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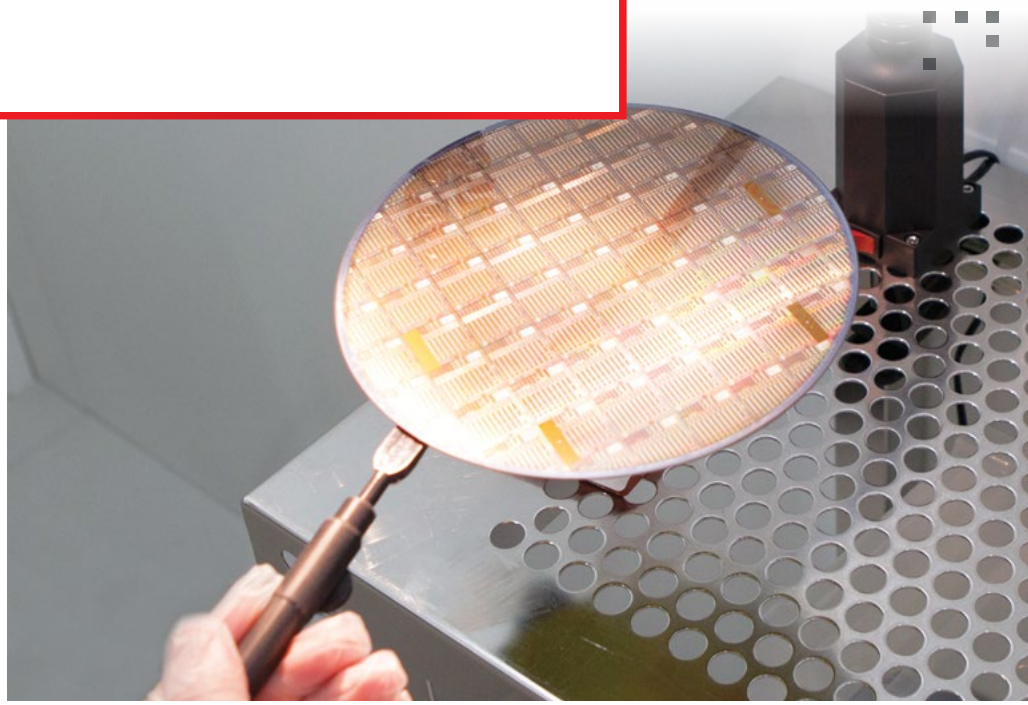
GaN POWER

Energy-efficient power electronics
with Gallium Nitride transistors



Leti, technology
research institute

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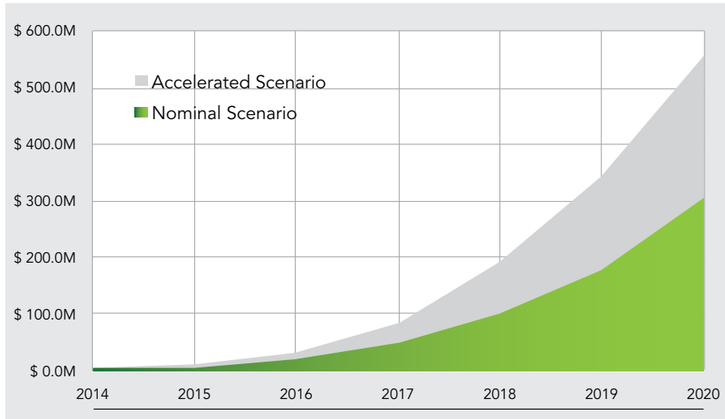
Leti GaN devices for **next-era power-electronics applications**

Leti is a technology research institute at CEA Tech. It has been involved in GaN/Si technology development since 2007, starting with the development of the material—a key in GaN-on-silicon device performance and cost.

CEA develops epitaxial GaN on 200mm silicon wafers and achieved state-of-the art electrical performance in 2015.
Leti is already involved with many industrial end users to develop new integrated systems with GaN inside. These mainly are for EV, in which GaN/Si devices are well adapted for DC-DC converters to improve power density for a more compact converter, increasing the final system efficiency.

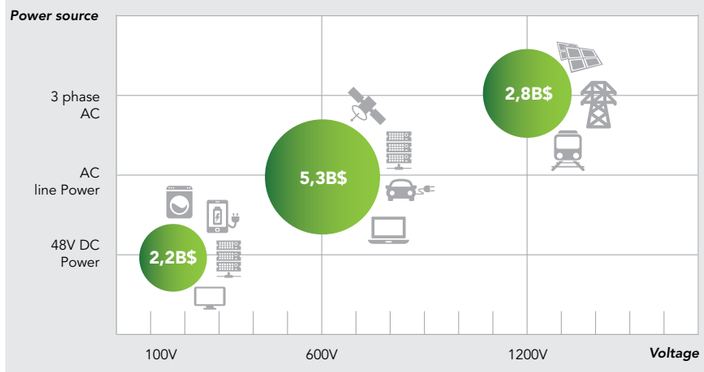
A MARKET IN GROWTH



GaN DEVICES MARKET SIZE (M$)
Source: Yole, GaN and SiC devices for power electronics applications

The GaN devices market for power-electronics applications will explode in 2016, reaching US$303 million in 2020, according to Yole Développement (GaN and SiC devices for power electronics applications - July 2015). But growth could accelerate in 2017. In this case, the market's size will reach 1.8X that of the nominal scenario by 2020.

A LARGE RANGE OF APPLICATIONS



GaN MARKET SEGMENTATION

The current GaN devices market is mainly dominated by devices <200V. 600V devices are expected to take off and keep growing. While SiC is used for high-voltage applications, GaN is mainly used for low voltage.
The 600-900V range will be the battlefield.

WHY GaN?

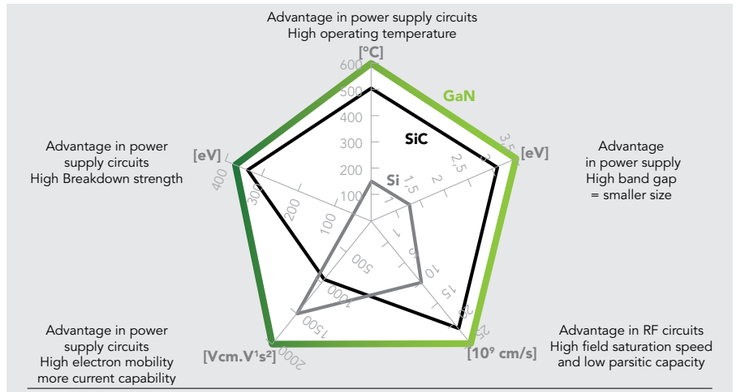
THANKS TO ITS PERFOMANCE, **GaN WILL IMPROVE CONVERTER POWER DENSITY AT LOW COST**

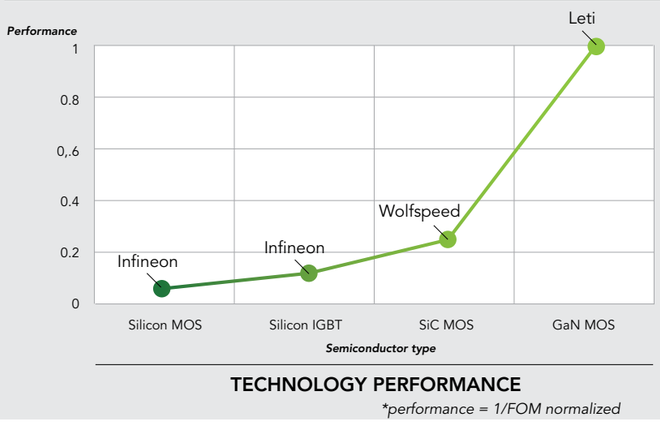
FOR ITS PERFORMANCE

GaN devices offer five key characteristics:

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

The special features 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.
The high breakdown voltage is achieved because GaN has a wide band gap property.
The low conduction resistance is achieved due to the high 2D electron gas mobility and density.

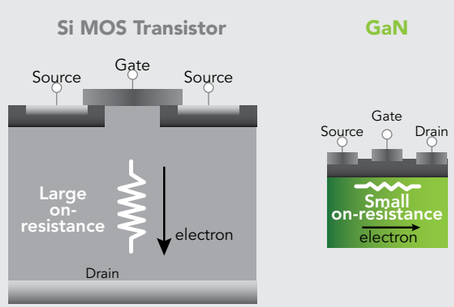




TECHNOLOGY PERFORMANCE

**performance = 1/FOM normalized*

Best performance vs. silicon (equivalent as SiC)



FOR MORE EFFICIENT POWER CONVERTER

Easier monolithic integration capability

- More "cleaver" device with new integrated functions: temperature sensor, pre-driver, short circuit protection...
- Bidirectional switch
- High capabilities component
- Very low Ron.S
- Very high speed commutation switching
- Bidirectional monolithic component adapted to 4-quadrant power conversion

Smaller device with more integrated function

FOR SYSTEM BREAK INNOVATION

Smaller, more integrated and more efficient.

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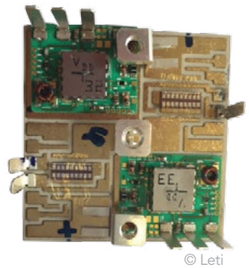

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Best performance vs. silicon, cheaper than silicon and SiC solution

GaN transistors enable the compact design of LED

WHY LETI?

LETI'S VALUE PROPOSITION IS A COMPLETE CHAIN
FROM DESIGN TO SYSTEM INTEGRATION
AND OPTIMIZATION OF CONVERTER

WHAT NEXT?
FROM DISCRETE... TO IC

2016

Function shift

- GaN/Si bidirectional switch
- 3D packaging and 3D WLP
- Simple monolithic integrated functions
- Multicell and interleaved / Multilevel converter topologies

2020

Monolithic integration shift

- Passive HF capability (inductance & capacity integration)
- Monolithic integrated functions
- Intelligent 3D packaging integration
- High-temperature isolated driver with autoalimentation & digital driver
- 1200V device capability with Ron.S < 1 mohms.cm^2

2025

High frequency shift

- 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 approaches GaN technologies:

- Low gate leakage device architecture
- Low Ron capability for 600V (Ron.S < 1 mohms.cm^2)
- 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

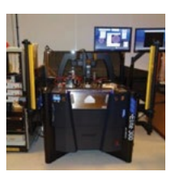
Technological reliability test and failure analysis:

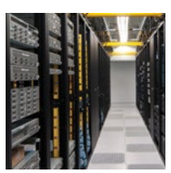
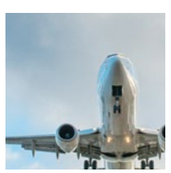
- Gate oxide integrity, TDDB at high voltage, HTRB, C(V)…
- Emission microscopy, DLTS, full physical characterization on a dedicated platform

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 auto-alimentation capability
- 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.

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