TriQuint
Reach Further • Reach Faster™

MMIC Integration & Packaging for Defence & Automotive Radar: Size & Cost Reductions Create New Market Opportunities

October 9, 2013

Outline

- Overview
- Radar: commercial and defence
- Spatium™ power amplifiers
- AESA radar components
- RF packaging
- Summary

TriQuint
Reach Further • Reach Faster™

Synergistic Organization

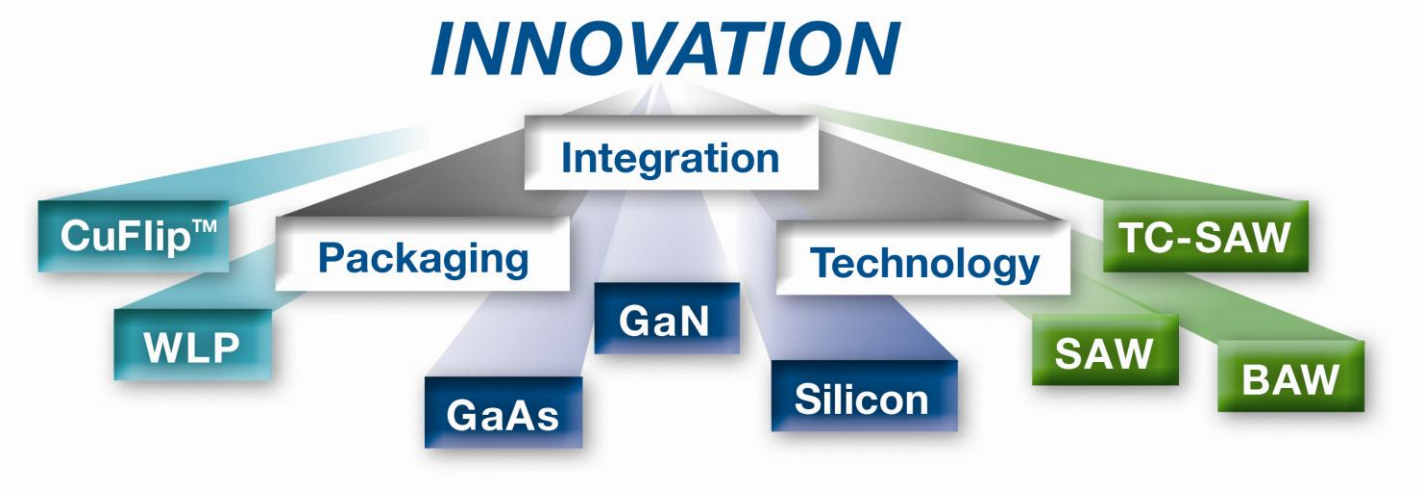
Mobile Devices
Drives volume scale, lower costs & speed of innovation

Defense
Drives technology research & product solutions

Network Infrastructure
Drives high-performance product portfolio

Technology Integration Leader

- **TriQuint is the only high-volume supplier integrating advanced, in-house active and passive technologies for the broad market**

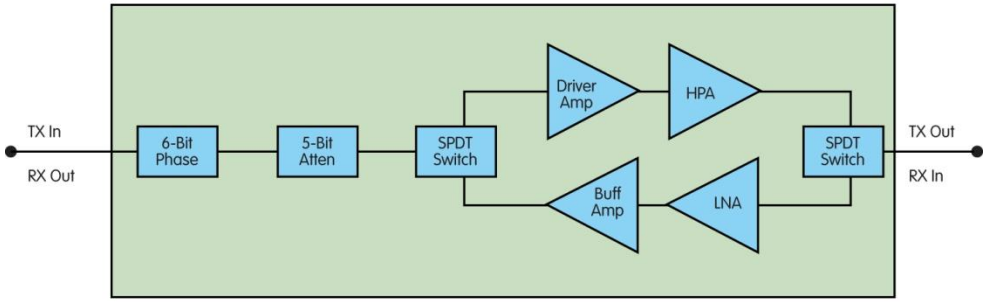


CUSTOMER BENEFITS

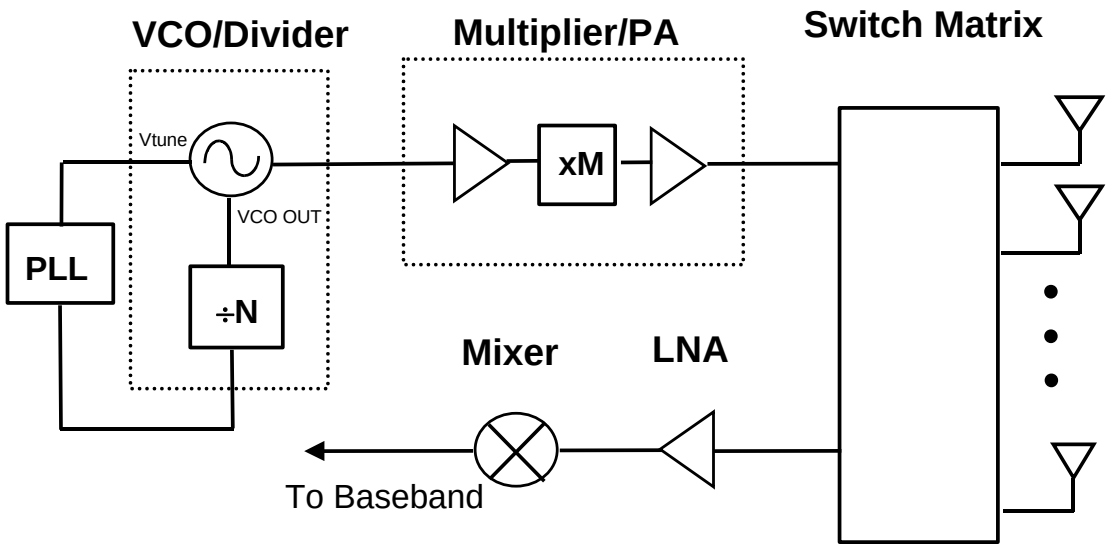
- Minimize board space
- Saves engineering resources
- Maximize power efficiencies
- Reduced BOM
- Streamlined manufacturing

TriQuint
Reach Further • Reach Faster™

Basic Defense and Automotive Radar Block Diagrams



AESA Radar Basic Block Diagram

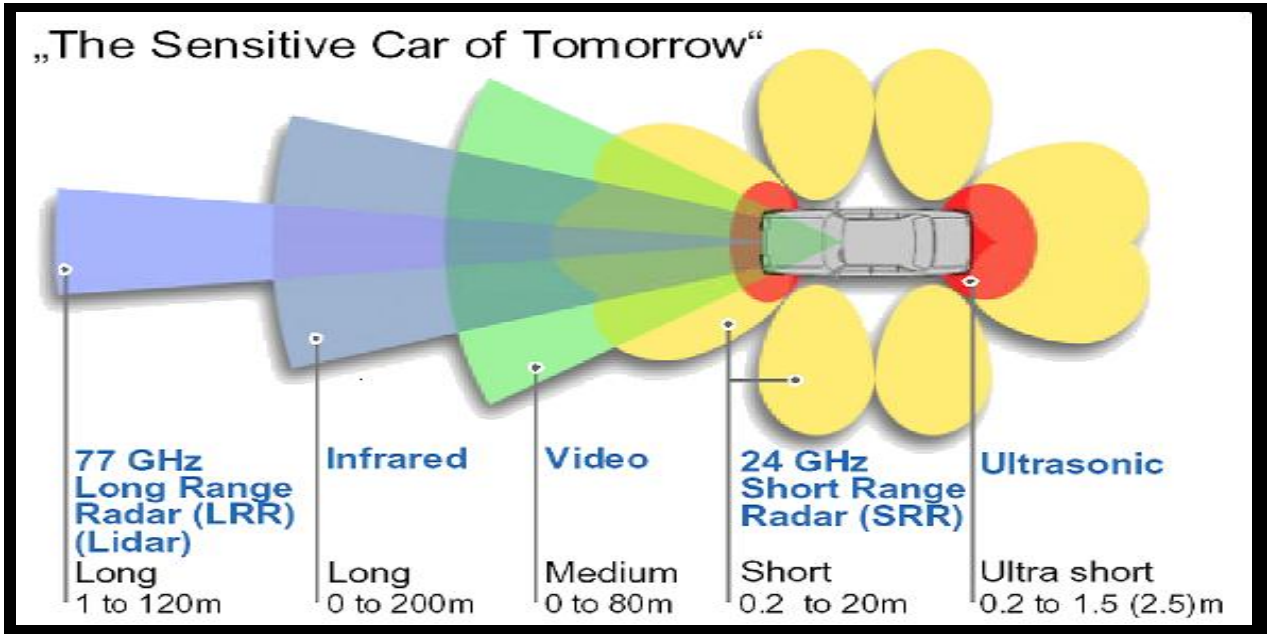


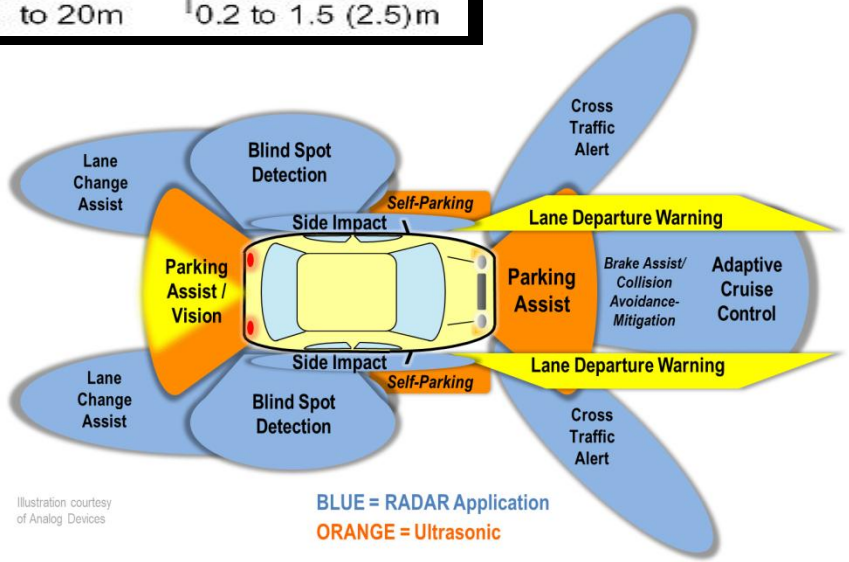
Pulse and Continuous Wave Radar Concepts

Varying complexity, trending towards more antenna ports for better resolution

TriQuint
Reach Further • Reach Faster™

Automotive Sensors / Radar





TriQuint
Reach Further • Reach Faster™

Center Radar: Solid-State Power Amplifier, TWT Replacements

TriQuint
Reach Further • Reach Faster™

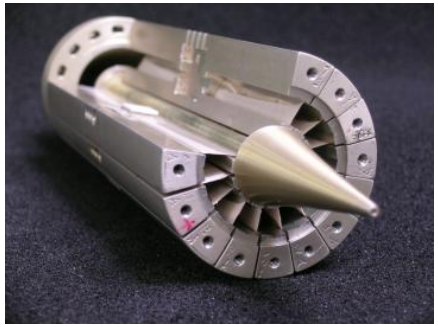
Center Feed Radars

TWTA Based Radar

TriQuint Spatium™ Power Amplifier Technology

- **Spatium™ power amplifiers**
  - TWTA upgrade / replacement
  - Electronic warfare
  - MilCom, data links
  - Radar
  - Test and measurement

- **Key Spatium™ PA features**
  - High efficiency
  - Compact form-factor
  - Low voltage operation
  - Graceful degradation
  - Short thermal path
  - High reliability / long life MTBF
  - No aging characteristics
  - Frequency scalable



Solid state PA reliability with PAE equal to or greater than a TWTA

TriQuint
Reach Further • Reach Faster™

AESA Radar Components

TriQuint
Reach Further • Reach Faster™

Phased Array Radars

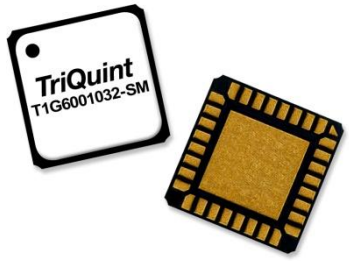
- **Radar designers are very focused on size, weight and power (SWaP)**

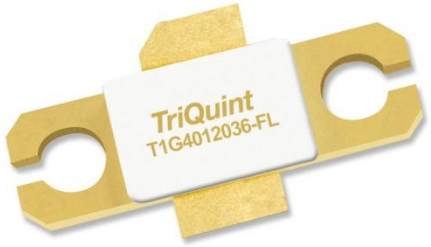
TriQuint
Reach Further • Reach Faster™

GaN Packaged Transistors

Part #	Frequency Range (GHz)	Psat (W)	Gain (dB)	DE (%)
T1G6001032-SM*	DC-6	10W	16	53
T1G4012036-FS / -FL	DC-3.5	120W	13	52
T1G4020036-FS / -FL*	DC-3.5	2x120W	13	52
T1G2028536-FS / -FL*	DC-2	250W	18	60
T1G4004532-FS / -FL*	DC-3.5	45W	16	54

** In Development*

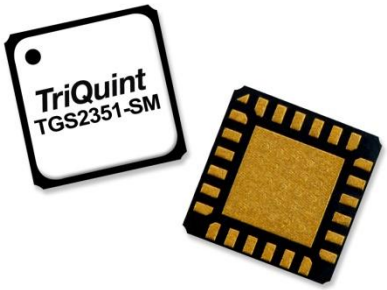


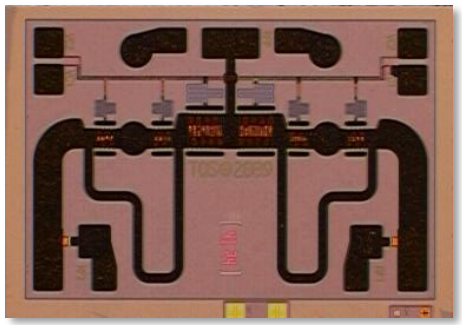


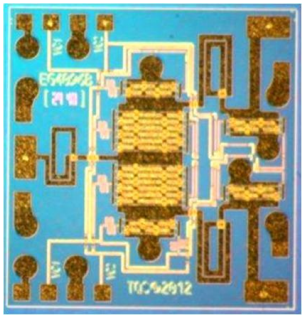
TriQuint
Reach Further • Reach Faster™

Transmit / Receive RF Switch

- **RF switch loss directly affects NF and PAE**





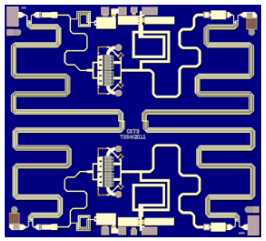


- **High-power switch options**
  - Asymmetrical RF switches: high power transmit path, lower loss receive path
  - GaN T/R switches
    - High power handling capability (>100W) CW
    - Very low current (<6uA)
    - Low insertion loss (<0.7dB)
    - High RF power handling capability

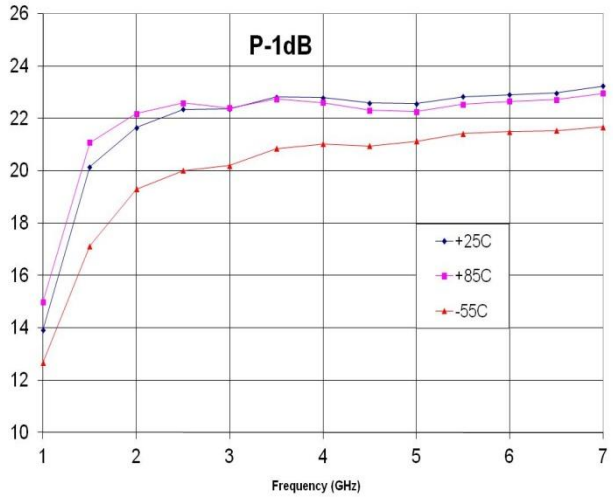
GaN Low-Noise Amplifier Products

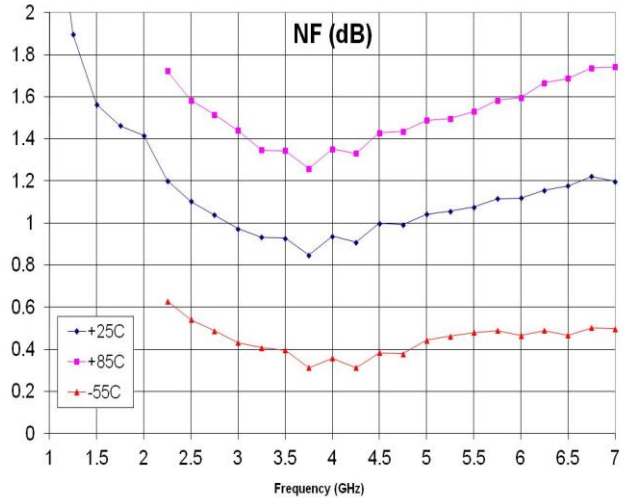
LNA	Frequency (GHz)	P1dB (dBm)	NF (dB)	SS Gain (dB)	TOI (dBm)	Tech	Export
TGA2611*	2-6	22	1	25	30	GaN25	EAR99
TGA2612*	6-12	20	1.5	25	29	GaN25	EAR99

** Plastic overmold package planned for Q4 2013*



3.3x3.0mm
*** 5x5 QFN Planned ***





Low noise figure with high input RF power survivability.
Do you still need a limiter?

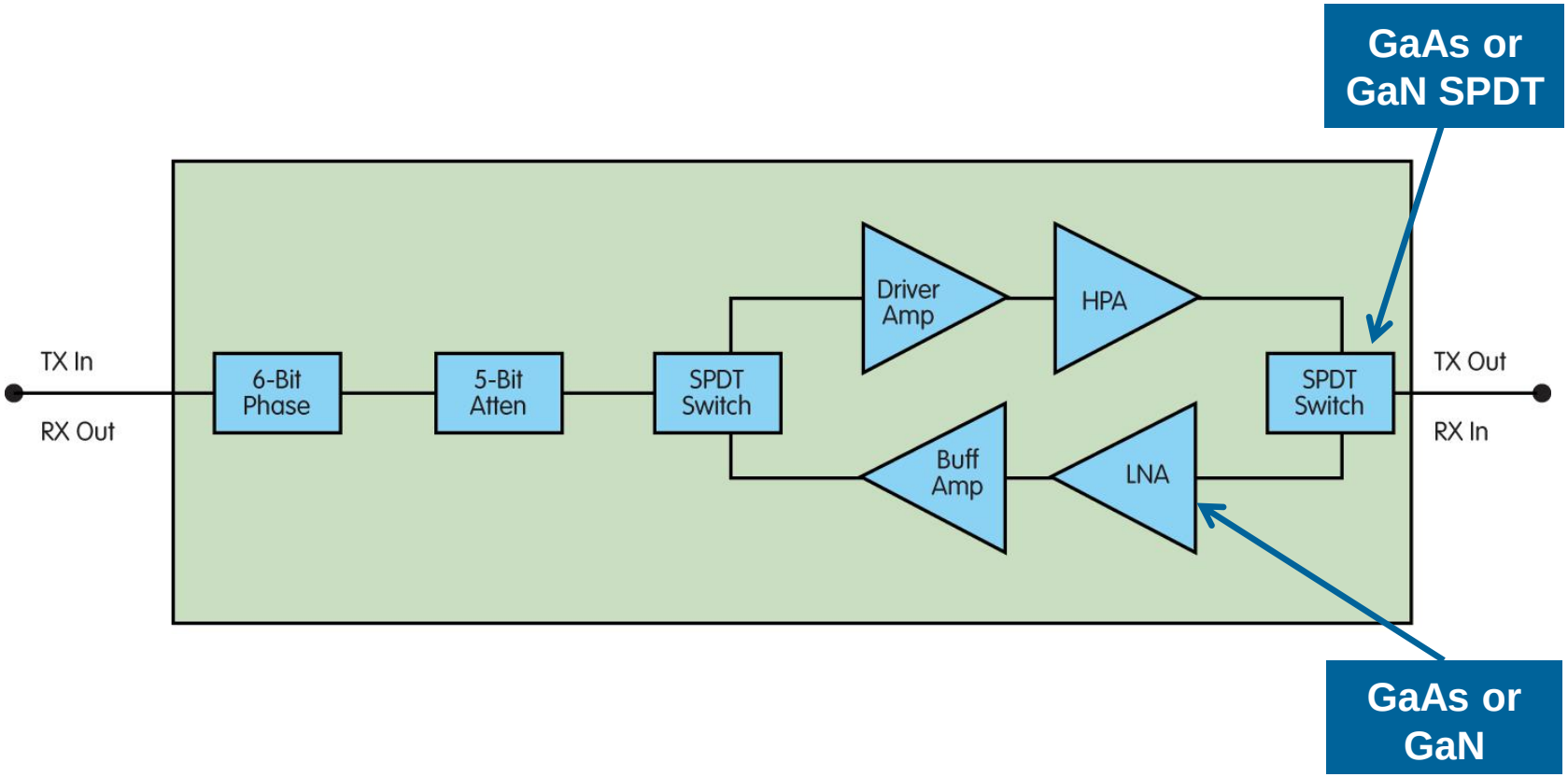
TriQuint
Reach Further • Reach Faster™

Tx / Rx Module on a Single MMIC

TriQuint
Reach Further • Reach Faster™

Transmit Receive Functions on a Single MMIC

- **Transmit, receive and control functions on a single MMIC delivers SWaP advantages**

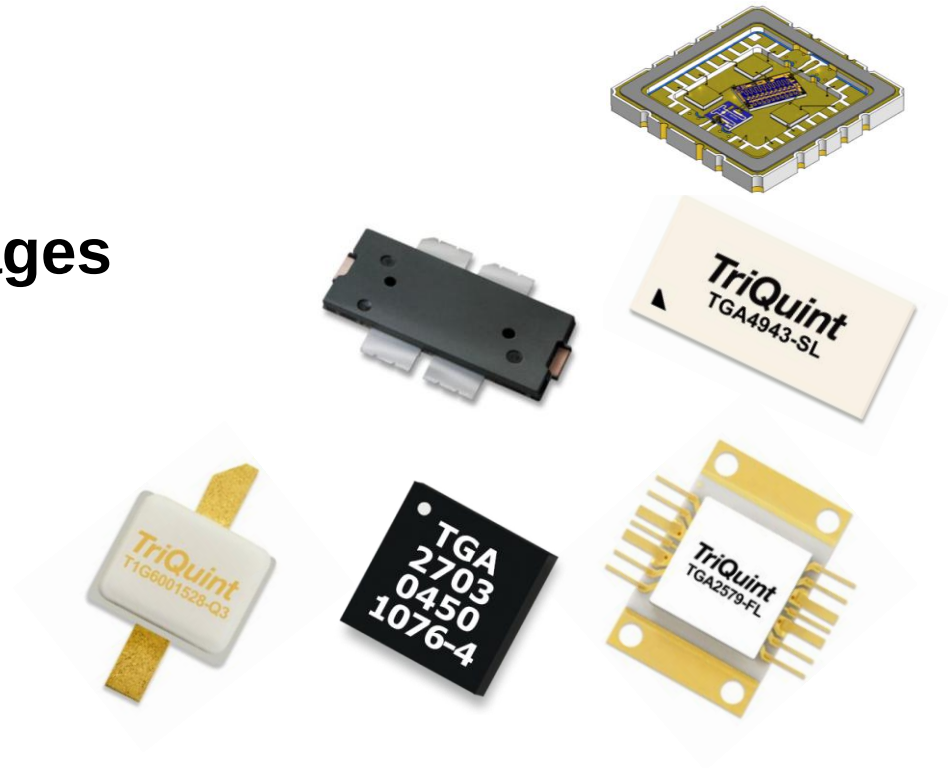


RF Packaging

TriQuint
Reach Further • Reach Faster™

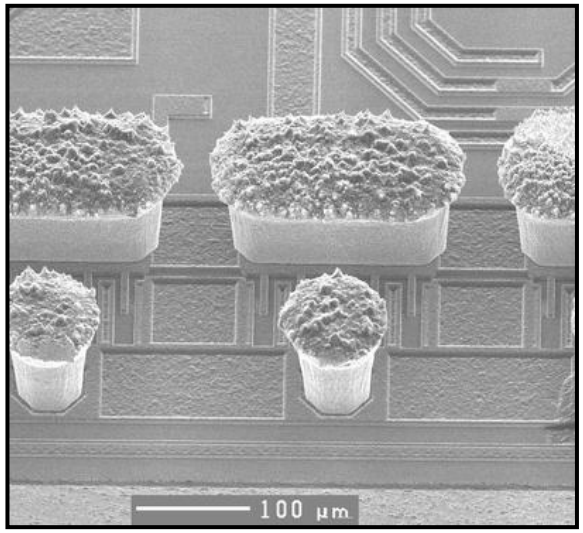
RF Package Types

- **TriQuint's Cu-Flip™ process**
- **Surface mount packages**
  - Air cavity QFN
    - Ceramic or LCP
  - Over-molded QFN
  - Rogers laminate
- **High-power flange packages**
  - Cu-Moly based
  - Plastic over-molded

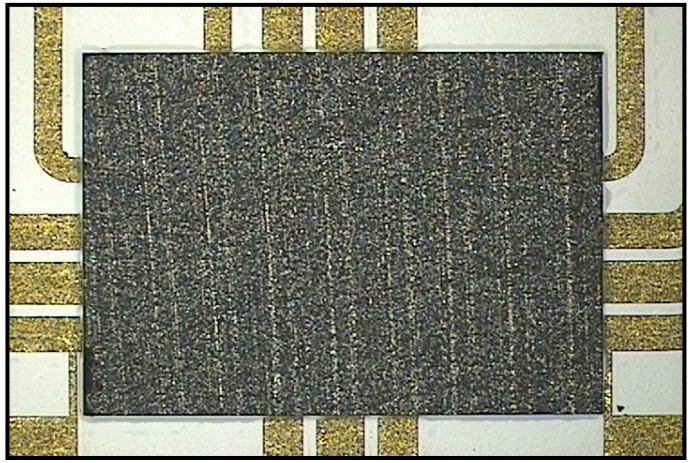


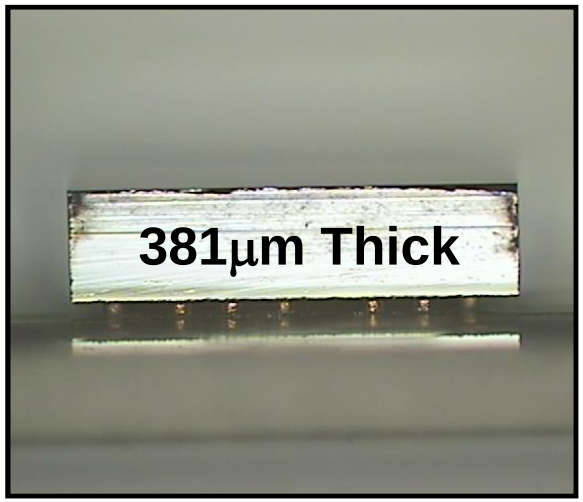
TriQuint
Reach Further • Reach Faster™

CuFlip™ TriQuint's Cu-Bump Interconnect Technology



- **CuFlip™ advantages**
  - Low inductance connection
  - Reduces performance variability
  - Potential board and die size reduction





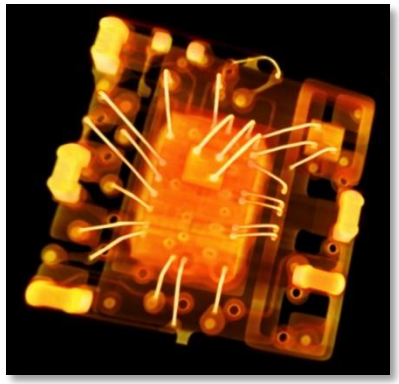
TriQuint
Reach Further • Reach Faster™

Technology Advantage: BiHEMT and CuFlip™

BiHEMT

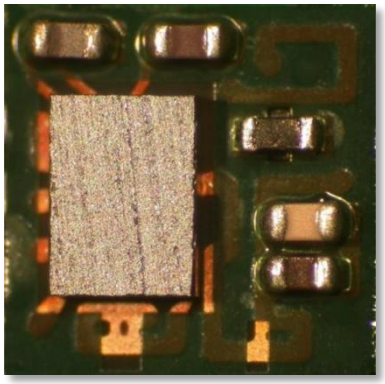
- Smaller, less complicated die
- Lower cost solution
- Provides path for higher integration

Conventional



VS

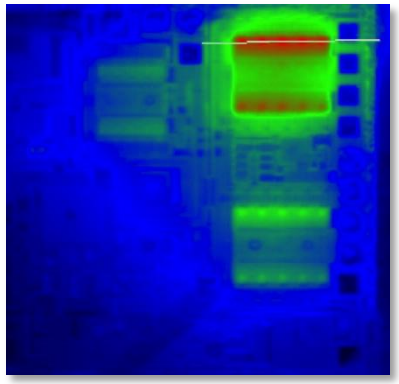
BiHEMT + CuFlip™



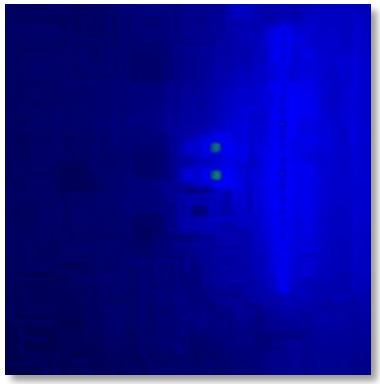
Size reduction and performance increase with using enhanced process technology

Cu-Flip™

- More efficient PA
- Cooler operation due to lower thermal impedance (30-50%)
- Less manufacturing variation



VS



TriQuint
Reach Further • Reach Faster™

Summary

- **Power amplifier advancements result in SWaP improvements for both center feed and AESA radar**
- **GaN RF switches and high-survivability LNAs improve performance and decrease size of the overall radar**
- **Packaging drives lower cost unit price and low cost assembly**

Thank You!

Dean White

TriQuint

Business Development Manager

dean.white@triquint.com

www.triquint.com

TriQuint
Reach Further • Reach Faster™