Bodo´s Power Systems®

Interview on Winning GaN Applications

Ahead of December's Power Conference in Munich, Bodo Arlt took the opportunity to get an insight into Alex Lidow's thoughts on where the GaN market is now and where he sees the potential applications for the future. Dr. Lidow is the CEO and Co-founder of Efficient Power Conversion (EPC).

By Bodo Arlt, Editor, Bodo's Power Systems

Bodo Arlt: Where is GaN winning business now? In which industries are seeing the most adoption?

Alex Lidow: EPC has been in production with GaN-on-Si for power conversion applications for 10 years. The success of these power transistors and integrated circuits initially came from the speed advantage of GaN compared with silicon. GaN-on-Si transistors switch about 10 times faster than MOSFETs and 100 times faster than IGBTs. Applications such as RF Envelope Tracking for 4G/LTE base stations and light detection and ranging (lidar) systems for autonomous cars, robots, drones, and security systems were the first volume applications that took full advantage of GaN's high-speed switching ability.

Not only were GaN transistors faster than Si MOSFETs and IGBTs, they were much smaller – about 5 to 10 times smaller. This opened up many applications in robotics and medical electronics as well as satellites and drones.

As volume built over the years, the cost came down and in about 2015 many of EPC's eGaN® FETs, were priced comparably with power MOSFETs with the same power handling ability.

Smaller, faster, and comparably priced! At this point, there are few reasons not to use eGaN FETs in applications with input voltages of 100 V or less. Today eGaN FETs are being used or designed into the most advanced servers and AI systems that use 48 V bus architectures. There is also a steady migration of more conventional computing systems to eGaN FET or IC-based DC-DC converters for USB-C converters.

Bodo Arlt: What share do automotive applications have in your plans? What trends do you see for GaN in the automotive market? For example, how does the trend to 48V systems influence your developments?

Alex Lidow: We see multiple application areas for GaN in automotive designs. We've already touched on the ubiquitous use of GaN for lidar systems for autonomous cars. The speed of the laser in these systems is critical to getting the incredibly high-resolution images required for safe autonomous transport. Thus, the faster the lidar operates, the higher the image resolution of the surroundings. GaN technology enables the laser signal to be fired at far higher speeds than comparable silicon MOSFET components. GaN-based lidar allows autonomous vehicles to see farther, faster, and better becoming the primary "eyes on the road."

Another automotive application is high-fidelity audio and infotainment systems. In Class-D audio systems, the audio performance is impacted by the FET characteristics.

The low on-resistance and low capacitance of the eGaN® FET enable high efficiency and lower open-loop impedance for low Transient Intermodulation Distortion (T-IMD). The fast switching capability and zero reverse recovery charge enable higher output linearity and low cross over distortion for lower Total Harmonic Distortion (THD). GaN FETs enable higher fidelity Class-D audio amplifiers.

A third automotive application is high-intensity headlamps. eGaN FETs have been powering truck headlamps for over 5 years. eGaN FETs and ICs offer designers lower overall losses, lower heat generation, and improved thermal management. This leads to higher reliability and longer life for the headlamp, compact and lighter assemblies, and lower system costs.

Lastly, but very significantly, the 48 V trend is a sweet spot for GaN. Automotive systems are also becoming challenged with higher and higher electrical loads and are therefore adopting GaN-based 48 V – 14 V bi-directional DC-DC converters to take advantage of the more efficient wiring that comes with higher voltage power distribution.

Bodo Arlt: What have been some of the challenges GaN power devices have to deal with on the road to adoption?

Alex Lidow: EPC manufactures eGaN FETs and ICs in a standard silicon foundry in Taiwan side-by-side Si BCDMOS products. The only exceptional processing for EPC's devices is the growth of the GaN epitaxial layer that sits on top of a standard Si wafer. The added cost of the GaN epitaxial growth is more than offset by the smaller size of the devices, and therefore greater number of devices on each wafer.

Yields are uniformly high, and manufacturing facilities are mature and low cost, so the challenges are in shrinking the devices further to accelerate adoption, improve performance, and open an even more significant cost gap with Silicon. To shrink devices further there needs to be improvements in the GaN crystal to reduce imperfections that lead to electron traps. Another limitation to shrinking eGaN devices is the need to get power into and out of the parts. High current densities get even higher as devices get smaller and we are already hitting the limits of the solder and copper layers to conduct such high current densities reliably. The only way to improve this situation is to integrate multiple power devices onto the same chip along with drivers, logic, level shifting, and protection circuits. The impact of this integration is to reduce the number of connections between the power system-on-a-chip and the underlying printed circuit board. Current densities can be more than doubled using strategic integration. EPC has introduced many such integrated devices such as our EPC21XX family of monolithic half-bridges, FETs plus drivers, and monolithic power stages that include drivers, level shifters, logic, and a power FETs all on one GaN chip.

Bodo Arlt: What does the future hold for GaN? Where do you see significant opportunities for future expansion in technology and sales?

Alex Lidow: The applications taking advantage of GaN's superior performance continue to expand, and the knowledge base of GaN users continues to broaden. The world has seen in operation the autonomous vehicles that GaN enables. This technology is also increasingly used for autonomous rendezvous and docking in spaceflight as well as for robotics. Digital communications have been vastly improved with the use of GaN FETs and ICs in high speed, energy-saving envelope tracking power supplies. The dream of a wireless world is coming closer to reality with the emergence of large surface area wireless power.

Additionally, power converters used in harsh environments, such as space, high altitude flight, or high-reliability military applications must be resistant to damage or malfunctions caused by radiation. Commercial-off-the-shelf (COTS) eGaN FETs and ICs are smaller, more efficient, and lower cost than aging silicon devices. eGaN FETs and ICs perform 40 times better electrically than the Rad Hard devices typically used in these systems. This enables entirely new architectures for satellite power and data transmission, robotics, drones, and aeronautical power systems.

GaN technology also continues to evolve where EPC's latest generation of FETs and new integrated circuits can outperform, while being cost-competitive with silicon-based products. This combination of superior performance and competitive pricing has provided the incentive for traditionally conservative design engineers to begin using GaN products in applications, such as dc-dc converters, ac-dc converters, and automotive. There has been a wave of new 48 VIN DC-DC power supplies, both isolated and non-isolated, adopting our latest eGaN FETs for high-end computing and automotive applications.

The most significant opportunity for GaN to impact the performance of power conversion systems comes from the intrinsic ability to integrate both power-level and signal-level devices on the same substrate. EPC has been developing customer-specific GaN ICs for the past several years. The general release of more complex monolithic GaN solutions will offer in-circuit performance beyond the capabilities of silicon solutions and enhance the ease of design for power systems engineers. Keep tuned for more developments in this space!

Bodo Arlt: What resources are available for design engineers looking to get started with GaN?

Alex Lidow: Our website is a fantastic resource for engineers. We have application notes covering everything from design basics to full application circuit designs, reliability information, videos, reference designs, and demo boards to start. All reference designs and demo boards are provided with the schematic, gerber files, and bill of materials – everything needed to get designs started quickly. Our Buck Converter Calculator allows designers to input their specific design requirements and select the GaN FET or IC best suited for their conditions. We've also authored a series of textbooks to provide guidance on the use of GaN transistors in widely used power electronics systems. Our seminal text GaN Transistors for Efficient Power Conversion is now in its third edition. Recently released, the third edition has been substantially expanded to keep students and practicing power conversion engineers ahead of the learning curve in GaN technology advancements.

Bodo Arlt: Dear Dr. Lidow Thank you sharing your expertise and knowledge of GaN development and progress with my readers and we look forward to hearing further details during your presentation at the Power Conference next month.

Dr Alex Lidow joined International Rectifier as an R&D engineer and is the co-inventor of the HEXFET power MOSFET, a power transistor that displaced the bipolar transistor and launched modern power conversion. Over the 30 years Dr. Lidow was at IRF, his responsibilities grew from engineer to head of R&D, head of manufacturing, head of sales and marketing, and finally CEO for 12 years. In addition to holding many power MOSFET and GaN FET patents, Alex has authored numerous publications; most recently he co-authored the first textbook on GaN transistors, GaN Transistors for Efficient Power Conversion. In 2004 he was elected to the Engineering Hall of Fame, and in 2005 IRF, under his leadership, International Rectifier was named one of the best managed companies in America by Forbes magazine. Dr. Lidow earned a Bachelor of Science in Applied Physics from the California Institute of Technology and a doctorate in Applied Physics from Stanford University. Since 1998 Alex has been a member of the Board of Trustees of the California Institute of Technology. Alex Lidow - A Lifetime in Power Management

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