



# GaN Transistors for Efficient Power Conversion

By Alex Lidow, Johan Strydom, Michael de Rooij, David Reusch

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Gallium nitride (GaN) is an emerging technology that promises to displace silicon MOSFETs in the next generation of power transistors. As silicon approaches its performance limits, GaN devices offer superior conductivity and switching characteristics, allowing designers to greatly reduce system power losses, size, weight, and cost.

This timely second edition has been substantially expanded to keep students and practicing power conversion engineers ahead of the learning curve in GaN technology advancements. Acknowledging that GaN transistors are not one-to-one replacements for the current MOSFET technology, this book serves as a practical guide for understanding basic GaN transistor construction, characteristics, and applications. Included are discussions on the fundamental physics of these power semiconductors, layout and other circuit design considerations, as well as specific application examples demonstrating design techniques when employing GaN devices.

With higher-frequency switching capabilities, GaN devices offer the chance to increase efficiency in existing applications such as DC–DC conversion, while opening possibilities for new applications including wireless power transfer and envelope tracking. This book is an essential learning tool and reference guide to enable power conversion engineers to design energy-efficient, smaller and more cost-effective products using GaN transistors.

Key features:

- Written by leaders in the power semiconductor field and industry pioneers in GaN power transistor technology and applications.
- Contains useful discussions on device–circuit interactions, which are highly valuable since the new and high performance GaN power transistors require thoughtfully designed drive/control circuits in order to fully achieve their performance potential.
- Features practical guidance on formulating specific circuit designs when constructing power conversion systems using GaN transistors – see companion website for further details.
- A valuable learning resource for professional engineers and systems designers

needing to fully understand new devices as well as electrical engineering students.

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### **Editorial Review**

#### Review

“This book will be the definitive text for Gallium Nitride (GaN) transistors and applications for many years. It is a well written text that will be useful for both new and seasoned engineers to this exciting, disruptive, technology. The text flows logically, expertly and very accessibly from material properties, through device physics to applications covering both the theoretical and practical aspects of this field. The authors present compelling data that shows GaN to be far superior to silicon in the power conversion arena and leaves the reader with a desire and a challenge to use GaN in their own applications. A great read! A great technology!”—**Simon P. Wainwright, Vice President & General Manager, Hi-Rel Group, Microsemi Corporation, USA**

“I have been working on power semiconductor devices for almost 30 years and I must say this a well written book on a great emerging technology. The book conveys complicated device physics in a simple to understand manner while focusing on practical application and impact. This is particularly timely since GaN power device is still a very new technology and few people understand it well. The discussion on circuit layout, parasitics and various applications are particularly useful and very insightful. As GaN devices keep pushing the envelope of high frequency applications, this book is a must read reference book for anyone who wants to design GaN transistors or any application engineers that want to develop the best GaN converters. I am recommending all my students to read this book”.—**Alex Q. Huang, NSF FREEDM Systems Center, Keystone Science Center, North Carolina State University, USA**

“GaN technologies and devices have received great attention in microwave and power electronics applications recently, due to its inherent material merits over the conventional Si. This is the right time to have this book published, particularly as the authors are from the industry and know exactly what engineers’ needs are. This book provides a broad and in depth knowledge of GaN device characteristics, design consideration and circuit topology – making it the perfect handbook for engineers or college students who are interested in semiconductor power electronics”.—**Ian Chan, Episil Technologies, Inc., Taiwan**

“This easy-to-follow text is well written for both engineers and students at all levels. It not only gives the information of device physics for readers to understand GaN transistors, but also presents the critical knowledge on how to using GaN transistors for efficient power conversion in terms of driving, PCB layout, and measurement, which is very important. I think authors have produced a piece of work that will become one of the classic texts for GaN technologies”.—**Qiang Li, Bradley Department of Electrical & Computing Engineering, Virginia Tech, VA, USA**

“For engineers and researchers interested in the emerging GaN power electronics, this book provides valuable and easy-to-read discussions on device technology, device operations and circuit applications. The authors have done a great job in providing insightful discussions on device-circuit interactions. These discussions are particularly valuable since GaN power devices exhibit many distinct characteristics and require tailor-made application approaches to fulfill their promise. I would recommend all my students and colleagues interested in developing high-efficiency power electronics”.—**Kevin J. Chen, Department of Electronic and Computer Engineering, The Hong Kong University of Science and Technology, Hong Kong, China**

“This book is a timely contribution to the field when the topics of electric energy efficiency and carbon emission have grabbed world-wide attention. Although the focus of the book is on the applications of the up-and-coming GaN power semiconductor switch, proper treatment of the device physics is given so that the users can gain insight into the limitation/potential of the new device. The knowledge gained will benefit further development of the device in the future. The addition of Chap. 8 on “RF Performances” is very beneficial. This is a new frontier for power electronics engineers. Overall, it is a very well written book with comprehensive references and proper coverage of the various subtopics. I would certainly recommend this for our curriculum in the Power Electronics Program here at Taiwan University”—**Dan Chen, Department of Electrical Engineering, National Taiwan University, Taiwan, China**

“The topics covered...provide an original contribution that revisits and expands the high frequency circuit analysis giving a good understanding to the reader of how GaN transistor circuit behavior can be modeled. Designers should find that the practical layout tips are useful when building prototype converters with GaN transistors...The hands-on content in the form of graphical data and experimental waveforms should be appreciated by power electronic circuit designers. History has shown that breaking through with a new technology with a lot of potential is not easy. Displacing any existing established technology is very difficult, and the question is what it would take for GaN power transistor technology to reach the tipping point. A book to educate engineers can help to build up momentum”—**Braham Ferreira, Faculty Electrical Engineering, Mathematics and Computer Science, TU Delft, The Netherlands**

This is a comprehensive book on GaN technology and its applications. The book firstly reviews the development of GaN technology, which includes the introduction of silicon devices and the structure of the GaN device. The core content of this book includes the characteristics, driving, layout, modeling and measurement of the GaN device. Also, the device parameter, parasitic parameter, thermal performance, driving circuit,  $dv/dt$  &  $di/dt$  performance, electrical modeling, thermal modeling of the GaN device for high frequency and high efficiency applications are analyzed in detail. I believe that [Alex Lidow's] pioneering work in GaN devices will give many insights to power electronics engineers in decades [to come]”—**Yongdong Li, Department of Electrical Engineering, Tsinghua University, Beijing, China**

"In the power semiconductor industry, the development of gallium nitride (GaN) transistors has been increasingly valued. On one hand, this rise of GaN is fuelled by its enhancement of robustness of devices under the operating conditions of high switching speed and low on-resistance, as well as its high output power capabilities. In addition, the adoption of GaN transistors has been propelled by the insatiable appetite for innovating higher-performance new material and technology in the semiconductor industry.

As one of the authors of this book, Alex Lidow has been contributing to the development of advanced power conversion with significant milestones. This 2nd Edition of “GaN Transistors for Efficient Power Conversion” textbook has been expanded from its 1st Edition. It includes the latest technological development of gallium nitride devices and an expansion of application examples, which makes the book an even more powerful and useful guiding tool for readers.

This book has been by far the most comprehensive textbook relating to gallium nitride transistors that I have ever read.”—**Yorbe Zhang, Editor-in-Chief and Head of Content, Global Sources eMedia Asia Group**

From the Back Cover

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About the Author

**Alex Lidow** is CEO of Efficient Power Conversion Corporation (EPC). Prior to founding EPC, Dr. Lidow was CEO of International Rectifier Corporation. A co-inventor of the HEXFET power MOSFET, Dr. Lidow holds many patents in power semiconductor technology and has authored numerous publications on related subjects. Lidow earned his Bachelor of Science degree from Caltech in 1975 and his Ph.D. from Stanford in 1977.

**Johan Strydom** is Vice President, Applications at EPC Corporation. He received his Ph.D. from the Rand Afrikaans University, South Africa in 2001. From 1999 to 2002 he worked as a post-doctoral researcher at the Center for Power Electronics (CPES), Virginia Tech. Dr. Strydom held various application engineering positions at International Rectifier Corporation and Linear Technology Corporation, working on DC-DC converters, motor drives, and class-D audio.

**Dr. Michael A. de Rooij** is Executive Director of Applications Engineering at Efficient Power Conversion Corporation (EPC). Prior to joining EPC he worked at Windspire Energy where he helped develop the next generation of small vertical-axis wind turbine inverters. In addition, Dr. de Rooij has worked as a Senior Engineer at the GE Global Research Center. Dr. de Rooij's research interests and activities include, solid-state high-frequency power converters and devices, utility applications of power electronics, uninterruptible power supplies, integration of power electronic converters, power electronic packaging, induction heating, photovoltaic converters, Magnetic Resonance Imaging (MRI) Systems and gate drivers with protection

features. Dr. de Rooij is a Senior Member of the IEEE. He received his Ph.D. from the Rand Afrikaans University (now called The University of Johannesburg), South Africa.

**David Reusch** is Director, Applications at EPC Corporation. Dr. Reusch earned a doctorate in electrical engineering from Virginia Tech, where he also earned his bachelor's and master's degrees. While working on his Ph.D. he was a Bradley Fellow at the Center for Power Electronics Systems (CPES). Dr. Reusch has first-hand experience designing with GaN transistors to meet the demands for lower loss and higher power density in power converters. He is active in IEEE organizations and during the last several years has published papers at APEC and ECCE conferences.

## Users Review

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Spent a free time for you to be fun activity to complete! A lot of people spent their leisure time with their family, or their friends. Usually they doing activity like watching television, about to beach, or picnic inside park. They actually doing same every week. Do you feel it? Will you something different to fill your personal free time/ holiday? Could possibly be reading a book can be option to fill your totally free time/ holiday. The first thing you ask may be what kinds of publication that you should read. If you want to test look for book, may be the reserve untitled GaN Transistors for Efficient Power Conversion can be great book to read. May be it can be best activity to you.

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