Challenges and Opportunities in Adopting Wide Band Gap Technologies like Gallium Nitride!

The power electronics industry is once again at a pivotal inflection point. The advent of wide band gap (WBG) semiconductors, especially Gallium Nitride (GaN), is unlocking unprecedented performance gains—from higher efficiency and smaller form factors to reduced cooling requirements and lower system costs. Yet despite these compelling benefits, adoption across certain industry remains sketchy, shaped by both technical and organizational challenges.

Challenges of technological shifts

Having started my career in the late 1980s, I have witnessed and taken part in several major transitions in power technology. I have seen the move from linear to switching power conversion, the shift from bipolar transistors to MOSFETs, and more recently, the transformation from analogue to digital control.

Now, we face the challenge and the opportunity of embracing WBG technologies such as GaN, but recalling from previous technology shifts, each change brought its own hurdles and there are always concerns about supply chains, reliability and customer's confidence and acceptance of something new.

GaN: A Leap Forward, not a Small Step

GaN offers a fundamentally different approach to power conversion. Its high electron mobility and breakdown strength allow devices to switch faster and handle higher voltages and frequencies than traditional silicon. This translates into higher system efficiency, more compact designs with improved thermal performance, and a greater operating frequency making magnetics smaller and boosting transient response. That sounds great but reaping these benefits is not as simple as replacing one device with another - if only it was!

IPC-9592 Standards			
Design For Reliability	**Design and Qualification Testing**	**Quality Processes**	**Manufacturing Conformance testing**
Specifying, designing and documenting performance and reliability	Performance to specification, Performance in intended environment EST, HALT	Quality Management Systems, Supplier and Sub-Tier Quality Requirements	Burn-In, ORT, HASS, HASA

Figure 01 – The four main sections of the IPC-9592 (Source: PRBX)

Engineering the Transition: Technical and Cultural Barriers
Adopting GaN devices demands a new design mindset. Engineers must contend with much faster switching transitions, tighter layout constraints, and stricter EMI control. While these are solvable with the right tools and experience, they mark a departure from traditional silicon design practices. Beyond design challenges, the broader ecosystem is still developing. Availability of GaN-compatible drivers, robust packaging, and clear application guidelines continue to improve but remain perceive as obstacles, especially for risk-averse organizations. And perhaps most importantly, rightly or wrongly, for many end-users' reliability remains a key concern. Many industries served by power electronics—such as medical, transportation, and industrial automation (without mentioning space and defense)—demand extreme reliability and any new technology must prove itself over time, under stress, and in the field. The power electronics industry is committed to ensuring a seamless and reliable transition as it works to change perception by building a trust and reliable transition processes.

Building trust in reliable transition processes

Keeping the IPC9592 in consideration
All power supply manufacturers thoroughly develop their own processes to verify the quality of their products before commercialization. This is all part of company know-how and their trade secrets, but I would like to take a minute to remember an initiative that took place twenty years ago and highly contributed to reducing the communication gap between Telecoms OEMs and suppliers when considering power supplies.

In 2005, with the guidance of the Institute of Printed Circuits (IPC), a group of leading Telecom OEM and Power Electronics professionals collaborated to establish a set of shared requirements for power conversion devices. These efforts culminated in the formulation of "Requirements for Power Conversion Devices for the Computer and Telecommunications Industries" which by the end of 2008 materialized as the so-called standard IPC9592. The document included guidelines for Design for Reliability, Design and Qualification Testing, and Quality Process and Manufacturing Conformance Testing (figure 01). With consideration for additional parameters, in 2010 the IPC9592A was released, followed in November 2012 by the IPC9592B.

Several power supplies companies are using in part or all of the IPC9592B standard but as many new technologies and market conditions have taken place over the last decade or more; e.g., Digital Control Technics, Wide Band Gap (WBG) semiconductors, and Cyber-resilience, naturally users now consider that the standard might need to be updated. Working groups such as the Power Sources Manufacturers Association (PSMA) Reliability Committee have initiated activities to restart this process which as at its origin will involve many experts from multiple disciplines.

It is difficult to predict when the next revision will be released but until then and in complement to the IPC9592B, power supplies manufacturers developing products for demanding applications are working in close collaboration with semiconductor manufacturers, and they are also conducting their own WBG component evaluations as specified by the JEDEC standard.

JEDEC and JC-70
With a long history starting in 1924 by the establishment of the Radio Manufacturers Association, by combining one council for both tubes and semiconductors, in 1958 the organization was renamed the Joint Electron Device Engineering Council (JEDEC). JEDEC has been the reference in the semiconductors industry and with the development of new technologies, in 2017 the JC-70 committee for Wide Bandgap Power Electronic Conversion Semiconductors was formed, along with two subcommittees: Gallium Nitride (GaN) and Silicon Carbide (SiC). In 2019 the JC-70 published its first document: JEP173: Dynamic On-Resistance Test Method Guidelines for GaN HEMT Based Power Conversion Devices. Since then, the JC-70 has published several documents such as the JEP198: Guideline for Reverse Bias Reliability Evaluation Procedures for Gallium Nitride Power Conversion Devices, which is used as a reference when qualifying GaN semiconductors.

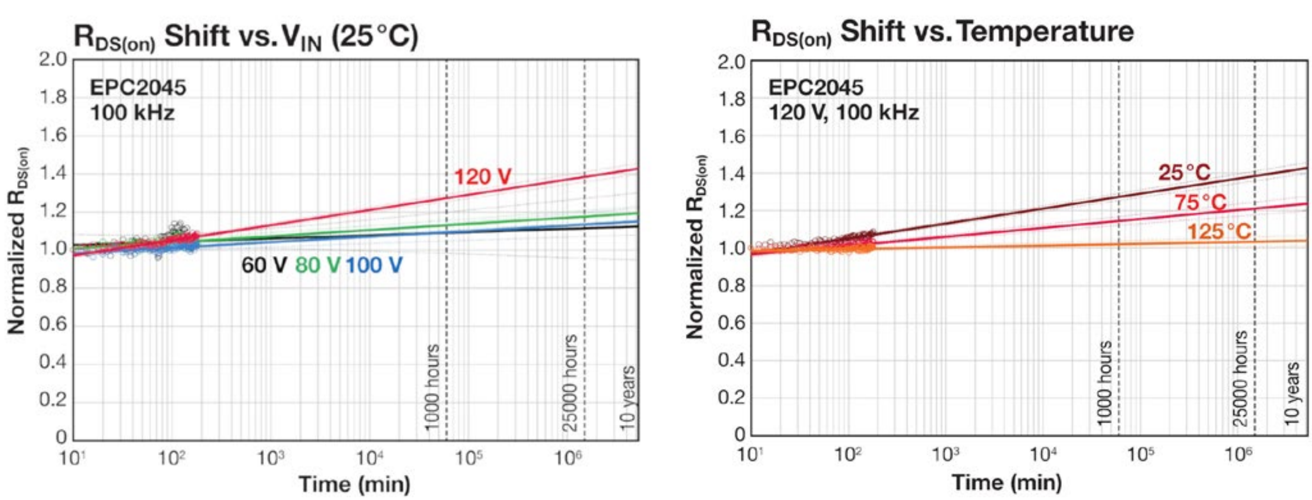
JEDEC standards for WBG are for sure important for semiconductors manufacturers but also for power supplies manufacturers as part of their new products development process and understanding of the reliability mechanisms related to that technology.

Demanding applications such as ruggedized industrial or space are extremely concerned by how power supplies manufacturers are qualifying new components and are requiring them to perform individual tests at component level based on the JEDEC standard, which requires a close collaboration with semiconductor manufacturers of a certain level of expertise in that area.

Building Confidence: EPC's Reliability Validation
As we have presented, adopting a new technology is very challenging and despite GaN transistors having been used in power amplifiers for a long time, the implementation of that technology to power electronics raises a lot of concern, requiring specific effort by the semiconductor manufacturers to demonstrate not only the benefits, but also to prove the long-term reliability of that technology.

In that respect, it's worth mentioning Efficient Power Conversion (EPC) which developed GaN semiconductors in a very innovative packaging when GaN power semiconductors were considered by many as a concept.

From its inception in 2007, to overcome skepticism EPC has conducted extensive reliability studies to validate device performance. The EPC's test programs included high-voltage bias stress, temperature cycling, power cycling, and accelerated life testing. These studies showed that GaN devices, when properly designed and integrated, can not only meet but exceed the reliability benchmarks established by silicon, which have been presented at conferences such as the Applied Power Electronics Conference (APEC).



**RDS(on) of a fifth generation EPC2045 GaN transistor over time at various voltage stress levels and temperatures.
On the left, the devices were tested at 25°C with voltages from 60 V to 120 V.
The graph on the right shows the evolution of RDS(on) at 120 V at various temperatures.**

Figure 02 – EPC2045 GaN RDS(on) shift versus input voltage and temperature, extracted from EPC GaN reliability and lifetime projection: Phase 17. (Source: With courtesy of Efficient Power Conversion (EPC))

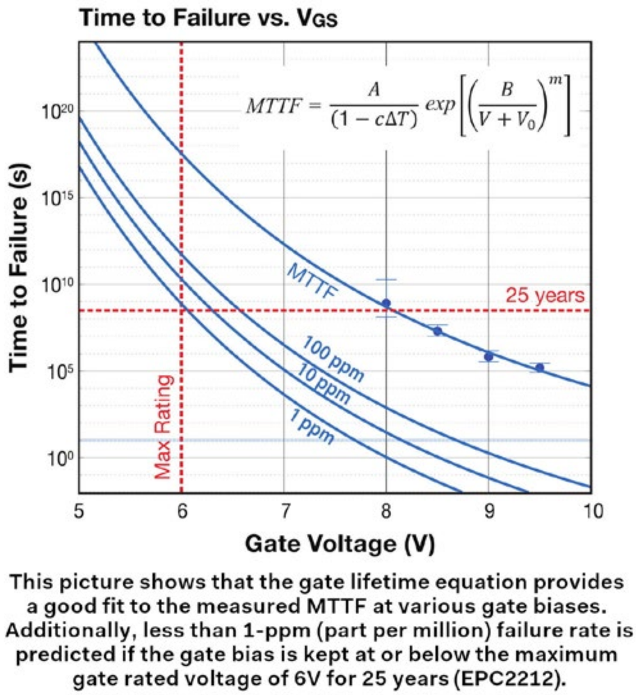


Figure 03 – EPC2212 lifetime calculation and verification, extracted from EPC GaN reliability and lifetime projection: Phase 17. (Source: With courtesy of Efficient Power Conversion (EPC))

Experimental results are interesting but equally important, EPC has published its findings openly, helping to create a foundation of trust and understanding of GaN technology. From Phase One released in 2019 to Phase Seventeen released in 2025, the test data shows that failure mechanisms in GaN are well understood and manageable, and that degradation is predictable over time, both being essential traits for designers to strongly consider when ensuring mission-critical operation (Figure 02, 03).

This type of third-party validation is crucial to driving broader acceptance. It bridges the gap between theoretical advantages and real-world deployment, particularly for engineers responsible for long-life systems.

COSEL: Applying GaN to Deliver Compact, Efficient Solutions

Established in Japan since 1969, the power supply manufacturer COSEL has been through the long chain of technology evolution and has been one of the pioneers in adopting switching power conversion and launching a range of commercial, Switch Mode Power Supplies, products in 1977. As we all know Japanese manufacturers have been the reference in developing quality best practices and so it's no surprise that when a new technology such as GaN emerged that they considered reliability first, before any technical benefit.

When qualifying GaN semiconductors for a new generation of power supplies, Cosel performed several tests such as High Temperature Reverse Bias reliability (HTRB). The High HTRB test is one of the most common reliability tests for power devices. Because HTRB tests stress the die, they can lead to junction leakage. There can also be parametric changes resulting from the release of ionic impurities onto the die surface, from either the package or the die itself. During an HTRB test the device samples are stressed, usually to 80 or 100% of repetitive peak reverse voltage (VRRM), at an ambient temperature close to their maximum rated junction temperature (TJMAX) over an extended period, usually 1,000 hours. (Figure 04). Then once the GaN power transistor has qualified and integrated into the power-stage of the power supply, a 1000 hours aging test has been performed to verify thermal stability. (Figure 05).

Figure 04 – 1000 hours High Temperature Reverse Bias reliability (HTRB), Ambient temperature 150∞C and 650VDds (Source: PRBX/COSEL).

COSEL TE series Aging test

Figure 05 – 1000 hours aging test to verify the temperature stability (Source: PRBX/COSEL).

COSEL TE series with GaN semiconductors

Figure 06 – COSEL TE series powered with GaN transistors and short-loop integrated transformers (Source: PRBX/COSEL).

The result is a new generation of power supplies that set benchmarks for performance, density, and reliability. In their latest research, COSEL demonstrated that by carefully co-designing the magnetic, control, and switching stages, power systems can achieve breakthrough levels of power density while maintaining stringent EMI and thermal targets (Figure 06).

Inspiring the Next Generation

What excites me most is the enthusiasm and innovation being driven by the next generation of engineers. Today's young designers are learning about GaN, SiC, and digital control as core elements of their engineering education. They're entering the field not with hesitation, but with a spirit of exploration.

They see power electronics not as a static discipline, but as a platform for invention where materials, control theory, packaging, and systems thinking all converge. And their openness to new technologies will be the catalyst for tomorrow's breakthroughs.

Even now, the industry is looking beyond GaN to diamond-based semiconductors which offer extraordinary thermal and electrical properties. While diamond devices remain in early research stages, their potential to redefine high-voltage, high-frequency conversion is enormous. This is not science fiction; this is where power electronics is headed.

Conclusion: The Opportunity Ahead

The adoption of GaN and other WBG technologies is more than a shift in materials, it's a shift in mindset. It requires embracing faster switching, smarter control, and tighter integration. It challenges power designers to break old habits and develop new skills. And it opens the door to efficiencies and capabilities that were previously out of reach.

Thanks to companies like EPC and COSEL, we are beginning to see the tangible impact of GaN in the real-world for demanding applications. Their work validates the technology, reduces the learning curve, and gives power designers the tools they need to succeed.

As someone who has seen several waves of innovation in this field, I believe we are at the beginning of one of the most exciting chapters yet. The technologies are here, the data is encouraging, and the new generation of engineers are ready to take the lead.

The future of power electronics is not just brighter, it's smaller, cooler, faster, and far more efficient. From GaN to diamond, the possibilities are limitless.

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About Powerbox

Founded in 1974, with headquarters in Sweden and operations in 15 countries across four continents, Powerbox serves customers all around the globe. The company focuses on four major markets - industrial, medical, transportation/railway and defense - for which it designs and markets premium quality power conversion systems for demanding applications. Powerbox's mission is to use its expertise to increase customers' competitiveness by meeting all of their power needs. Every aspect of the company's business is focused on that goal, from the design of advanced components that go into products, through to high levels of customer service. Powerbox is recognized for technical innovations that reduce energy consumption and its ability to manage full product lifecycles while minimizing environmental impact. Powerbox a Cosel Group Company.

Patrick Le Fèvre
Powerbox Chief Marketing
& Communication Officer

About the author

Chief Marketing and Communications Officer for Powerbox, Patrick Le Fèvre is an experienced, senior marketer and degree-qualified engineer with a 40-year track record of success in power electronics. He has pioneered the marketing of new technologies such as digital power and technical initiatives to reduce energy consumption. Le Fèvre has written and presented numerous white papers and articles at the world's leading international power electronics conferences. These have been published over 450 times in media throughout the world. He is also involved in several environmental forums, sharing his expertise and knowledge of clean energy.

For more information

Visit www.prbx.com
Please contact Patrick Le Fèvre, Chief
Marketing and Communications Officer
+46 (0)158 703 00

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