



#### MACOM Technology Solutions Holdings (MTSI)

February 2019



#### **Safe Harbor**



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#### GaN-on-Si Basestation Power Amplifiers







# **Over 1.5 Million GaN-on-Si Devices in the Field Today**







GaN-on-Si provides GaN on SIC performance at an LDMOS cost structure at scaled Volume Production Levels

	LDMOS	GaN on Si	GaN on SiC	
Power Gain	++	++	++	Antenna range and network coverage
Drain Efficiency	+	+++	+++	Basestation energy consumption 24/7
Cost & Capacity	++ Silicon	++ Silicon	+ Silicon Carbide	To Meet 5G scale and cost targets
Integration Capability	++	++	+	High density M-MIMO solutions

- > 5G Massive MIMO PAs 32 to 64X
- > Dollar TAM ~3X (estimated)
- Cost per PA must be 1/10 to 1/20 (90-95% cost reduction)

#### MACOM & ST Investment in Industrialization



**RF** Power Amplifier TAM Expected to Exceed \$3 Billion by CY2022

#### Catania, Italy

#### Singapore



- Dual, independent sources in Europe and Asia
- Copy exact, 6"/8" (150/200mm) capacity
- **>** 0.5μm > 0.25μm > 0.15μm



#### **5G Millimeterwave Growth Engine**

John Croteau President & CEO, MACOM

### **5G Requirements for RF Components**

#### To Support 5G Across All Frequencies and Power Levels and Geographies – Cost, Performance, Integration and Technology



- Frequency 600 MHz  $\rightarrow$  5 GHz ٠
- Traditional "Basestation" model of discrete • transistor based power
- Additional Bands at 3.5 and 4.9 GHz  $\rightarrow$  drives GaN solutions
- Integrated Solutions Power Levels <10 Watt
  - **Requires GaN MMIC products**
  - Integration key for performance and cost

- - **Multiple Approaches**
  - **Requires Beamforming**
  - Common Issues: Cost, Component Size, Thermal Management, Architecture
  - Multiple Frequency Bands: 24 GHz  $\rightarrow$  39GHz  $\rightarrow$  ??

MACOM

#### **The Global 5G Landscape**



#### **Critical challenges remain:**

- Cost structures are not yet affordable for mainstream deployments
- Supply chains for key technologies are not robust across the industry
- Quality of service goals are constrained by the performance of traditional RF technologies
- Form factor and associated thermal constraints inhibit the move to conventional beamforming architectures



#### **Metamaterial Array Antennas**



- Uses an Array of MACOM GaAs and AlGaAs Components
- > Holographic Beam Forming<sup>™</sup> Antenna Topology
- Lowest C-SWaP compared to all other technologies
- Markets: 5G, Access-in-Motion<sup>™</sup>, Transport, Tactical Communications, A&D





- Patented AlGaAs Discrete and MMIC Processes and Products
- Broad Portfolio of mmW PAs and LNA's to offer full system solutions





#### Move from 4G to 5G Requires Heterolithic Integration









#### **Overcoming 5G Millimeterwave Challenges**

Brian Deutsch CEO, Pivotal Commware

#### **Pivotal Commware Overview**

- » Incubated for two years at Invention Science Fund
  - 230+ patents filed licensed from Intellectual Ventures
  - Headquartered in Kirkland, WA USA, 55+ FTEs and growing
- Spun out June 2016
  - Immediate revenue \$2M- 2016, \$10M 2017
- Closed Series A in June 2017
  - Bill Gates Globalstar Starwood DIG LUX
- Closed Series B, in November 2018

Glass-attached, customer-installable Echo 5G Subscriber facilitates Gigabit+ broadband service to homes and businesses.





\$445.0

\$350.3

 US leadership in 4G accounted for nearly \$100 billion of the increase in annual GDP by 2016 (Recon Analytics, 2017)

- » US 4G leadership also meant roughly \$125 billion in revenue to American companies including more than \$40 billion in additional app store revenue flowing to US companies and app developers
- The launch of 4G in the US increased total wireless-related jobs by 84% from 2011 to 2014
- The economic impact of 5G will eclipse that of 4G as new capabilities emerge



The Changing Trajectory of U.S. Wireless GDP

\$500.0

\$450.0

\$400.0

\$350.0

The Mobile Value Chain in 2016, United States, \$B's – Recon Analytics, 2017



\$332.9

### 5G Leadership

## 5G is PIVOTAL

- Holographic Beam Forming offers the lowest cost, size, weight and power consumption envelope operators need to deploy 5G widely and cost-effectively. )))
- HBF is an essential element in the 5G ecosystem. )))

#### HBF inside gNodeB

- Combines lowest cost, size, weight and power consuming beamformer with 80° scanning range to reduce gNodeB deployment costs.
- Lowers small cell profiles, increasing municipal acceptance and lowering **OPEX** rents.

#### HBF inside Echo 5G Network Product

Cost effectively extends, redirects and shapes 5G coverage on demand and with low latency. Saves carriers base station deployment CAPEX and reduces ongoing OPEX. Reduces siting costs.

Matches CAPEX to revenue ramp.

#### HBF inside Echo 5G Subscriber Product

PIVOTAL

Enables Gigabit+ in-building 5G penetration at one kilometer, even at 80° angle of incidence Customer self-installable. Increases subscribers per gNodeB ratio.

gNBs without Echo 5G Network

aNBs with Echo 5G Network







3-4 gNBs using non-HBF 60° scan range



2 gNBs using HBF 80° scan range







## PI√OT^L



### Why MACOM?

PIVOTAL

- Leadership MACOM is "all-in" on a strategy to be the leader in mmWave RF components
- Collaboration MACOM has demonstrated its desire to invest, innovate and collaborate every step of the way
- Technology "Powered by MACOM" means among other things, the leading power-handling, efficiency, insertion loss and channel isolation
- Products MACOM Diodes, LNA, driver amp, attenuator, and coupler/detector components have a great combo of price and performance
- **Competitiveness** MACOM has the experience to scale production and drive economies to meet the market demands



