

WMF (IMS) Monday 08:00 – 17:00 BCEC Room 157AB
Is GaN Ready for System Insertion?
Full-day workshop reviewed by MTT-6, MTT-16, MTT-20

Organizer(s):

Bernie Geller, BDG Consulting Services, , USA; MTT-6, MTT-20, IMS TPC.

Ruediger Quay, Fraunhofer Institute, Freiburg, Germany; MTT-6.

Frank Sullivan, Raytheon Company, Sudbury, MA, USA; MTT-6, MTT-16, IMS TPC.

The significant benefits of power density, efficiency, and bandwidth brought by GaN technology have brought with them substantial system-related issues, such as the need for higher operating voltages, more efficient heat removal techniques, high reliability, and, of course, affordability. These issues have called for innovative solutions not only on the system side, but also in the design, manufacture, packaging, and testing of these devices. The objective of this workshop is both to help GaN component developers understand system issues which will effect their designs and, conversely, to help system designers understand both the potentials and limitations of GaN technology in its various forms. We will have eight speakers covering a broad range of topics. The first two speakers, from Cree and Nitronex, deal with the component-level technical status and reliability of GaN discretes and MMICs on both silicon carbide and silicon substrates. The third talk, from RWTH, addresses the status and trends of non-linear modeling of GaN-rf devices. The fourth talk, from the Fraunhofer Institute, discusses the management of power densities with respect to ruggedness and thermal performance. The fifth talk from Alcatel-Lucent deals with the potential of GaN technology in mobile radio communication systems. The sixth and seventh talks, from Rockwell and EADS defense electronics are devoted to military and government system requirements and the application of GaN MMICs in military systems, specifically radar and electronic warfare. The last talk, by Raytheon, will focus on cost and affordability issues. The workshop will conclude with a panel discussion in which the attendees will be asked to submit their questions and comments to the speakers.

Speakers:

1. Ray Pengelly, Cree Inc. Research Triangle Park, NC 27709

“GaN HEMT Technical Status: Transistors and MMICs for Military and Commercial Systems”

GaN HEMT devices have recently emerged from research and development through pre-production and into qualified production status. Cree’s standard 28 volt GaN on SiC HEMT COTS (0.45um gate length) process operates at 4 watts per millimeter of gate periphery at frequencies to 6 GHz while Foundry processes are capable of operating to 18 GHz. In addition, through the use of field-plated structures breakdown voltages have been substantially increased such that transistors can be operated at drain voltages over 50 volts. In the latter case power density is increased to over 8 watts per millimeter. The ultimate performance of the devices at these high power densities will be limited by thermal management. Examples will be given using thermal modeling (both CW and transient) of bare and packaged transistors (and MMICs) to show what determines overall

thermal resistance and time constants. Various new package materials that have improved thermal conductivity will also be covered.

2. Kevin Linthicum, Nitronex Corporation, Durham, NC USA
“Status of GaN-on-Silicon for Military and Commercial Communications Systems”

Initial adoption and design wins of GaN-based technology for wireless communication has clearly been established in 2008 in military secure communications and electronic warfare. Although both markets leverage power amplifier performance enabled from the intrinsic properties of GaN-based HEMTs (e.g. high power density, high breakdown voltage, high input/output impedances and reduced die-level parasitics), the system architectures and consequential device level requirements lead to different product specifications. Military secure communications require robust performance over much broader bandwidths, favoring transistor products with less complicated internal designs, high breakdown voltage and better heat dissipation. Whereas commercial communications call for device designs favoring relatively narrower bandwidths, high efficiency using high PAR. Given these guidelines, we will discuss the status of our product line which addresses these different market requirements.

3. R. H. Jansen, RWTH Aachen University
“Advanced Large-Signal Modeling of GaN Power Devices, Electrical, Thermal and Distributed Effects”

GaN power devices have now arrived in the commercial market place, e.g. in WIMAX base stations, and are reaching power and efficiency levels which could soon replace vacuum tubes in radar. In parallel to this, modeling techniques for such power HEMTs have become more sophisticated and accurate, also suitable scaling techniques have been explored for devices which exceed measurement equipment power levels. The respective approaches are outlined and address interacting electrical, thermal and distributed effects up to describing temperature distribution in devices under LS operation. First results of combined electro-thermal distributed simulation will be presented.

4. Rüdiger Quay, Fraunhofer Institute of Applied Solid-State Physics
“Managing Power Density of High-Power GaN Devices”

While the rf-power densities of GaN scale up to values of 40 W/mm unit-gate width, quantities such as thermal conductivities of the substrate and packaging materials, maximum system temperatures, and allowable dissipated power per area do not scale accordingly. Thermal management is thus crucial in order to harvest at least a fraction of the maximum electrical potential of GaN in packaged devices and mounted MMICs. The rf-power is clearly limited by thermal constraints even for efficient operation, and ruggedness and VSWR-constraints further modify the potential of GaN in real systems. This is especially true for high voltage operation and for harsh environments with reduced thermal budget. This talk addresses considerations of RF-power densities in GaN

discretes and MMICs. It is based on thermal simulations and imaging, packaging and integration of discretes and MMICs, and investigations of typical VSWR- and ruggedness constraints with regard to the high power levels and densities.

5. Patrick Jüschke, Alcatel-Lucent Bell Labs Radio Communications
“GaN Technology for Future Mobile Radio Communication from a System Supplier’s Perspective”

Modern radio communication is characterized by complex modulation schemes like WCDMA or OFDM, in order to enable high data rates, required by today's and future multimedia applications. However, complex modulation leads to high linearity requirements over a wide power range e.g. for the power amplifier module. This causes reduced amplifier efficiency, compared to e.g. GMSK modulation, used for GSM. Due to the fact, that the power amplifier module causes a high portion of the total power consumption of modern base stations, there is a urgent demand for highly efficient power amplifiers. In addition to the described demand for clear efficiency improvement, a further challenge for the power amplifier arises out of future applications such as Software Defined Radio (SDR) or Cognitive Radio. Both applications require multiband and multistandard capable base stations in order to address several communication standards and frequency bands by the same hardware.

6. Mike Wojtowicz, Northrop Grumman
“Status of GaN HEMT Technology for MMW Applications”

7. Patrick Schuh, EADS Defense Electronics, Ulm, Germany
“Using GaN Technology in Military Systems”

Active electronically scanned array (AESA) radars are increasingly being favored over conventional mechanically-scanned systems. The achievable radar range of such an AESA radar is mainly determined by the output power and the noise figure of the antenna. T/R-modules are key elements in active phased array antennas for radar and electronic warfare applications. Inside these T/R-modules two main building blocks are the amplifier chain in the transmit path and the low noise amplifier in the receive path. For these applications the use of amplifiers based on GaN technology is a very promising approach. With GaN MMICs it is possible to realize AESA EW jammers, due to the output power level and also the broadband capability. With these new jammers an intelligent directed jamming is possible, reducing the total effective radiated power. The GaN technology is an enabling technology for multi-functional array systems.

8. Colin S. Whelan, Raytheon Company, Andover, MA
“Affordability of Gallium Nitride Technology”

Gallium nitride (GaN) provides not only revolutionary RF performance over gallium arsenide (GaAs), but does so cost effectively. Because of the higher power densities in GaN, an equal size Monolithic Microwave Integrated Circuit (MMIC) in GaN would produce significantly more power than in GaAs, making it cost effective in dollars per Watt. Conversely, a GaN MMIC of equal power to GaAs would be significantly smaller in size, also resulting in an affordable solution.

9. Panel Discussion