InRel-NPower

Innovative Reliable Nitride-based Power devices and applications

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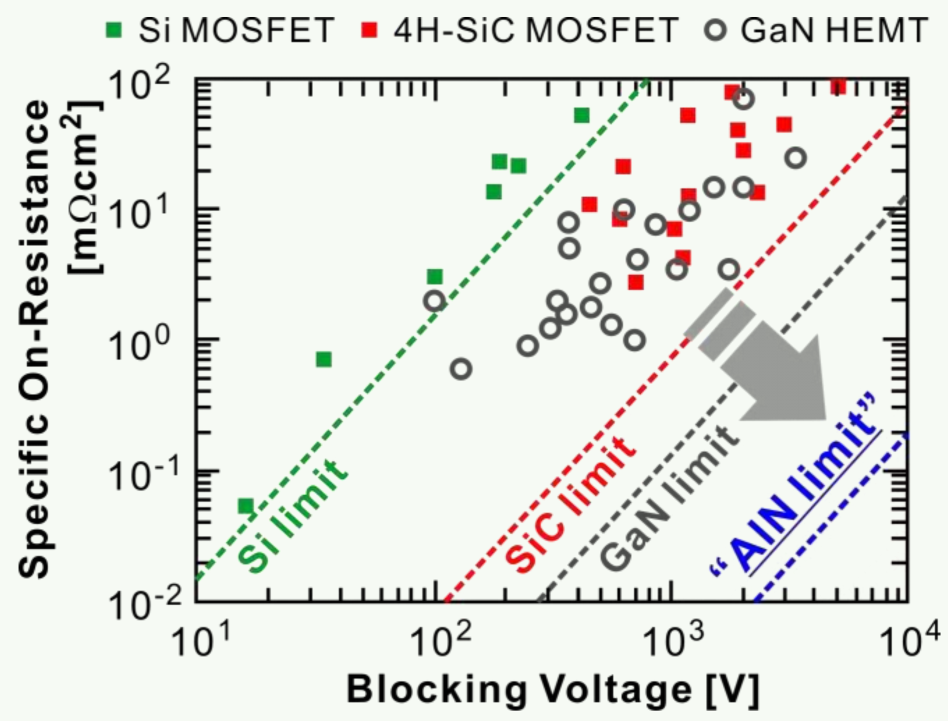
Over 10% of our electric energy is wasted

We generate huge amounts of electric energy, and everyday we consume more and more. A major part of the produced electricity is lost in the transmission and the distribution to the electric grid. Even more energy disappears due to inefficient conversion while charging your laptop, mobile phone or electrical car.



We aim for a 99%-efficient power transistor

The most popular material for electric power transistors is silicon. This material is only usuable with exessive cooling and for relative low voltages. *InRel-NPower* aims to further develop GaN– and AlN-based devices, which can perform 10 to 100 times better then silicon.

This technology will be demonstrated:

- In a motor drive invertor
  60% reduction of power losses, 50% higher power density.
- In a DC to AC power converter
  peak efficiency up to 99% while operating at 2 kW at 30V.

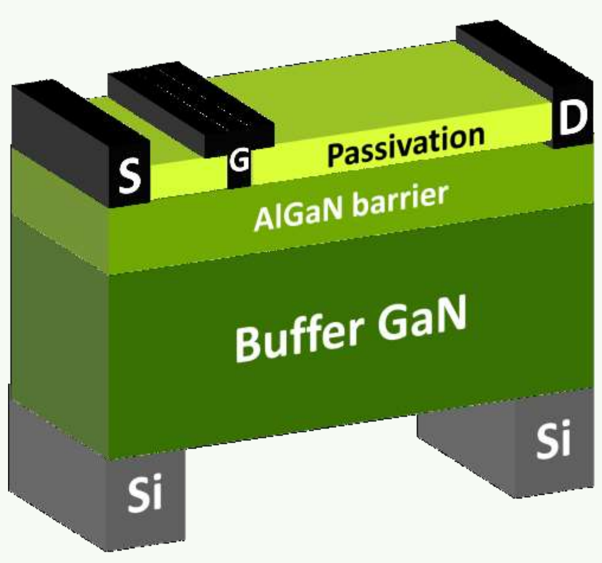
We aim to mature the nitride-based power transitor by focusing on the whole

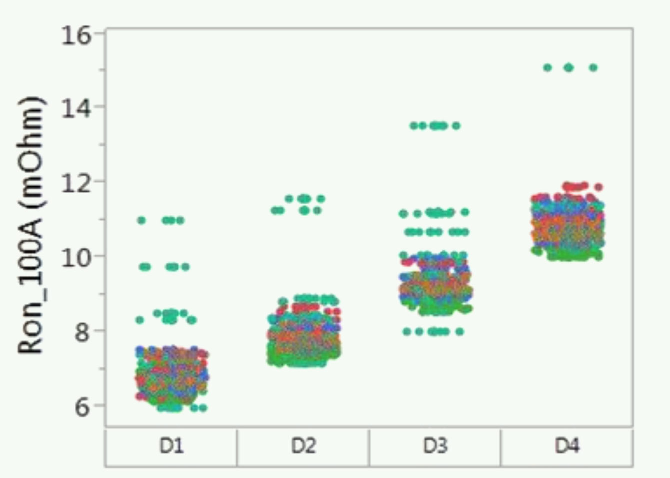
Optimised structures

We aim to improve the R_{ON} resistance and the maximum current by a factor of two by optimising the gate module, passivation layer, ohmic contacts and the epitaxial buffer structures.

We target for GaN-based power devices with $R_{ON} < 10m\Omega$ with I_{MAX} over 100A.

These optimised devices will finally be processed at ONSemiconductors 6-inch GaN-on-SI pilot line.

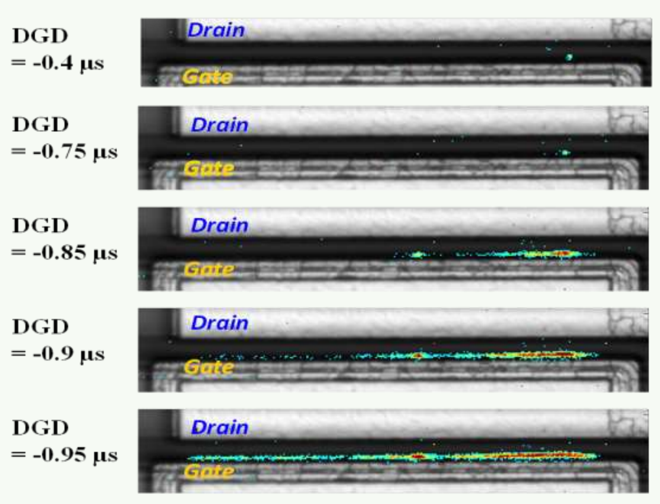




results from ONSemiconductor

Proven reliability

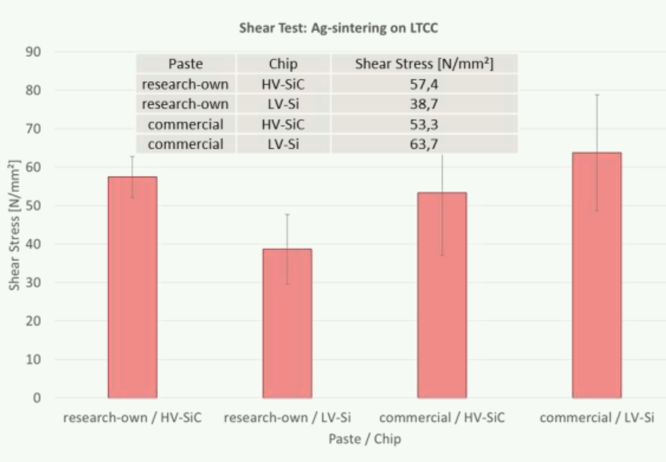
Studying degredation mechanisms such as hot electrons and buffer traps while ramping the temperature or using high currents will enable **reliable life-time predictions of GaN-based devices**



results from University of Padua

Innovating GaN-packaging

Power losses can be reduced while increasing the power density by developing **two innovative low inductance packaging technologies** with integrated cooling: a pure ceramic material and a ceramic-polymer concept.

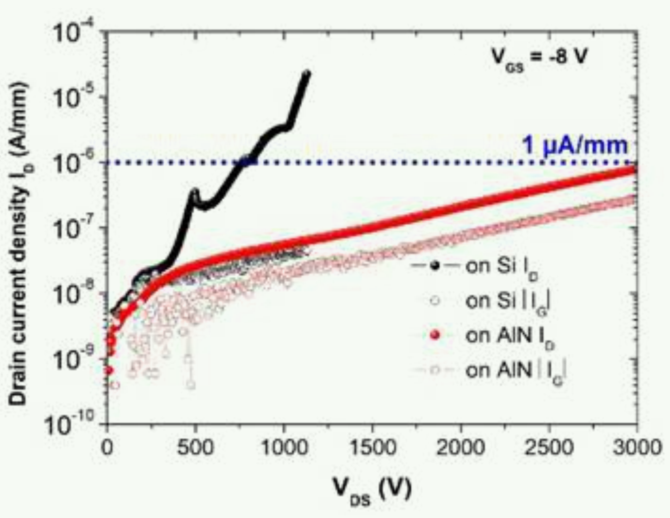


Shear values of Ag-sintered chips on a Low-Temperature Co-fired Ceramics on dummy (SiC and Si) substrates illustrate suggest no obvious barrier for GaN-chips.

results from BOSCH

Implementing substrate removal

GaN is grown on a Si substrate, a design where the blocking voltage capacity of Si limits the transistor due to device preakdown above 650V.. **Local removal of the Si substrate** is investigated to obtain reliable 1200 V rated devices.

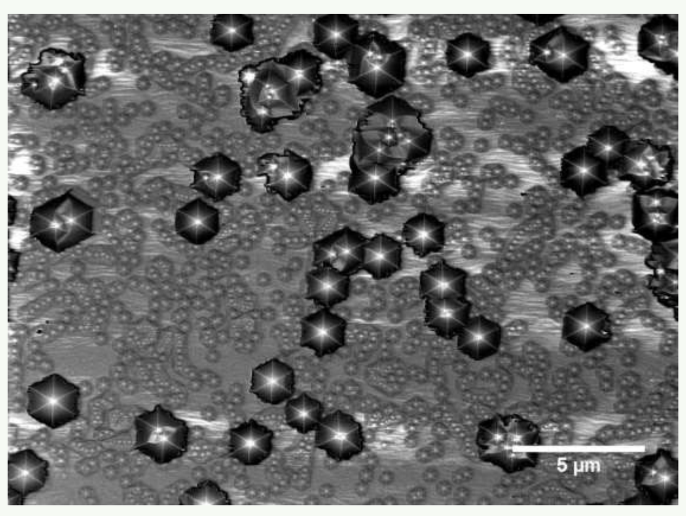


The figure above illustrates that the current collapse is significantly reduced through silicon-substrate-removal on GaN devices

results from CNRS

Exploring AlN semiconductors

Exploring **ultra-wide bandgap systems** which rely on **AlN templates** (obtained by HVPE, and 3SG or PVT for bulk substrates) can enable breakdown voltages above 2500 V and sheet

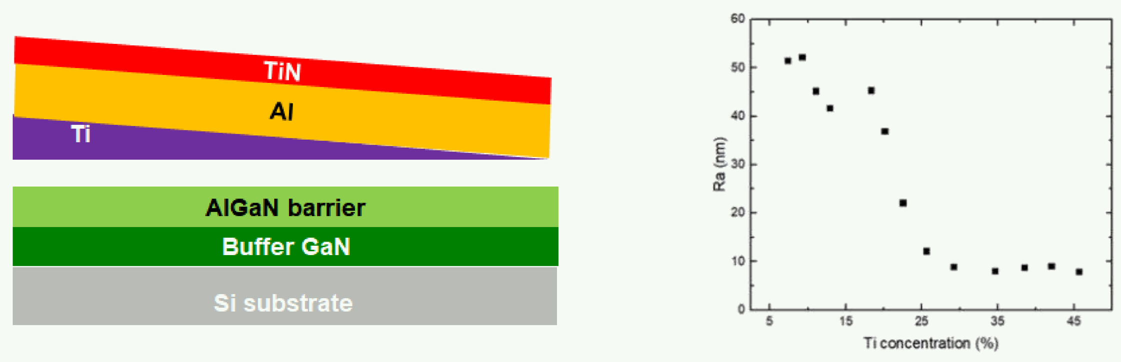


The density of different types of dislocations on AlN templates were investigated by etching the surface with KOH/NaOH.

results from Fraunhofer IISB

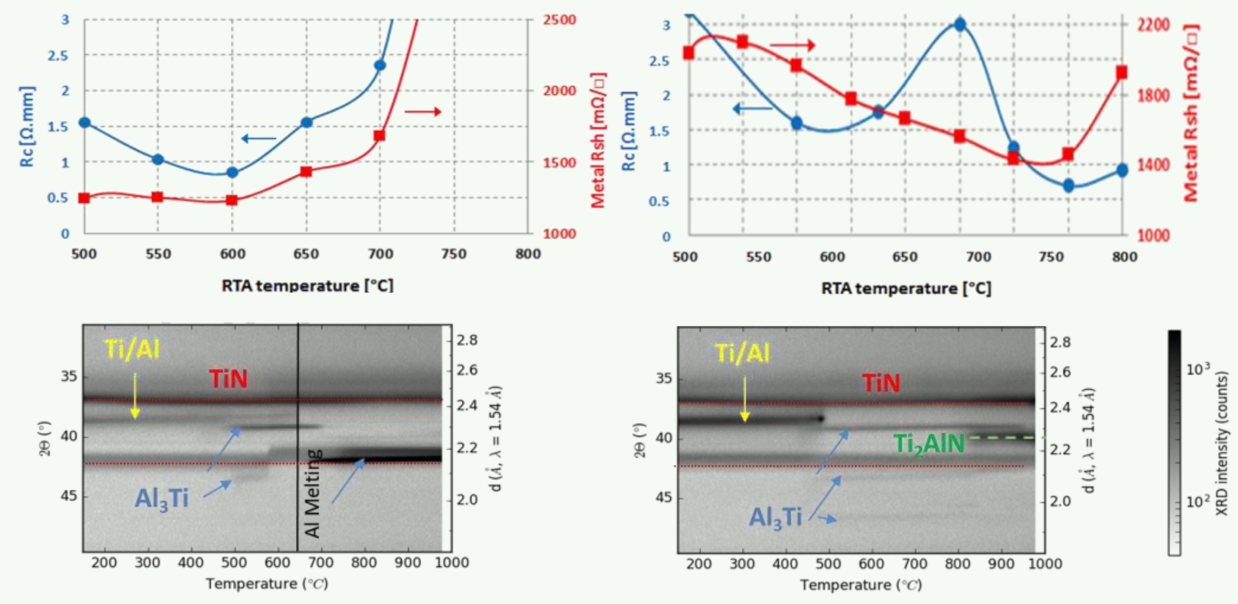
Ghent University optimises the ohmic contact

Alternative metallization schemes are explored to enable stable, Au-free ohmic contacts below R_C of 0.3 Ω.mm, where the total resistance of an industrial 650V-rated power device is 10 Ω.mm, while limiting the sheet resistance of the substrate below 300 Ω/sq.



A combinatorial gradient allows to inspect a series of compositions on a single wafer.

Morphological assessment indicates that Al melting is a severe issue for Ti concentrations below 25%.



(top) The contact resistance R_C changes significantly as a function of annealing temperature for Al-Ti based contacts (left: 16% Ti, right: 25% Ti) [1]. **(Bottom)** *In situ* X-ray diffraction (XRD) measurement explains this evolution. Further *pole-figure* XRD shows that Ti_2AlN aligns its hexagonal lattice with the underlying hexagonal AlGaN barrier.

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Summer school July 8-12, 2019 Ghent, Belgium

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