



Low Cost and High Performance MMIC Solutions for Automotive Radar

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Life is About Connections.

TriQuint 
SEMICONDUCTOR

Connecting the Digital World to the Global Network®

Agenda

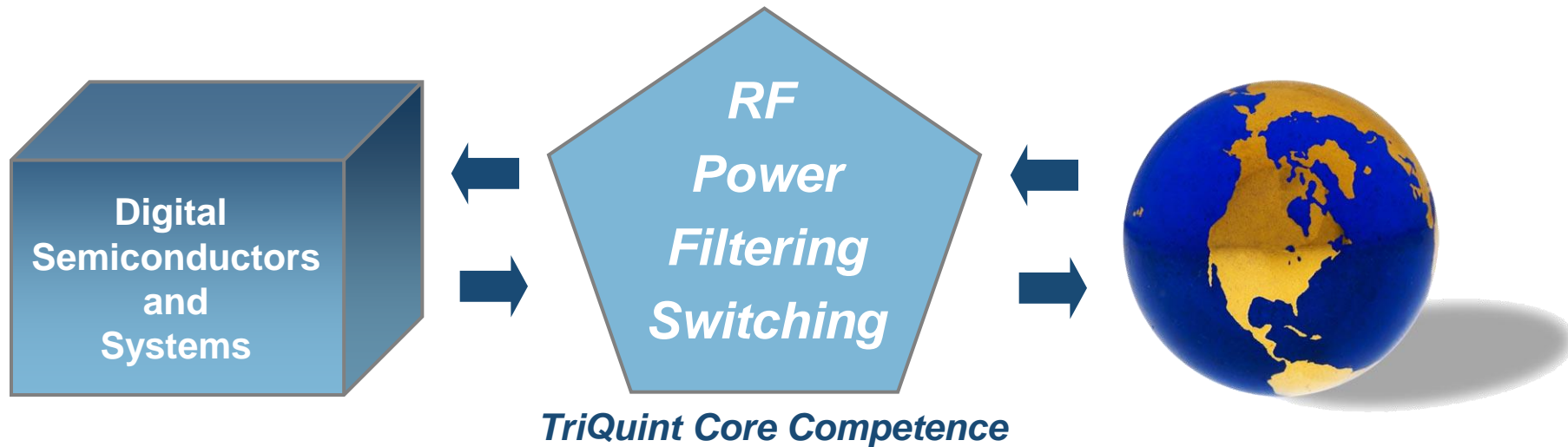
- **TriQuint at a Glance**
- The Automotive Radar Market from a GaAs Manufacturers Perspective
- Process Technologies, Assembly Considerations
- Product Development 77 GHz Automotive - Examples
- Summary

“Connecting the Digital World to the Global Network[®]”
Improving the performance and lowering the cost of our customers applications.

What We Do

Connecting the Digital World to the Global Network®

Improving the performance and lowering the cost of our customer's applications



World's largest GaAs foundry

World's third largest GaAs semiconductor supplier

TriQuint – Broadest Technology Portfolio

Higher
Power

GaN, High Voltage pHEMT

Higher
Frequency

mHEMT, Ka-band GaN

Improved
Linearity

Linear pHEMT, HFET, HV HBT

Filtering

SAW, BAW, Wafer Level
Package

Integration

E/D pHEMT, BiHEMT, Passives
Interconnect, Modules

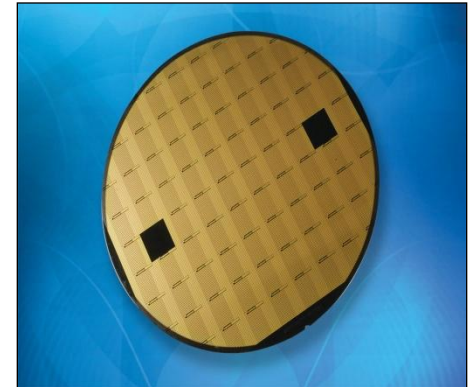
Market Focused Business Units

Handsets

Military

Networks

**Commercial
Foundry**



**Volume &
Manufacturing
Efficiency**

**New
Technology
Development**

**Standard
Products**

**Access to
Broader Markets**

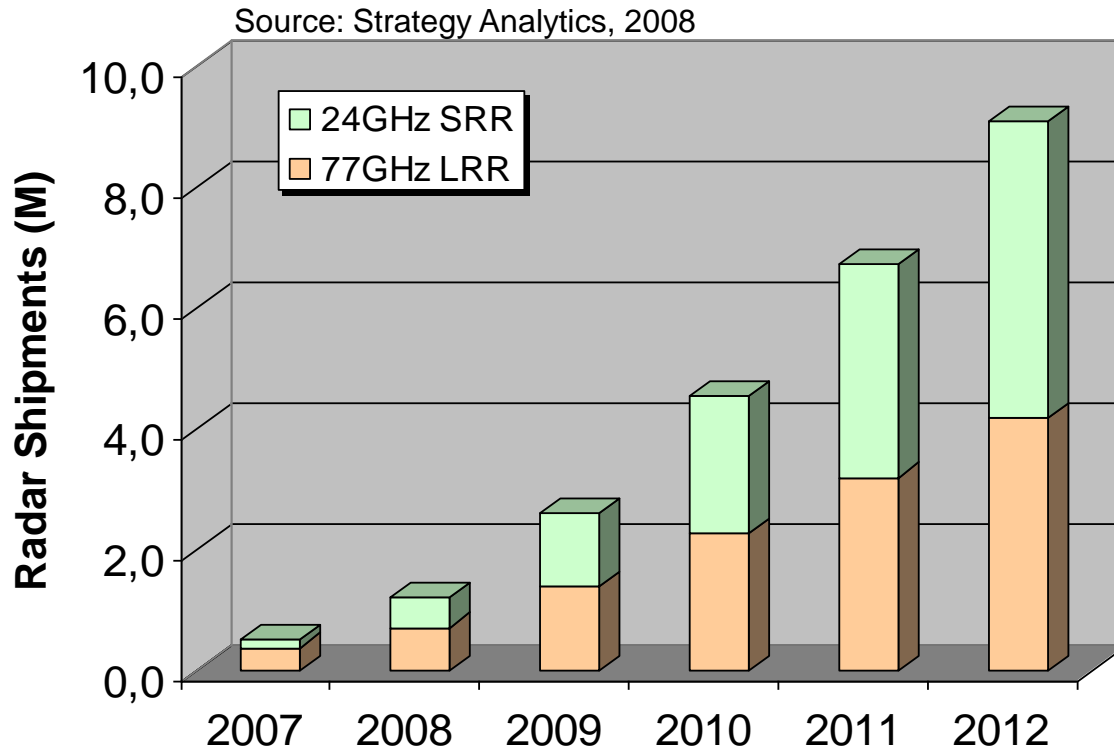
Diversified Business Strategy Drives Greater Long Term Profitable Growth

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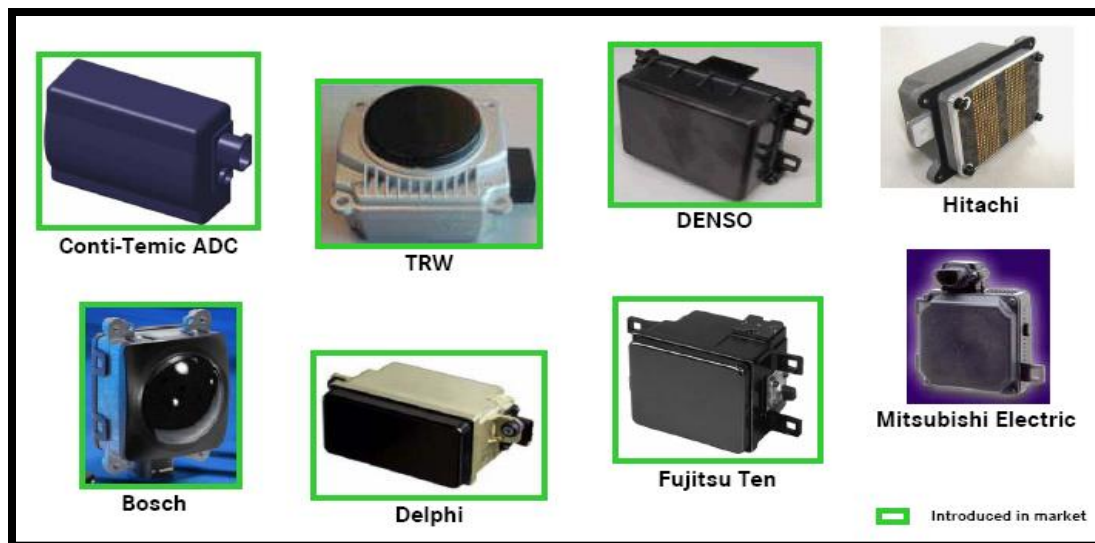
Promising Outlook Before the Economic Crash



- Semiconductor TAM for 77 GHz Auto Radar in 2008 was approx. \$20M
- Above 77 GHz Radar projections will most likely shift by one year due to the difficult economic environment
- Other Industrial Applications: Level or Proximity Sensing

Characteristics of the 77GHz Radar Market

- No standardization of radar architecture or MMICs
- Trend is that MMIC suppliers partner with system integrators to develop custom MMIC solutions
- Volumes per tier 1 system integrator will range from 50k-250k per year with typical product life times of 5 years: small volumes for GaAs & especially SiGe MMIC suppliers!
- Integration level & price are main application considerations



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Benefits: Today's GaAs Technologies for 77 GHz Applications

- **Proven Technology**

- Long-standing performance & track record in mmWave technologies for auto radar, defense, satellite & Point-to-Point radio applications

- **Proven Reliability**

- In both high frequency / high reliability environments & commercial products such as handsets & computers

- **Low Development Costs**

- Prototype cost 1/10th that of High Performance Si or SiGe
- Quick Turn times (4 - 6 weeks)

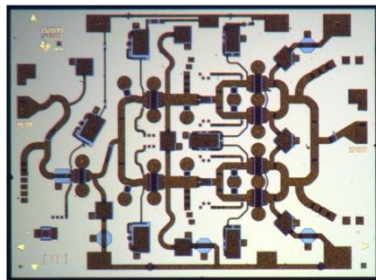
- **Low Production Costs & High Volume Capability**

- Recent developments have enabled mmWave processes on larger substrates & lower-cost processes, namely optical lithography

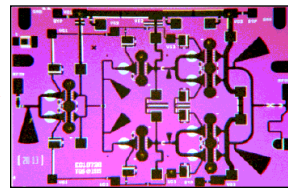
Device Size and Yield Drives Price

Auto Radar MMICs: It's all about cost!

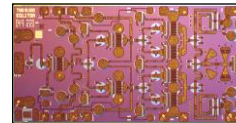
GaAs designers need to make their designs as compact as possible!



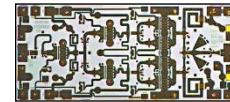
4.1 x 3.0 mm
(12.3 mm²)



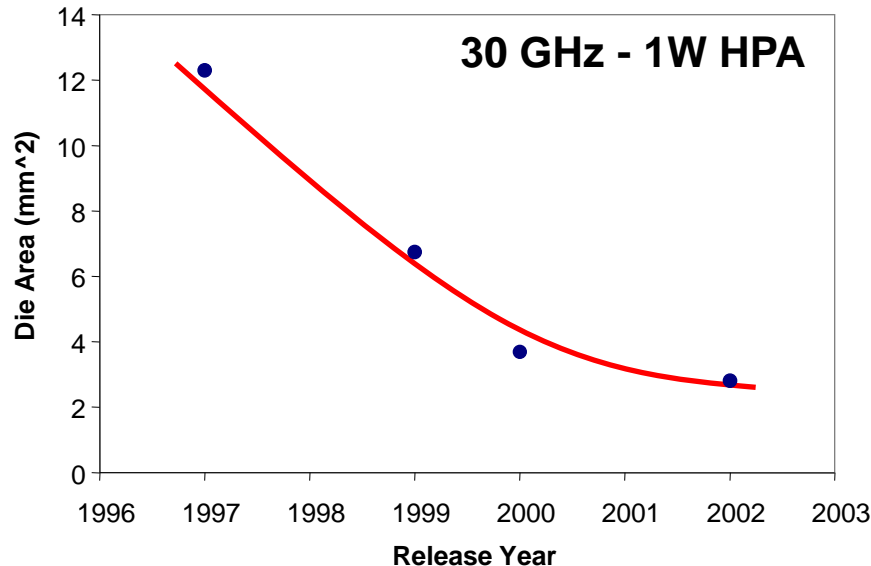
3.12 x 2.16 mm
(6.74 mm²)



2.69 x 1.37 mm
(3.69 mm²)



2.436 x 1.154 mm
(2.811 mm²)

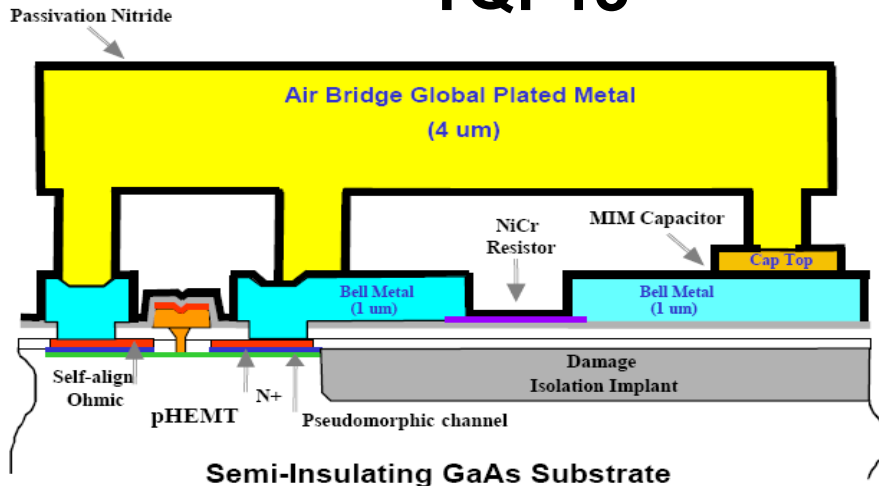


Final size is limited by

- Technology Performance
- Size of Passives
- Gate Finger Spacing
- Output Periphery (Power)
- Number of Stages (Gain)
- Bandwidth

Low Cost mmWave GaAs Process Example

TQP13

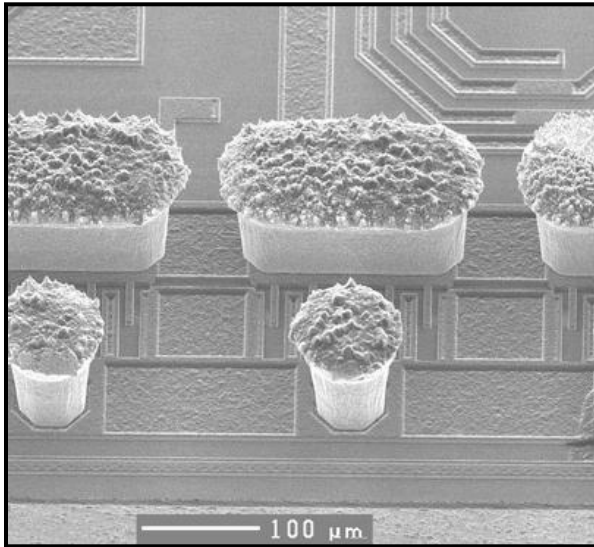


- Already actively used for applications with similar demands:
 - Automotive Radar (up to 77 GHz)
 - 60 GHz WPAN (WiHD)
 - Pt-2-Pt Radio
- Proven up to 110 GHz
- Sufficient power
- Low noise
- High volume / Low cost

0.13 μ m Optical 150mm pHEMT

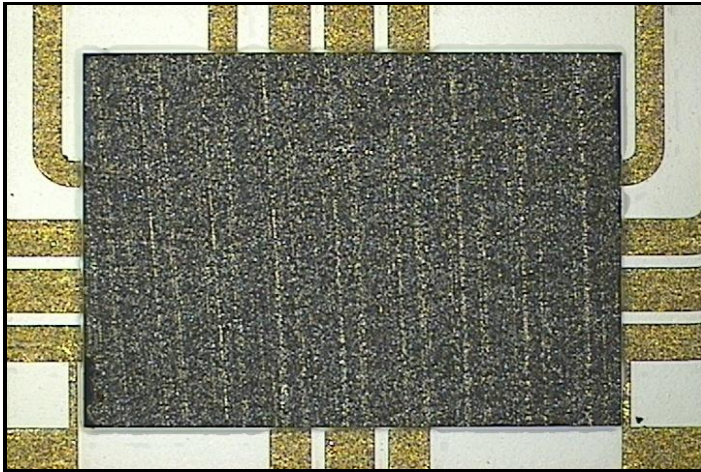
- 0.13 μ m optical D-mode for low noise
- D-FET: $V_p = -300$ mV
- $F_{max} > 200$ GHz
- $BV_{gd} = 8$ V typical
- $GM = 750$ mS/mm
- $I_{max} = 550$ mA/mm, $I_{dss} = 100$ mA/mm
- $NF < 0.5$ dB (@ 12GHz)
- Metal Interconnects:
 - 1 Local, 1 Global (airbridge)
- Includes 340 pF/ μ m MIM, 50 ohm NiCr Resistors
- 30-50% savings over similar processes that use E-Beam lithography

Flip-Chip Cu-Bump Interconnect Technology



Flip chip

- Lowest inductance connection
- Attachment independent of number of connections
- Potential board and die size reduction
- No backside wafer processing



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Standard Low Cost 77 GHz GaAs Radar Chipset

TX

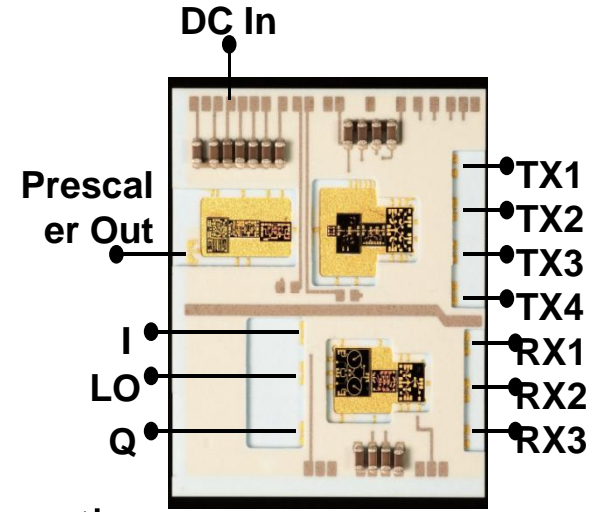
19GHz VCO with $\div 8$ 19GHz/38GHz Doubler 38GHz/76.5GHz Doubler/MPA 76.5GHz SP3T

6''- HBT 6''- 0.13 μ m pHEMT 6''- 0.13 μ m pHEMT 4''- VPIN

RX

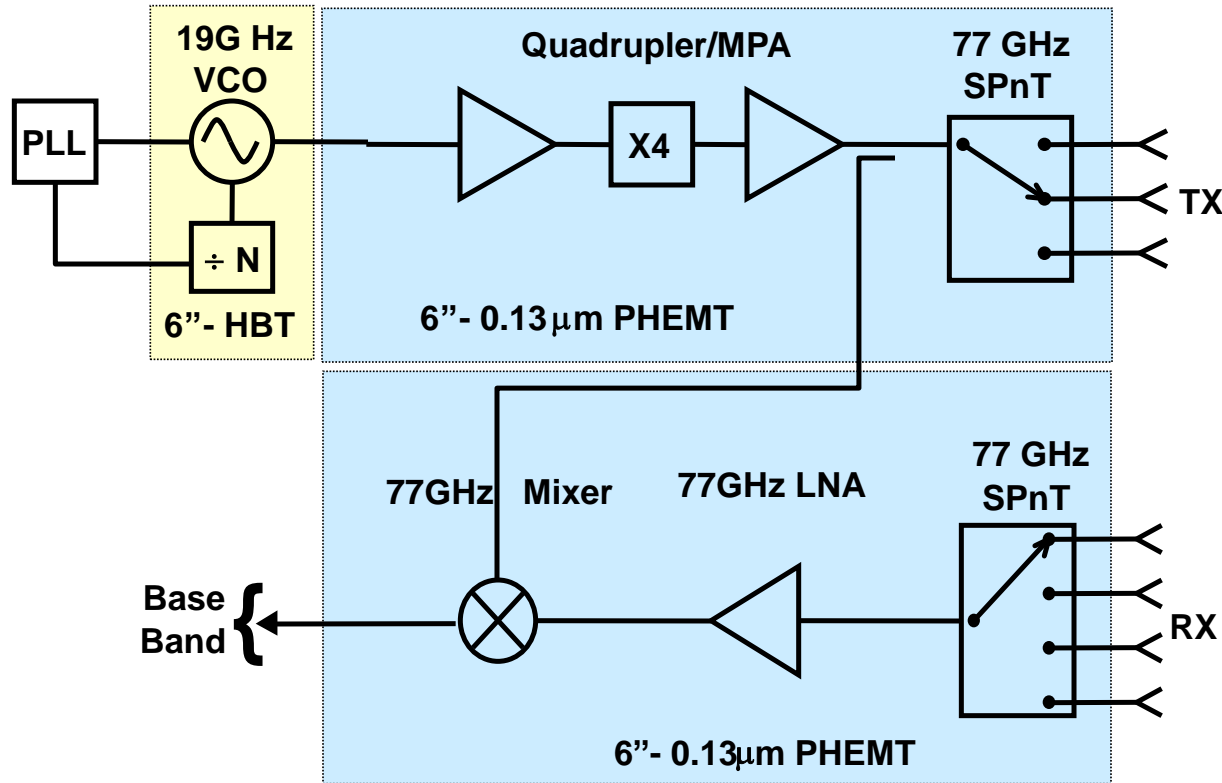
76.5 GHz I/Q Downconverter 76.5GHz LNA 76.5GHz SP4T

6''- HBT 6''- 0.13 μ m pHEMT 4''- VPIN



- Optimum process technology was used for each function
- Lead customer is ramping radar using this coplanar chipset in flip-chip configuration

High Integration: Possible with GaAs for 77 GHz Radar Front-end!



- Only 2 or 3 MMICs on low-cost, 6-inch GaAs processes needed for a complete 77 GHz front end!
- Scalable switch matrix allows more antenna ports for better resolution

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Summary and TriQuint Value Proposition

- GaAs offers the optimum technologies to serve each auto radar RF function at optimized performance and at minimum cost **AND** GaAs has a track record for 77 GHz radars
- TriQuint has a coplanar 77 GHz MMIC chipset available which is applicable to various front-end architectures
- TriQuint is TS16949 certified and all 77 GHz products are 100% DC/RF on-wafer tested
- TriQuint can develop very price competitive custom MMIC solutions on 6-inch, high-volume GaAs processes for higher integration and provide engineering support for flip-chip integration
- **For Auto Radar details, contact Dr. Markus Behet (markus.behet@tqs.com), or visit these web locations:**
 - **Automotive Applications** on **www.triquint.com**