Application of GaAs pHEMTs for High Frequency Switching Power Conversion Circuits

by

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ABSTRACT

The innovations in low voltage (under 50 V) power electronic systems are driven by the requirements of high energy efficiency, bandwidth, size and cost, mainly in the portable electronics domain. The specifications imposed by system trends require switch mode power conversion circuits to operate at increasingly high switching frequencies without compromising the power efficiency, and to be implemented in System-On-Chip or System-in-Package form factors using power ICs.

This research presents a power IC technology platform based on AlGaAs/InGaAs/AlGaAs pseudomorphic field effect transistors (pHEMTs) on a GaAs substrate. Firstly, a quantitative assessment of a foundry-available 11 V pHEMT process is presented and the device properties are extensively characterized and modeled. It is shown that due to their superior material properties, the intrinsic figure of merit for pHEMT switching devices show an order of magnitude improvement over the state-of-the-art Silicon NMOS transistors. Secondly, a superior pHEMT structure is presented which can extend the voltage range of this technology to up to 47 V. The characterization results of these devices are also presented and shown to be comparable to GaN based transistors for power switching applications. Thirdly integrated pHEMT DC-DC converters that can switch at frequencies above 100 MHz are demonstrated. A 4.2 V pHEMT buck converter designed for envelope tracking applications achieved 88 % conversion efficiency at 100 MHz, while achieving a bandwidth of 14.5 MHz. The power efficiency is among the highest reported for switching converters in the presented power and frequency range.

The research shows that GaAs pHEMTs could be an excellent alternative to Silicon for DC-DC converters powering microprocessors, base band amplifiers, and in other applications where wide bandwidth power supplies are required. In a scenario where innovations in silicon based low voltage power transistors have saturated, this approach is a new way of breaking the paradigm and making large leaps in performance.