Guest Editorial

SOLID-STATE power amplifiers are replacing vacuum tubes for microwave and millimeter-wave power applications. However, since the operating voltages of conventional solid-state devices are low, a large device periphery is needed, which presents a low-impedance level and leads to high matching losses. Also, the complexity associated with large periphery devices reduces production yield and reliability. Over the last several years, wide-bandgap semiconductor devices, such as SiC MESFETs and GaN high electron-mobility transistors (HEMTs), have lived up to their promise and, in both university and industry laboratory settings, have yielded the much anticipated 5–10 times increase in power density when compared to more conventional device technologies such as Si LDMOS and GaAs- and InP-based HEMTs and HBTs. Now, for the same output power, a fivefold to tenfold reduction in device periphery can be realized. This will ultimately result in reduced circuit complexity, higher bandwidth, improved gain, efficiency, yield, reliability, and low cost. Maturation of this technology will directly impact both military (e.g., radar) and commercial applications (e.g., base station, wireless local area network (WLAN), satellite communications, local multipoint distribution system (LMDS), and digital radio).

While many technical challenges still remain before wide-bandgap technologies can be fully exploited for the range of applications listed above, SiC- and GaN-based materials and devices have now matured to the point where university and industry laboratories have begun to investigate circuit applications. SiC MESFETs have already made their way into product offerings. In this TRANSACTIONS' Special Issue is presented a set of contributed papers that cover a wide range of topics relevant to the application of wide-bandgap semiconductor devices for RF (microwave) applications.

In order to begin to exploit the wide-bandgap devices for circuit application, one requires two things, i.e., the semiconductor device and its equivalent-circuit model. In the first paper, Rashmi *et al.* provide a comprehensive analysis of the electrical performance of AlGaN/GaN HEMTs as a function of strain. They propose a device model that predicts the dc and small-signal transistor performance and incorporates the effects of strain and strain relaxation.

Current collapse and trapping in GaN-based HEMTs is a major industry-wide challenge. Green *et al.* present an excellent dynamic load-line analysis, illustrating microwave performance limits of state-of-the-art GaN HEMTs and suggest electron trapping associated with the surface of the device between the gate and drain as the mechanism that limit the ultimate power, power-added efficiency (PAE), and linearity of AlGaN/GaN HEMTs. Khan *et al.* present a comprehensive review of their device engineering efforts to develop current collapse-free insulating gate GaN-based heterostructures field-effect transistors (HFETs) and describe high-power microwave amplifiers and switches based on these devices. Kohn *et al.* discuss electrical and thermal transient effects and report on structures in which field-induced image charges are substituted by doping impurities. These structures are also aimed at eliminating the aforementioned current collapse.

While output power is one key figure-of-merit for many applications, of equal and sometimes greater importance are amplifier efficiency and linearity. To this end, Paidi *et al.* discuss the development of high-linearity high-efficiency GaN HEMT power amplifiers. Their paper provides a thorough tutorial on high-efficiency amplifier design covering various approaches including class-B push–pull and single-ended class-B common source and common drain. Chung *et al.*, using their active integrated antenna concept, discuss the direct integration of a GaN HFET amplifier with a microstrip antenna. This novel approach utilizes the microstrip antenna as the transistor output matching to realize a highly efficiency integrated RF front-end. Nagy *et al.* present data on GaN HEMT linearity for use in wireless communication base-station applications. Smorchkova *et al.* report on the power and noise-figure performance of AlGaN–GaN HEMTs and discuss viability of AlGaN–GaN HEMTs for higher frequency (K- and Ka-bands) and low-noise amplifier (LNA) applications. Finally, Simons *et al.* describe the development of low-intermodulation-distortion SiC Schottky barrier RF mixer diodes and circuits for use in avionics applications.

We express our sincere gratitude to all the reviewers for their thorough evaluations of the submitted papers and to Dr. David Rutledge, Dr. Robert York, and Ms. Heather Hein for their guidance and help in the process of making this Special Issue.

This TRANSACTIONS' Special Issue papers are just the tip of the iceberg. As material and device technologies continue to mature, we will witness an explosion of applications (and papers) that capitalize on the unique properties and circuit-enabling characteristics of the wide-bandgap semiconductors. Happy reading.

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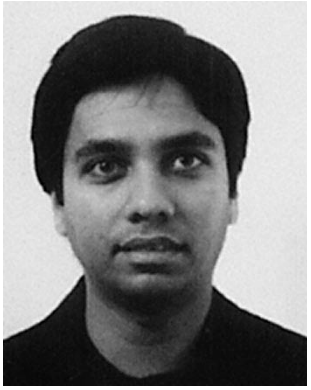
Digital Object Identifier 10.1109/TMTT.2002.807679



Primit A. Parikh (S'94–M'97) received the B.Tech. degree in electrical engineering from the Indian Institute of Technology (IIT), Bombay, India, in 1993, and the M.S. and Ph.D. degrees in electrical and computer engineering from the University of California at Santa Barbara (UCSB), in 1994 and 1998, respectively. His doctoral dissertation focused on high-efficiency power amplification, which led to the fabrication of record-high-efficiency GaAs-on-insulator (GOI) transistors.

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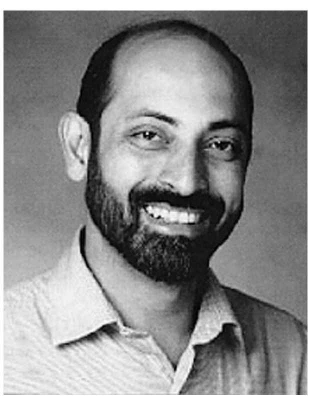
Dr. Kazior was a recipient of the 2001 Raytheon Excellence in Technology Award for his leadership role in the development of advanced compound semiconductor device technology, as well as a participant in the National Academy of Engineering's 2002 Frontiers in Engineering Symposium.



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Dr. Mishra was a corecipient of the Hyland Patent Award presented by Hughes Aircraft and the Young Scientist Award presented at the International Symposium on GaAs and Related Compounds.