UWB 5G Package-Integrated Antenna Array Design

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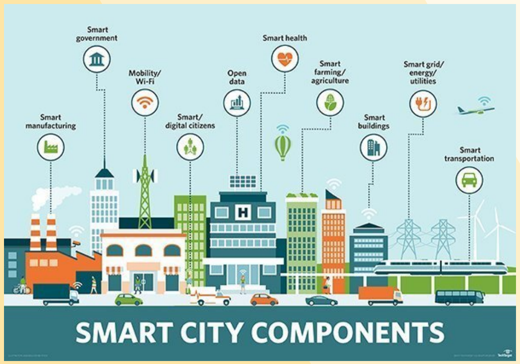
Goals and Objectives

- Modeling and Designing ultra wideband (UWB) Yagi and Horn antenna on thin glass substrates for 5G mm-wave communications.
- Using the designed antennas and phase arrays to implement UWB and high gain antenna arrays.
- Integrating the designed antennas with precision RDL and interconnections to form a fully-functional D&D test vehicles

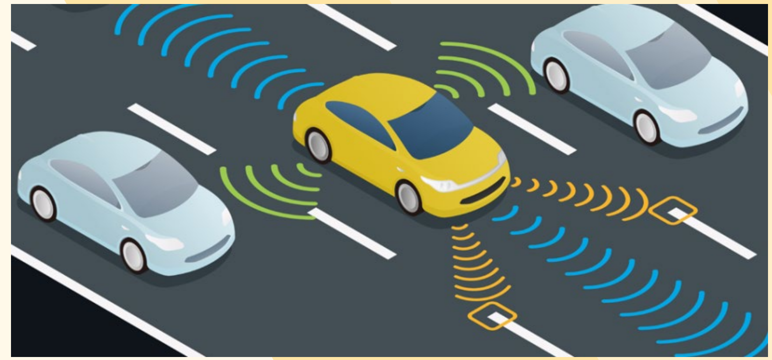
	Objectives	Prior Art	Challenges	Tasks
Performance (Yagi)	• RL > 10dB • Gain ≈ 4 dBi • **FBW > 49 %** • **24.25 - 40 GHz** • Size < λ/2	• FBW<20%	• UWB matching circuit and balun • UWB radiator	• Task1: UWB matching circuit design • Task2: UWB balun design • Task3: UWB radiator design • Task4: Optimize antenna design
Performance (Horn)	• RL > 10dB • Gain ≈ 4 dBi • **FBW > 49 %** • **24.25 - 40 GHz** • Size: As small as possible	• FBW<20%	• Thin substrate for horn antenna • Broadband design • Size reduction	• Task1: Glass properties effects on the antenna performance • Task2: Embedding cavity design • Task3: Planar corrugated horn structure design • Task4: Broadband Horn to Air Transition Design • Task5: Stack the horn design with the Yagi design to get dual-polarization antennas
Performance (Array)	• RL > 10dB • FBW > 55 % • Phased array design	• FBW<20% • Not phased array	• Precise phase shift for the phase array and feed line • Broadband phase array	• Broadband phase array design

Strategic Need – 5G UWB

IoT



V2V, Automatic Driving



Wearable, Smart Skin , Health Monitoring

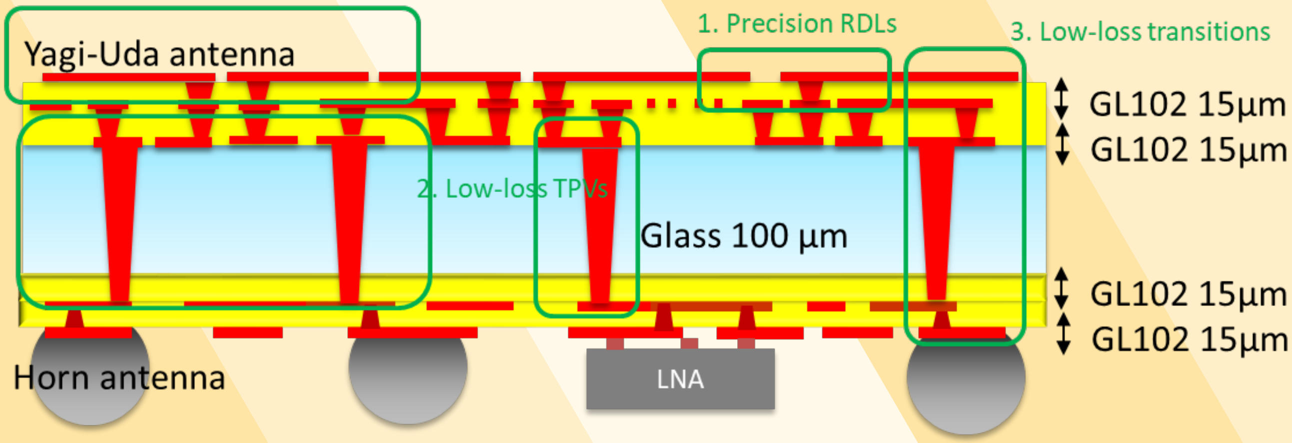
Potential

- 1000x faster data rate, nearly 0 latency
- Broader bandwidth
- Connecting 50 billions of things
- Smaller size for RF components, SoP designs

Challenges

- High communication path loss
- mm-wave band, broadband requirement
- High parasitic

Strategic Need – Package-Integrated Antenna

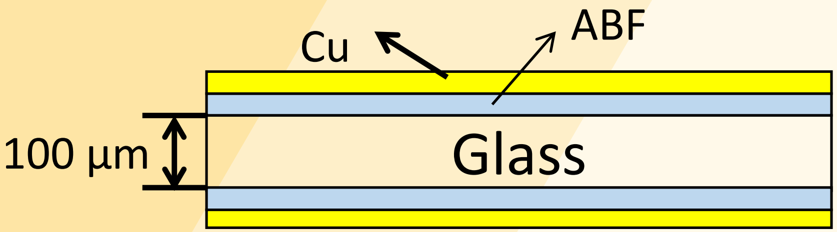


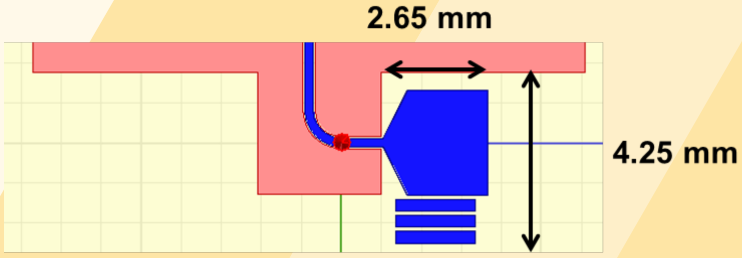
Challenges & GaTech Solutions

- High communication path loss
  - ➢ New antenna design with higher gain
  - ➢ Smaller antenna size to form massive antenna array
- mm-wave band, broadband requirement
  - ➢ UWB antenna design
  - ➢ Simplified the feeding network
- High parasitic
  - ➢ Package-integrated design to reduce the interconnect length
  - ➢ Ultra-thin glass to reduce the interconnect length
  - ➢ Low loss polymer to reduce loss

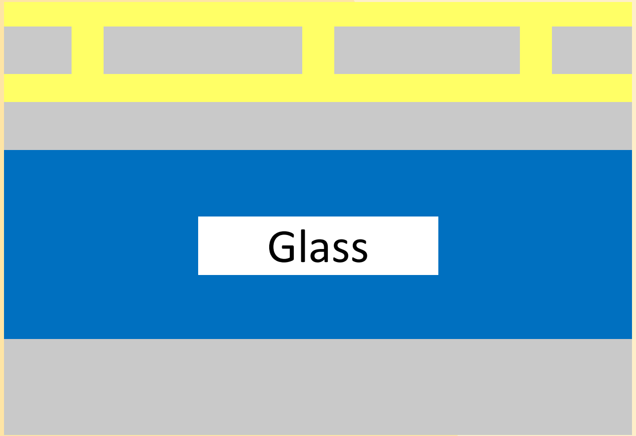
Prior Work

- 100 µm ultra-thin glass package
- Monopole radiator to achieve UWB
- Miniaturization by removing balun and matching circuit
- 24 – 43.5 GHz, FBW > 57.8 %
- S11 < -10 dB
- Realized gain > 4 dBi
- Size: 0.22 λ_0 x 0.35 λ_0





Technical Approach (1/2)

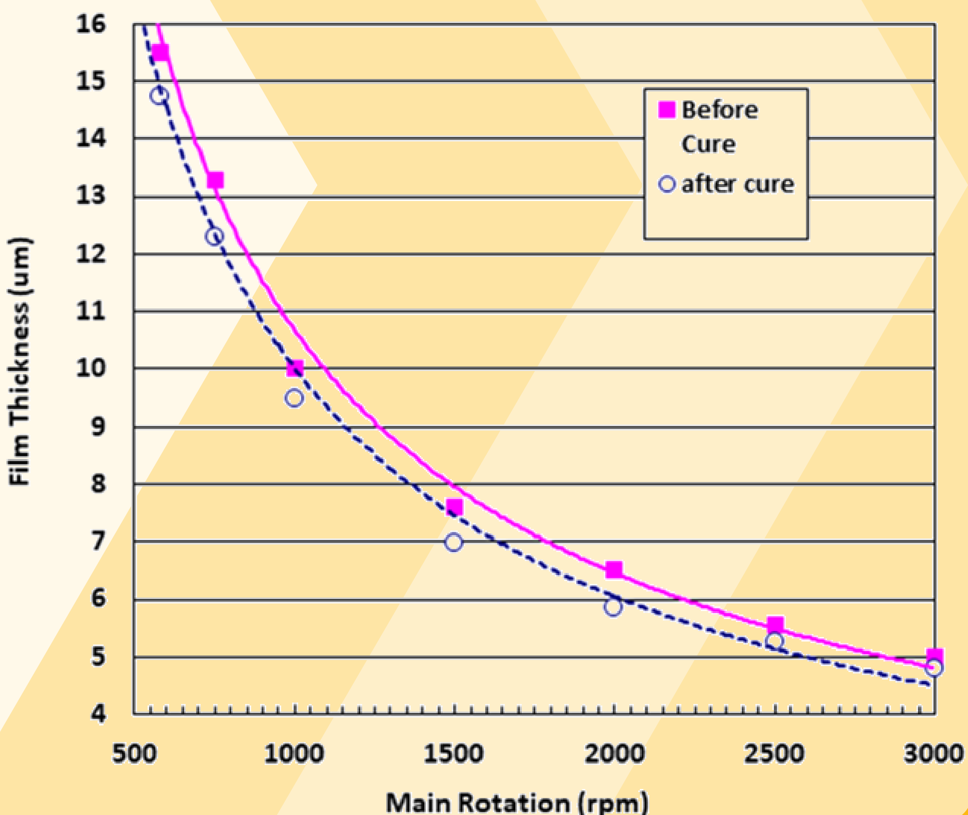


Layer	Details
M1 (Top)	Microstrip Passive Components (5-8 µm)
Dielectric-1	JSR (15 µm)
M2	GND, Dicing Clearance (5-8 µm)
Dielectric-2	JSR (15 µm)
Core-Glass	AGC EN-A1 (100 µm)
Dielectric-3	JSR (15 µm)
Dielectric-4 (Bottom)	JSR (15 µm)

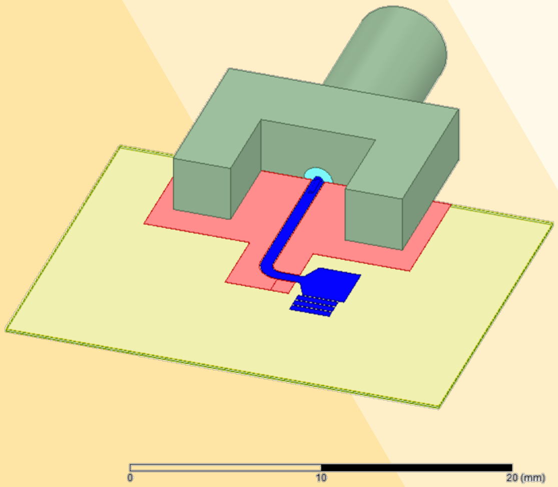
Technical Approach (2/2)

- ❑ JSR materials to reduce warpage
- ❑ Precise thickness control to reduce variations
- ❑ Include end launch connector into simulation

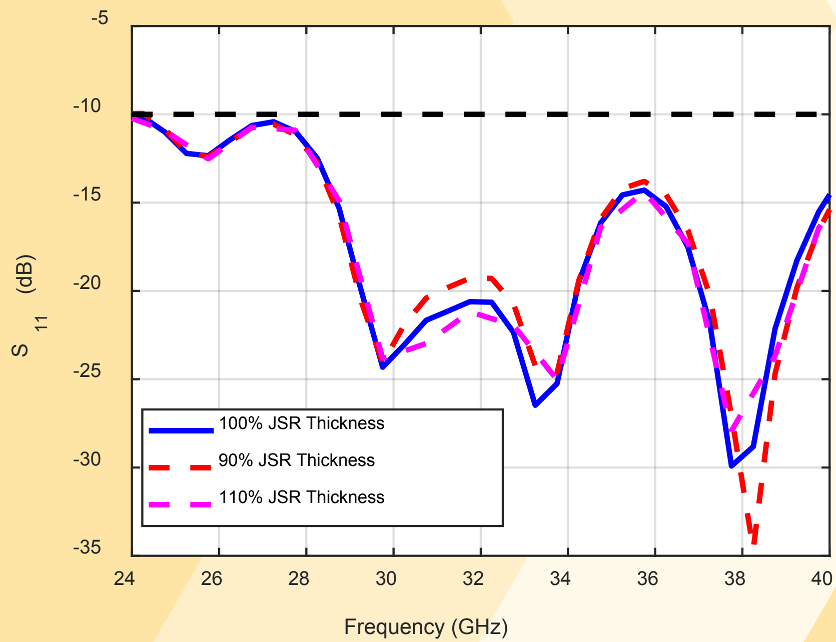
	JSR Material	ABF
Young's Modulus (GPa)	2.8	5
Elongation (%)	55	5.6

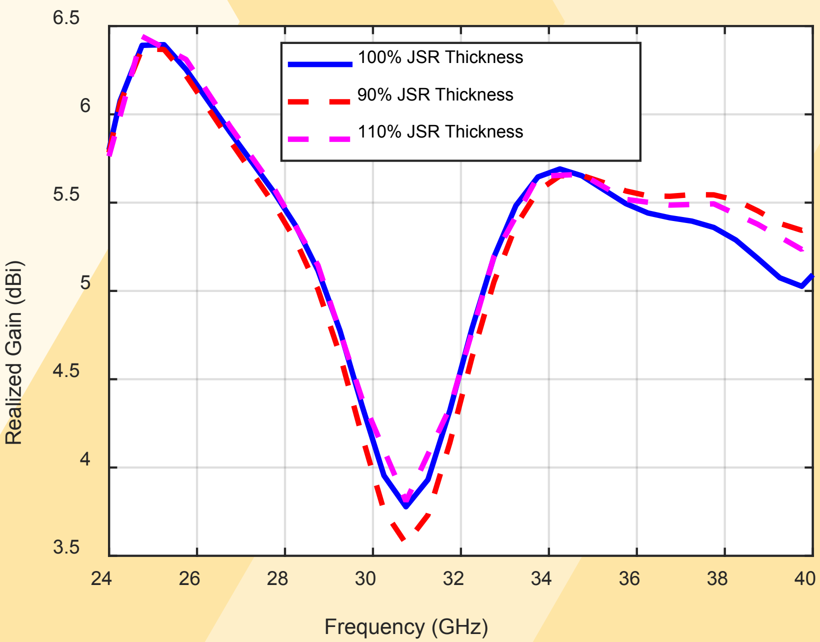


Results & Key Accomplishments (1/3)

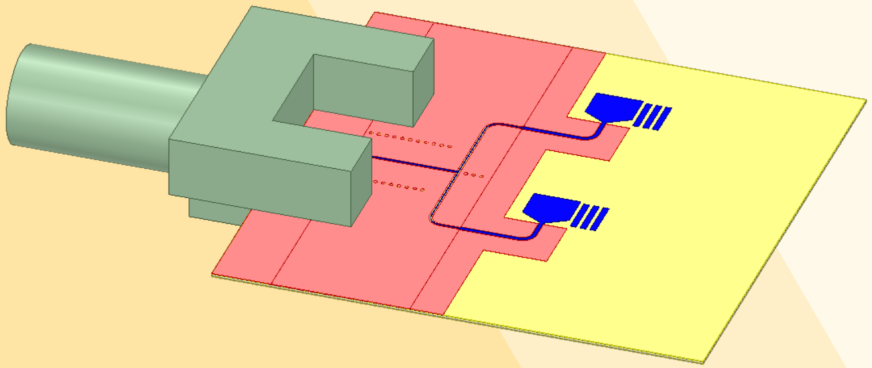


- Operation Band: 24 – 40 GHz
- S11 < -10 dB
- Realized gain > 3.8 dBi
- Good resist to thickness variation

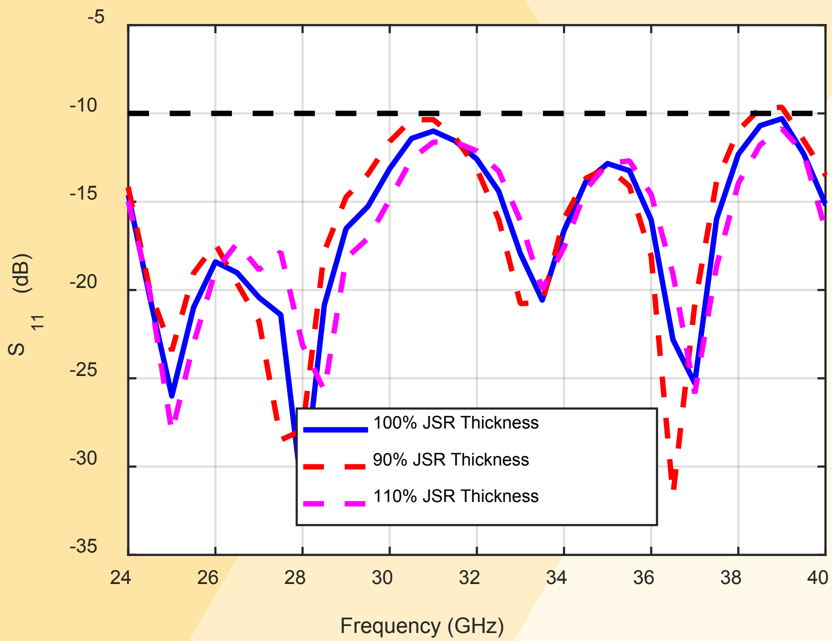


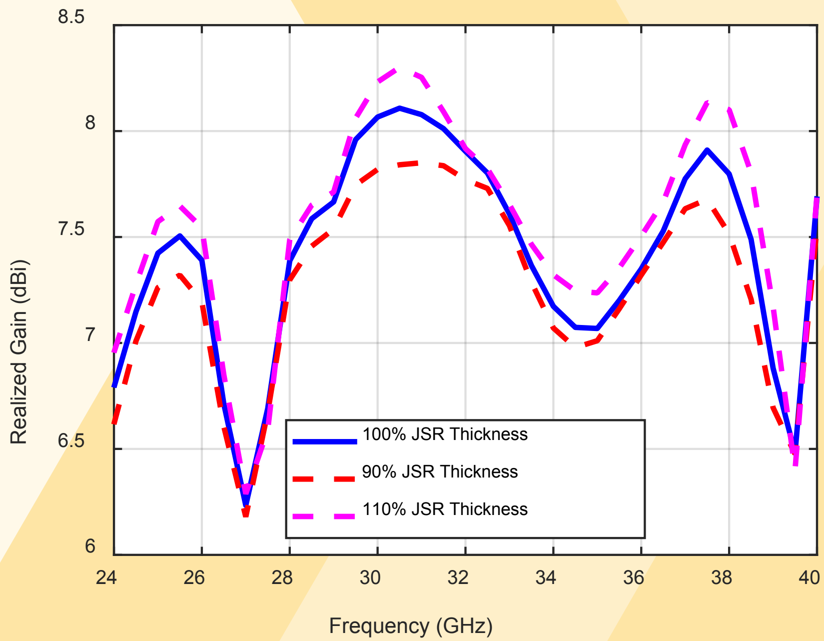


Results & Key Accomplishments (2/3)



- Operation Band: 24 – 40 GHz
- S11 < -10 dB
- Realized gain > 6.2 dBi
- Good resist to thickness variation

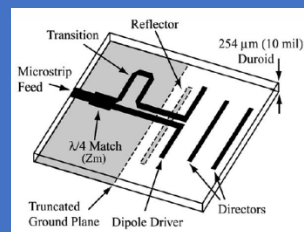
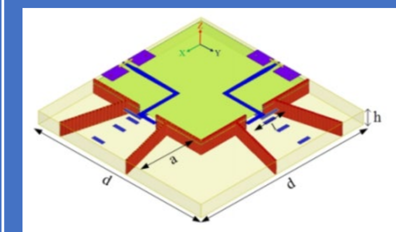




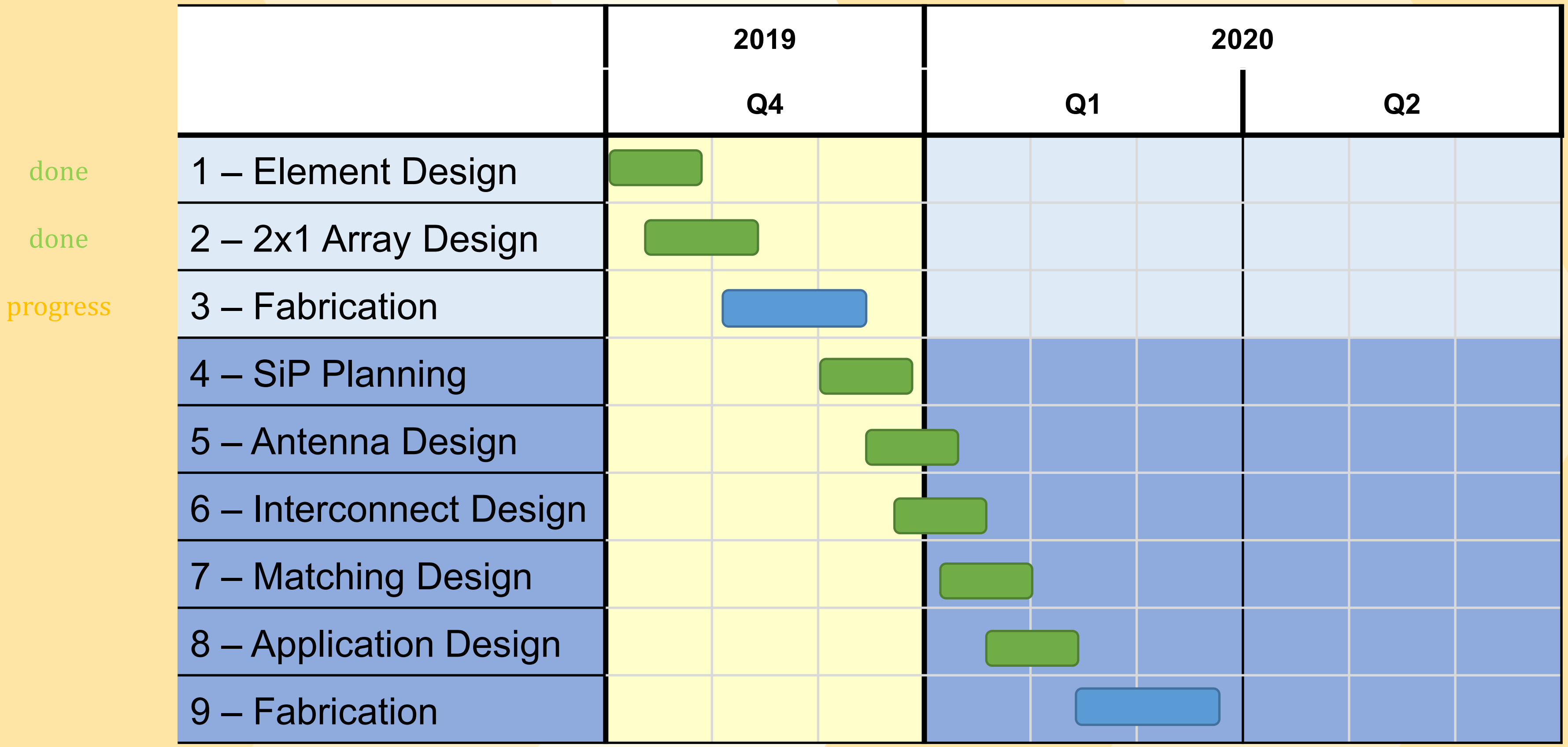
Results & Key Accomplishments (3/3)

Panel Design Figure
Coming Soon

Comparison with Prior Art

			**This work**
Fabrication method	Laminate	LTCC	Glass
Band (GHz)	24	37.5 – 42	24 – 40
Bandwidth (GHz)	< 1	4.5	16
FBW (%)	3	12.5	49
Thickness (µm)	254	832	176
Realized Gain (dBi)	9.3	5	3.8
Size	$0.45\lambda_0 \times 1.12\lambda_0$	$0.48\lambda_0 \times 0.63\lambda_0$	$0.13\lambda_0 \times 0.24\lambda_0$

Schedule



Light blue: UWB 5G Array Design
Dark blue: UWB 5G System Design
Light Yellow: Current time window

Design
Fabrication

Summary

- Designed UWB and miniaturized Yagi antenna element
- Covered both 5G band simultaneously
- Consider effects of end launch connector and thickness variation
- Panel design for fabrication

Future Work

- Prototype fabrication and characterization
- UWB 5G modules utilized the designed antenna (array)