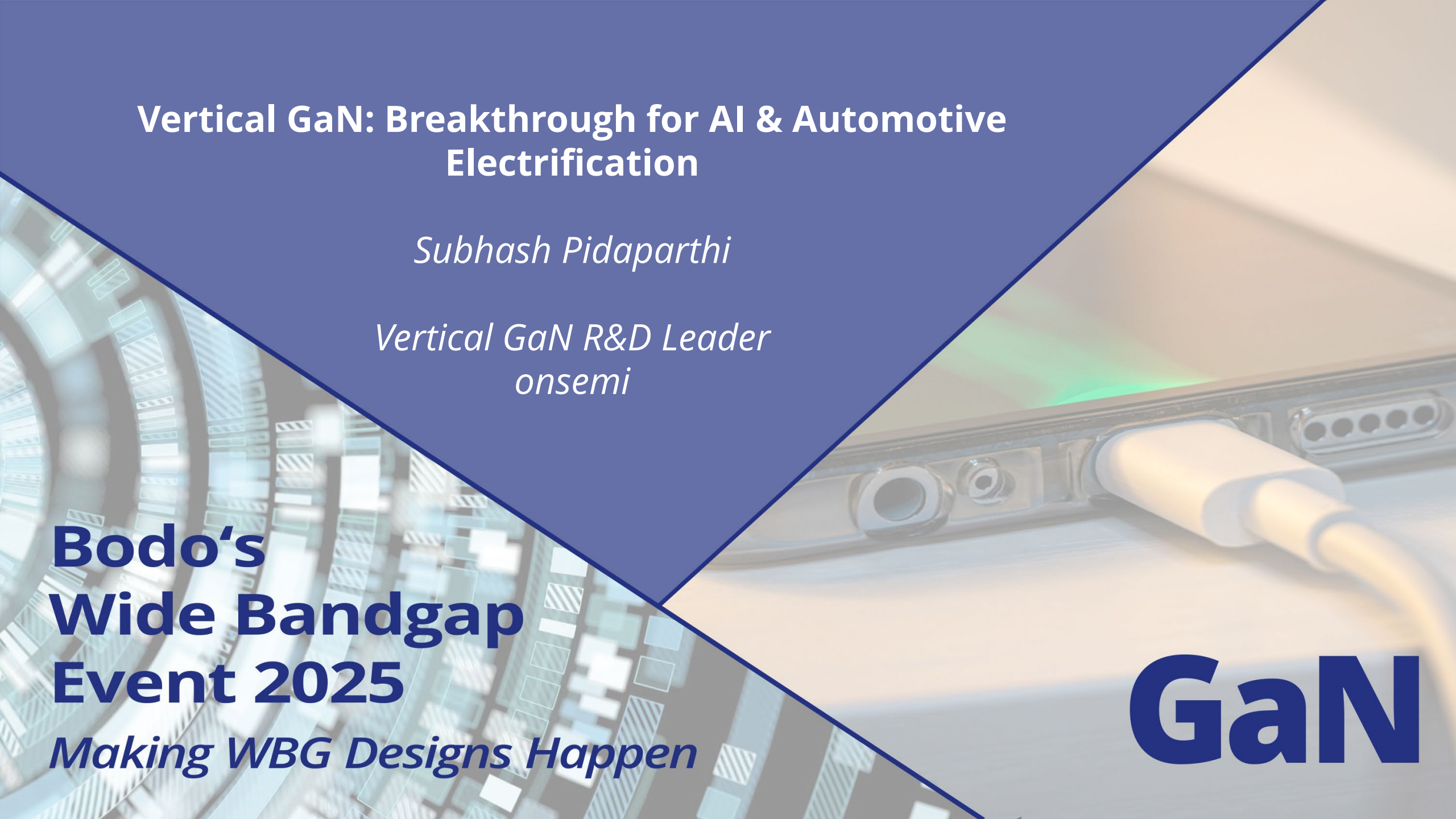
Vertical GaN: Breakthrough for AI & Automotive Electrification

Subhash Pidaparthi

Vertical GaN R&D Leader
onsemi



Bodo's Wide Bandgap Event 2025

Making WBG Designs Happen

GaN

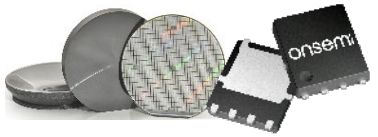
Vertical GaN: Breakthrough for AI & Automotive Electrification

Subhash Pidaparthi

GaN Business Unit

December 3rd, 2025

onsemi enters the GaN market!

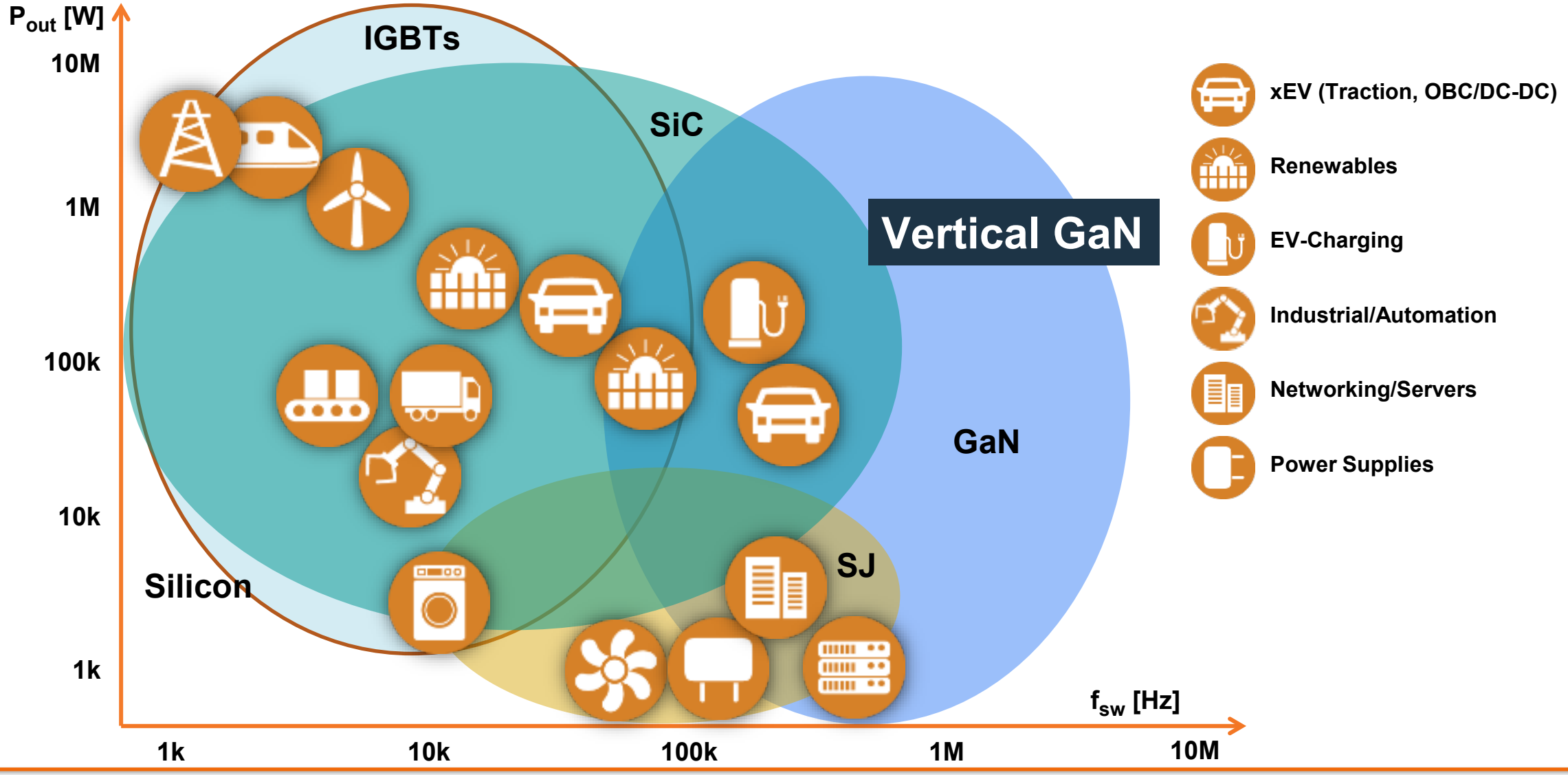


- onsemi is offering **ALL key power electronics technologies**: Si, SiC & GaN
- For UHV (>1200V) applications **onsemi innovates with Vertical GaN device**
- Acquired in 2024 from **NexGen Power Systems, Vertical GaN IP** is being integrated into **onsemi** manufacturing operations:
  - Proven & resilient supply chain
  - Quality & reliability
  - Manufacturing to scale

Process running in onsemi Fab (Syracuse, USA)

Sampling to Key Partners. Expanding in H2'26!

Power Switching Technologies for Various Applications



vGaN Architecture – Compact and Robust Device

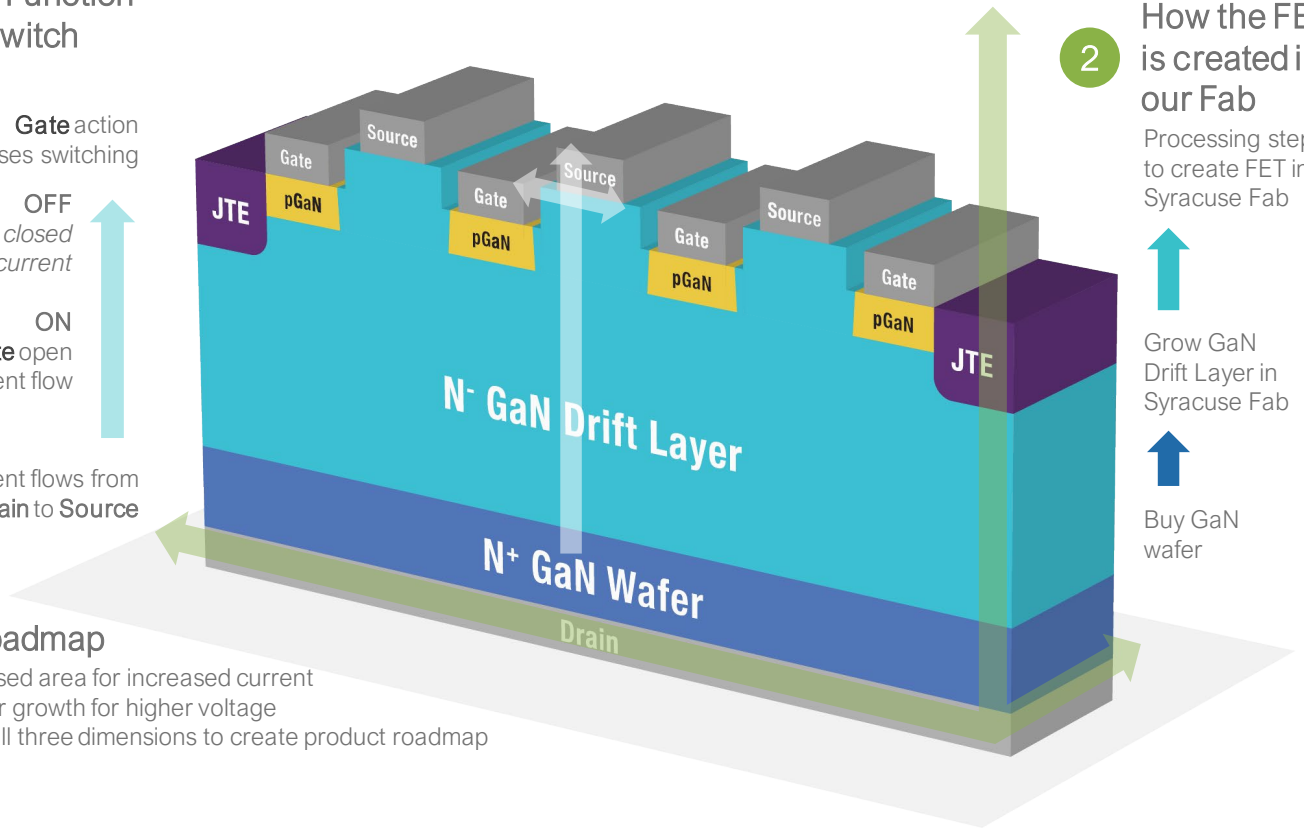
1 Basic Function of a Switch

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

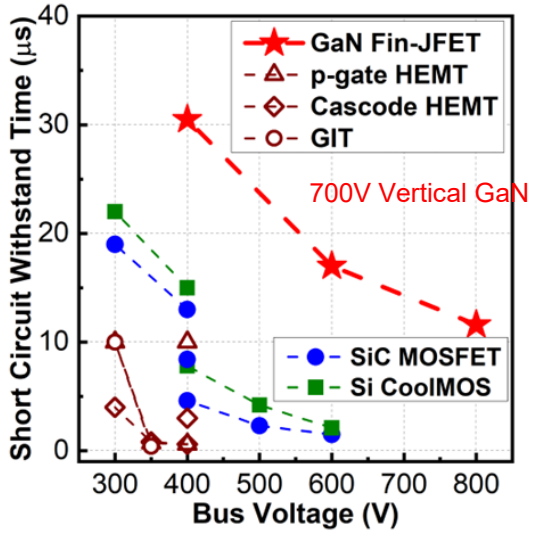
3 3D Roadmap

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

- Vertical GaN-on-GaN provides a scalable, high conductivity, Normally-OFF power switch
- Channel utilizes high bulk GaN mobility to achieve ultra low $R_{DS,ON}$ with no dynamic variation
- Device structure enables robust edge termination for full avalanche capability

vGaN Performance – Setting new benchmark

Best-in-class Short-Circuit Ruggedness



V_{BUS}=800V

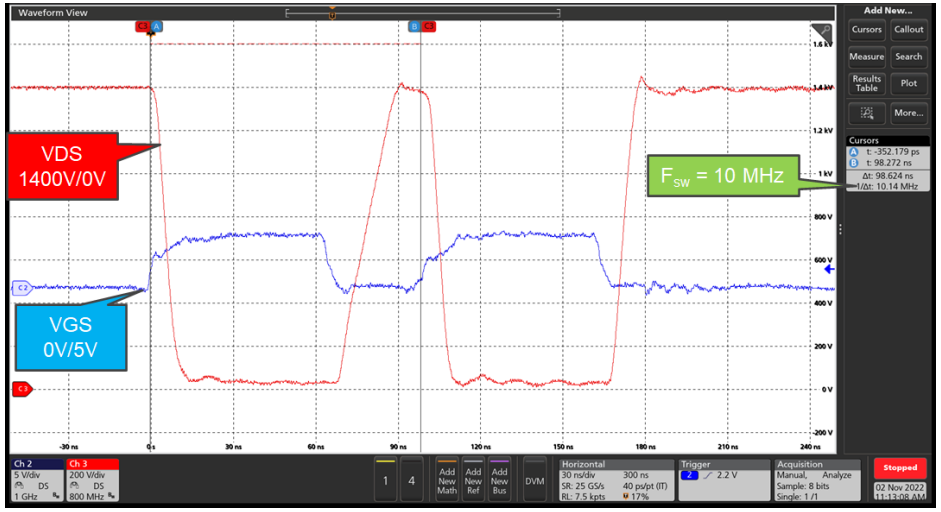
- 700V FET SCWT=10µs
- 1200V FET SCWT > 40µs

V_{BUS}=400V

- 700V FET SCWT=30µs
- 700V FET no degradation after 30K cycles

"Breakthrough Short Circuit Robustness Demonstrated in Vertical GaN Fin JFET" published in IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 37, NO. 6, JUNE 2022

Fast Switching: 1.4kV at 10 MHz



Edwards, Andrew, et al. "Switching of a Bus Voltage of 1400 V at 10 MHz Using Vertical GaN Fin-JFETs." *2023 35th International Symposium on Power Semiconductor Devices and ICs (ISPSD)*. IEEE, 2023.

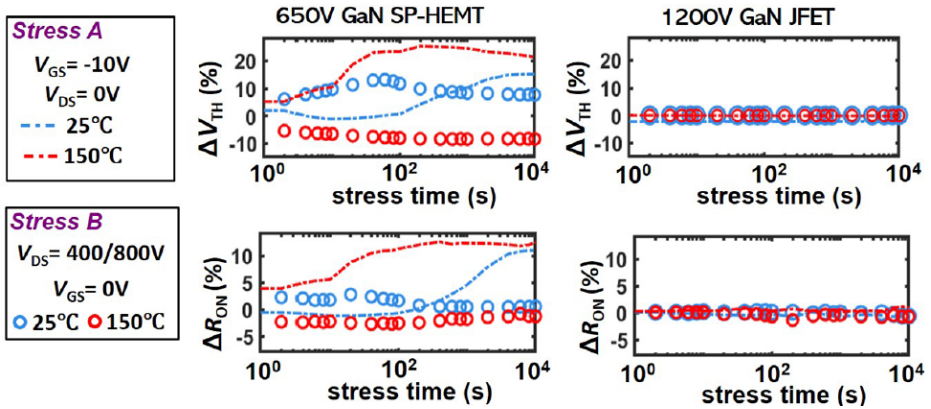
Repetitive Avalanche

Device	Voltage Rating (kV)	E_{AVA} (J/cm^2)	Repetitive Avalanche E_{AVA}%[a]	Period	Cycle survived	Failure signature
GaN Fin JFET	**0.65**	**10.0**	**70%**	**3 s**	**>3700***	**FTO**
Si CoolMOS	0.6-0.9	1.3 [22]	62% [8]	3 s	10000	FTS
SiC JFET[b]	1.2	18 [10]	90% [10]	4 s	1000	FTS
SiC MOSFET	1.2	7.5[c] [4]	<77%[d] [6]	0.5 s	80000	FTS

FTO = Failure to open. The device maintains blocking voltage after failure.
FTS = Failure to short.
* >1M cycles at 20% of E_{AVA}

Zhang, Ruizhe, et al. "Robust through-fin avalanche in vertical GaN Fin-JFET with soft failure mode." *IEEE Electron Device Letters* 43.3 (2022): 366-369.

No Dynamic $R_{DS,ON}$ Variation with V_T Stability



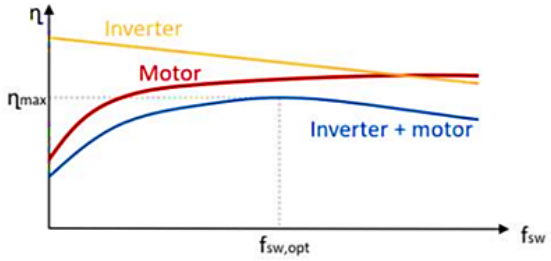
Yang, Xin, et al. "Dynamic R_{ON} Free 1.2-kV Vertical GaN JFET." *IEEE Transactions on Electron Devices* (2023).

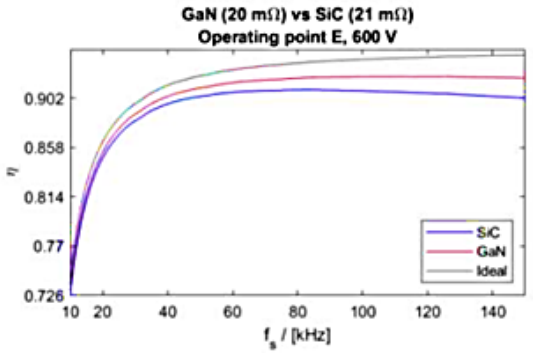
Application – Next level of power density and performance

EV Traction: next-level of System Efficiency

800V

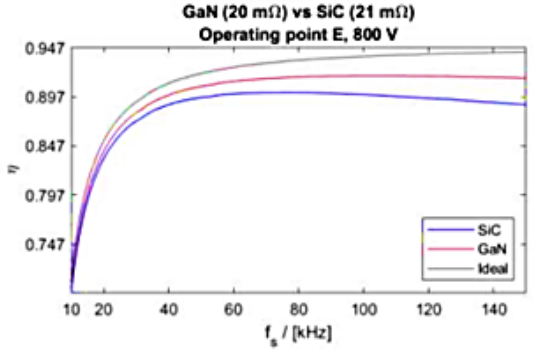
- Optimal Inverter Switching Frequency improves E-drive Efficiency
- With lowest switching losses, vGaN improves System Efficiency by ~2%





Operatin point: (0.6x560Hz, 0.5x63Nm)
I ≈ 160A

Optimal sw. point:
SiC: 81kHz, 90.94%
GaN: 126kHz, 92.14%



Operatin point: (0.6x560Hz, 0.5x63Nm)
I ≈ 160A

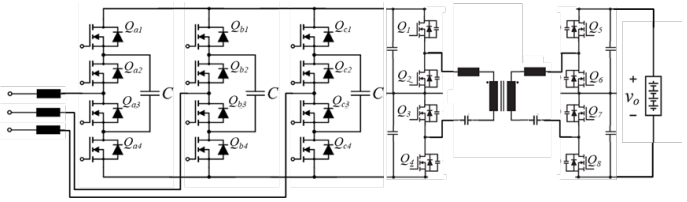
Optimal sw. point:
SiC: 77kHz, 90.13%
GaN: 105kHz, 91.83%

Efficiency Improvement of Induction Machine Powertrain by High Switching Frequency and Wide Bandgap Semiconductors
IEEE PEDS 2023, Montreal, Canada , 7 – 10 August 2023

AI Server: power density ↑, complexity ↓

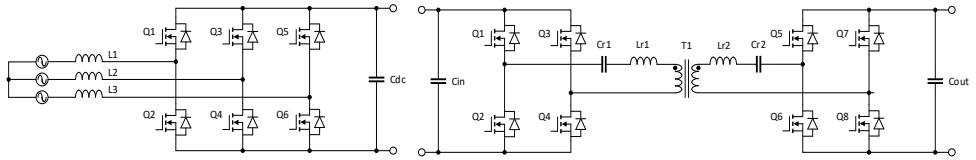
- Vertical power delivery → Highest power density and best system-level thermal management
- BOM reduction and simpler control vs 3-level or stacked topologies

Multilevel converter with 650V GaN



⊕ Higher* power density
⊕ Smaller* magnetics and capacitors
⊖ Complex

3 phase B6/2L with 1200V vGaN



⊕ **Highest** power density and Efficiency
⊕ **Simplest**

* vs. B6/2L 1200V SiC

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