

Accelerating WBG Power Semiconductor Technology Commercialization

A promotional banner for a workshop. The background is a collage of images related to energy and technology, including a circuit board, a wind turbine, a globe, a hand holding a glowing orb, and a satellite. The text is white on a dark blue background.

**Power Electronics &
Energy Conversion
Workshop**
July 30th & 31st
8:00AM MT - 4:00PM MT
Location: Albuquerque, New Mexico
Venue: State Bar of New Mexico
Hosted By: Sandia National Laboratories



Sandia
National
Laboratories

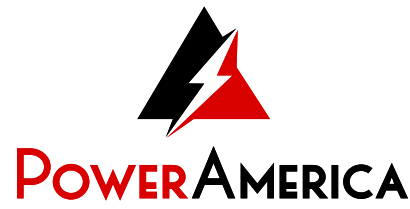
Victor Veliadis, Ph.D.

Executive Director & CTO, PowerAmerica

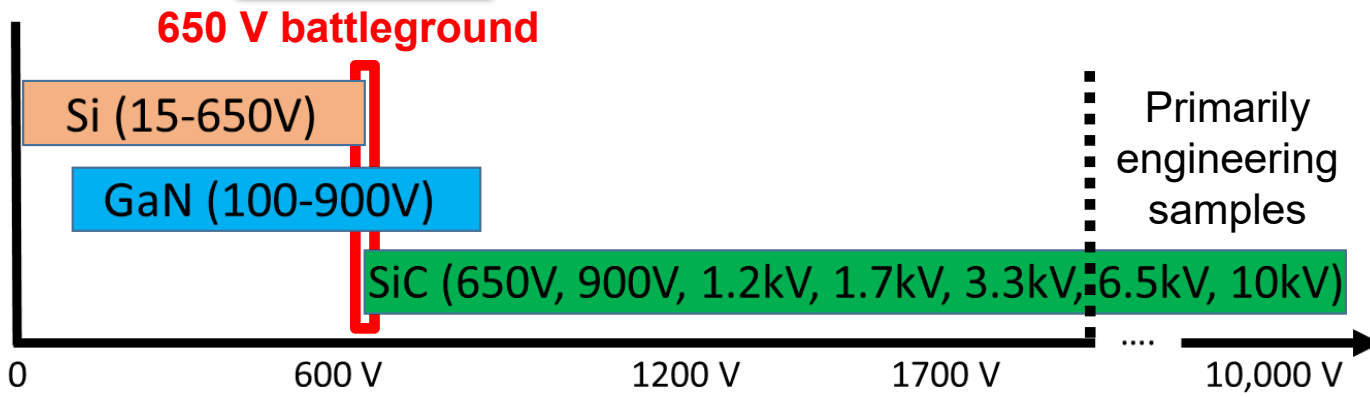
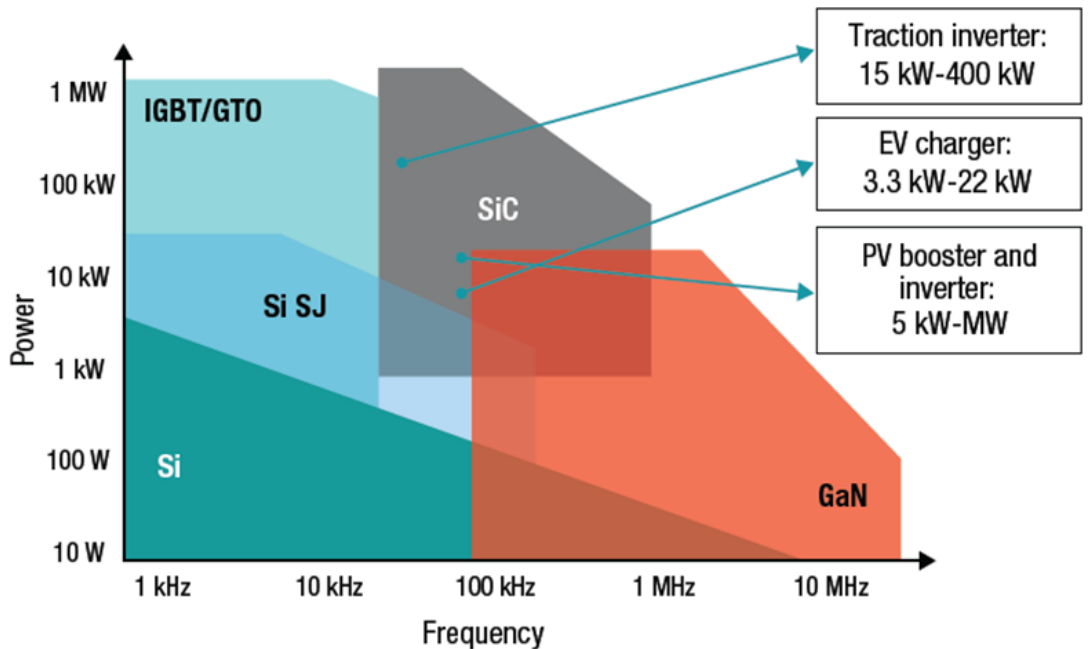
Professor in ECE, North Carolina State University



Si/SiC/GaN Power Device Selection is Driven by Voltage, Current, Power Density (Frequency), Efficiency, Temperature, and Cost



Source: Texas Instruments



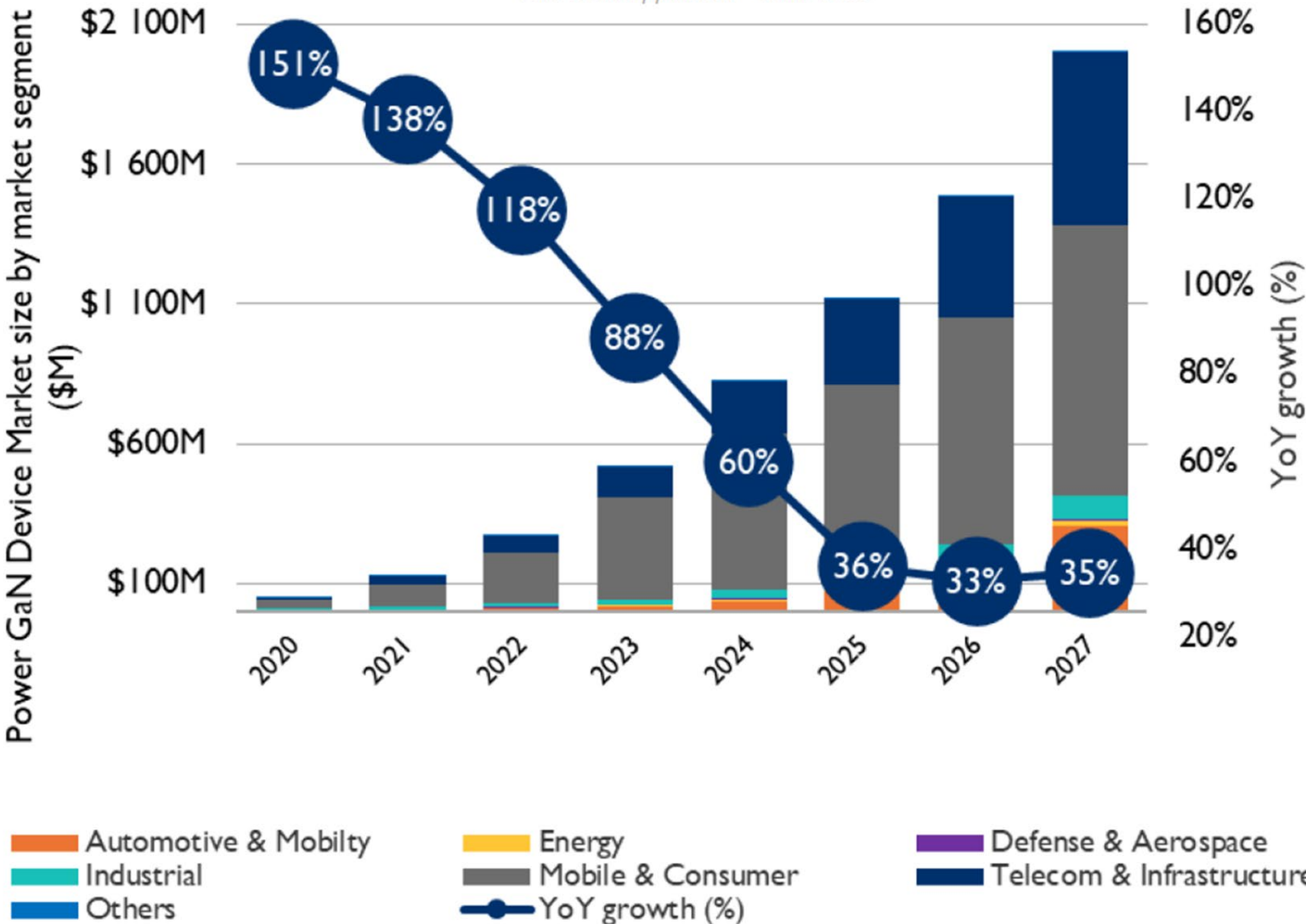
Si, GaN, and SiC all compete in the lucrative 650 V range:

- *Si* is reliable, rugged, cheap, capable of high currents, and has device/circuit design legacy
- *SiC* is efficient and operates at high currents and frequency
- *GaN* offers efficient very high frequency operation at reasonable cost

The GaN Power Device Market is Dominated by Consumer Applications and is Projected to Reach \$2B by 2027



Yole Développement – June 2022



The GaN market is dominated by consumer applications, with devices in mobile phones and laptop fast chargers.

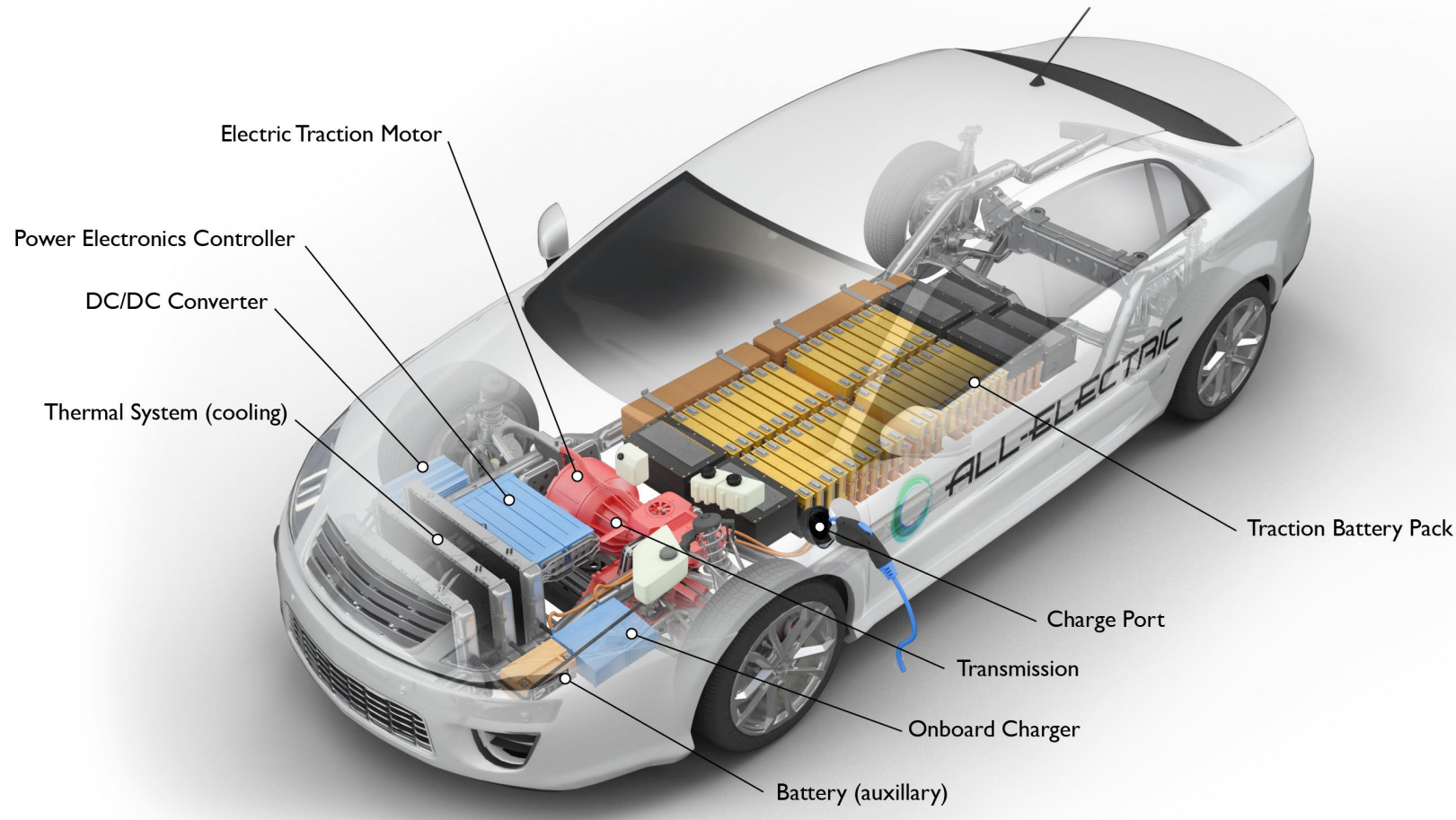


Vehicle Electrification is the Mass Commercialization Opportunity for SiC Power Electronics (and GaN)



POWER AMERICA

All-Electric Vehicle



EV Power Electronics

Traction inverter and motor: Uses power from the traction battery pack to drive the vehicle's wheels

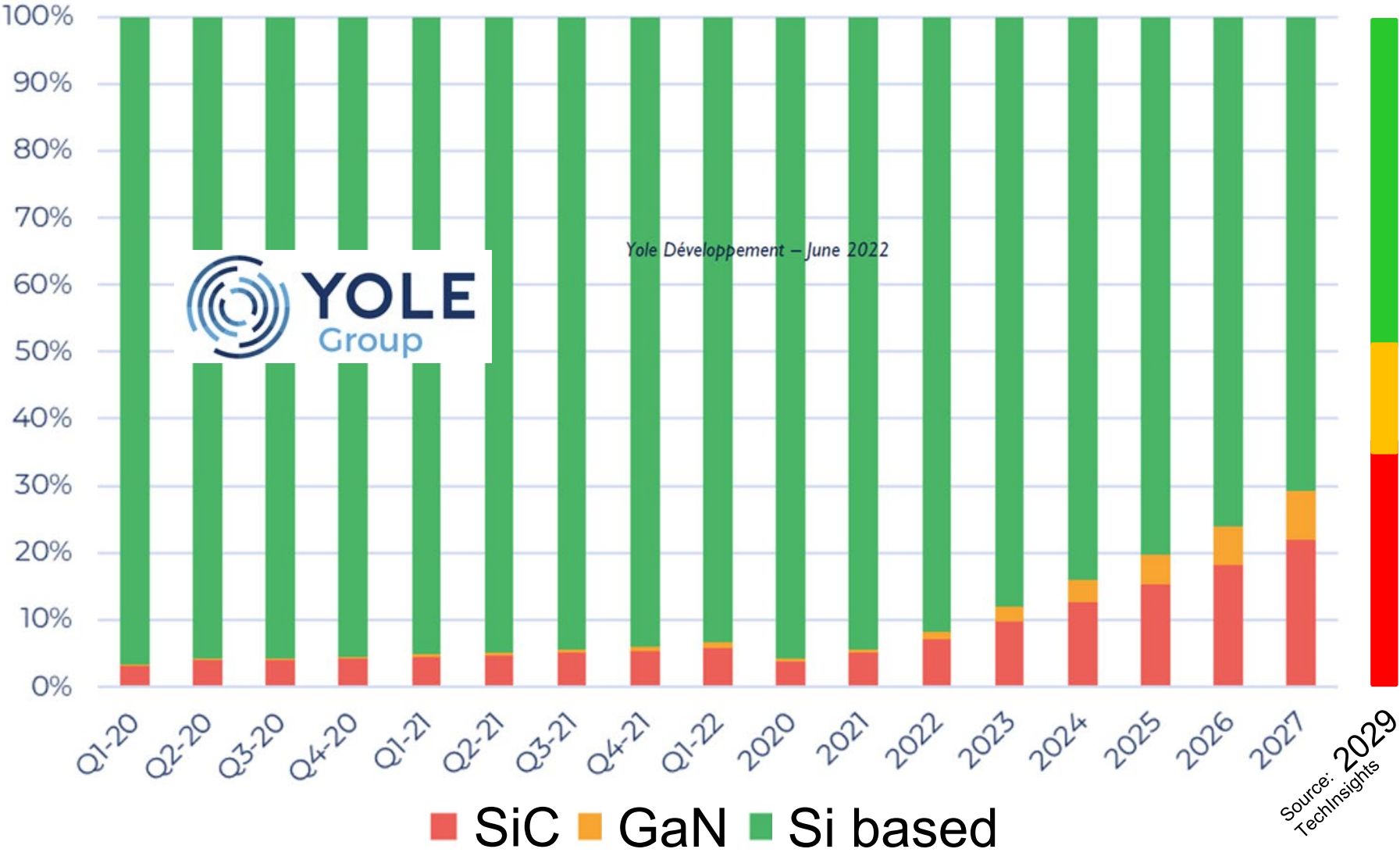
DC/DC converter: This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.

Onboard charger: Takes the incoming AC electricity supplied via the charge port and converts it to DC power for charging the traction battery.

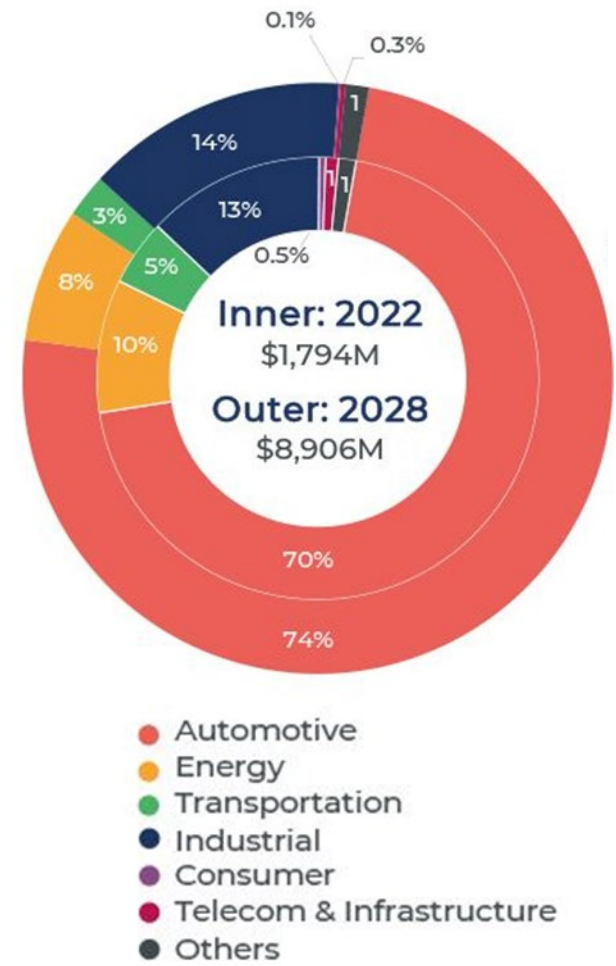
PTC Heater Module: The positive temperature coefficient (PTC) heater is a self-regulated heating device that uses electricity to supply efficient heat control for various vehicle systems, including in-vehicle air conditioning and battery thermal management.

<https://afdc.energy.gov/vehicles/how-do-all-electric-cars-work>

The SiC Power Device Market is Projected to Reach US\$8.9B in 2028, with 70% of that Attributed to Automotive



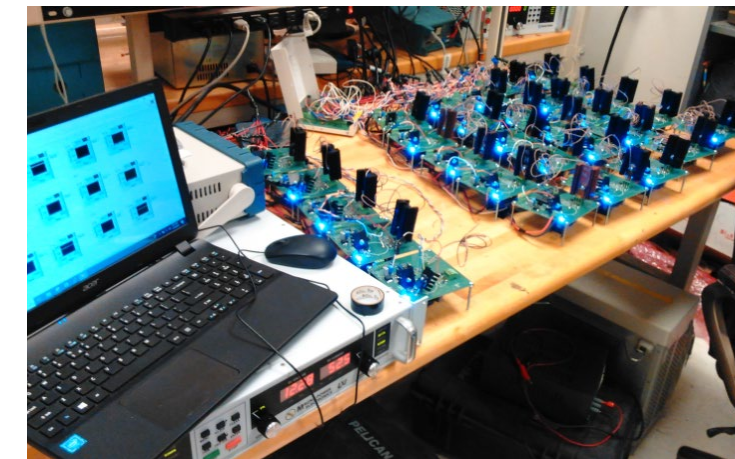
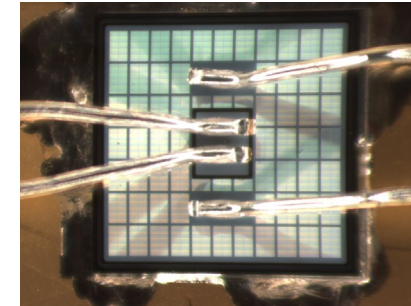
Silicon devices include: Rectifiers, Thyristors, bipolar, X-FETs such as MOSFETs and JFETs, IGBTs, and modules/IPMs.



Mass Commercialization Brings Economies of Scale to WBG

Barriers to mass commercialization:

- High device cost
- Defects and scalability of device area
- Reliability/Ruggedness concerns
- Need for workforce training





96 MEMBERS

PowerAmerica is a member-driven consortium of industry, universities, and national labs, accelerating the commercialization of energy-efficient SiC and GaN power semiconductor chips and power electronics. Our membership spans the WBG technology ecosystem, including the leading universities that train the workforce. PowerAmerica catalyzes semiconductor manufacturing job creation and is a critical enabler of the “electrification of everything” which is vital in the push for decarbonization and energy sustainability.

ACADEMIC INSTITUTIONS



GOVERNMENT LABS



MATERIALS, EQUIPMENT, FAB, MODULES



WIDE BANDGAP SYSTEMS



PARTNERS





PowerAmerica's **\$156M** Investment in **212** Power SiC and GaN Projects Addressed All Major Technology Areas

PowerAmerica's \$150M in power SiC and GaN projects address design, fabrication, testing, modules, reliability, ruggedness, and all major applications including automotive and rail traction, on-board chargers, photovoltaic, consumer electronics, aerospace, flexible alternative current transmission systems (FACTS), high-voltage DC systems (HVDC), microgrids, energy storage, wind power, motor drives, UPS, and data centers.

Execution of these seed projects demonstrates SiC and GaN competitive system advantages. The outcomes are industry investment in these technologies that creates high-tech manufacturing jobs and energy savings (reductions in CO₂ emissions); both crucial to U.S. economy and national security.

PowerAmerica \$145M investment	2016	2017	2018	2019	2020	Total
Industry Projects	14	14	16	15	14	73
Academic Projects	18	25	19	24	26	112
National Lab Projects	2	2	2	2	3	11
Yearly projects	34	41	37	41	43	196
Industry Projects 2016-2020						73
Academic Projects 2016-2020						112

The 196 Project Areas:

- 67** SiC Device and Fabrication
- 28** Modules and Reliability
- 24** Low-Voltage GaN Applications
- 40** Low-Voltage SiC Applications
- 21** Medium-Voltage SiC Applications
- 20** Education and Workforce training

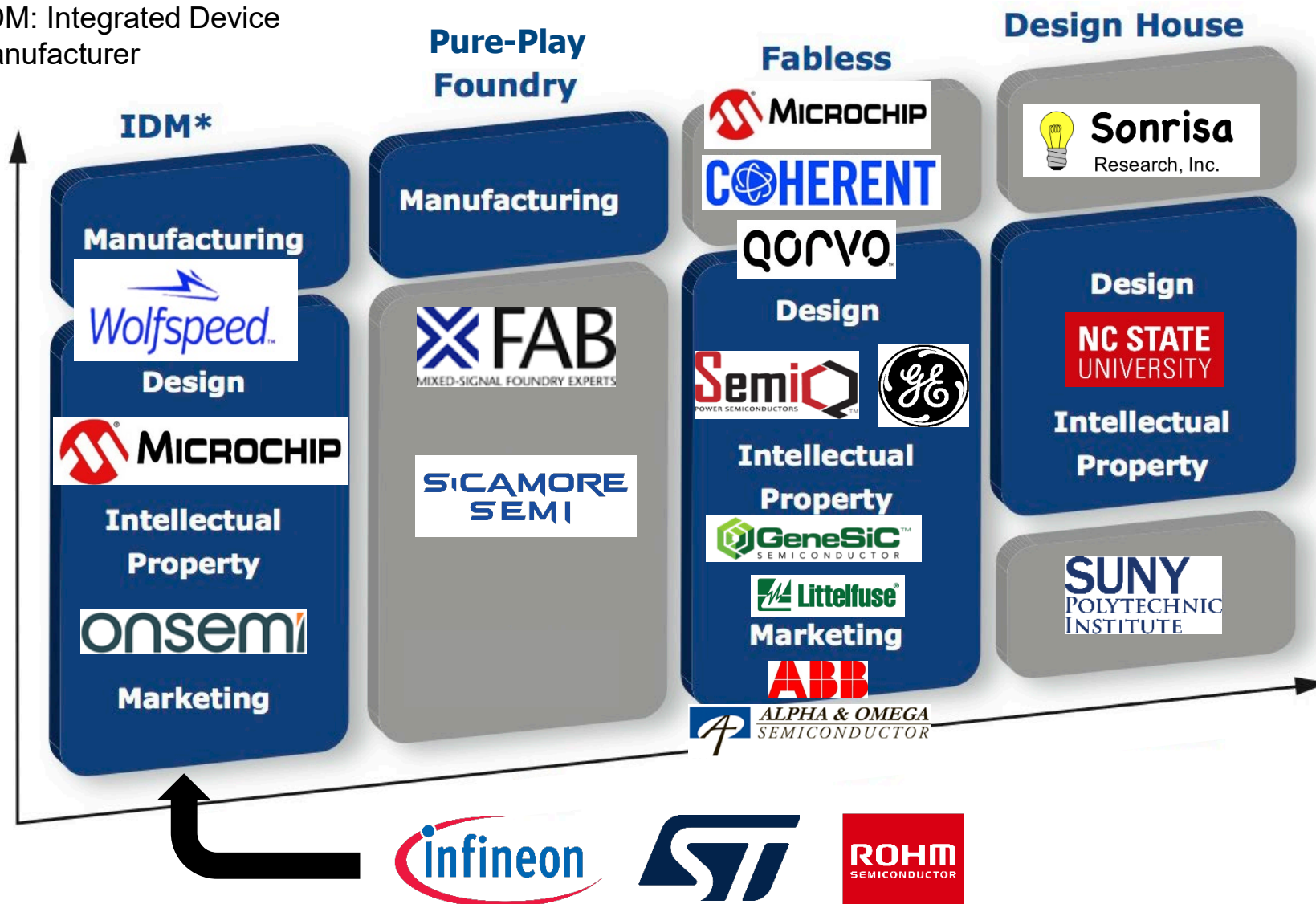
16 additional projects since 2021

The U.S. Mature SiC Fab Infrastructure Mirrors that of Si



POWERAMERICA

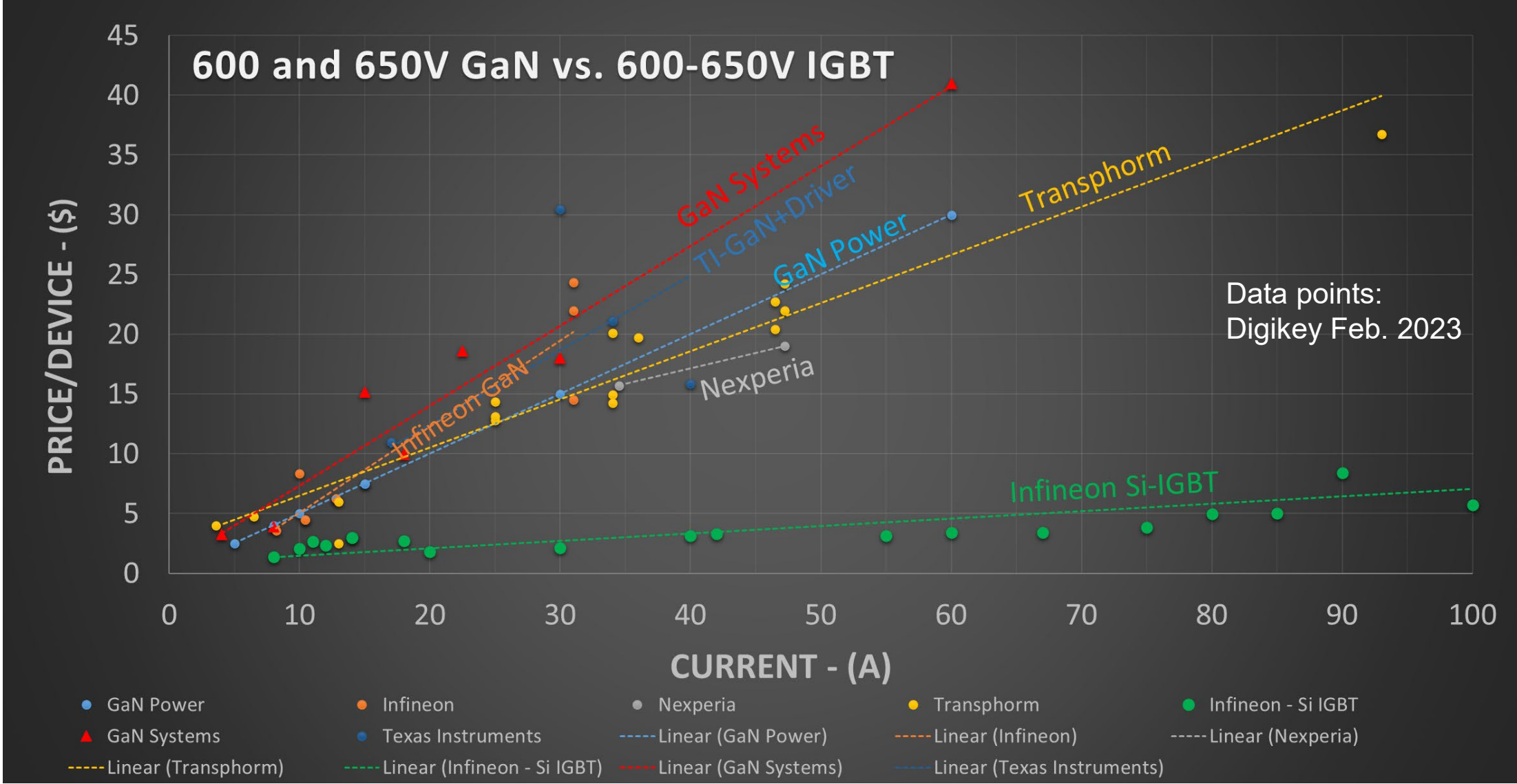
*IDM: Integrated Device Manufacturer



SiC Fab particulars:

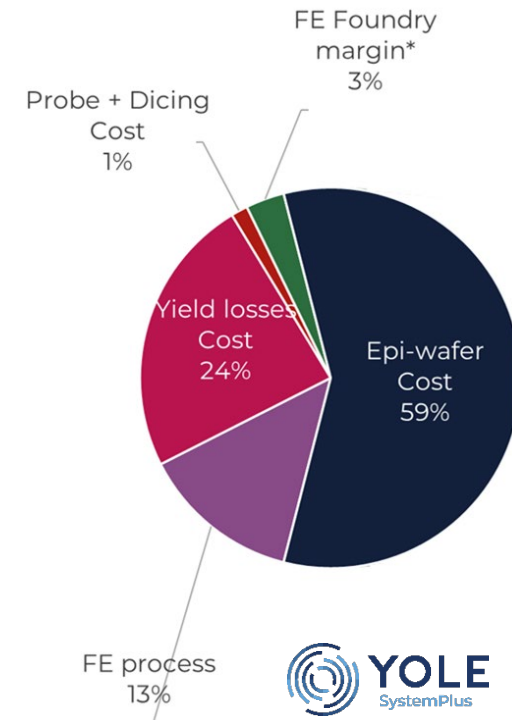
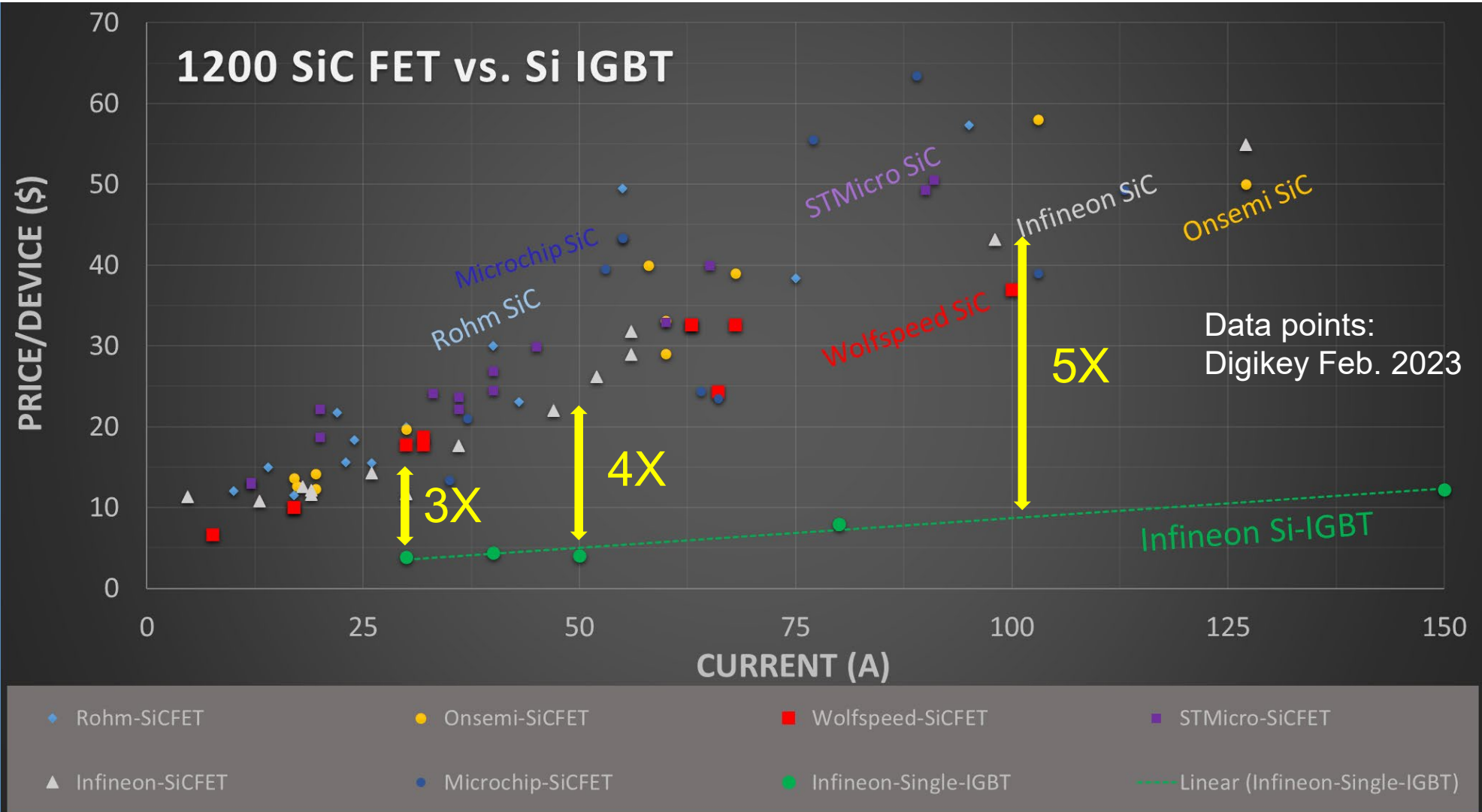
- Compete on process in addition to design
- Wafer quality and supply chain concerns

650 V GaN HEMTs Are More Expensive Than Similarly Rated Si Devices with Cost Disproportionally Increasing with Device Area





1200 V SiC MOSFETs Are More Expensive Than Similarly Rated Si Devices with Cost Disproportionally Increasing with Device Area



The wafer (substrate and epitaxy) is **59%** of total 1200 V MOSFET cost

SiC MOSFETs Enable System Mass and Volume Reductions to Achieve Overall Cost Advantage



PV Reduction of system cost and size with SiC

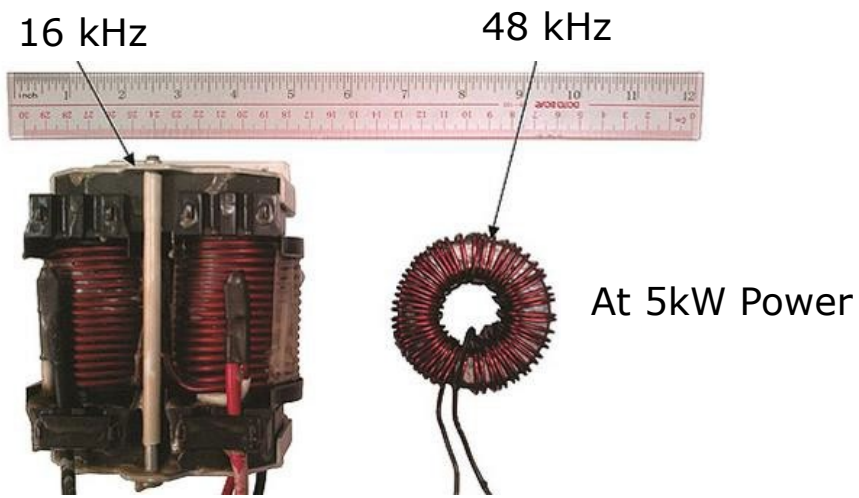
- > 10-15% lower BOM
- > 2-3x higher semiconductor costs

Total system cost [US\$]

Component	Si-based solution	SiC-based solution
semi-conductor	Low	High
other (e.g. magnetics, housing, etc)	High	Low

Graphics courtesy: Dr. Levett, Infineon

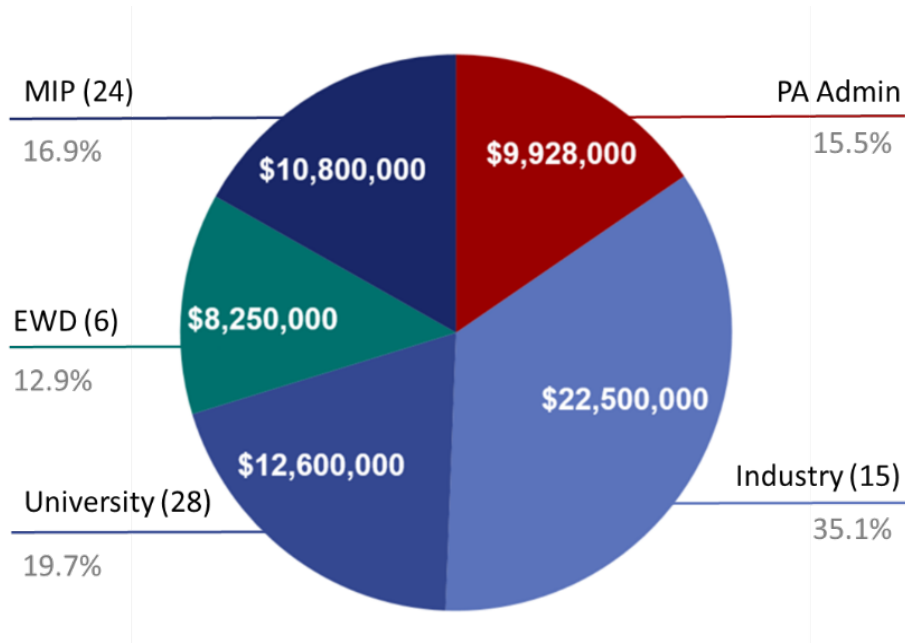
Lower system losses provide energy savings throughout the life of the system



Price parity can be achieved at the system level due to reduced mass/volume of magnetics, and simplified thermal management.

12 For Mass Commercialization: cost savings at the system level must outweigh the higher cost of manufacturing SiC devices.

U.S. Department of Energy \$64M PowerAmerica Renewal Will Fund 67 Projects Across the WBG Supply Chain



Proposed Budget Allocation

Proposed \$64M allocation:

- \$10M to Operating Expenses and Outreach
- \$23M to 52 University projects
- \$23M to 15 Industry projects
- \$8M to Education and Workforce Training

Objective: Accelerate innovation in SiC materials, chip design, fab equipment and processes, advanced modules, passive circuit components and thermal management, **and** key applications including grid modernization, data centers, motor drives, transportation electrification, renewables, and energy transmission and storage.

A banner for a workshop featuring a collage of images related to energy and technology, including solar panels, wind turbines, a globe, and a hand holding a glowing orb. The text is overlaid on a dark blue background.

**Power Electronics &
Energy Conversion
Workshop**
July 30th & 31st
8:00AM MT - 4:00PM MT
Location: Albuquerque, New Mexico
Venue: State Bar of New Mexico
Hosted By: Sandia National Laboratories



Sandia
National
Laboratories

Thanks for your attention!

Questions?