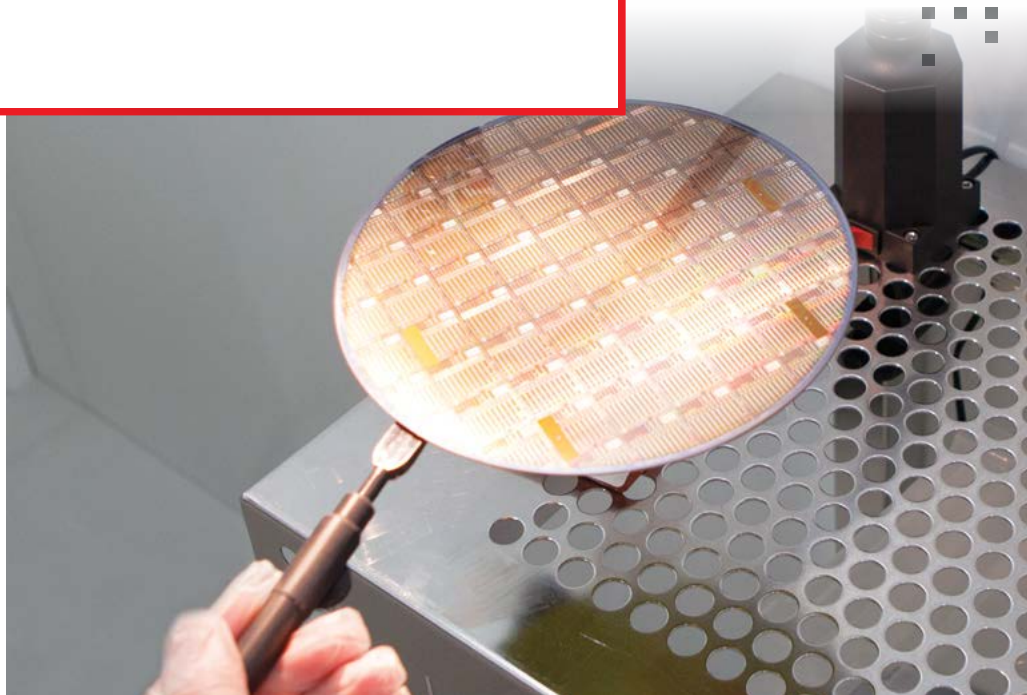
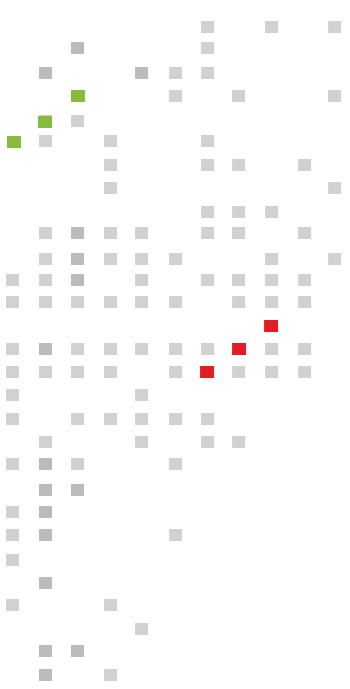


GaN POWER

Energy-efficient Power Electronics
using Gallium Nitride Transistors





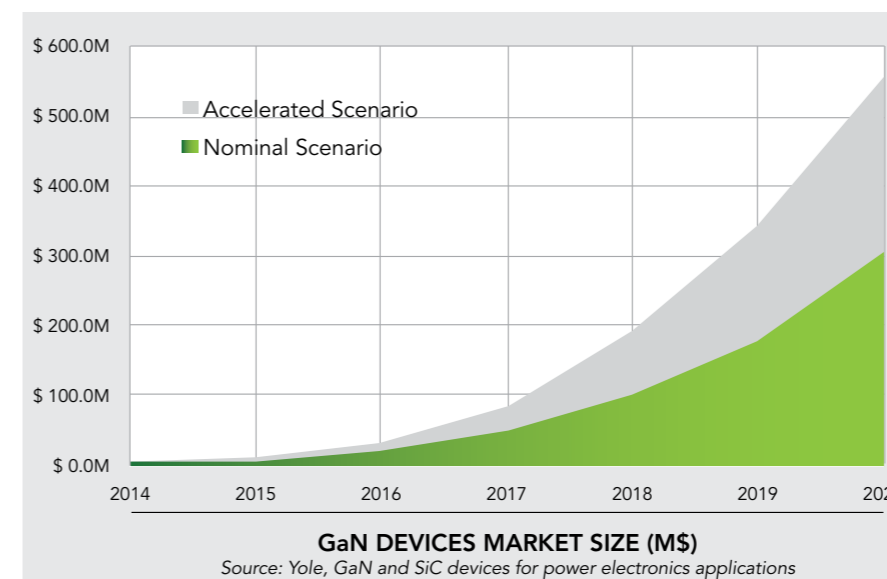
Leti GaN Devices for Next-Era Power Electronics

Leti, a technology research institute within CEA Tech, has been developing GaN/Si technology since 2007. Its GaN-on-silicon material is a cornerstone of device performance and cost.

CEA produces chips comprising epitaxial GaN on 200mm silicon wafers to deliver state-of-the-art electrical performance from 2015 onwards.

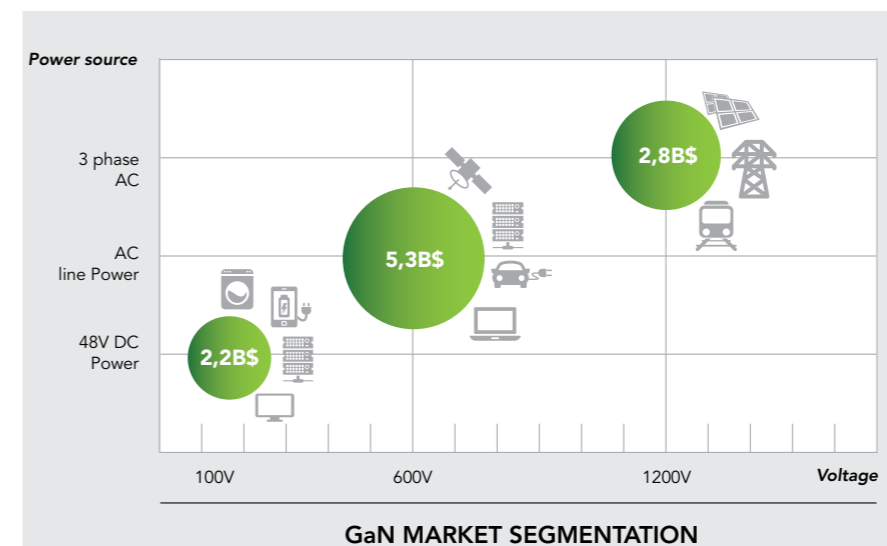
Leti is cooperating with multiple industrial end-users to develop new integrated systems containing GaN. These systems are mainly used in EV. GaN/Si-based devices are perfectly suited to DC-DC converters, in which they improve power density to give more compact components. This effectively increases final system efficiency.

A GROWTH MARKET



The GaN device market for power electronics applications exploded in 2016 and will reach US\$303 million in 2020 according to Yole Développement (GaN and SiC devices for Power Electronics Applications, July 2015). Growth is accelerating in 2017 and is forecast to reach 1.8 times its nominal scenario size by 2020.

LARGE RANGE OF APPLICATIONS



Today's GaN device market is mainly dominated by devices smaller than 200V. 600V devices are expected to take off and sustain their growth. SiC and GaN are used for high- and medium-voltage applications respectively. The 600-900V range represents the commercial battleground.

WHY GaN?

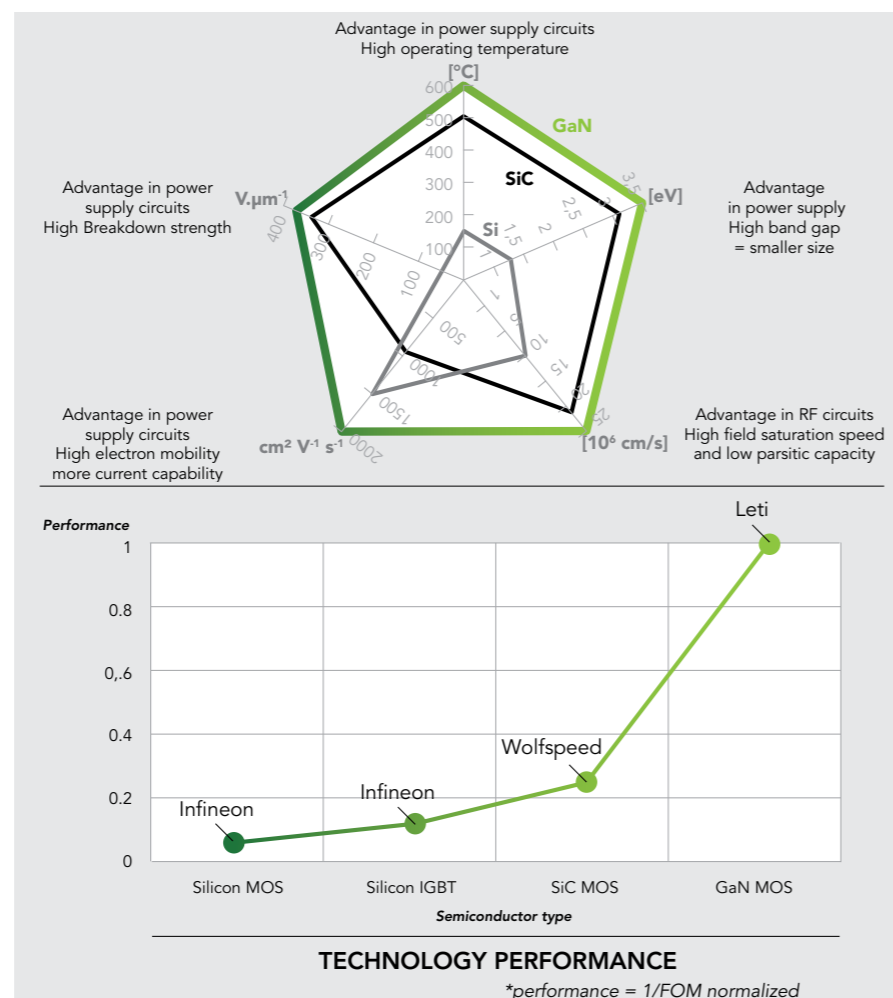
ITS PERFORMANCE WILL IMPROVE CONVERTER POWER DENSITY CHEAPLY

PERFORMANCE

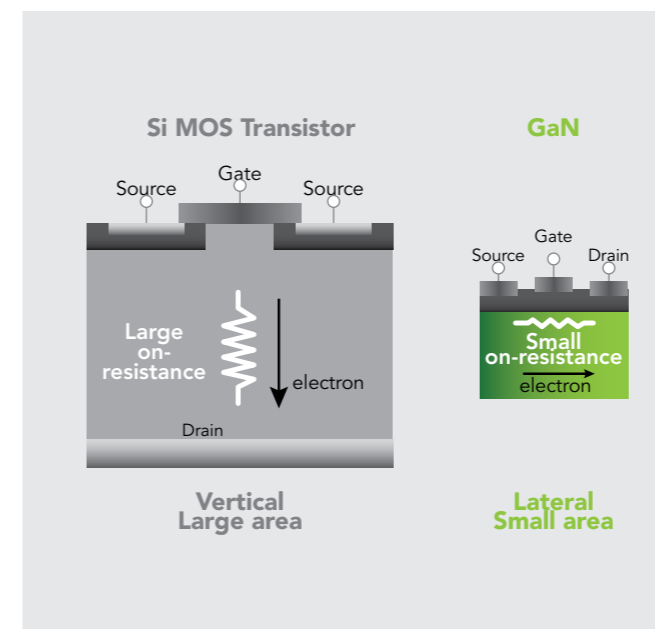
GaN devices possess five key characteristics:

- high dielectric strength
- high operating temperature
- high current density
- high speed switching
- low on-resistance

Its specific characteristics of GaN, such as high voltage potential, ease of miniaturization and high-speed switching, enable GaN to achieve high breakdown voltage and low conduction resistance. High breakdown voltage is achieved because GaN has a wide band gap property and low conduction resistance results from high 2D electron gas mobility and density.



+ Best performance vs. silicon (SiC equivalent)



MORE EFFICIENT POWER CONVERSION

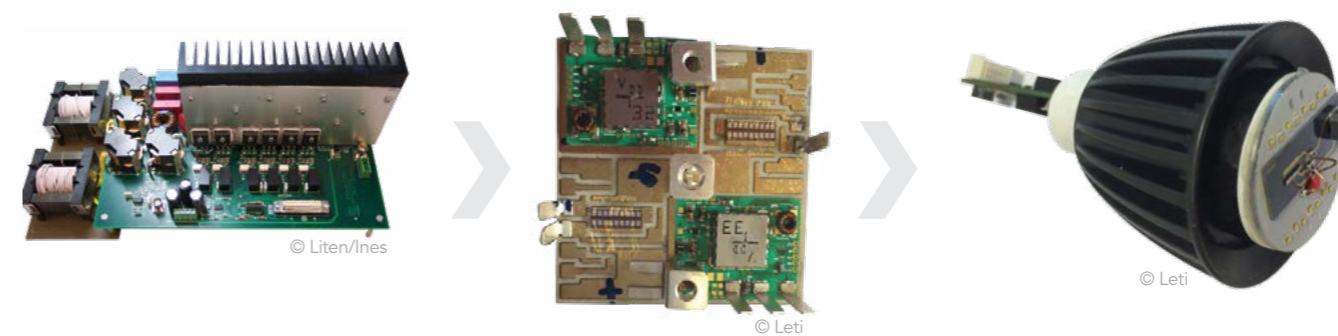
Easier monolithic integration capability:

- A "smarter" device with newly integrated functions: temperature sensor, pre-driver, short circuit protection, etc.
- Bidirectional switching
- High capability component
- Very low Ron.S
- Very high speed commutation
- Bidirectional monolithic component suitable for 4-quadrant power conversion

+ A smaller, more functionally integrated device

SYSTEM BREAK INNOVATION

A smaller, more integrated and more efficient.



+ Better performance and cheaper than Si and SiC

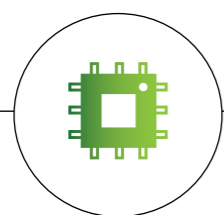
GaN transistors enable compact LED design.

WHY LETI?

LETI'S VALUE OFFER IS A COMPLETE CHAIN FROM DESIGN TO SYSTEM INTEGRATION AND OPTIMIZATION

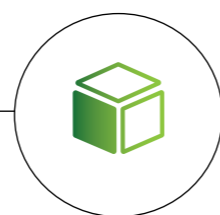
WHAT NEXT? FROM DISCRETE TO INTEGRATED CIRCUITS

2018	2022	2025
Function shift <ul style="list-style-type: none"> GaN/Si bidirectional switch 3D packaging and 3D WLP Simple monolithic integrated functions Multicell and interleaved / Multilevel converter topologies 	Co-integration shift <ul style="list-style-type: none"> Passive HF capability (inductance & capacity integration) Monolithic integrated functions Intelligent 3D packaging integration High-temperature isolated driver with embedded power supply & digital driver 1200V device capability with Ron.S < 1 mohms.cm² 	High-frequency shift <ul style="list-style-type: none"> Integrated passive HF capability GaN Integrated Circuits (integrated driver + power in one package: SoC with RF) High temperature capability



COMPONENT

- 200mm CMOS compatible GaN/Si technology
 - 200mm GaN/Si epitaxy with low leakage at 600V
 - 600V N.ON and N.OFF devices
 - Bidirectional GaN/Si Device
- + Multi-approach GaN technologies:**
- Low gate leakage device architecture
 - Low Ron capability for 600V (Ron.S < 1 mohms.cm²)
 - High positive threshold voltage for N.OFF devices
 - MOS HEMT devices



PACKAGING

- + 2 technology approach:**
- Optimized module for high current capability (KW segment):**
- Low inductance integrated power module
 - Integrated driver (SIP)
 - Capacity integration near active transistors
- Disruptive 3D packaging integration for more performance at high frequency (W segment):**
- Pillar and bump connection technology
 - Silicon active interposer
 - TSV technology
 - 3D wafer level packaging with copper leadframe
 - Fan out wafer level packaging



CHARACTERIZATION & INDUSTRIAL TESTS

- Specific electrical characterization:**
- Current collapse (Ron_dyn) & Vt shift analysis
 - Dynamic test: clamping inductive switching, gate charge
 - Full static device characterization
- Technological reliability test and failure analysis:**
- Gate oxide integrity, TDDB at high voltage, HTRB, CMV...
 - Emission microscopy, DLTS, full physical characterization on a dedicated platform



SYSTEM INTEGRATION

- Innovation for a more compact, efficient and low-cost converter:**
- New high-frequency system design architecture to reduce passive size (resonant topology, matrix converter...)
 - Better thermal management
 - New high-temperature isolated driver with embedded power supply capacity
 - Monolithic commuted cell integration (capacity + half bridge)



ABOUT LETI

Leti is a technology research institute at CEA Tech and a recognized global leader in miniaturization technologies enabling smart, energy-efficient and secure solutions. Committed to innovation, its teams create differentiating solutions for Leti's industrial partners.

By pioneering new technologies, Leti enables innovative applicative solutions that ensure competitiveness in a wide range of markets. Leti tackles critical, current global issues such as the future of industry, clean and safe energies, health and wellness, safety & security...

Leti's multidisciplinary teams deliver solid micro and nano technologies expertise, leveraging world-class pre-industrialization facilities.

For 50 years, the institute has been building long-term relationships with its industrial partners providing tailor-made solutions and a clear intellectual property policy.

Leti, technology research institute

Commissariat à l'énergie atomique et aux énergies alternatives

Minatéc Campus | 17 rue des Martyrs | 38054 Grenoble Cedex 9 | France

www.leti-cea.com

