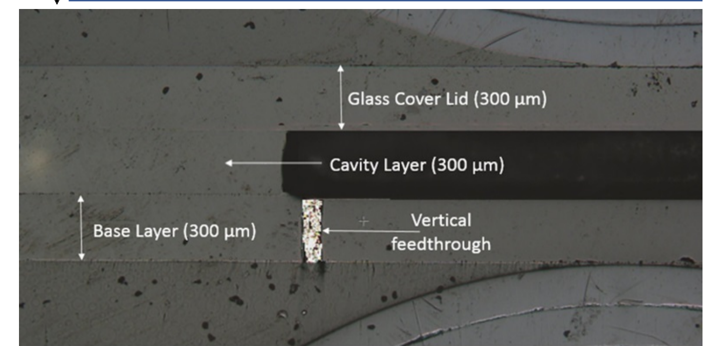


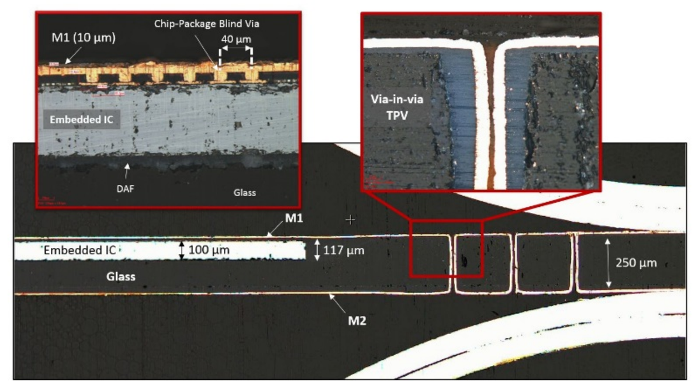












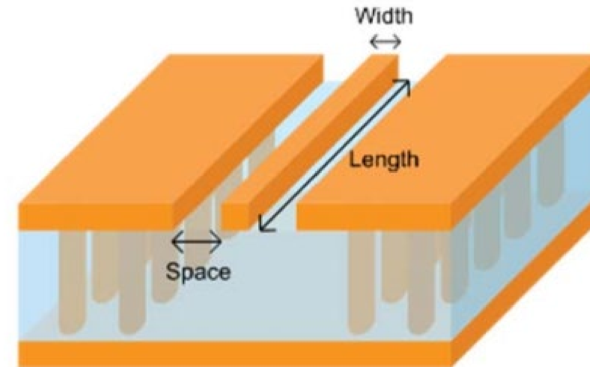
Siddharth Ravichandran, et al; JMEP (2019)

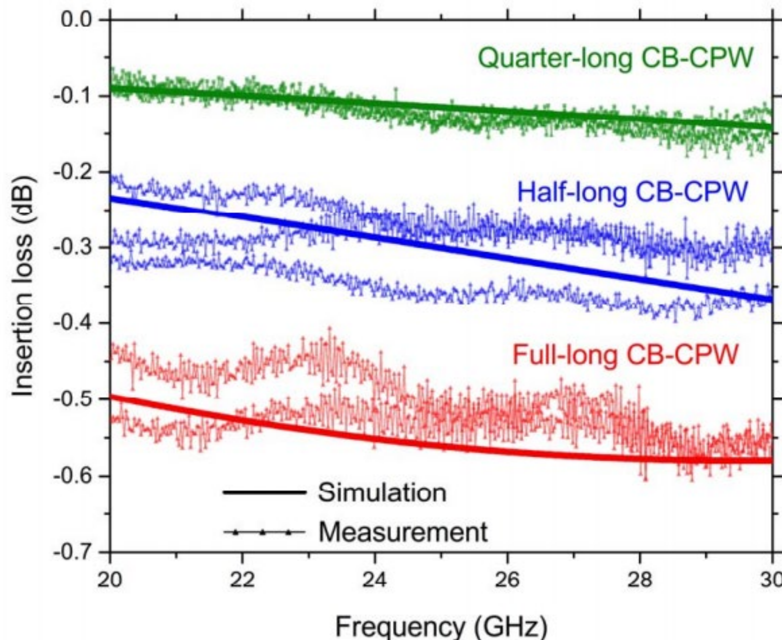
Courtesy: Chintan Buch

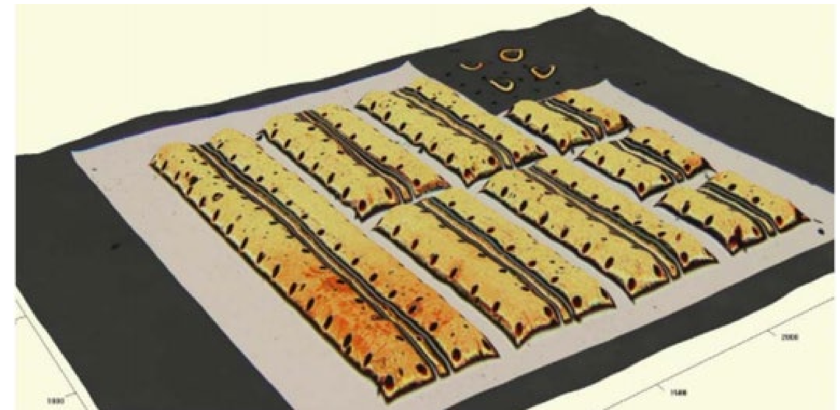
Glass Based Interposer for 5G-Prior Work

Characterization of Glass based Transmission Lines for 5G

- CPWG lines
- Measured Insertion loss :**0.3dB/mm@ 30GHz**

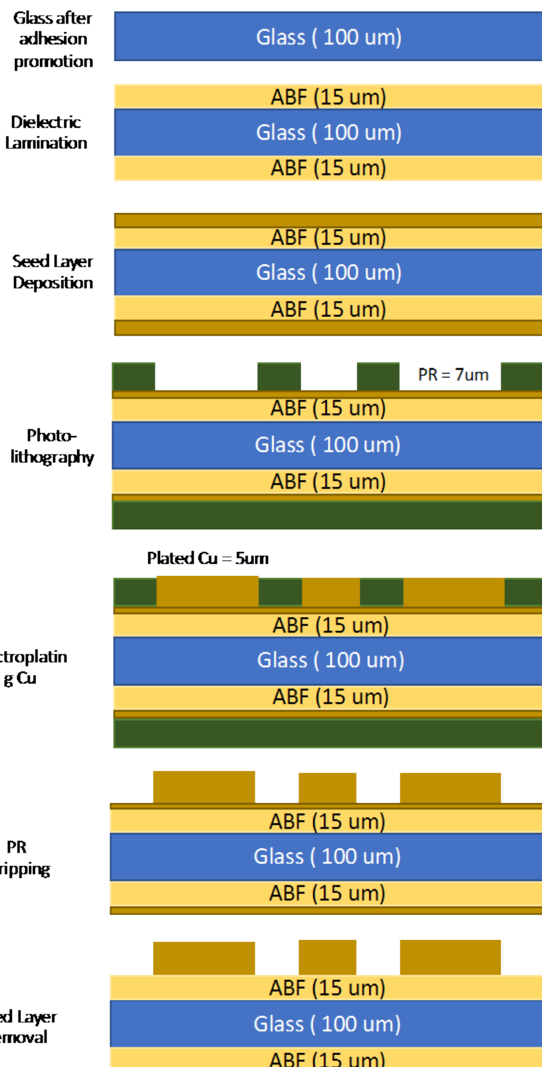


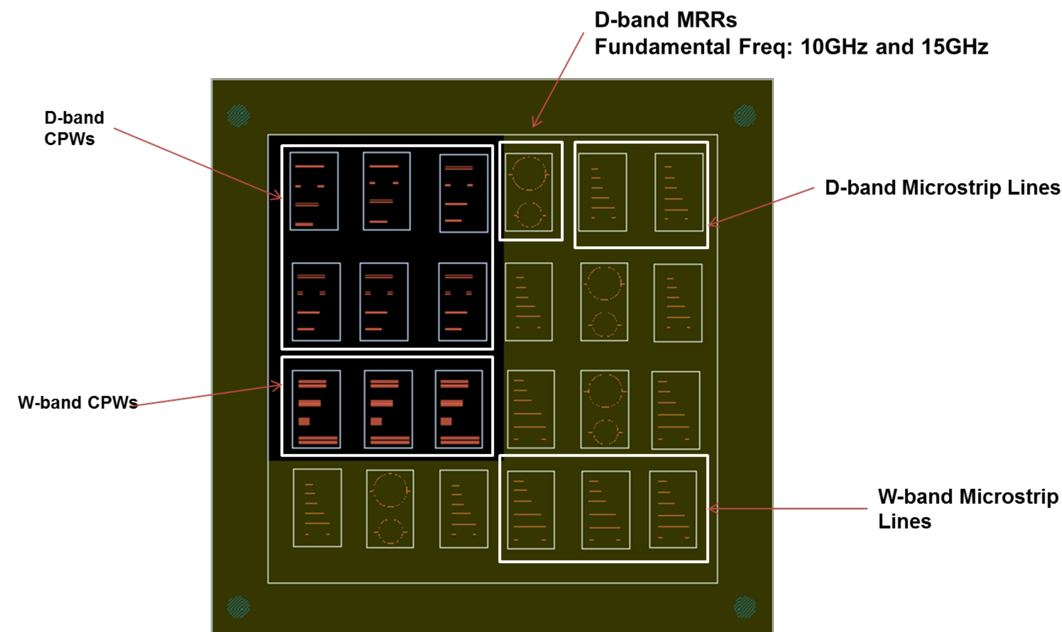


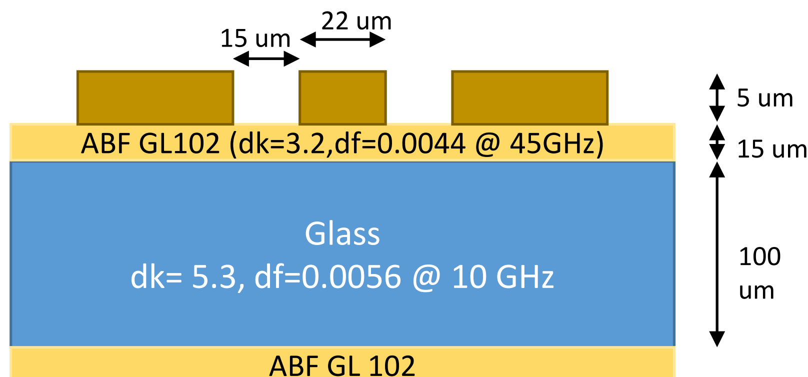


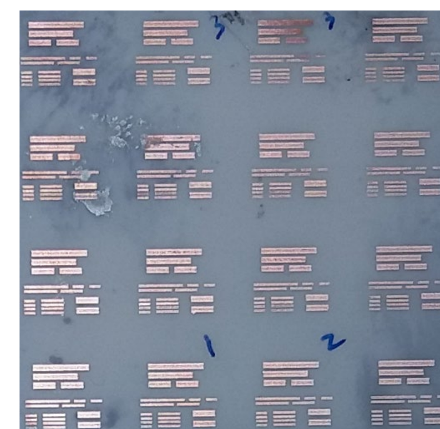
Atom O. Watanabe, Muhammad Ali, Bijan Tehrani, Jimmy Hester, Hiroyuki Matsuura, Tomonori Ogawa, P. Markondeya Raj, Venky Sundaram, Manos M. Tentzeris, Rao R. Tummala "First Demonstration of 28 GHz and 39 GHz Transmission Lines and Antennas on Glass Substrates for 5G Modules," *2017 IEEE 67th Electronic Components and Technology Conference (ECTC)*, Orlando, FL

Material Characterization Test Vehicle
W & D-band test structures





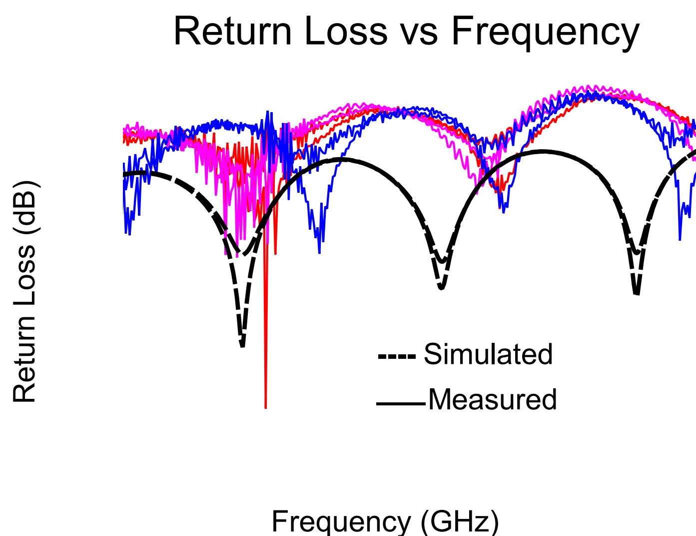


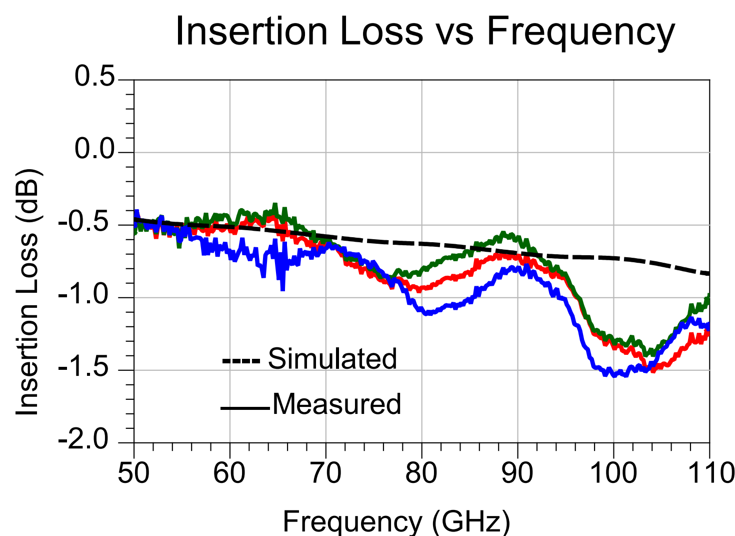


Fabricated Test Vehicle

Glass Based CPWs– Electrical Measurements Preliminary Results

- Scattering Parameters of 5mm long designed CPW Lines were measured from 50GHz to 110GHz





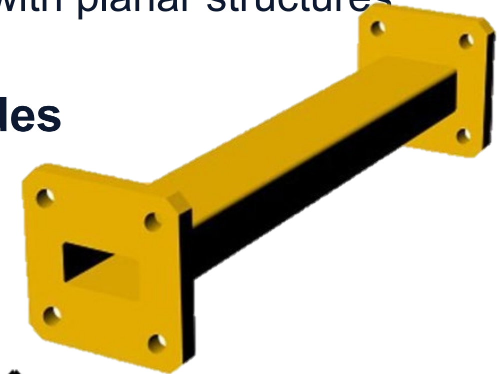
- The measured results show insertion loss of 0.2dB/mm at 110GHz
- Good electrical performance
- Merits further investigation and characterization

Substrate Integrated Waveguides

Traditional Waveguides have advantages over Microstrip and CPW lines

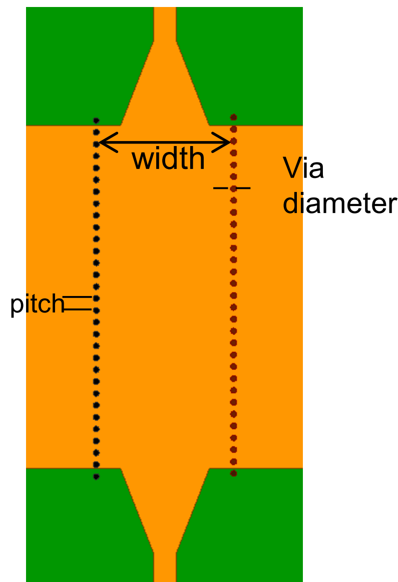
❑ Challenges

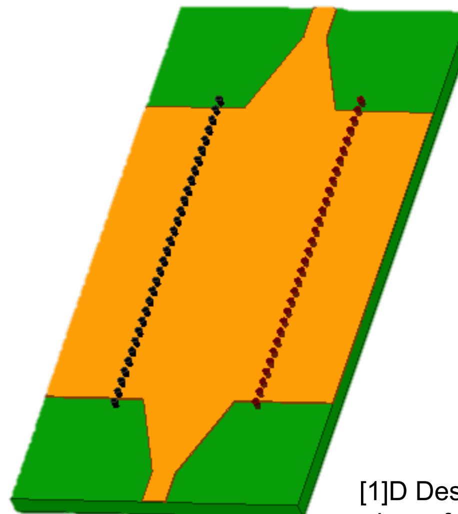
High Cost, bulky, Difficult to **mass produce ,**Difficult to **integrate** with planar structures

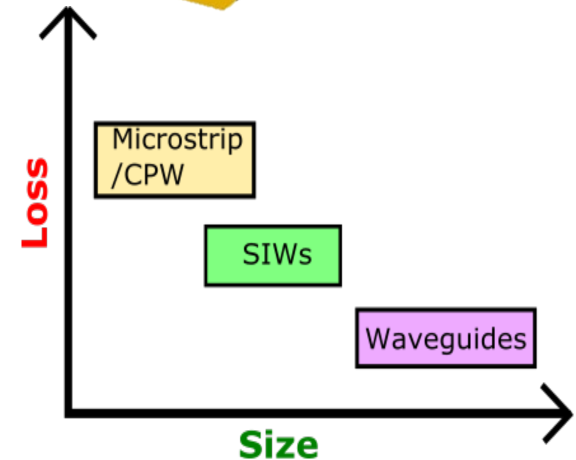


SIWs[1] **bridge the gap between MS/CPWs and Waveguides**

- ❑ Attenuation = 0.3dB/mm (GT work) @ 170GHz
- ❑ 3X-4X higher bandwidth with Zero crosstalk
- ❑ Easier to fabricate and integrate

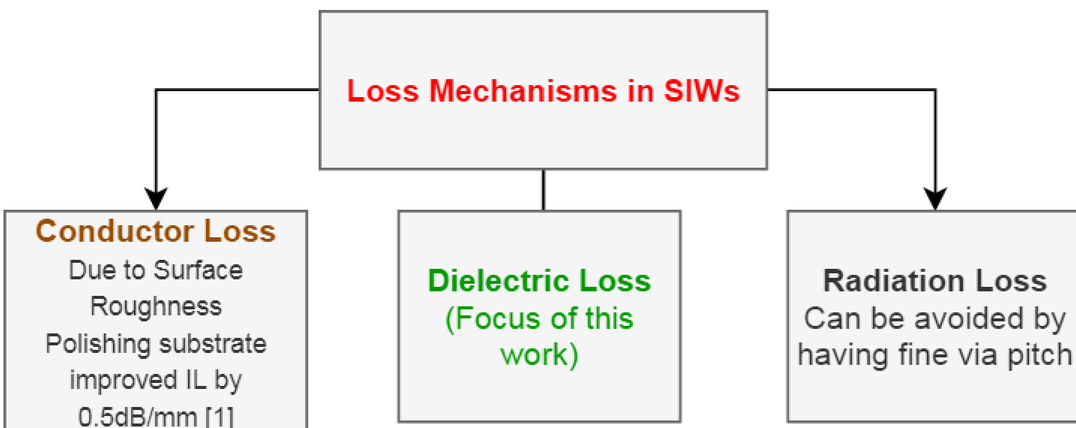


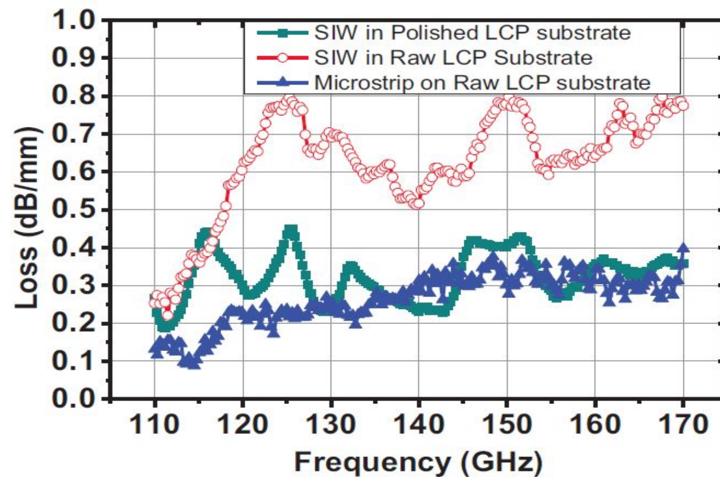




[1]D Deslandes, K Wu, *"Integrated microstrip and rectangular waveguide in planar form"*

Substrate Integrated Waveguides→ Prior Art





- SIW [2] technology is well known for <40GHz
- Sub-THz region challenges → material losses, surface roughness

Challenges for SIWs @ sub-THz

- Use of low loss materials
- Developing new processes → low cost and easy
- Smooth surface finish
- Looking into ways to reduce dielectric loss

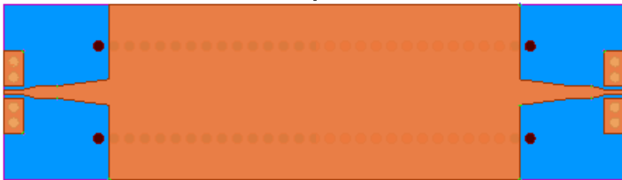
[1] Sensen Li , Ming Yi , Spyridon Pavlidis, Huan Yu, Madhavan Swaminathan, John Papapolymerou et al, RWS, 2017

[2]D Deslandes, K Wu, *"Integrated microstrip and rectangular waveguide in planar form"*

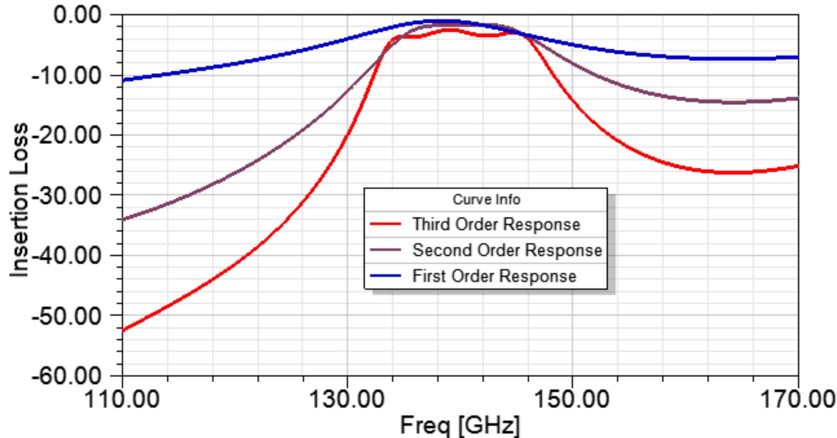
SIW Test Vehicle
Modeling Results

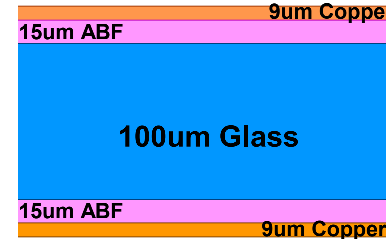
- Characterization of Glass Based SIWs
- Glass Based SIW Resonators

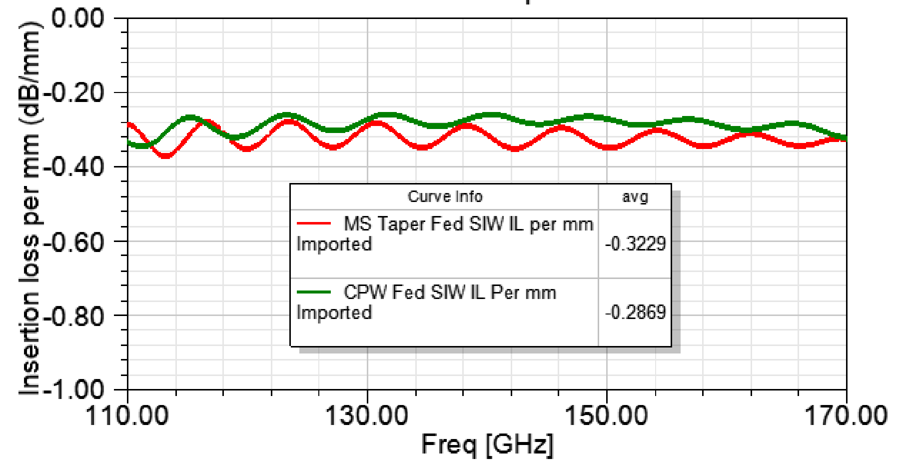
Microstrip Fed SIW

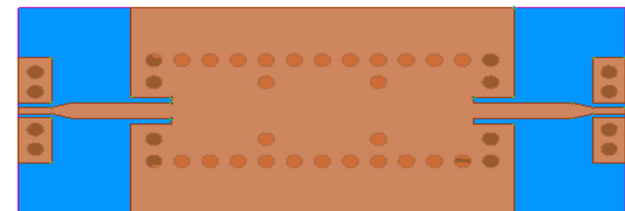


CPWG Fed SIW









3rd Order SIW Resonator

Timeline

		2019	2020				2021		
		Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
done	Glass CPWs in W-band								
progress	Glass Characterization								
Plan	Solid SIWs Characterization								
	SIW based Passives TV								
	Sub-THz SIWs Characterization								
	Sub-THz SIWs Based Passives								

Summary

- ❑ Sub-THz Module
    - Carrier Frequencies 140 GHz, 220GHz, 340GHz
- ❑ Glass Panel Embedding for Sub-THz
- ❑ Characterization of Glass- W and D-Band
    - Measured 0.2dB/mm for CPWs at 110GHz on Glass & ABF polymer based stack up
    - Test Vehicle designed for further characterization
- ❑ SIW Technology
    - Prior Art 0.3dB/mm at 170 GHz
    - Test Vehicle for characterization on Glass