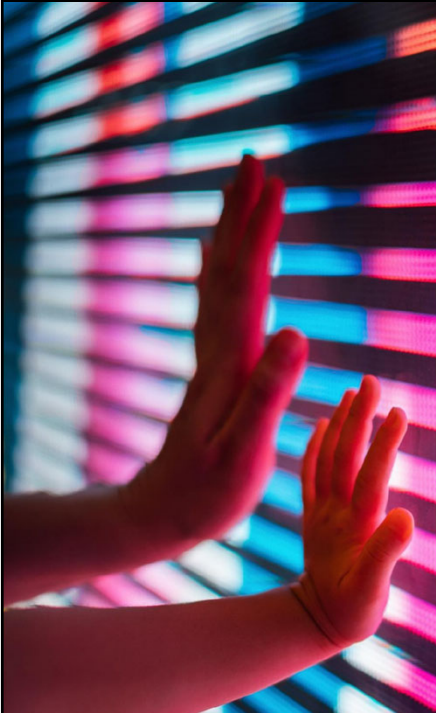




Semiconductors and electromobility: Innovations and trends for a sustainable future.

Miguel Angel Meza Campos
SMTS Layout Designer Engineer
November 7, 2024
[Sand to Silicon v2 - YouTube](#)

1



GF at a glance

\$7.392B 2023 revenue	2.2M 2023 wafer shipments (300mm eq.)
200+ Customers	4 manufacturing sites across three continents
~13,000 employees	~9,000 patents

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Resilient global manufacturing footprint

Malta, NY, USA 300mm	Capacity: 404 kwpa Technology: FinFET, NVM, RFSOI, SiPh
Singapore 300mm & 200mm	Capacity: 790 (300mm) & 361 (200mm) kwpa Technology: BCD/BCDLite, HV, NVM, DDI, RFSOI, LP SiGe
Dresden, Germany 300mm	Capacity: 800 kwpa Technology: FDXTM, NVM, HV, BCDLite
Burlington, VT, USA 200mm	Capacity: 263 kwpa Technology: RFSOI, SiGe, GaN
Crolles, France	Under Construction

Products on the differentiated technology platforms our customers need where they want them produced

Note:
 1. Kwpa is defined as installed capacity in thousand wafers per annum as of 12/31/23
 2. 200mm capacity translated to 300mm equivalent

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A world-class test solutions provider

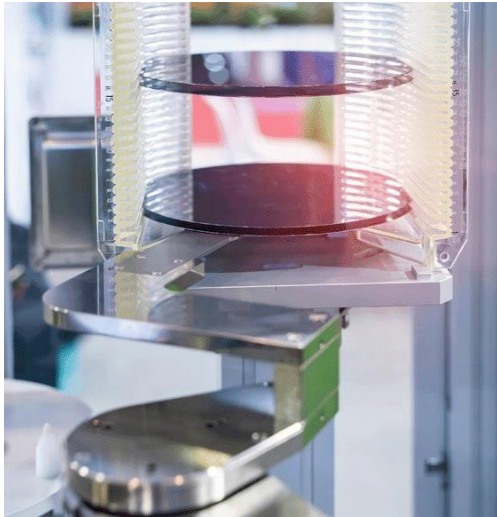
A leader in complex testing, GF has developed over 600 test solutions that provide customers with the reliability assurance they need at every stage of production.

- Extensive RF testing solutions
- High and low temperature test capabilities
- Analog and digital Transmitter/Receiver (TxRx) testing
- Memory testing including embedded Non-Volatile Memory (eNVM)
- High speed interface test capabilities
- High voltage and high current testing

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Wafer services



- As a part of a full turnkey offering, GF offers Bump, Wafer Level Package and Probe capabilities, complemented by OSAT partnerships, to provide a one-stop-shop for customers' wafer needs. Creating a reliable and high-quality path to production, GF streamlines manufacturing so customers can realize their designs quicker.
- Bump offerings for 200mm and 300mm, including SnAg bump, copper pillar and WLCSP
- Wafer sort with Known-Good-Die methodology
- Backside grind, wafer sort and bake, dicing, marking and binning services available

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Engineering services

From design to product packaging and testing needs, GF's engineering services go beyond standard manufacturing practices to deliver the solutions that enable unique ideas to become reality. For questions of design feasibility, connectivity enablement and package resilience, GF has the experience and partnerships to address the specific questions customers need answered.












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Innovation beyond transistor size

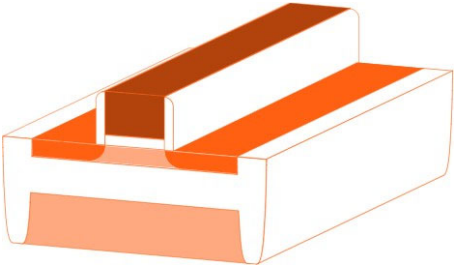
Feature-rich CMOS	Ultra-low power CMOS		Silicon Photonics	RF			Power	
 Feature-rich CMOS	 FinFET	 FDX™ FD-SOI	 Silicon Photonics	 RF SOI	 SiGe	 RF GaN	 BCD & BCDLite®	 Power GaN
3D / heterogeneous integration / advanced packaging								
Feature-rich, application-specific features	The ultimate in performance and ultra-low power		Energy-efficient data transmission at the speed of light	Leading RF performance, signal power and reliability			Power density and efficiency, integrated reliably	

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Automotive platform innovations with 22FDX® technologies

- GF's FDX platform offers full System on Chip (SoC) integration including digital, analog and high-performance RF for signal range. The 22FDX platform offers a versatile SoC when you can't compromise between ultra-low power and performance.




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Automotive

Driving innovation in the software defined future

5G Connection:
RF FEM mmWave
 FDX™
 RF mmWave
 Low power connectivity

Vehicle Power:
DC-DC, BMS, Charger
 Feature-rich CMOS (BCD, eNVM)
 High voltage
 Precision
 Power efficiency
 Power management

Vehicle Network:
Zone/Domain/Fusion Controllers
 FDX, FinFET
 Power efficiency
 High performance
 High temperature

Comfort/Customization/
Keyless Entry:
MCU, NFC, BLE, UWB
 Feature-rich CMOS (eNVM)
 Power efficiency
 Edge intelligence

ADAS: Radar
 FDX
 RF mmWave
 Power efficiency
 Edge intelligence

Touch Screen: Display
 Feature-rich CMOS
 Sensor fusion
 Power efficiency

ADAS: LiDAR
 Silicon Photonics
 High transfer rate
 Power efficiency
 Edge intelligence

User Experience:
IVI, Cluster
 Feature-rich CMOS (BCD)
 Power efficiency
 Power management

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GF Automotive Quality – Reliability, Robustness and Safety



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Emerging Technology – Mega-Trends in Automotive

- **Autonomous Driving: Level 1 → 5**
 - Enhanced Safety and Increased Mobility
- **In-vehicle Infotainment (IVI) with broader Connectivity**
 - Elevating the in-cabin experience (Silicon Photonics)
- **Hybrid / Electric Vehicle (EV)**
 - Extending Battery Life (GaN) and Energy Harvesting (Regenerative braking)
- **Vehicle to Vehicle (V2V) and Vehicle-to-Infra (V2X) Communications**
 - Smarter Transportation
- **Security Concerns**
 - Increasing needs for Control and safe-guarding Privacy

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ADAS & Autonomous Systems Require a Full Range of Technologies

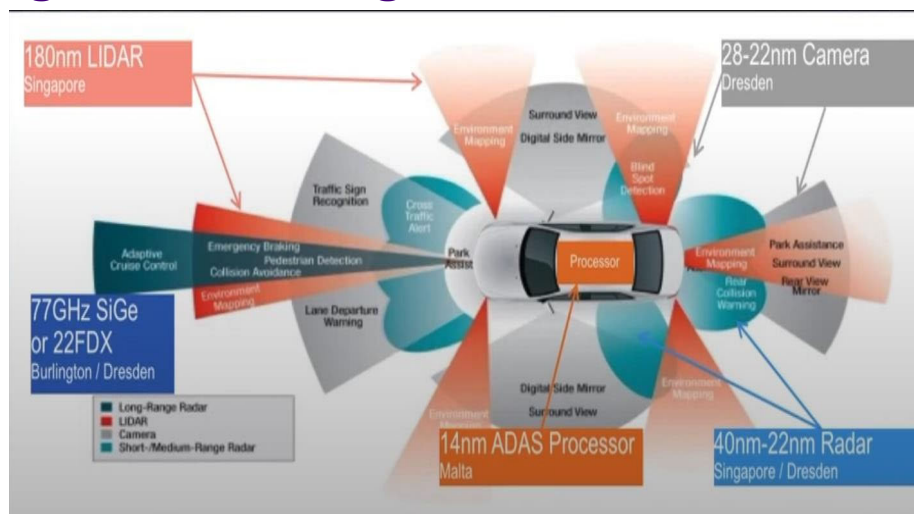
- **ADAS surround sensores will be cameras, radar, infrared and LIDAR**
 - Cameras will be 2Mp to 7+Mp with most processing done in ADAS Core CPU
 - Radar Moving from 24GHz – 64GHz / Ultrasonic to 77GHz (even 140 GHz) Radar with integrated logic
 - Long range front Radar was predominantly 77GHz SiGe with a moving to 22FDX FD-SOI for power and range
 - LIDAR generates high resolution long range and surround view augmenting camera and radar.
- **Sensor data will flow into an ADAS Central Processor to create a 360° view and implement vehicle response**
 - Sensor processing with AI / DNN, and fused with HD Maps

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ADAS & Autonomous Systems Require a Full Range of Technologies

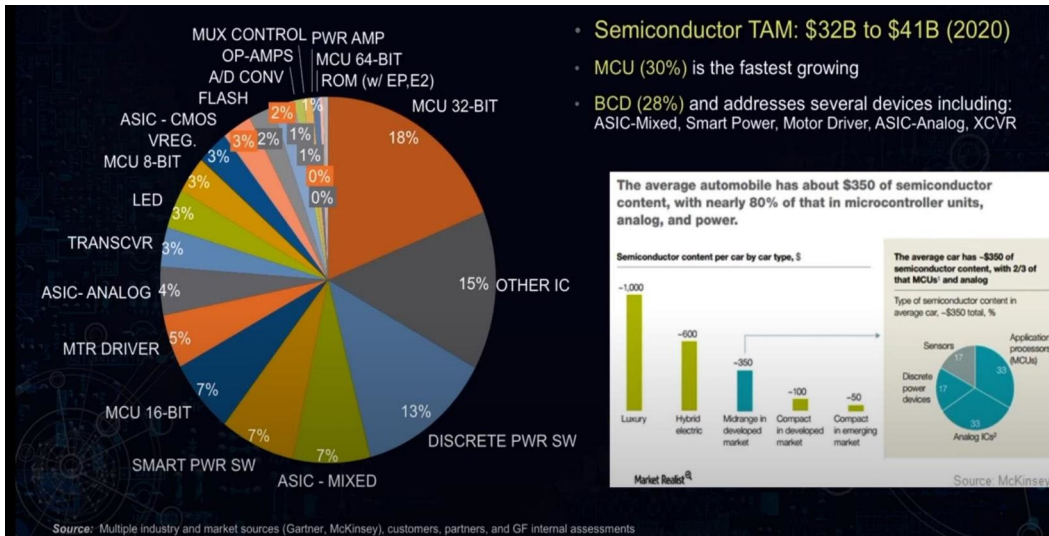


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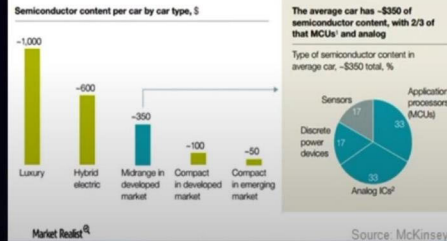
14

Overall Automotive Market View



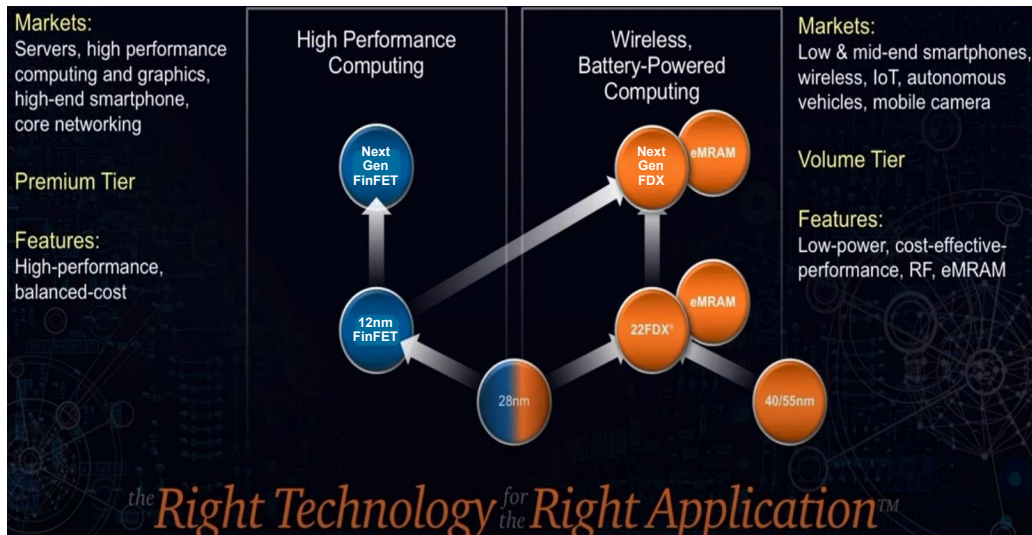
- Semiconductor TAM: \$32B to \$41B (2020)
- MCU (30%) is the fastest growing
- BCD (28%) and addresses several devices including: ASIC-Mixed, Smart Power, Motor Driver, ASIC-Analog, XCVR

The average automobile has about \$350 of semiconductor content, with nearly 80% of that in microcontroller units, analog, and power.



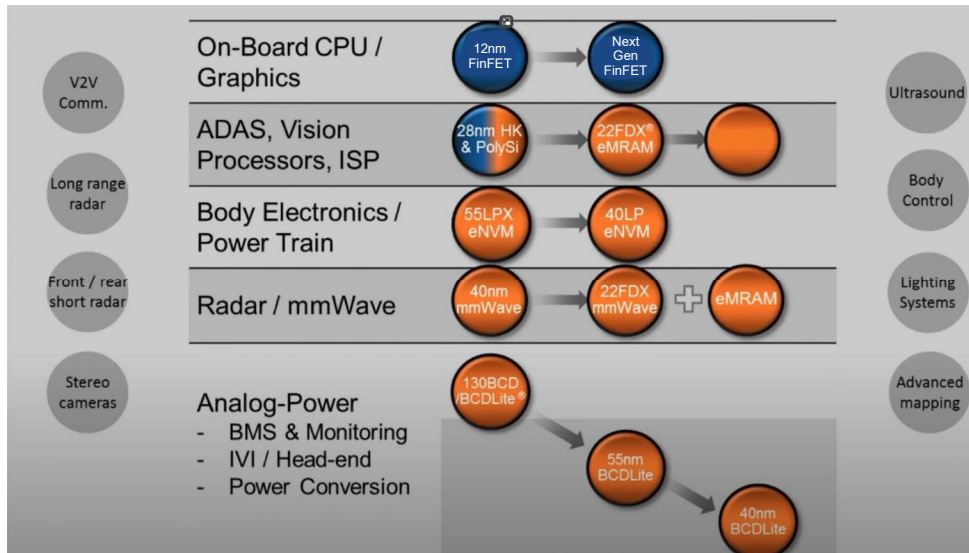
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CMOS Roadmap



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CMOS Roadmap (cont...)



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FDX for Automotive



Application Tiers

- ADAS (Vision), Infotainment (IVI), Body Electronics MCU, mmWave Radar
- Automotive Grade 3, 2 and 1 rated

Technology Suited For Market Needs

- ADAS (Vision): Low Power (<5W), Processing < 1.2GHz, Auto Grade 2 / 1
- IVI: ~1GHz performance, Auto Grade 3 / 2
- MCU: MHz to < 1 GHz, 22FDX® + eMRAM + SRAM, Auto Grade 2 / 1
- mmWave: Key 22FDX mmWave advantage over 40 and 28nm
 - Higher Pout on SoC for mid to long range radar single chip solutions
 - @77GHz 10dBm <Pout <18dBm
 - Stable Pout performance at 150°C (Grade 1)

Value

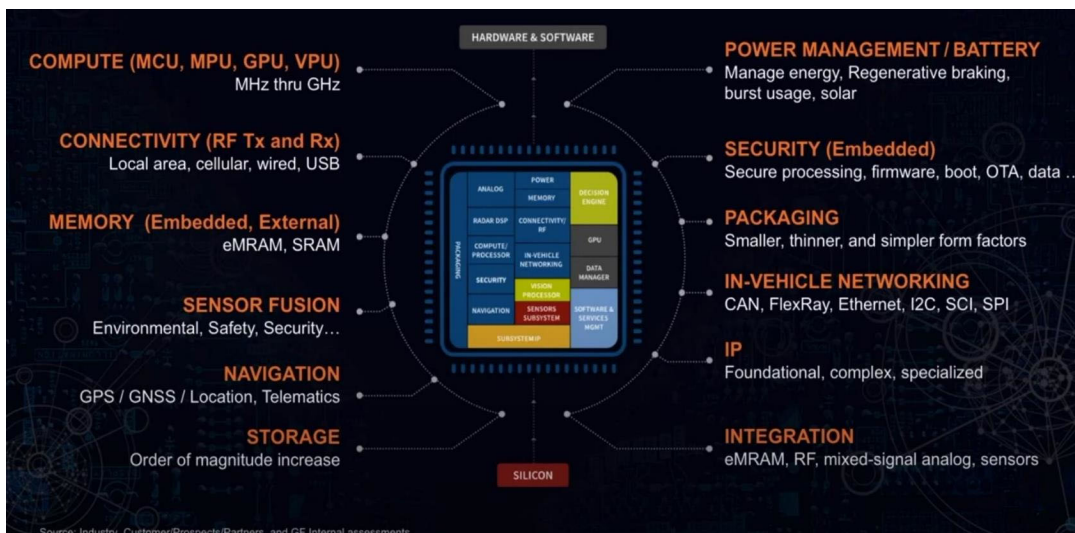
- 22FDX® offers a lower-power, performance-on-demand positioning for ADAS (Vision) capabilities for Autonomous driving Levels 1 to 3
- Is extremely well-suited for Automotive MCU with medium density NVM
- 22FDX mmWave is a key advantage for Automotive Radar System's fT / fMAX

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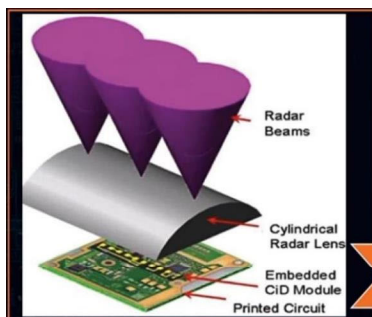
22FDX System-on-Chip



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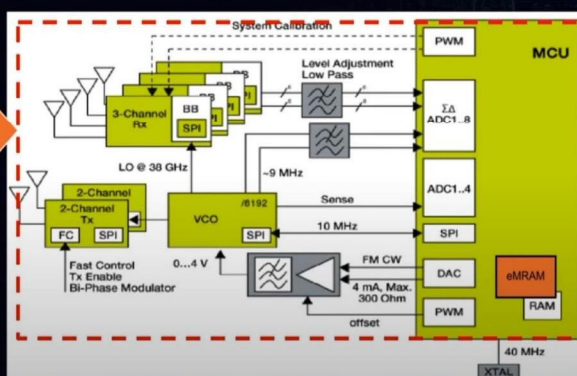
19

22FDX CMOS mmWave Automotive Radar



- Solutions tend to be discrete and lack scalability for further integration
- Performance dictated by PCB design and layout and require careful control of parasitics at these frequencies

GLOBALFOUNDRIES 22FDX[®] mmWave RF solution allows *integration* of mmWave, DSP, MCU, SRAM, and eMRAM into a single chip automotive radar solution



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Embedded Memory: eMRAM capabilities

Automotive	MCU	IoT	Capability
			✓ = Capable
Tj=125°C (grade 2); grade 1 TBD			Operating Temperature
260°C, 5 minutes			Solder Reflow Retention
100mT, non-operating			Magnetic Immunity

✓ = Capable
✗ = Not Capable

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22FDX eMRAM Advantages

- Fast write speed**
 - Up to 1000x faster than eFlash
- High Endurance**
 - Much more than 10E6 cycles
- Versatile**
 - Code storage and working memory
- Small cell Size**
 - 0.047um²
- Data retention**
 - Goal: solder reflow and auto grade

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What 22FDX has proven in the Automotive Industry

Feb. 2017 – First Silicon for ADAS Computer Vision SoC on 22FDX®

Advanced driver assistance system (ADAS) computer vision SoC developed for European THINGS2DO project with working first silicon fabricated on GLOBALFOUNDRIES' 22nm FD-SOI Platform

Collaborators:
Dream chip, ARM, Cadence, Arteris, INVECAS, GLOBALFOUNDRIES


Targeted use-cases:

- 360 degree Top View Camera
- Digital Mirroring
- Video Analytics – Object/Pedestrian Detection

MOBILE WORLD CONGRESS
BARCELONA 27 FEB - 2 MAR 2017

Chip Carrier (SOM) – Chip and two LPDDR-Memories

Dreamchip Development board with socket for Chip Carrier

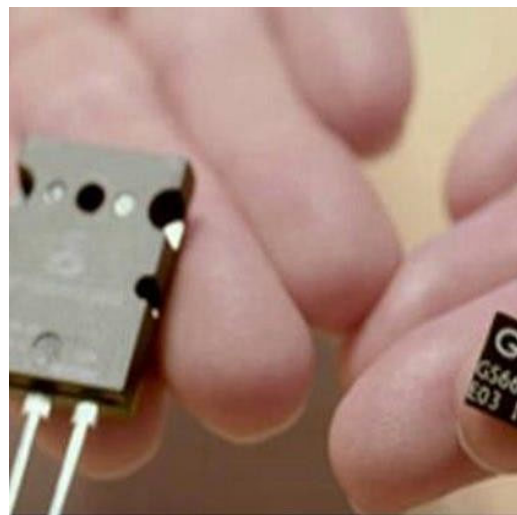


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What About Power Electronics

- At this point we have talked about sensors, RF (radar & communications), microcontrollers, HD mapping, LiDAR, cameras, etc.
- What about power in the automobile? Battery chargers, motor drivers, i.e. automobile power management.
- To this day, the most used semiconductors for those needs are Power MOSFET modules and Silicon Carbide (SiC) devices.
- However, the new trend is the use of GaN-based semiconductors.
- Let's talk a little bit about GaN Technology and Devices!



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GaN Technology and Devices (Introduction)

What is GaN-on-Silicon: Understanding Gallium Nitride Technology

Gallium nitride (GaN) is a very hard, mechanically stable wide bandgap semiconductor. With higher breakdown strength, faster switching speed, higher thermal conductivity, and lower on-resistance, power devices based on GaN significantly outperform silicon-based devices.

Gallium nitride crystals can be grown on several different substrates like:

- Sapphire
- Silicon Carbide (SiC)
- Silicon (Si)

Source : Efficient Power Conversion EPC

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GaN HEMT

Devices known as High Electron Mobility Transistors are transistors that use two-dimensional electron gas (2DEG). GaN-based HEMTs feature:

- Faster switching speed
- Higher thermal conductivity
- Lower on-resistance

outperforming silicon-based devices. Additionally, these features allow GaN Transistors to be used in electronic circuits to increase efficiency, shrink size and reduce cost of a wide variety of power conversion systems.

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Applications for GaN HEMTs

- DC-DC Converters
- Motor Drivers
- Lidar
- Space - Satellites
- Radiofrequency
- Class-D Audio Amplifiers
- Robotics

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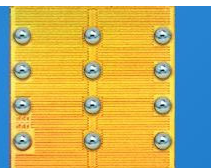
Packaging of GaN Devices

V_{DS} , 200 V
 $R_{DS(on)}$, 5 m Ω
 I_D , 102 A
Pulsed I_D , 260 A



Package Size: 3 mm x 5 mm

V_{DS} , 350 V
 $R_{DS(on)}$, 80 m Ω
 I_D , 6.3 A
Pulsed I_D , 26 A
RoHS 6/6, Halogen Free

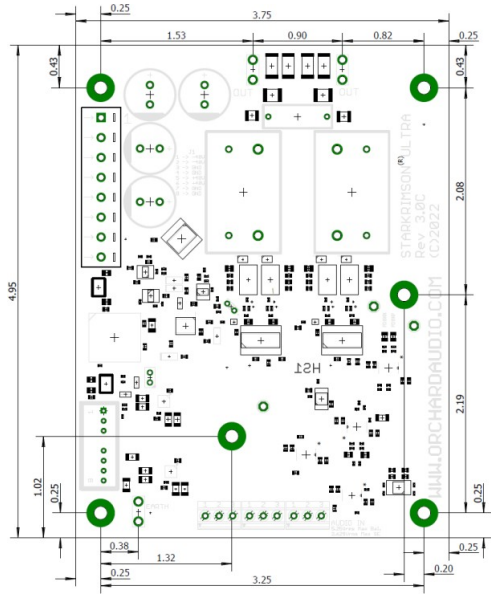


Die Size: 1.95 mm x 1.95 mm

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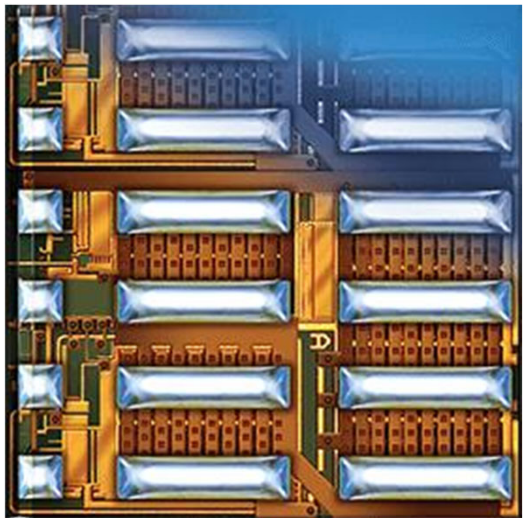
**Example:
Audio Amplifier.**



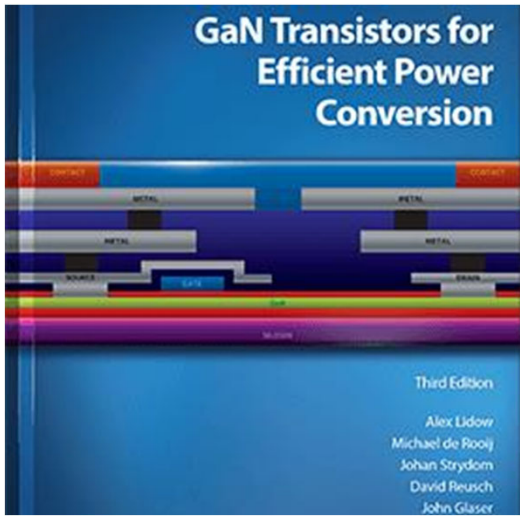
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Some GaN Literature Available




Source : Efficient Power Conversion EPC



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