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TriQuint Delivers High Power - Wideband GaN Technology

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GaN Development and Defense Applications

TriQuint Semiconductor began investigating gallium nitride (GaN) technology in 1999 along with industry and university partners who also saw advantages in developing GaN for defense and commercial applications. Through subsequent years, a baseline process was developed and success with these efforts led to TriQuint's award in 2005 of a DARPA (Defense Advanced Research Projects Agency) contract focusing on technology maturity and wideband performance. This research and development effort, now in the third year of a five-year plan, has resulted in a production-released 0.25um gate process supporting products from DC to 18GHz and achieving power levels in excess of 100W.

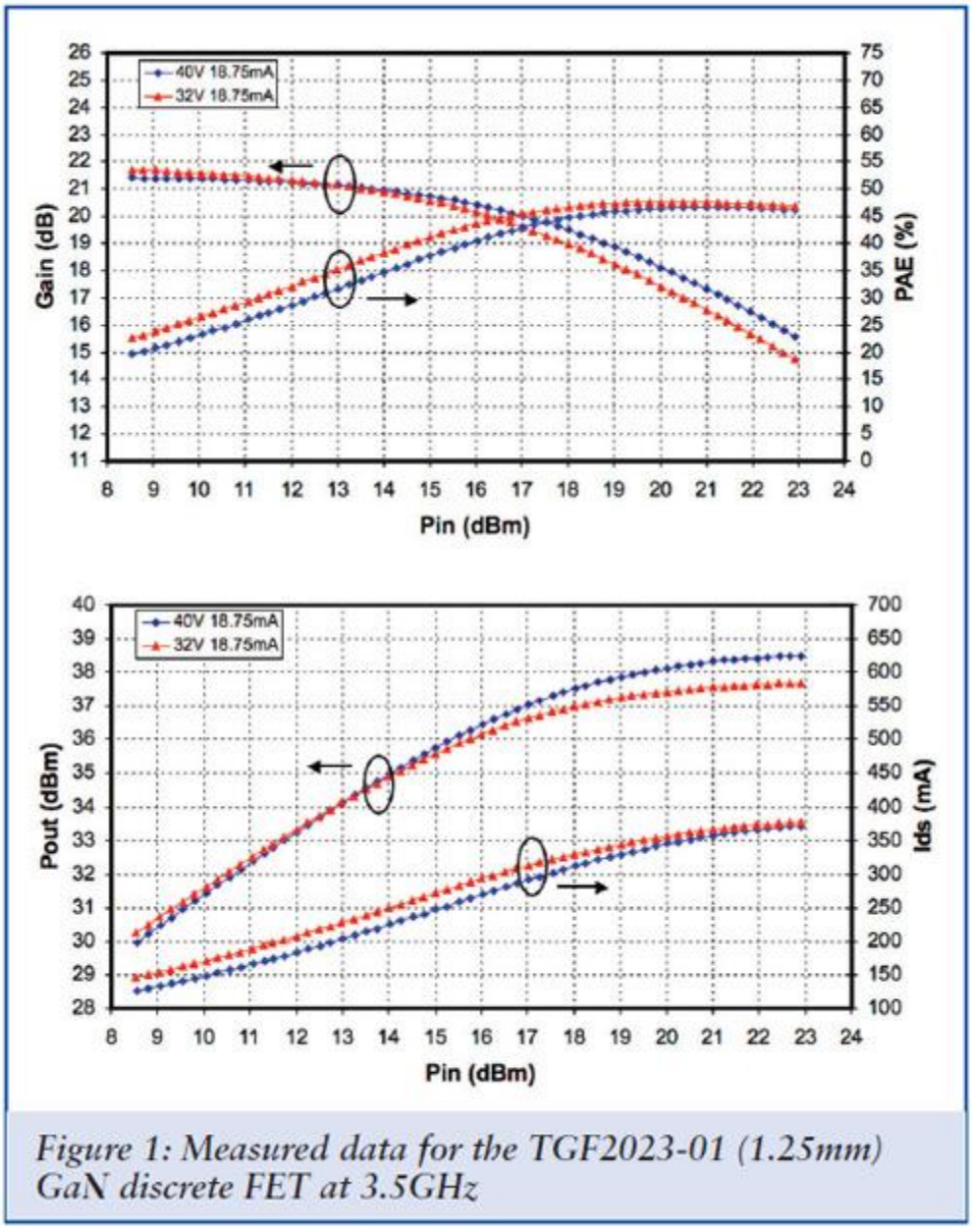

Figure 1: Measured data for the TGF2023-01 (1.25mm) GaN discrete FET at 3.5GHz

Designers of many different military systems, such as phased array radars, communications and electronic warfare, are anxious to benefit from the advantages of GaN technology. GaN offers high power density, high efficiency and exceptional wideband performance compared to existing processes now used in major defense applications. Therefore, GaN's entrance as a viable product technology and impact on how these military systems are designed is expected to be dramatic. Key benefits such as higher power densities would allow smaller device form factors or more power in the equivalent space. High efficiency will simplify circuit designs and relieve system level stresses. Couple these benefits with GaN's good noise and linearity characteristics and one can begin to appreciate the range of applications this technology will be able to support.

Potential Drives Research and Reliability Focus

A key gallium nitride advantage is its ability to maintain high operating voltages at higher frequency ranges. Gallium nitride devices perform in this manner because the expected trade-off between operating voltage and frequency occurs at a slower rate in GaN-based products when compared to other high power technologies such as silicon carbide, LDMOS and high-voltage gallium arsenide (GaAs). Therefore, as frequencies move into the higher range (>10GHz), GaN will quickly distinguish itself from competing technologies in terms of power generation. By maintaining high operating voltage, GaN can achieve millimeter-wave power levels never before realized by solid state devices. In order to support this leap in high frequency power, TriQuint currently has a 30W Ku-band high power amplifier (HPA) in development, with initial results expected in early 2009. In addition to the Ku-band activity, longer lead development is targeting a 5W Ka-band HPA. Additional information regarding TriQuint's Ka-band development can be obtained through the 2007 IEEE MTT-S paper titled, "ALGaN/GaN HEMTs with PAE of 53% at 35GHz for HPA and Multi-Function MMIC Applications."

Although raw performance is a product characteristic that designers commonly seek, reliability continues to be a key factor impacting the industry's full acceptance of GaN as a viable technology. Given this concern, reliability integrity has been a central focus for TriQuint as the company moved through development stages and brought this technology into production. TriQuint's preliminary reliability data shows a typical lifetime of 2E6 hours at 150 degrees junction temperature. Resulting activation energy is 1.08eV. Thermal management is key in achieving acceptable reliability. Because of this, TriQuint has selected silicon carbide (SiC) as the substrate of choice, combining the best overall grade in thermal conductivity, price and electrical performance. Along with SiC, TriQuint has worked with various substrates including silicon (Si) and diamond, with each having potential in certain areas. In a continuous improvement effort, TriQuint is working with alternative substrates and other material and process characteristics with the goal of improving robustness and overall reliability without sacrificing the electrical performance that customers require.

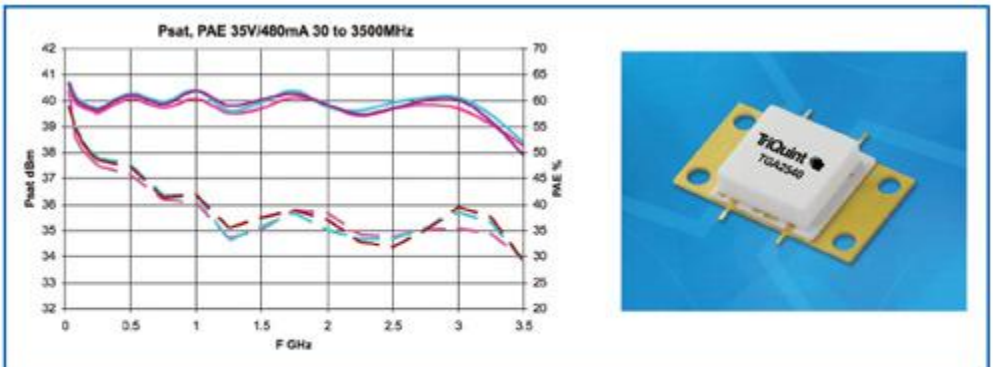

Figure 2: TriQuint's new TGA2540 is shown along with data from measurements taken at a drain bias of 35V, 480mA

TriQuint Products and Foundry Services

To meet industry demand, initial product development at TriQuint has focused on discrete FETs (field effect transistors) along with wideband amplifiers. TriQuint's family of discrete GaN transistors is documented on the company's website under part number TGF2023. The devices' operating frequency range is DC to 18GHz, providing for full coverage of many military and commercial applications. Furthermore, in order to cover a wide range of power requirements, available FET sizes begin at 1.25mm and increase to 2.5mm, 5mm, 10mm and 20mm. The larger discretes all use the 1.25mm device as their building block.

The TGF2023 family was designed for reliable CW operation under a drain bias of 28V. This results in a power density of approximately 4W/mm. Under these conditions, the 1.25mm discrete will provide 6W of output power, with the 20mm discrete producing up to 100W of output power. Efficiency levels for all the discrete devices run in the 50% range. Online datasheets provide relevant electrical, thermal and mechanical information along with linear models and s-parameter files. Non-linear models are planned and are estimated to be available by mid-2009. Discrete products available today are in bare die form, providing customers with maximum flexibility in hybrid design as well as a vehicle for proving out system level concepts. Figure 1 illustrates RF performance of the baseline 1.25mm discrete at 3.5GHz.

In addition to its present discrete device offerings, TriQuint is in the process of releasing two new wideband GaN amplifiers. The first such new GaN product, the TGA2540, is scheduled for release and sample availability in January 2009. The TGA2540 is a 30-3000MHz packaged distributed amplifier designed for military radio applications. The TGA2540 achieves a relative flat 10W across the entire operating band with 38% average power added efficiency; package size is 17x11.5mm.

The TGA2570 is the second GaN amplifier scheduled by TriQuint for early 2009 release. It is a 2-17GHz distributed wideband amplifier providing 10W minimum output power through 15GHz, with 8W output power at 17GHz. With an optimum drain bias of 35V, power added efficiency is typically above 20% across the entire operating band. Planned enhancements will include the extension of the upper end of the band to 18GHz for full Ku-band coverage. Ideally suited for EW applications, the TGA2570 is 15mm2 and offered in bare die form.

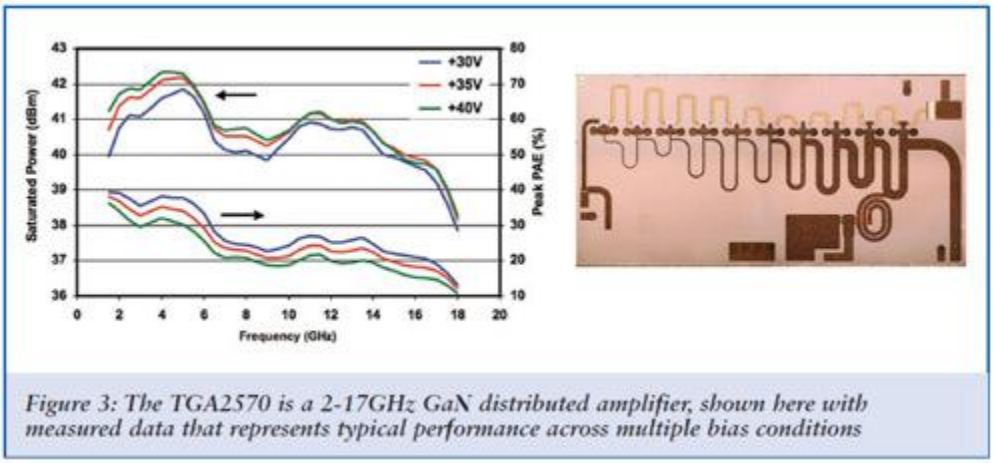

Figure 3: The TGA2570 is a 2-17GHz GaN distributed amplifier, shown here with measured data that represents typical performance across multiple bias conditions

TriQuint's gallium nitride standard product portfolio is complemented by its world-class foundry services group1. Utilizing available design kits that include linear and non-linear models, design rules, artwork and process information, customers have the necessary tools to design for their specific frequency and performance requirements. In addition, TriQuint offers various fabrication options to better align with customers' needs. The prototype chip option (PCO) is a pre-scheduled, multiple customer mask which provides a basic fabrication run without electrical test and minimal delivered die. For a customer seeking an enhanced level of service and testing, TriQuint also offers its prototype wafer option (PWO), with a mask dedicated to that customer, paired with the advantages of full electrical testing and delivery of two PCM-good wafers.

Conclusion

In the ever-changing defense landscape, current and future military applications are requiring the next step in power and efficiency along with multi-function capability from component suppliers. TriQuint's GaN technology and related products will make possible smaller, more efficient systems producing equivalent power compared to their predecessors, along with wideband systems that deliver power levels never before achievable from solid state devices. Applications once thought to be out of reach are now being realized. TriQuint will continue to bring technology and products to market that allow customers to make the next leap in system evolution.

Information about TriQuint's TGF2023 gallium nitride device family is available at www.triquint.com. The company's newest GaN devices will be detailed beginning in January 2009 on the website. For access,

samples or to discuss engineering requirements, e-mail TriQuint at:

info-military@tqs.com; or check the TriQuint website for the nearest local representative sales office: http://www.triquint.com/sales/index.cfm

1TriQuint has been ranked as the world's largest GaAs foundry service and the defense industry's leading foundry provider, according to Strategy Analytics' 2008 semiconductor market reports: © Strategy Analytics, August 2008: GaAs Device Vendor Market Share, North America; GaAs Device Vendor Market Share: Asia-Pacific and Europe.