Substrate Integrated Waveguides for sub-THz Region

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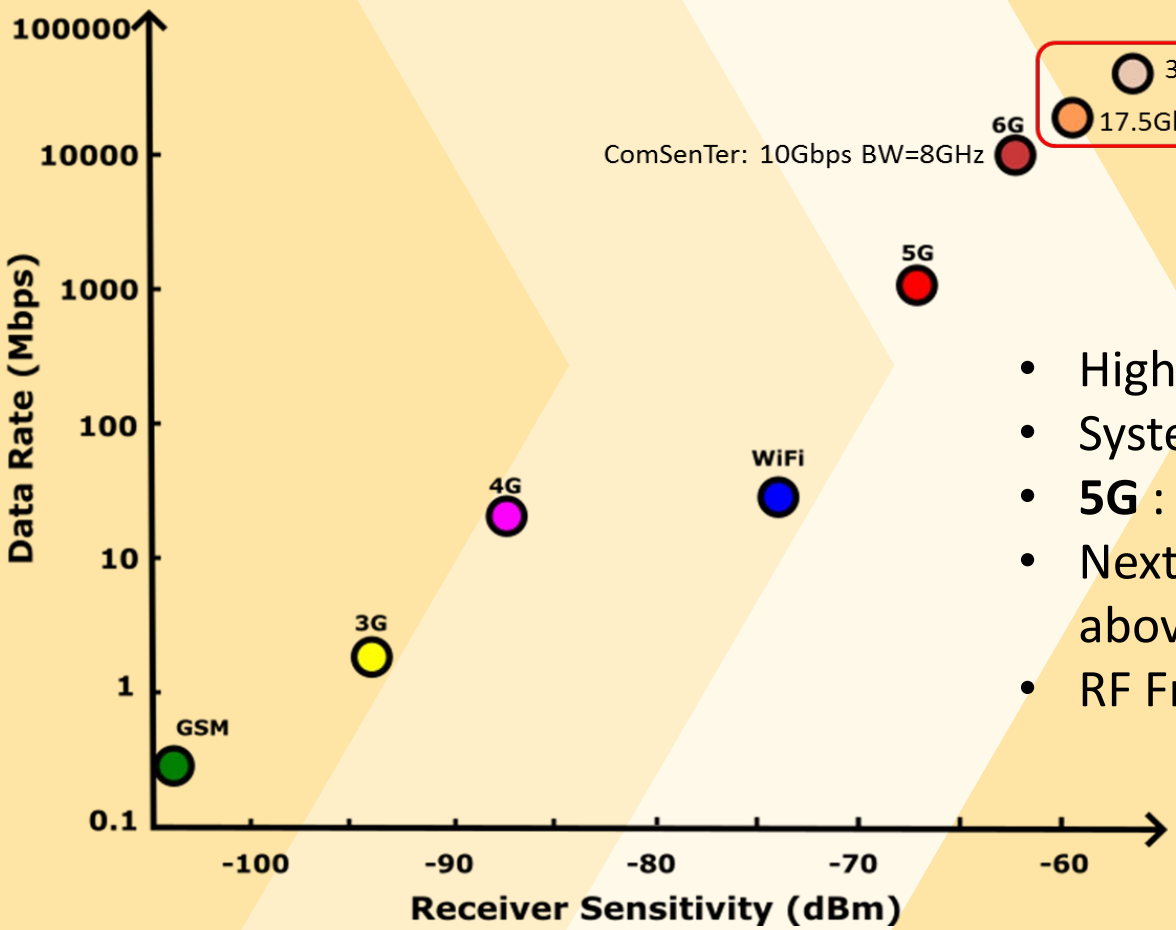
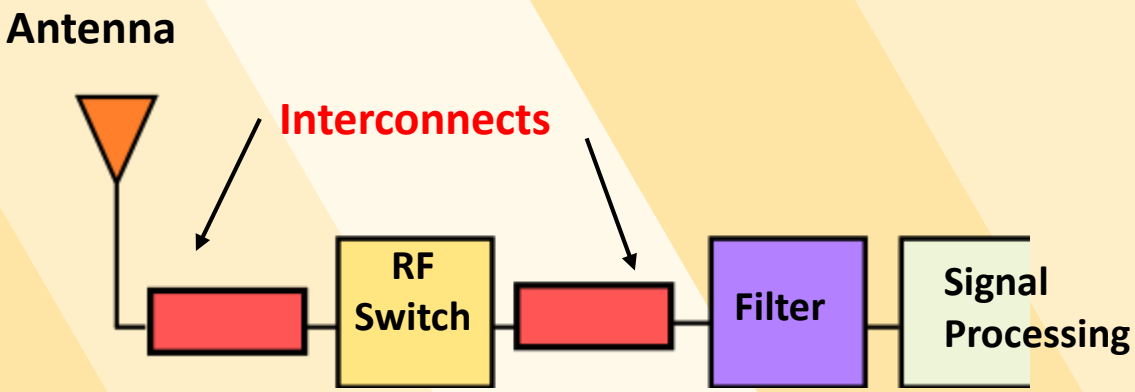
Next Generation Wireless Systems



- High Data Rate Demands
- Systems with High Bandwidths
- **5G** : 800MHz BW @ 28GHz
- Next Generation Systems → above 100GHz
- RF Front End Design

RF Front End Design Challenge



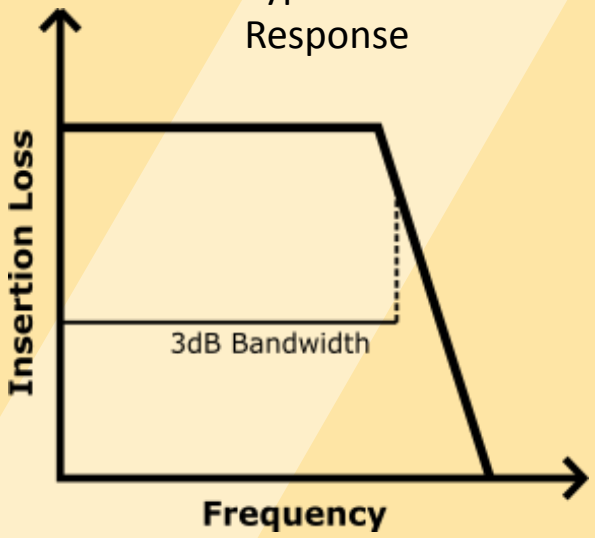
Microstrip Lines(MS) and **Coplanar Waveguide** (CPW) → traditional interconnects

- ❑ Limited bandwidth
- ❑ Higher loss based on structure
- ❑ Higher Coupling and Crosstalk

Objective is to develop new technology for developing high performance passives (interconnects, filters, couplers) in sub-THz region with

- ❑ Low Loss
- ❑ Zero Cross Talk
- ❑ Broadband performance
- ❑ High Power Handling capability

Typical Interconnect Response



Substrate Integrated Waveguides

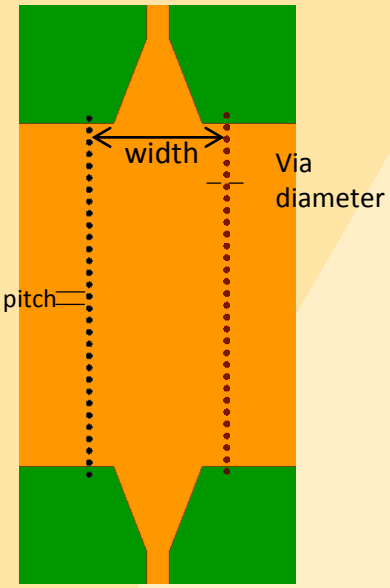
Traditional Waveguides have advantages over Microstrip and CPW lines

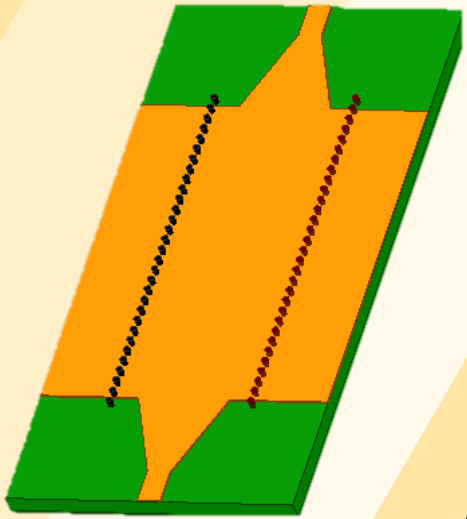
Challenges

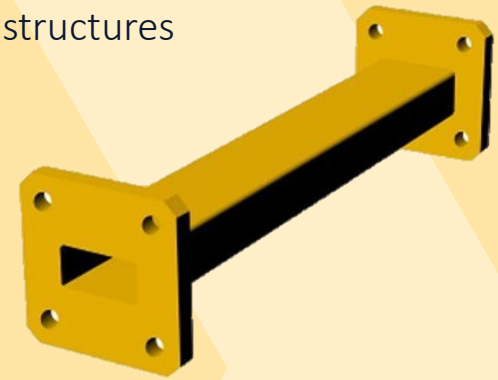
High Cost, bulky, Difficult to mass produce ,Difficult to integrate with planar structures

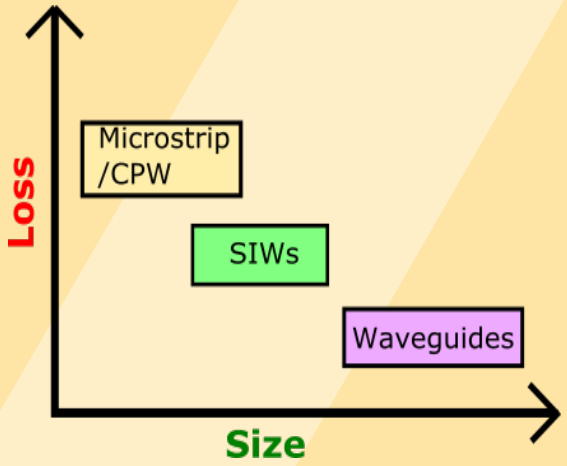
SIWs[1] bridge the gap between MS/CPWs and Waveguides

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





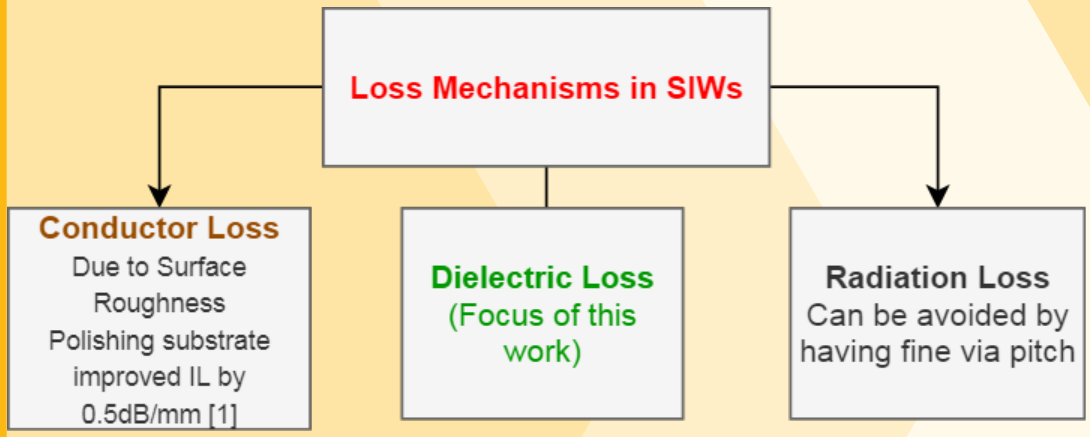


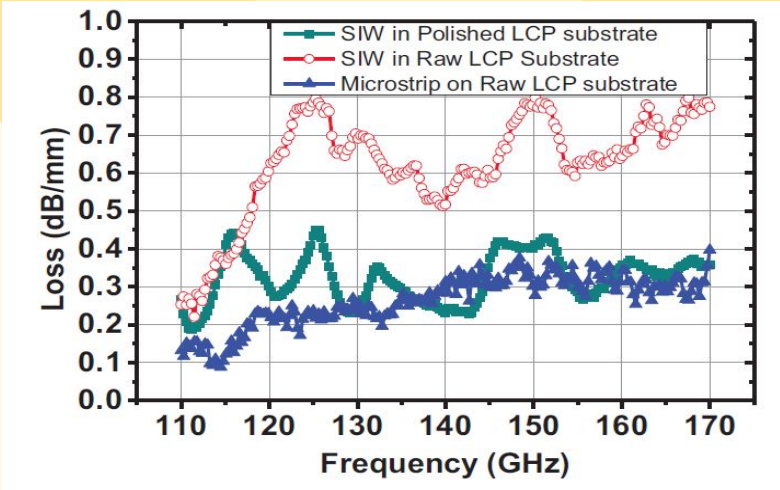


[1]D Deslandes, K Wu, *"Integrated microstrip and rectangular waveguide in planar form"*

SIWs Prior Art

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





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

Challenges @ THz

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

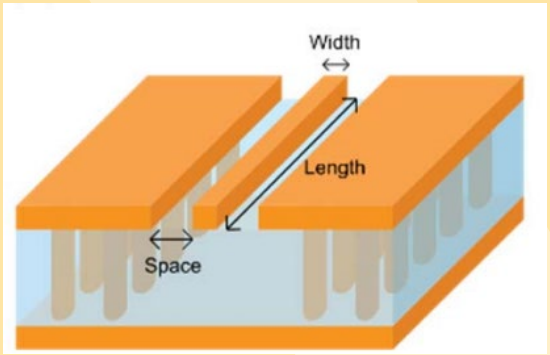
Material Characterization is important

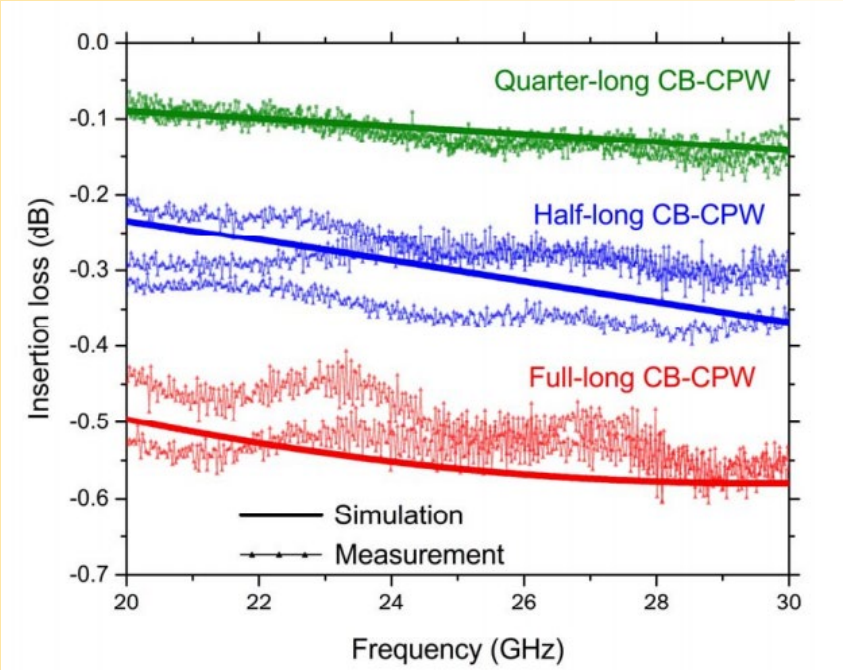
[2]D Deslandes, K Wu, *"Integrated microstrip and rectangular waveguide in planar form"*

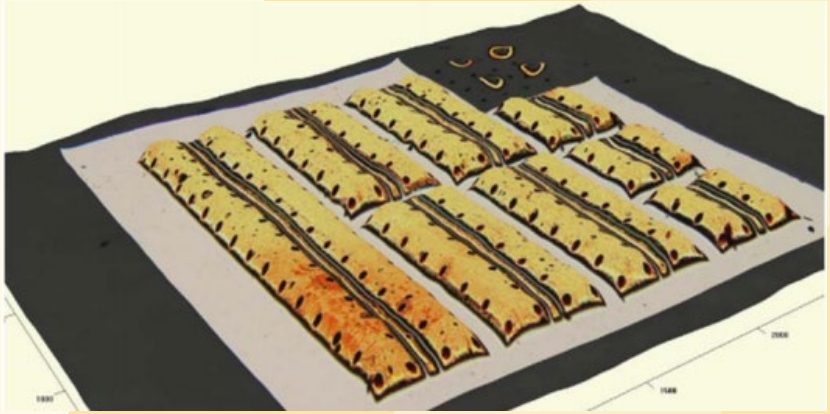
Glass Based CPWG Lines 5G-Prior Work

Characterization of Glass based Transmission Lines for 5G

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



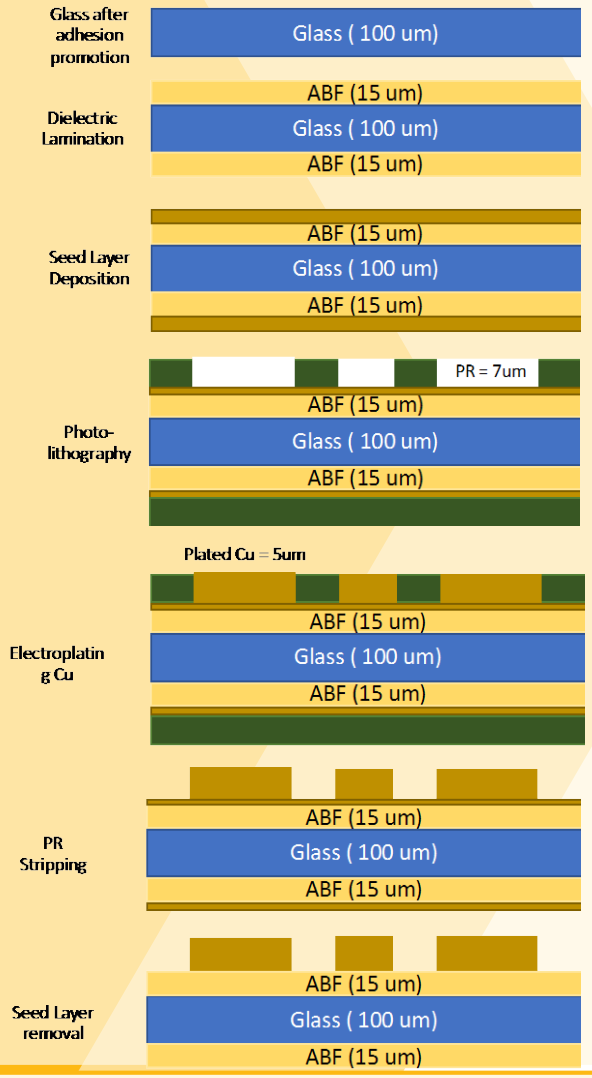




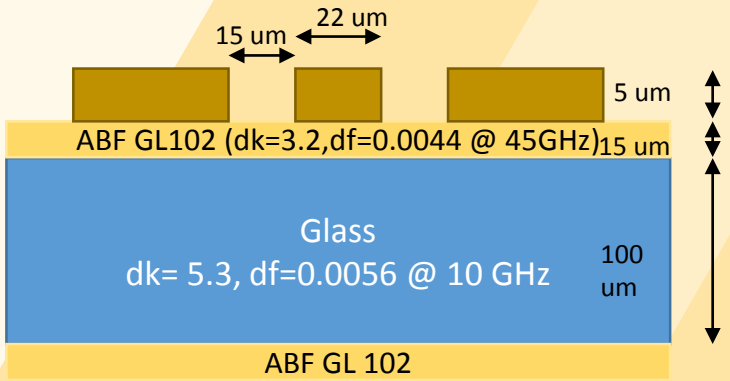
Atom O. Watanabe, Muhammad Ali, Bijan Tehrani, Jimmy Hester, Hiroyuki Matsuura, Tomonori Ogawa, P. Markondeya Raj, Venky Sundaram, Manos M. Tentzeris, Rao R. Tummala "First Demonstration of 28 GHz and 39 GHz Transmission Lines and Antennas on Glass Substrates for 5G Modules," *2017 IEEE 67th Electronic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

Glass Based Transmission Lines – W Band

Fabrication Process



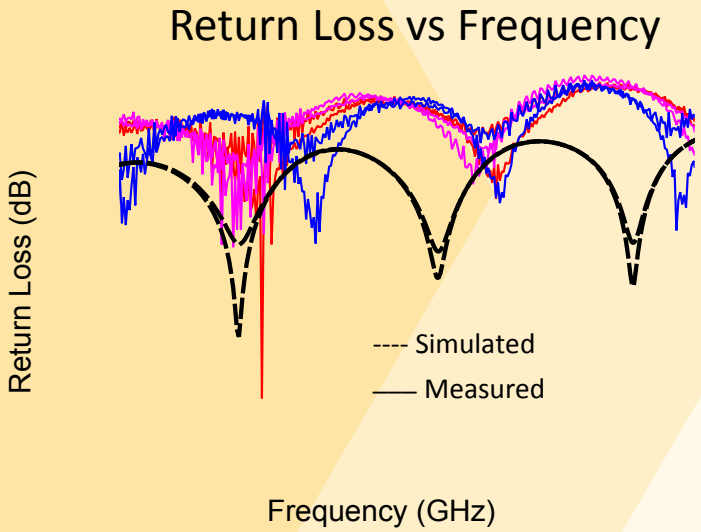
Fabricated Test Vehicle

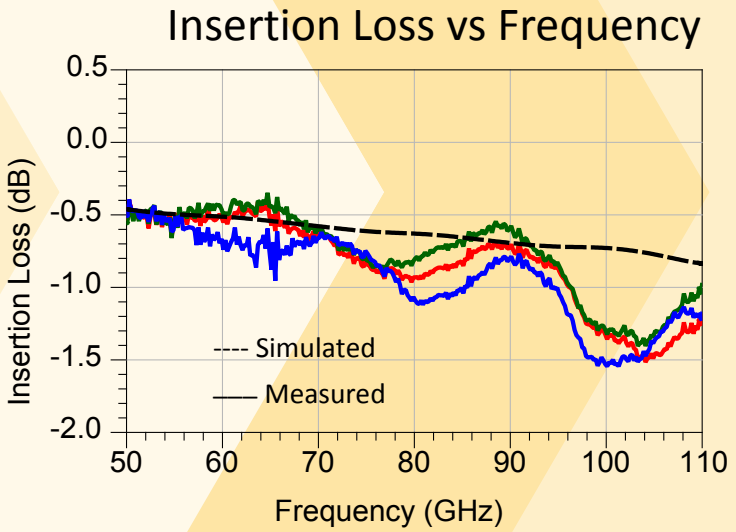


Glass Based CPWs– Electrical Measurements

Preliminary Results

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

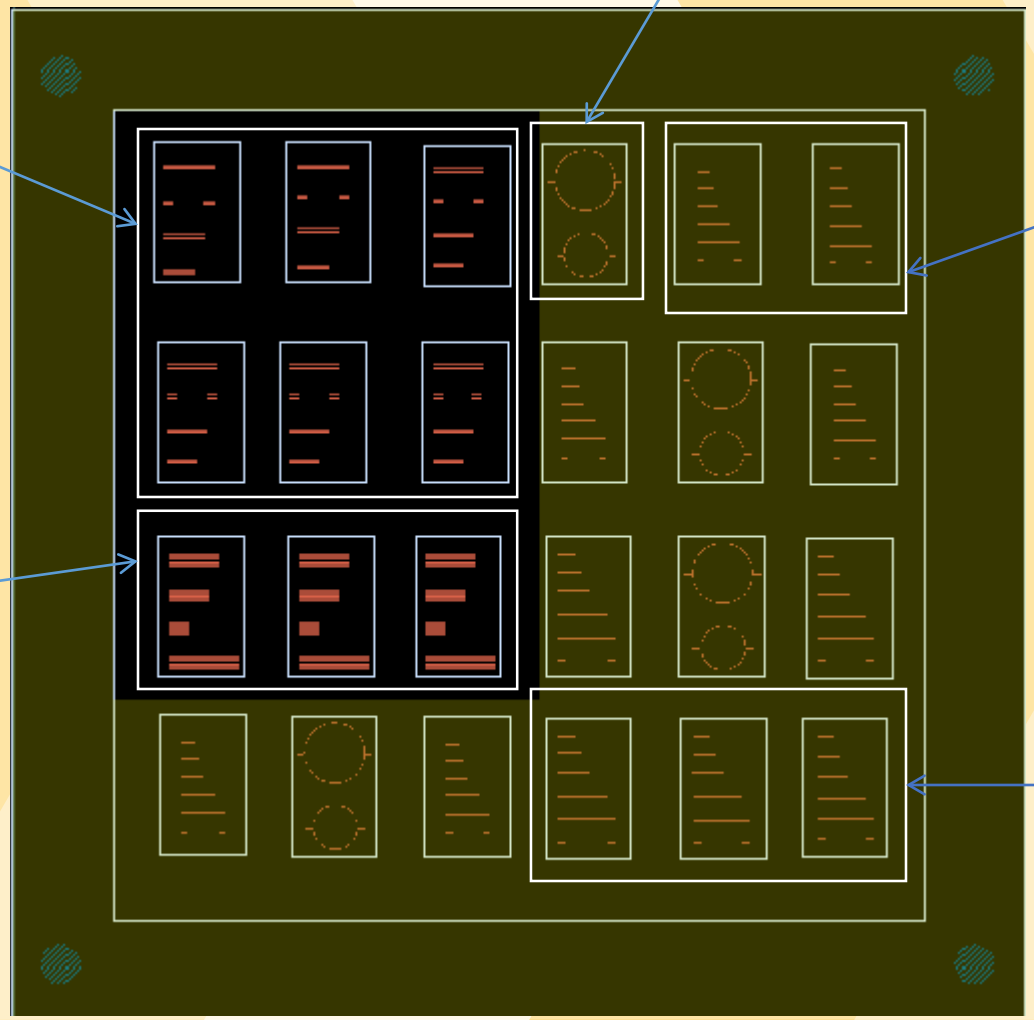




- The measured results show insertion loss of 0.2dB/mm at 110GHz
- Good electrical performance
- Merits further investigation and characterization

Test Vehicle for Material Characterization in W and D band

Glass and Astra Characterization Test Vehicle

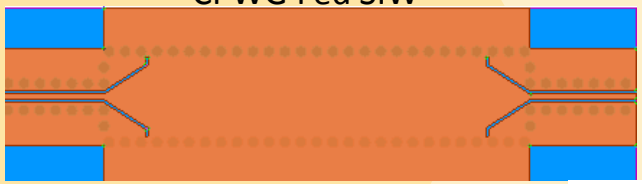


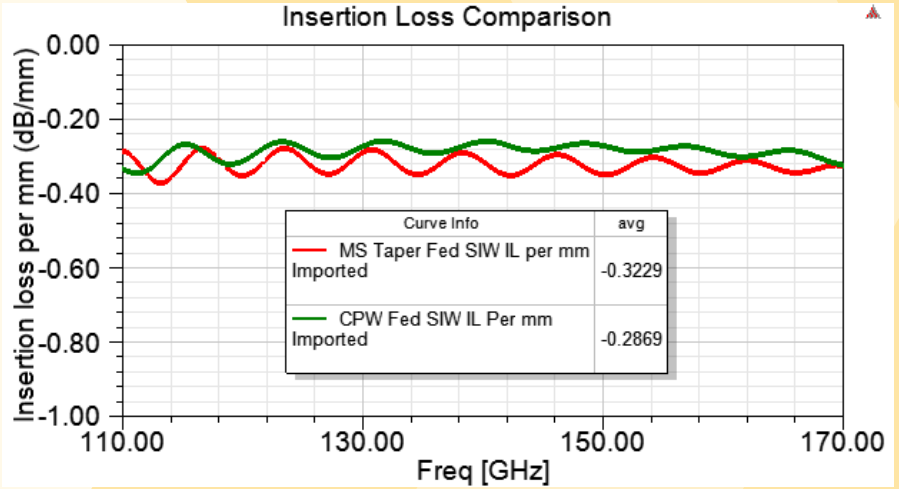
SIW Test Vehicle
Modeling Results

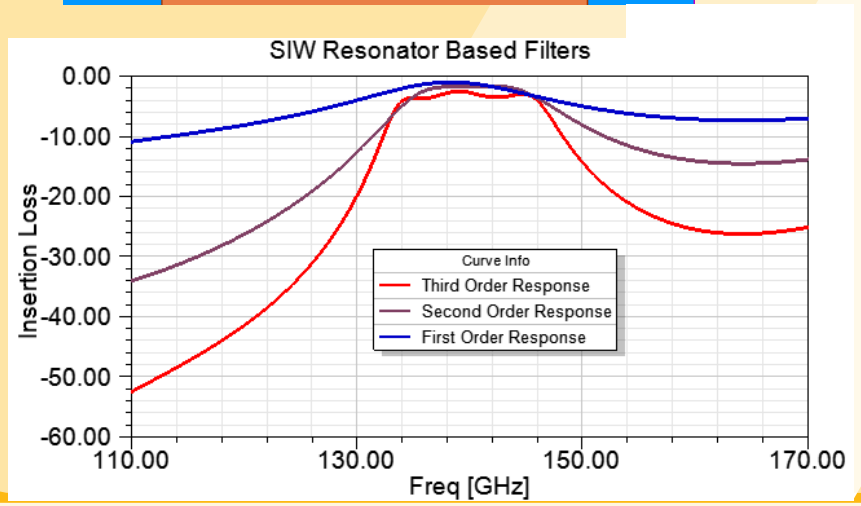
- Characterization of Glass Based SIWs
- Glass Based SIW Resonators

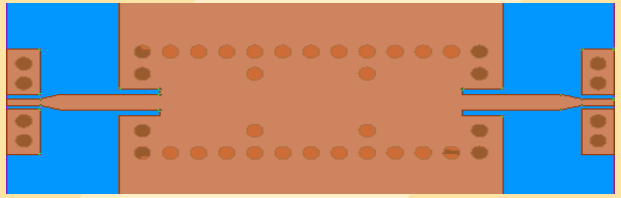
Microstrip Fed SIW

CPWG Fed SIW









3rd Order SIW Resonator

Future Plan

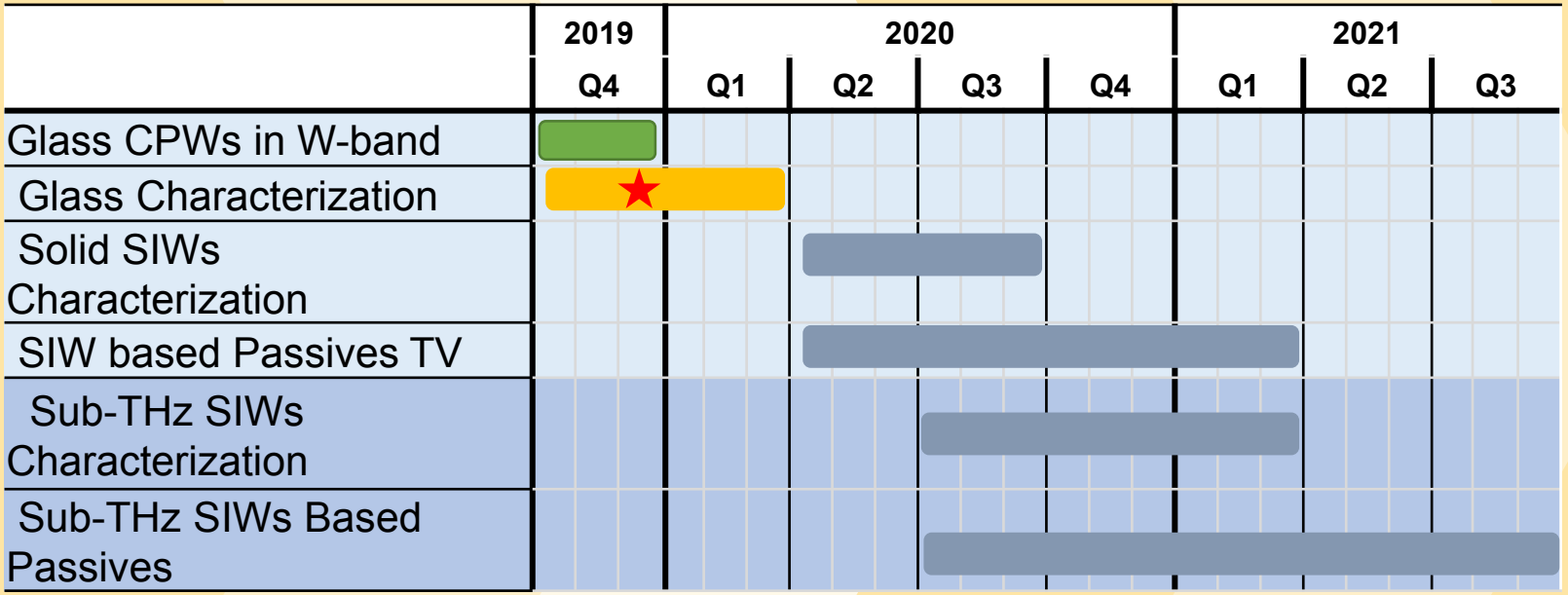
- Fabrication of Test Vehicles for characterization of Glass and Astra
- Measurements for characterization
- Process planning for development of Sub-THz SIW Technology
- Characterization of solid SIWs on Astra and Glass
- Working towards making other passive microwave components like filters, couplers, phase shifters and power dividers using SIW as a building block

Timeline

done

progress

Plan



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