onsemi Powering Next Leap Forward in Electrification

Introducing Vertical GaN

Vertical Vision: The New Scale of Power

Vertical GaN Innovation

vGaN enables high voltage and high frequency with superior efficiency over silicon chips

Advanced Manufacturing Facility

Development occurs in a 66,000 sq ft cleanroom facility with specialized tools for GaN production

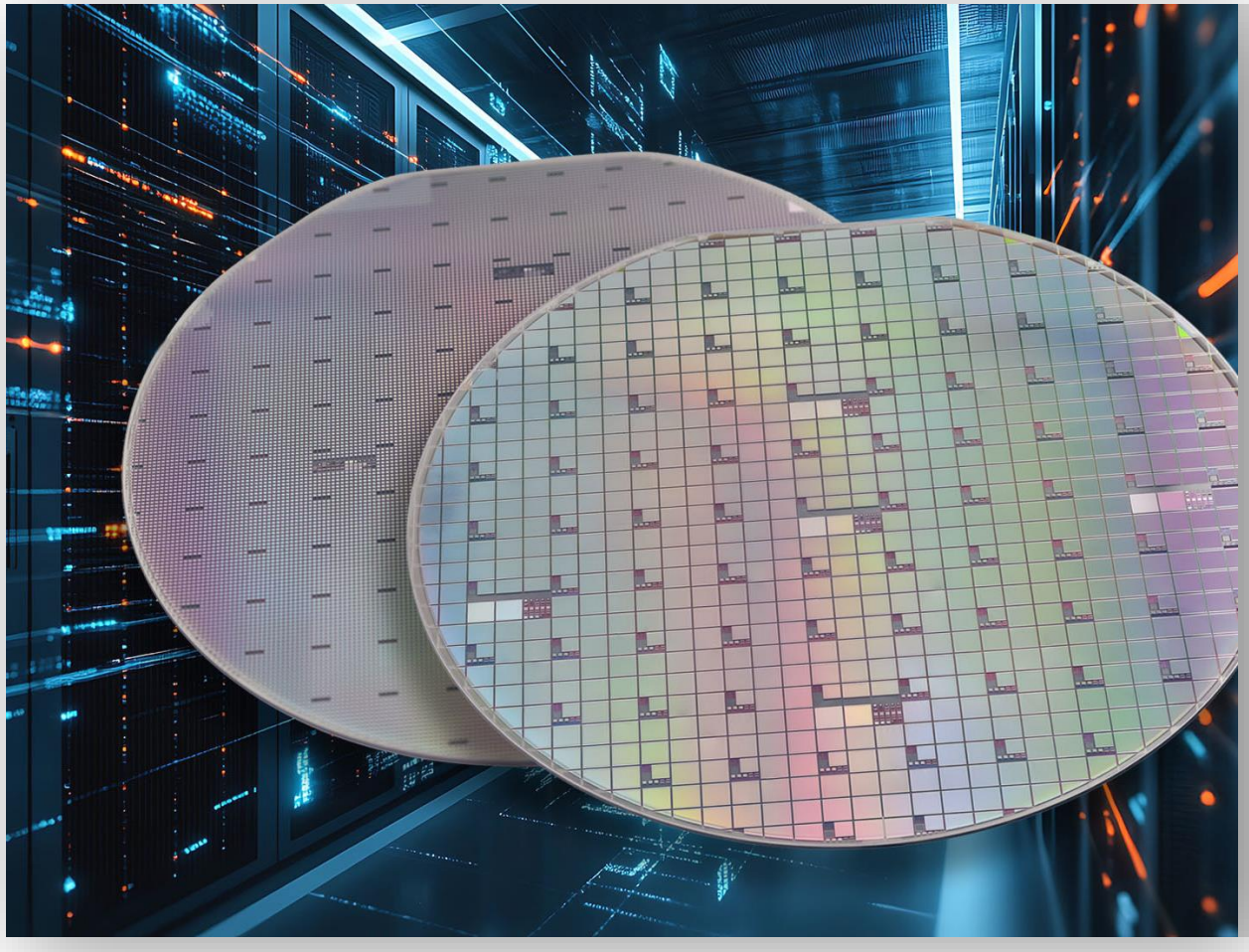
Proprietary GaN Growth Process

Engineers grow GaN layers directly on GaN wafers using unique **onsemi** proprietary technology

Market Leadership and Timeline

onsemi leads the market as first to scale vGaN with 700V and 1,200V devices sampling to early access customers

What is Vertical GaN?



Vertical GaN Structure

GaN grown on GaN substrate allows current to flow vertically through the chip

Higher Performance

Enables higher current densities and voltages than lateral GaN devices

Superior Switching Speed

Supports switching frequencies beyond silicon and silicon carbide capabilities

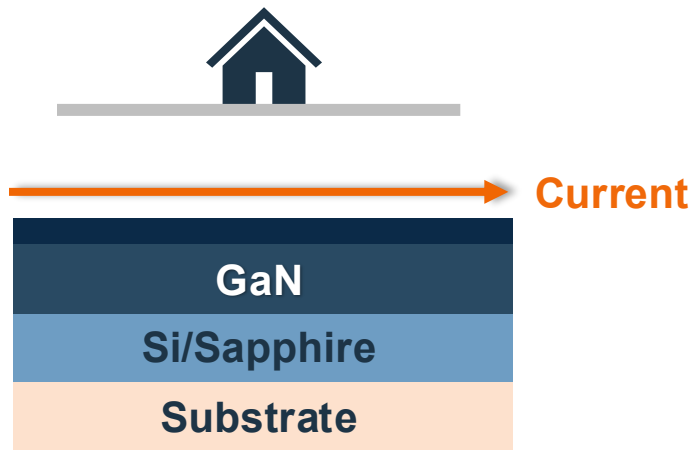
Advanced Applications

Ideal for AI data centers, EV chargers and traction inverters, and renewable energy systems

Vertical vs. Lateral GaN

A Power Showdown

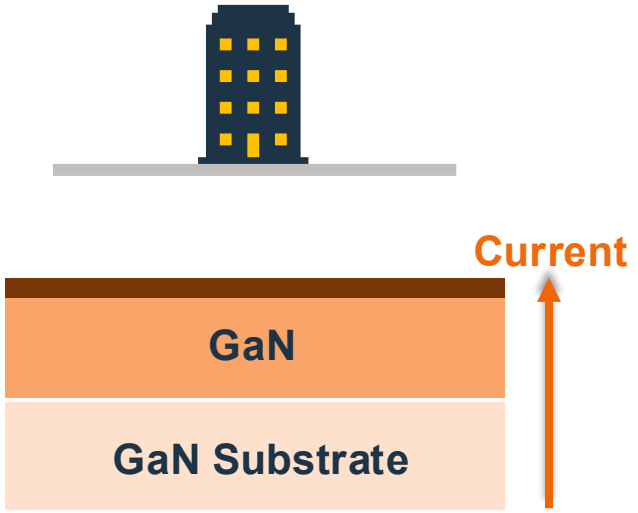
Lateral GaN



Key Differences

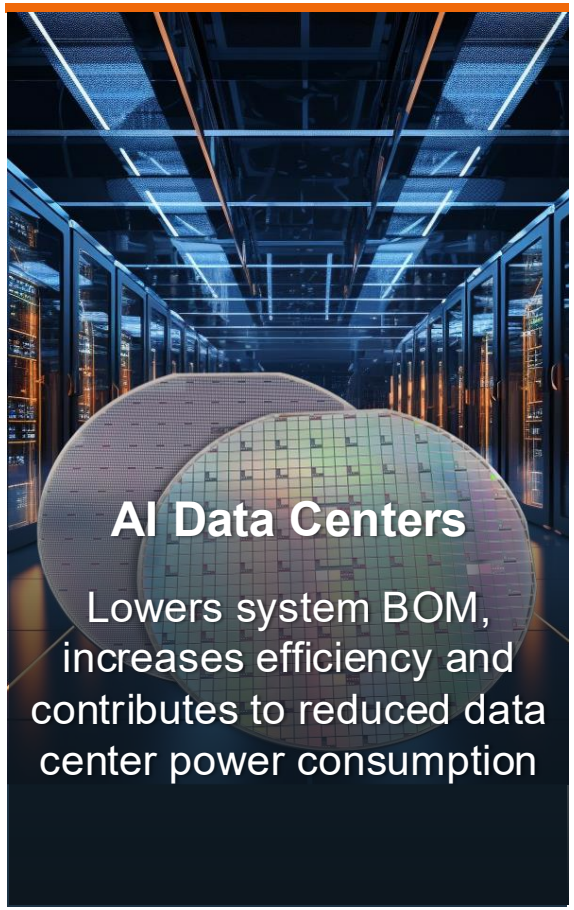
- Substrate Material
- Current Flow Direction
- Voltage Capability
- Efficiency (lower energy loss, less heat)

Vertical GaN



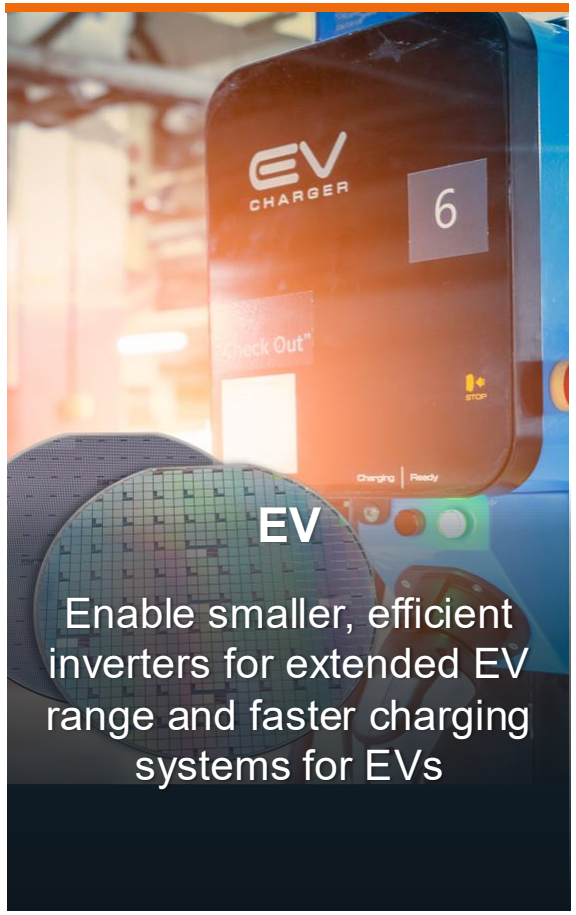
Substrate Differences	GaN-on-Silicon or Sapphire	→	GaN-on-Gan
Current Flow Paths	Horizontal (across the surface)	→	Vertical (through the chip)
Voltage Class	Up to 1700V	→	Over 1,200V (up to 3,300V)
Current Density	Moderate	→	High
Size	Small	→	Smallest, compact system
Applications	Consumer electronics, data centers & automotive OBC (excluding high power & ruggedized applications)	→	AI data centers, automotive OBC, traction inverters, industrial, renewable energy & aerospace, defense and security

vGaN is Driving Innovation and Efficiency Across Critical Sectors



AI Data Centers

Lowers system BOM, increases efficiency and contributes to reduced data center power consumption

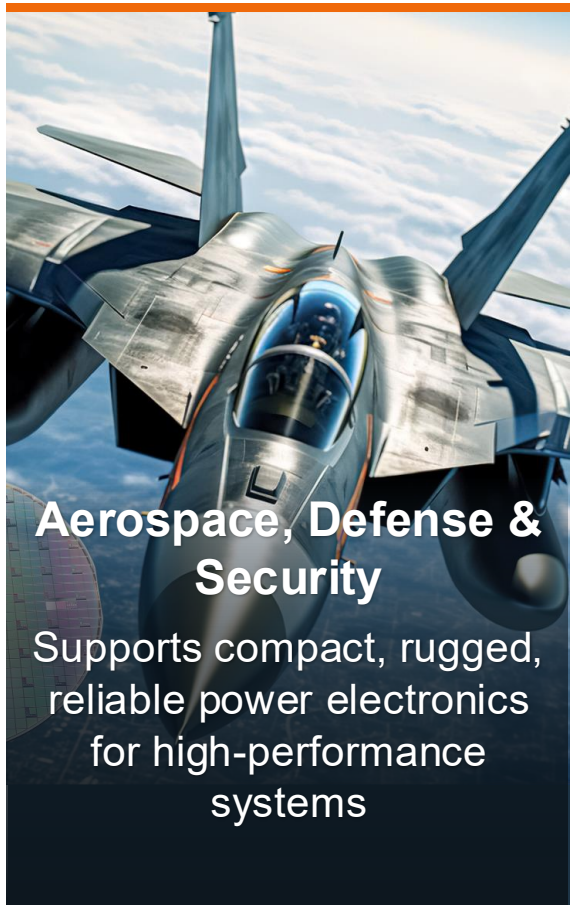


EV

Enable smaller, efficient inverters for extended EV range and faster charging systems for EVs

Renewable Energy

Improves efficiency of solar inverters and wind energy conversion systems



Aerospace, Defense & Security

Supports compact, rugged, reliable power electronics for high-performance systems

onsemi's Vertical GaN

Powering the Future

AI Data Centers

Increases compute density by reducing the size of 800V power converters

Electric Vehicles

Faster EV charging, smaller and more efficient

Renewable Energy

Efficient solar inverters and wind energy systems, lower energy waste

Aerospace, Defense & Security

Compact, rugged and reliable high-performance power systems

onsemi Scaling Innovation by Mastering Complexity

Manufacturing Breakthrough

Pioneering Vertical GaN

Researchers pursued this technology for over 15 years. **onsemi's** commercialization of vertical GaN is a major manufacturing milestone.

State-of-the-Art Manufacturing Process

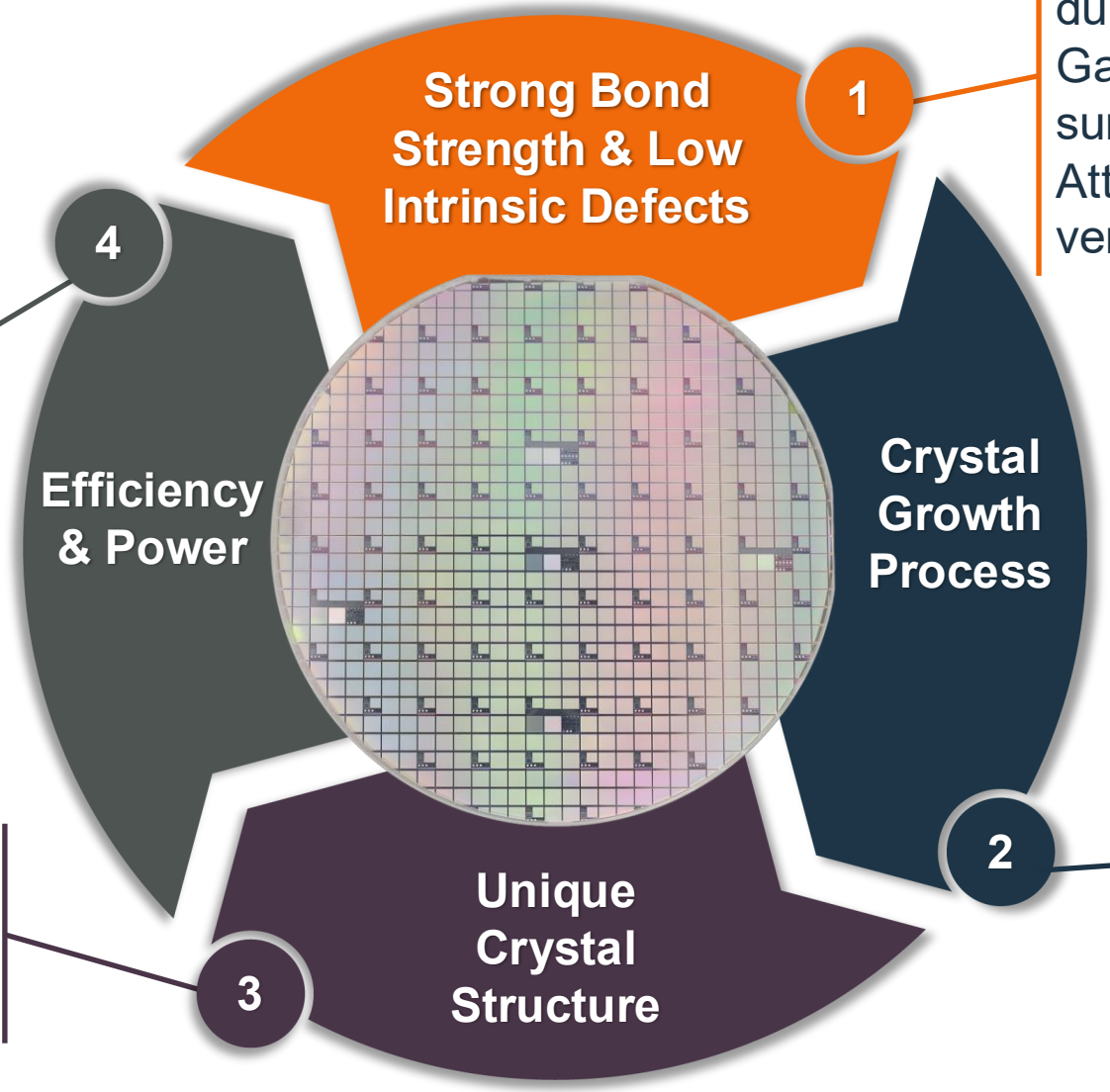
Manufacturing involves growing thick, defect-free GaN layers on bulk substrates, requiring precision epitaxy and novel fabrication methods

Innovation and Patent Portfolio

onsemi holds 130+ patents covering device architecture and processing, showcasing strong innovation and intellectual property protection

Did you know?

Doping in GaN must occur insitu during epitaxial growth. P-type GaN regrowth on patterned surfaces is especially challenging. Attempt to implant ions requires very high temperatures.



Vertical architecture enables power to flow straight through, shrinking power converters to paperback size.

pGaN and nGaN are grown by epitaxy. **onsemi** has mastered regrowing pGaN on patterned surfaces and has many patents for this technique.

Vertical GaN has hexagonal wurtzite structure, providing distinct electronic and optical properties.

The Science of GaN

Wurtzite – Hexagonal Power

Strong bond strength & low intrinsic defects

Doped vertical GaN crystals are grown and doped to provide performance and reliability and are responsible for the simplicity of its manufacturing.

This property sets it apart from silicon and silicon carbide, making it a strategic material for the future of high-efficiency electronics.

Hexagonal Power: Wurtzite Structure Boosts Performance

Vertical GaN's hexagonal wurtzite structure is fundamental to its superior performance, enabling unique electronic properties, higher voltage handling and miniaturization of power systems.

This crystal power and method to create pGaN and nGaN sets vertical GaN apart from traditional materials and is a key driver of its benefits in next-generation electronics.

Volcanic Precision: Vertical GaN Thrives in Extreme Heat

Vertical GaN is grown at very high temperatures leading to its stability and performance, enabling the next leap in energy-efficient and reliable power electronics.

Vertical GaN devices can handle over 1,200V. Devices with 3,300V rating have been demonstrated using this technology.

Strategic Edge: Vertical GaN's Impact on Defense & Security Systems

Vertical GaN's strategic value for defense and military lies in its critical technology status, its ability to deliver reliable performance in demanding environments and its role in enabling next-generation military systems.

Si, SiC and GaN Material Parameters

GaN shines in high frequency applications

Operating at high voltage operation with significantly higher frequencies and extremely low losses results in

- Increased efficiency
- Reduction in size of passive components at higher frequency
- Reduction in overall power conversion system size, weight and cost

Parameter		Si	SiC	GaN	GaN Strength
Bandgap	(eV)	1.1	3.2	**3.4**	**Higher Breakdown Voltage, Higher Temperature**
Electron Mobility	(cm^2/V.s)	1500	700	**2000**	**Higher Switching Frequency**
Peak Electron Velocity	10^7 cm/s	1	2	**2.5**	
Critical Electric Field	MV/cm	0.3	3.0	**3.3**	**Higher Breakdown Voltage**
BFOM[1]	W/cm^2	1	392[2]	**993[2]**	**Higher Switching Frequency, Higher Breakdown Voltage**

[1] Baliga Figure Of Merit = $\varepsilon\mu E_c^3$. Where ε = dielectric constant, μ = mobility, E_c = critical electric field.
[2] Normalized to Si

GaN-on-GaN Offers High Ruggedness

Vertical construction of GaN-on-GaN offers innate robustness based on its homoepitaxial structure, compared to lateral devices such as GaN-on-Si / GaN-on-SiC

Attribute		GaN-on-Si	GaN-on-SiC	GaN-on-GaN	Impact
Defect Density	(cm^{-2})	10^9	5 x 10^8	**10^3 to 10^5**	**Better Yields, Higher Reliability**
Lattice Mismatch	(%)	17	3.5	**0**	**Elimination High stress in Epitaxy causing Dislocations → Better Reliability**
CTE Mismatch	%	54	25	**0**	**No Wafer deformations (cracking, warping)**
Layer Thickness	µm	1-2	2-6	**>40**	**Higher BV → Higher voltage applications**

Vertical GaN: Simple GaN-on-GaN 3D Structure

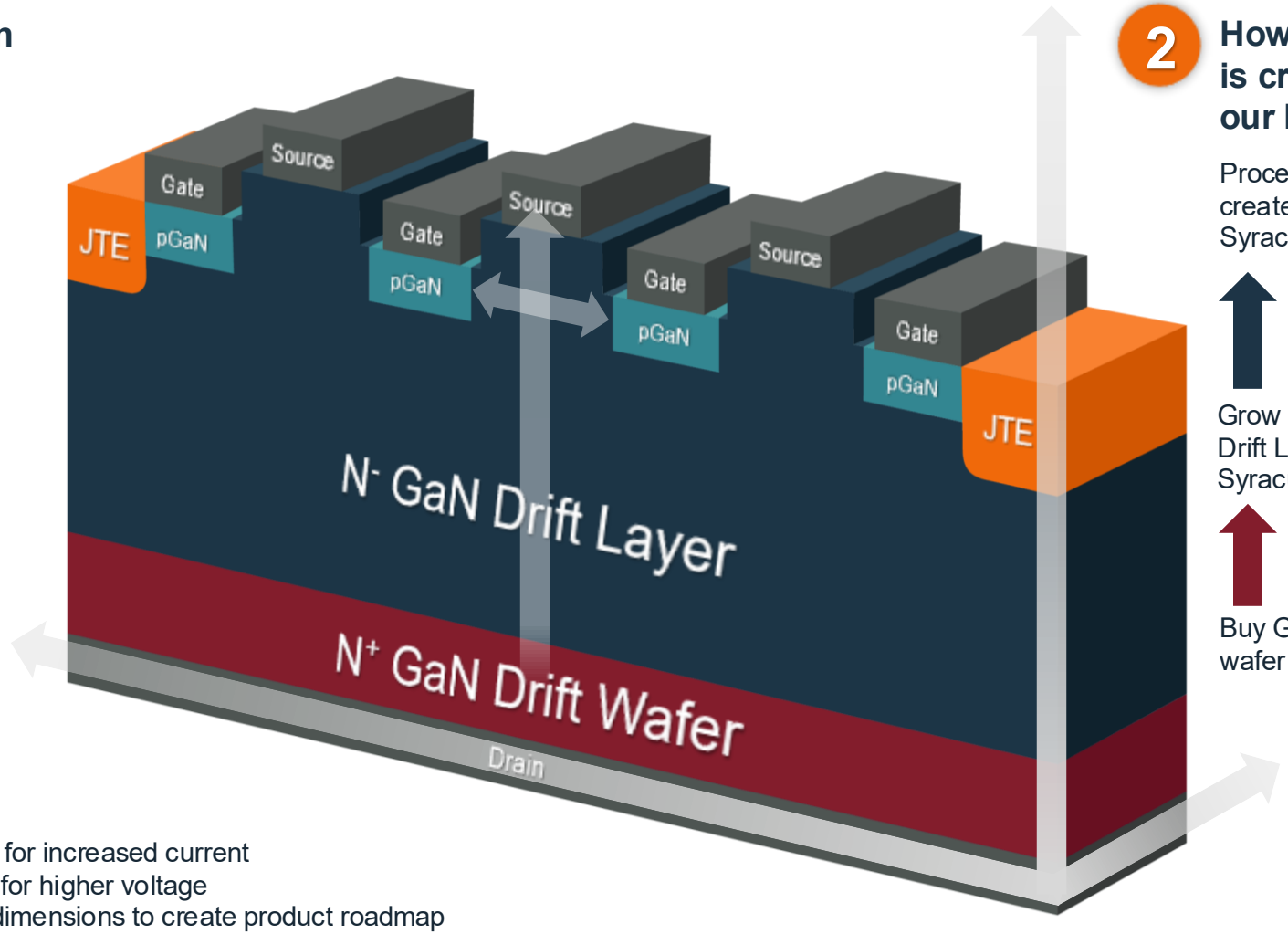
1 Basic Function of a Switch

Gate action causes switching

OFF
Gate *closed*
no current

ON
Gate *open*
current flow

Current flows from **Drain** to **Source**



2 How the FET is created in our Fab

Processing steps to create FET in Syracuse Fab

Grow GaN Drift Layer in Syracuse Fab

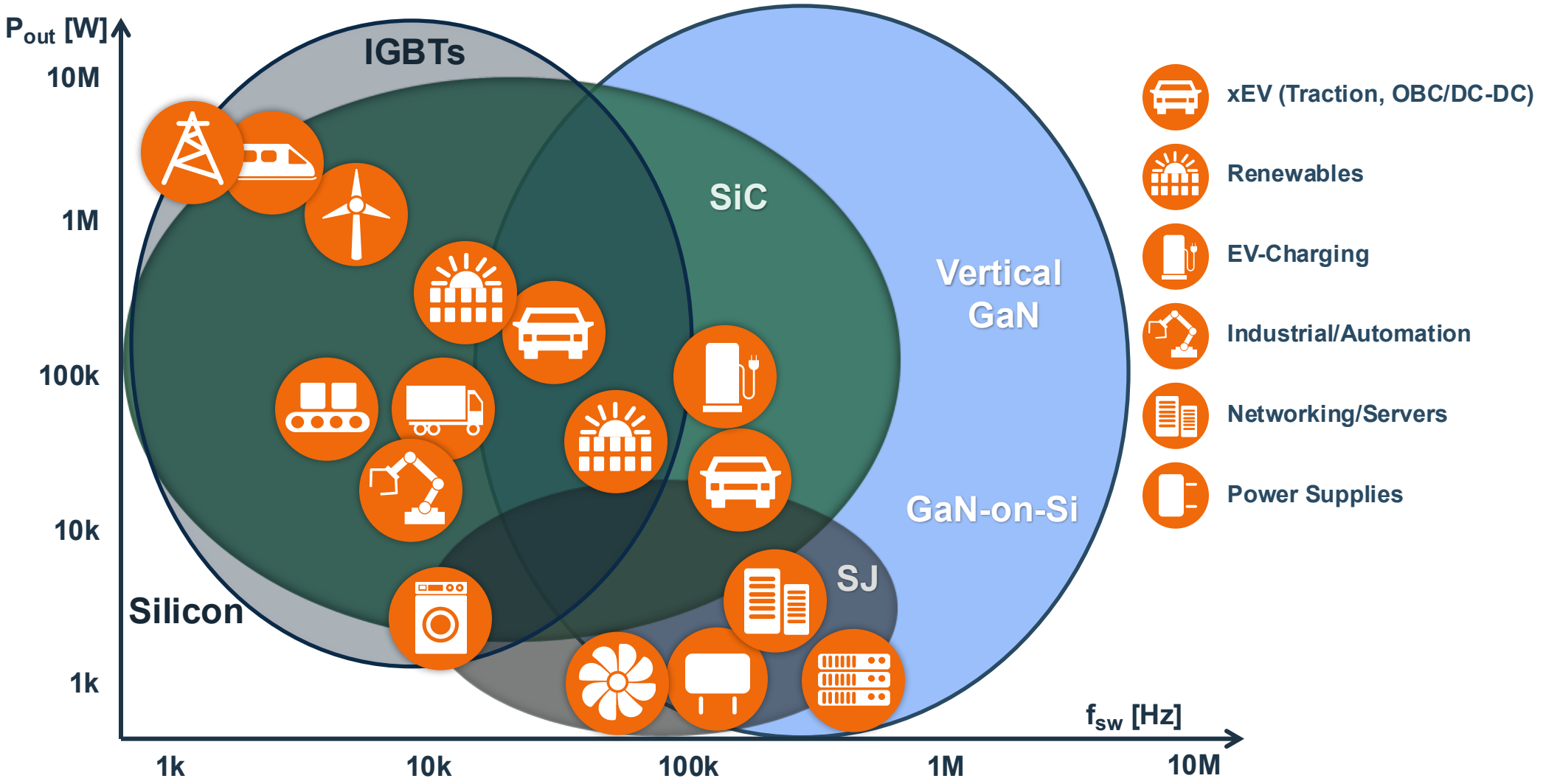
Buy GaN wafer

3 3D Roadmap

- Increased area for increased current
- Thicker growth for higher voltage
- Uses all three dimensions to create product roadmap

- Vertical GaN-on-GaN e-JFET provides a scalable, high conductivity power switch
- JFET channel utilizes high bulk GaN mobility to achieve a low overall $R_{DS(ON)}$
- Device structure enables robust edge termination for full avalanche capability

Power Switching Technologies for Various Applications



onsemi's Vertical GaN technology is not just a technical breakthrough, it is a strategic asset for companies and nations seeking to lead in energy efficiency, electrification and advanced manufacturing.

Energy Demands

Meets rising needs from AI and EV markets with efficient, high-performance power electronics

Performance & Efficiency

Smaller, lighter and more efficient than traditional solutions; enables advanced product designs

Industry Investment

Competitive advantage and future-proofing for energy-efficient electronics

National Security

Recognized as key technology by US DoD; supports industrial and defense progress

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