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INTRODUCING GaN TECHNOLOGY IN PREMIUM

Introducing GaN technology in Premium power supplies

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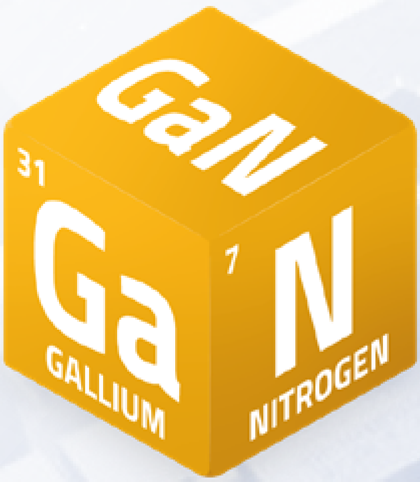
Power electronics engineers are continually looking for the perfect switch, the one that will efficiently convert the electrical raw energy into a controlled energy with a useful flow of electrons. Ideally, the one that allows switching in zero-time, carrying infinite current and blocking infinite voltage. In practice, faster switches with less capacitance and lower conduction loss.
Let's introduce GaN!

Gallium Nitride (GaN) is an inorganic chemical compound of gallium and nitrogen that has an hexagonal crystalline structure of high hardness and mechanical stability. **It is a semiconductor material with a 3.4eV bandgap, three times that of silicon**, which is why it is considered a wide bandgap material or semiconductor (WBG). **WBG allows operation at much higher voltages, frequencies and temperatures than conventional silicon**. This translates into smaller inductors, capacitors and heatsinks, the possible elimination of fans and the conversion from liquid to air cooling in a switched power converter. The switching and conduction losses of GaN transistors are lower, as the wider bandgap allows the development of semiconductors with very short or narrow depletion regions, leading to device structures with a very high carrier density. With much smaller transistors and shorter current paths, very low resistance and capacitance are achieved, allowing for **much higher switching speeds**.



In power electronic applications, GaN-based high electron mobility transistors (HEMT) are often used, which have excellent electrical properties (high electron mobility, high carrier concentration, and high critical electric field). These are field effect transistors (FET) that incorporate an hetero-junction called 2DEG between two materials with different bandgaps as channel, instead of a doped region as in the case of MOSFET.

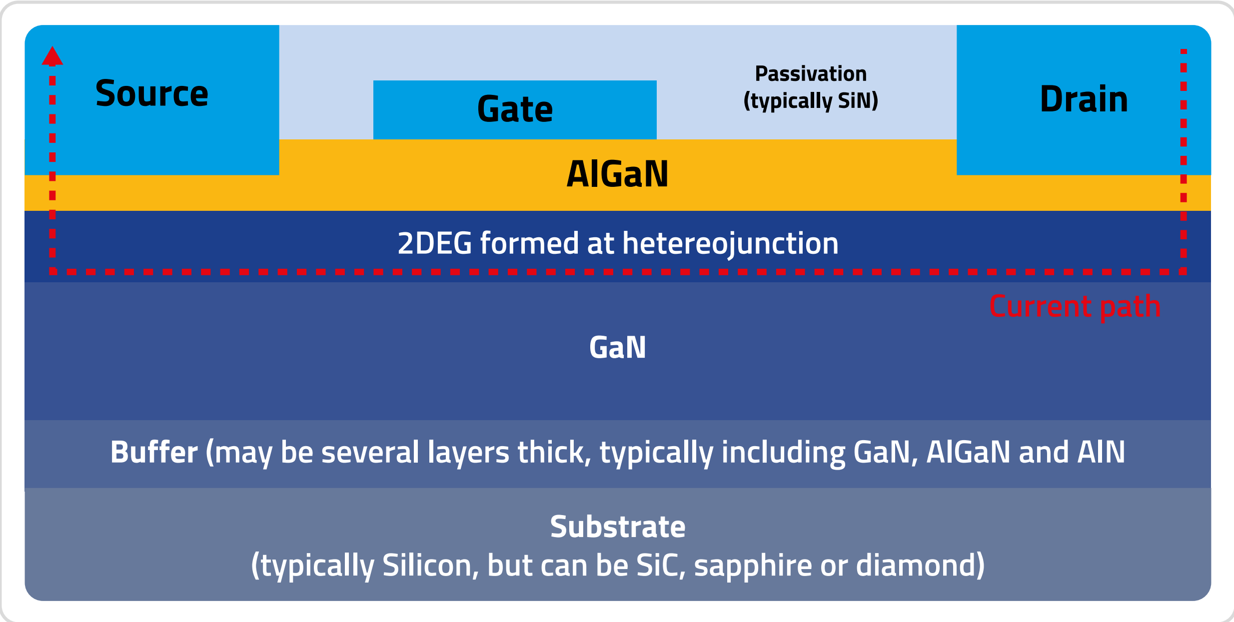


Fig.1 - GaN HEMT structure

With higher breaking strength, higher switching speed and lower channel resistance, GaN-HEMT power switching devices significantly outperform silicon-based devices. In general, **in power conversion systems, GaN technology allows lower heat dissipation, higher power density and volume reduction**, which translates into device weight reduction and a decrease in cost of materials.

Depending on the electrical behavior, there are two versions of GaN transistors. On one hand, the Depletion-mode GaN (dGaN), a normally ON transistor which is turned off by negative voltage applied to the gate, relative to the drain and source electrodes. dGaN transistors are inconvenient because at start-up of a power converter a negative bias must first be applied to the power devices, otherwise a short circuit will result. On the other hand, the Enhancement-mode GaN (eGaN), usually referred to as GaN FET, a normally OFF which is turned on by positive voltage applied to the gate.

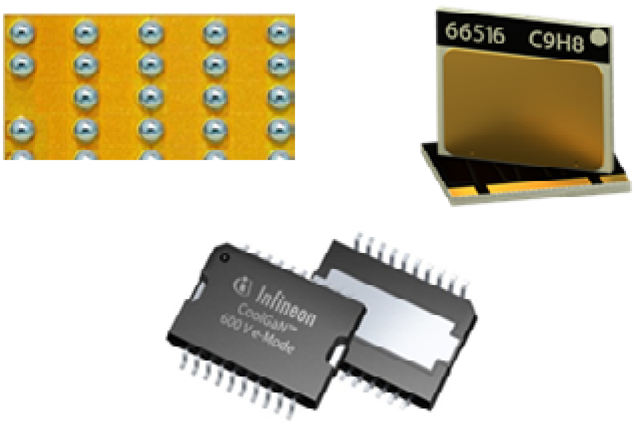


Fig.2 - Discrete EPC, GaN Systems and Infineon eGaN FET's

dGaN is often packaged in cascode with a low voltage silicon MOSFET to allow normally OFF operation. The cascode configuration provides the ruggedness of a silicon gate, coupled with the improved voltage blocking characteristics of a high voltage GaN HEMT. The low voltage silicon MOSFET has very low QRR due to its body diode, which is orders of magnitude lower than a high voltage silicon device with similar ratings to the high voltage HEMT. Also, there are no special requirements for the gate driver since the gate is connected to a standard silicon gate rated at +/- 20 volts with threshold around 2 volts.

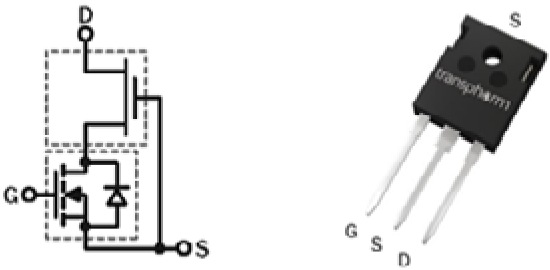
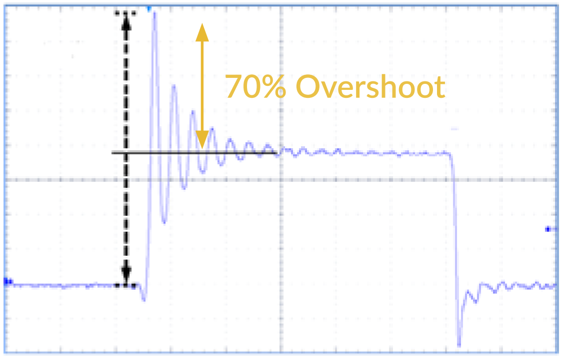
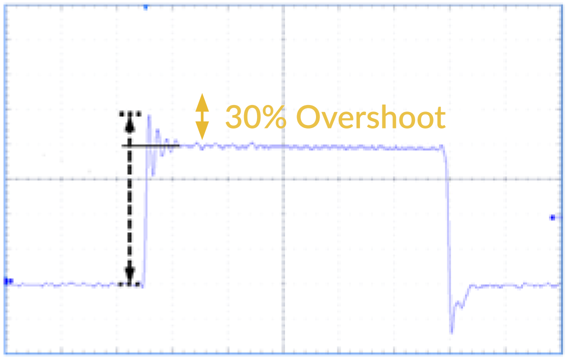


Fig.3 - Transphorm cascode configuration



a) L_{LOOP} = 1*nH*



a) L_{LOOP} = 0.4*nH*

Fig.4 - Voltage overshoot in a buck switching node
Differences between two PCB L_LOOP's switching at 1 MHz

Besides its low $R_{DS_{ON}}$, the lateral structure of the eGaN FET makes it a very low capacitance device, without the common parasitic bipolar junction of the silicon MOSFET. The eGaN FET can switch hundreds of volts in nanoseconds and therefore the parasitic inductances of the PCB layout and the own switching device must be as small as possible. The high frequency power loop must be as low as possible to minimize the loop inductance in order to improve the overshoot and the switching ringing. All this translates into **an improvement of the system efficiency**.

Regarding the reverse bias or diode operation of a eGaN FET, with zero bias gate-to-source there is an absence of electrons under the gate region. As the drain voltage decreases, a positive bias on the gate is created relative to the drift region, injecting electrons under the gate. Thus, there are no minority carriers involved in conduction, and therefore no reverse recovery losses. Although QRR is zero, output capacitance (COSS) has to be charged and discharged with every switching cycle. For devices of similar RDS(ON), eGaN FETs have significantly lower COSS than silicon MOSFETs. However, the body diode forward drop can be a volt higher than comparable silicon MOSFETs.

At Premium PSU we are currently designing devices with new topologies that incorporate GaN technology.

Premium´s RDI department is working on updating equipment already designed to apply GaN technology, starting with the EDS-500 battery charger and the new bridgeless PFC totem pole topology, which will allow us to increase the power density and reach 1kW, duplicating the power of the battery charger. In addition, the rest of UPSs will follow along with GaN technology application in resonant LLC and H-bridge topologies. With this, **we will be able to lauch increasingly efficient devices with high power densities and lower costs**.

EDS-500

EDT-150

ODS-3000

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Premium is one of the largest power supply companies in Europe, offering solutions to the industrial market being some of them in high-tech machinery, transportation, energy or extreme environments applications. Founded in 1981, Premium designs and manufactures power conversion systems for customers all around the world. Premium´s power range includes DC/DC converters, uninterrupted power supplies, DC/AC inverters, AC/DC power supplies and any solution that requires high reliability from 50W to 50kW.

Custom is Premium´s standard, so any current product variation or new development can be done by our R&D department, a team of over 50 engineers with a wide know-how.

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