GaN devices for Industrial applications: opportunities and challenges

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Presentation plan

Proprieties of GaN devices and customer values

Interest of GaN devices for Industrial applications

Challenges

Conclusion

Proprieties of GaN devices and customer values

Low switching losses

Low conduction losses

High junction temperature

Bidirectional devices

Low cost potential

High efficiency

Low foot print

Competitive system cost

but lateral device, so normally limited to low power and low voltage (600V ?)

Power converters by Schneider Electric

Major products : Variable speed drive, UPS, PV inverter

UPS
(Uninterruptable Power Supply)

Energy Storage

Photovoltaic inverter
Renewable Energy

Variable Speed Drives

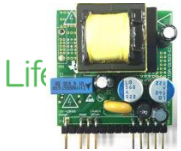
Servomotor drive

Active Filters
(Power Quality)

Electrical Vehicle Charging

> View EVlink™ range

Power Supply



Interest of GaN devices for Industrial applications

GaN devices should find first implementation in small power applications.

Electrical Vehicle Charging

> View EVlink™ range

UPS
(Uninterruptable Power Supply)

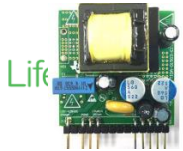
Photovoltaic inverter

Variable Speed Drives

Servomotor drive

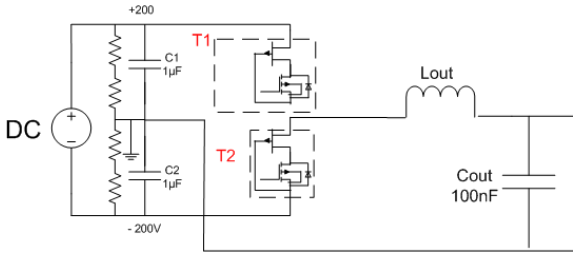
Power Supply

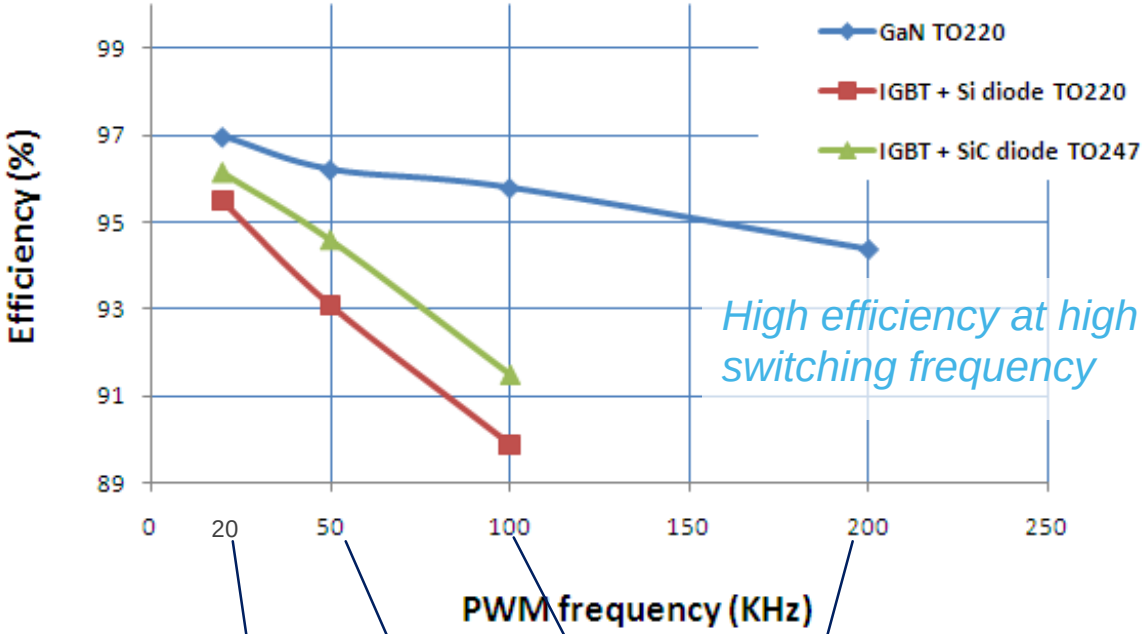
USB Type-C



Experimental results confirm interest of GaN device

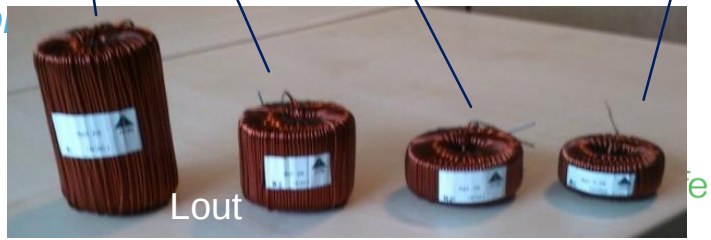
DC/AC inverter





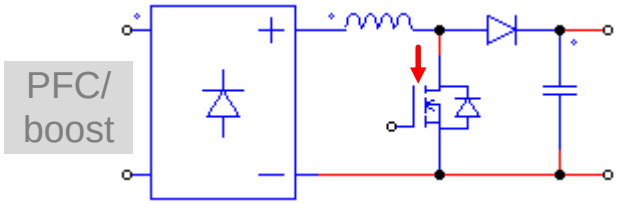
High efficiency at high switching frequency

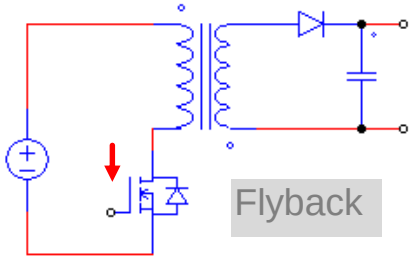
Reduction of size of inductor when switching frequency increase



Challenges: positioning versus Superjunction MOSFET

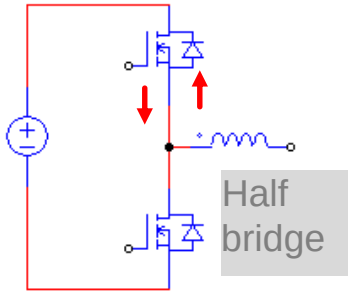
Thanks to it's fast switching and low conduction losses, SJ MOSFET is well adapted to PFC (power factor correction) and small power supply .



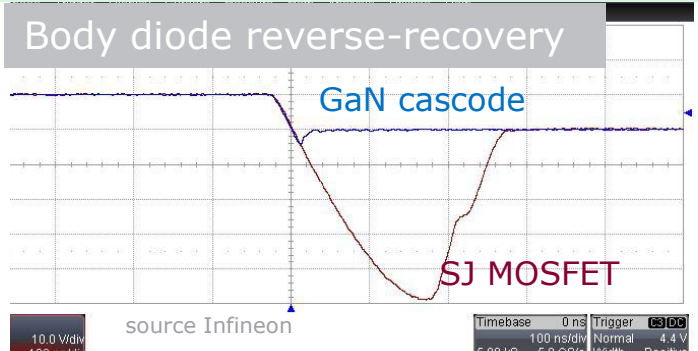


GaN could still bring some improvement, but quite limited on such topologies.

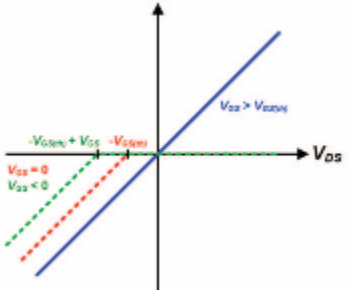
Due to its slow body diode, SJ MOSFET could hardly be used in half bridge topology.
GaN should make difference with fast recovery and proper reverse conduction.



Body diode reverse-recovery



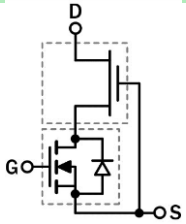
Reverse conduction versus Vgs



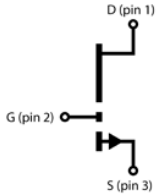
Challenges : Device types

Today, several device types are still in competition, each one with advantages and drawbacks

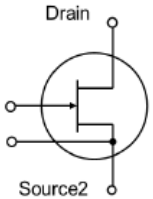
- Depletion mode (Normally-on) & Cascode



- Enhancement mode (Normally-off)



- GIT (Gate Injection, Normally off)



- MIS (Metal Insulator Semiconductor)

But device type diversity does not help industrial adoption.

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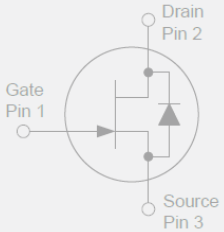
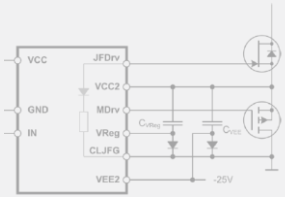
Challenges : *Comparative perspective with Convergence of SiC device types*

Convergence of SiC device type happened just few years ago.

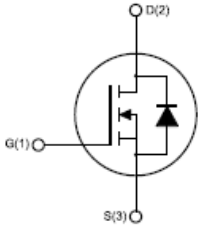
SiC JFET
- cascode
- dedicated driver





Cree
Semisouth
Infineon/SiCED
Hitachi
Toshiba

SiC MOSFET



ST
Infineon
Rohm
OnSemi
Wolfspeed
…

Cree
Fairchild
Mitsubishi
Philips
Rohm
GE
…

SiC BJT

TranSiC
Cree

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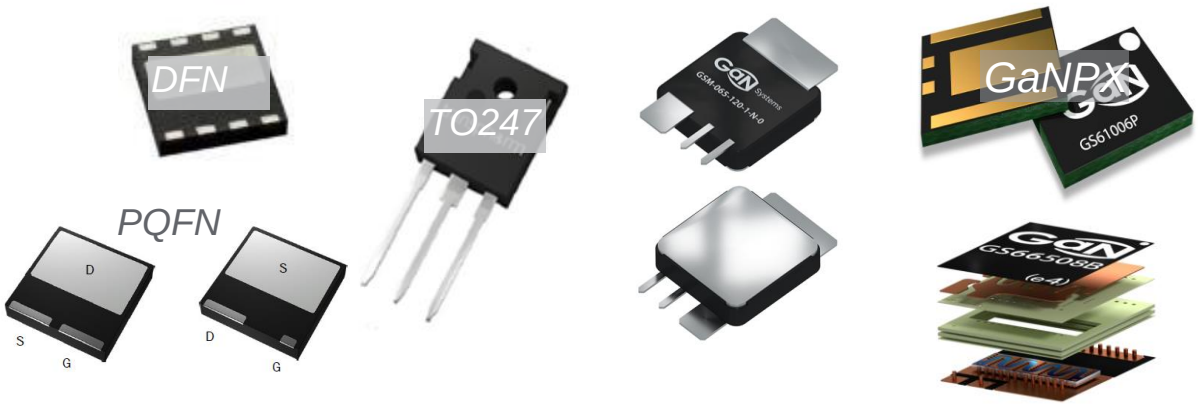
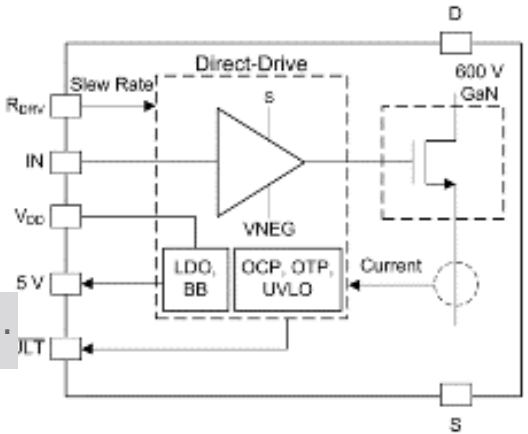
Challenges : diversity of packaging & integration

Faster than SiC, packaging and integration of GaN device are more important and challenging.

Today, there are multiple packagings (DFN, PQFN, TO220/TO247, GaNPX …)
as well as various integration levels (Switch-alone, Gate driver integration)



Gate driver + GaN

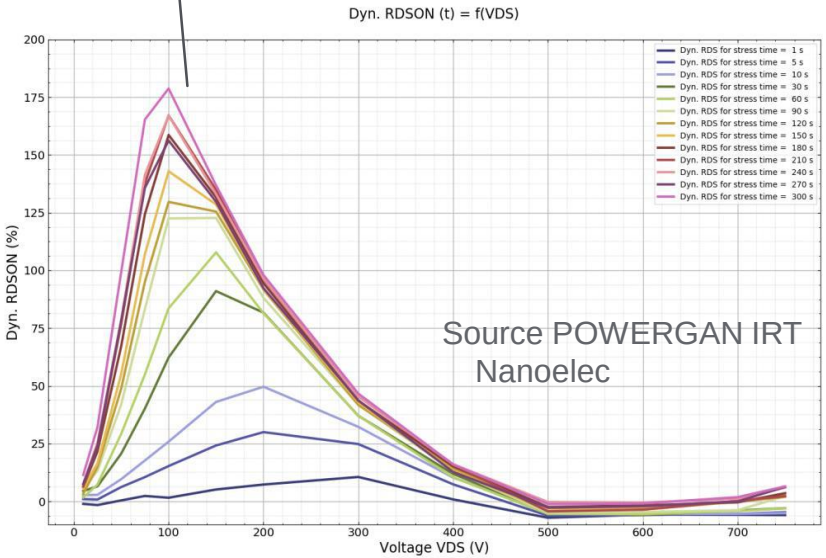


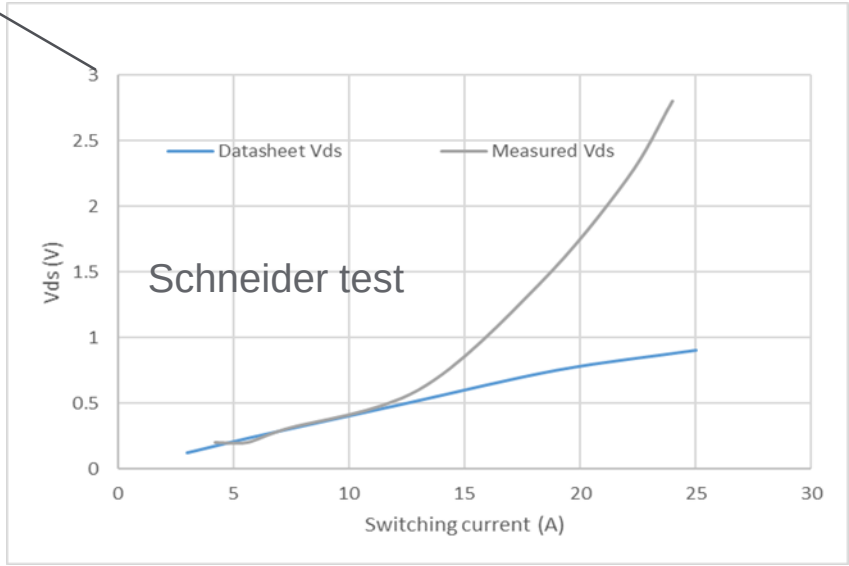
But packaging and integration diversity does not help industrial adoption.

Challenges : *Reliability*

GaN devices show still some particular behaviors such as :

- gate threshold voltage drift,
- charge trapping or current collapse(Rds_on temporary increase due to drain voltage in off state or due to gate voltage in reverse conduction.





Conclusion

GaN is very promising technology with competitive cost potential.
First industrial applications in low voltage (<600V) and low power.

Research effort should be focused on:

- *reverse conduction*
- *device type*
- *packaging & integration*
- *and reliability.*

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