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GaN half-bridge integrated circuits for power converters

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At AMICSA 2021, first results of an integrated IC containing GaN half bridge & their associated drivers have been presented.

These results originate from an ESA program where IMEC has partnered with MinDCet (IC design house) & Thales Alenia Space for the development of a single chip half bridge with integrated pre-drivers. The IC is designed on IMEC's GaN on SOI & high voltage (200V) process.

The run2 fixing some issues is expected to be tested in April & May 2022. So results should be right on time for the conference. Also preliminary radiation tests show excellent behavior of this technology towards both dose & heavy ions.

The component includes follow features:

- High-side and low-side, high current (22 mOhms) P-GaN HEMT
- Integrated high-side & low-side gate drivers
- Temperature sensing
- Gate driver voltage regulation
- Isolated level-shifter for gate control signal propagation to floating levels
- Dead-time generator

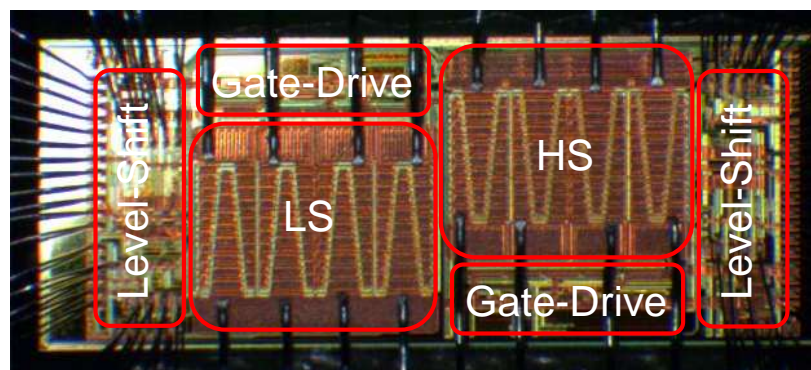


Figure 1 P-GaN HEMT Half-bridge 2x 22mOhm 200V with integrated drivers

Clearly this IC is a breakthrough as it is stepping away from traditional GaN and silicon co-packaging, where the performance limit is defined by package integration. Key enabler is the GaN on SOI technology developed by IMEC. This technology allows to co-integrate several devices on the same die using deep trench isolation. Although the co-integration of high-side & low-side power devices sounds straightforward, practical parasitic substrate capacitances often cause the exercise to fail.

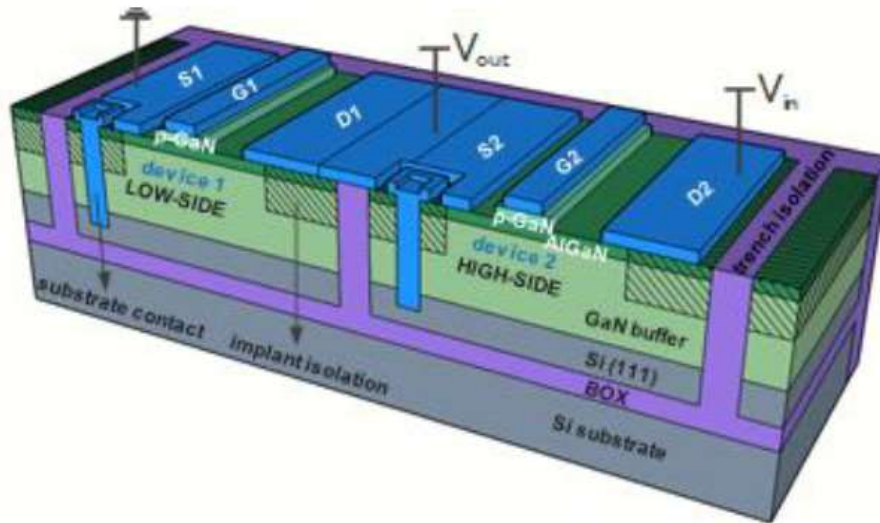


Figure 2 Cross-section of monolithic integration of HS and LS switch

First GaN Half-bridges were developed and tested in the frame of SloGaN VLAIO project (Flemish regional funding). The aim was to achieve integration of high voltage & high current transistors with low voltage control & gate drive devices.

Second step is a full feature 3..8A 200V integrated GaN IC Half-bridge been developed under an ESA GSTP program. Figure 1 shows the run1 (=prototype) of IC.

As a step forward, the same consortium extended with Wurth Electronics is looking forward to develop an high current low voltage point of load converter based on GaN integrated half-bridges and new magnetic components.

This PoL converter aims at delivering 75 Amp. current at low voltage output (down to 0.7V) in order to supply high complexity integrated circuits like FPGA or processors. With new technologies transistor size is shrinking while power consumption [watts] stays about the same. The result is an increased demand for lower & lower supply voltages combined with higher & higher currents. It is expected that GaN technology nicely deserve those needs as it can offer lower R_{dson} than silicon & higher switching frequencies.

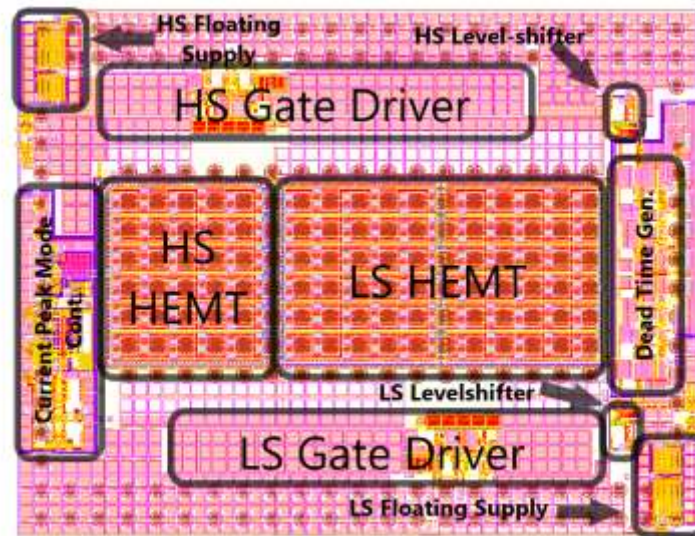


Figure 3. P-GaN HEMT Half-bridge 5 & 10 mOhm with integrated regulation loop.

The first IC runs are currently being processed in IMEC's fab. The design exercise was clearly a race to squeeze the design as much as possible chasing any fraction of mOhms. As a result the half-bridge combines 10 mOhms high side & 5 mOhms low side in 7 x 3mm power cell.

Next to that, we have taken advantage of this de-risking foundry run to integrate as much as possible regulation features. The IC contains operational amplifiers, high comparators, level shifters, current sensing amplifiers, ... These are still quite experimental features on a process that is for the moment still dramatically missing complementary devices: only HEMT (N-ch like) devices & resistors can be used.

Acknowledgments

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<https://www.imec-int.com/en/what-we-offer/research-portfolio/slogan>
2. Project GANIC4S Monolith ic integration of GaN gate driver and power transistor switching functions under ESA Contract No.4000128515/19/NL/FE
3. Project EleGaNt: high current low voltage point of load converter based on GaN integrated half-bridges.
<https://cordis.europa.eu/project/id/101004274>