InP HBT Technology and Applications

A.K. Oki, D.C. Streit, K.W. Kobayashi, A. Gutierrez-Aitken, L.T. Tran, T. Block, P. Chin, P.C. Grossman, F. Yamada, D. Sawdai, M.D. Lammert, M. Wojtowicz, E. Kaneshiro, K. Sato, G. Leslie, L. Yang, and H.C. Yen

TRW Inc, One Space Park, Redondo Beach, CA 90278
aaron.oki@trw.com, (310) 814-1862

Abstract

The performance and cost advantages of our gallium arsenide (GaAs) based Heterojunction Bipolar Transistor (HBT) technology has enabled several high volume commercial applications. TRW is currently delivering over 4 million MBE based HBT integrated circuits per month for low cost commercial wireless applications, as well as for high performance high reliability defense avionics, ground, and space applications. Indium Phosphide (InP) based HBT technology has several enabling advantages over GaAs HBTs for commercial communication applications, in particular for high efficiency cellular and millimeter wave power amplifiers, 40 GBPS fiber-optic communications, and signal processing ICs.

Molecular Beam Epitaxy Technology

TRW pioneered the use of MBE for high-volume commercial GaAs HBT production. Reproducible and reliable MBE growth techniques were initially developed for GaAs HBTs using single wafer MBE systems and these techniques were later transferred to multi-wafer MBE systems. The ability to produce production quantities of reproducible and reliable MBE-grown GaAs HBT material is key to the commercial viability of this technology.

MBE brings to the InP material system, the same advantages of material reproducibility and uniformity that it brings to GaAs. Advanced calibration tools and non-contact materials analysis such as double crystal x-ray diffraction, photoluminescence, deep level trap spectroscopy, and photoreflectance allow precise control and lattice matching of the epitaxial layers using SPC methodology. InP substrate quality is rapidly improving as volume ramps up, just as with GaAs. While InP substrate cost is coming down as volume ramps up, just as with GaAs.

InP HBT Production

The production capability of InP HBT technology is dependent on three core capabilities: stable epitaxial material, a stable frontside process, and a stable backside process. The InP HBT frontside process is step-for-step very similar to TRW's flight-qualified one-micron GaAs HBT process, with minor metal, and etch chemistry differences. The InP HBT backside via process is identical to the InP HEMT process which provides significant efficiency of scale.

Cellular Telephony

Cellular telephone power amplifiers have a combination of very stringent performance requirements including high power added efficiency, and low off leakage for long talk time and standby time, high breakdown voltage for robust use, and low implementation cost. InP HBT offers improved performance over GaAs HBT technology. Demonstrated device measurements include 3 volt PAE > 85% and 1 volt PAE > 65%. Comparable microwave power amplifiers have demonstrated greater linearity for an InP HBT implementation as compared to a GaAs HBT implementation [1].

Fiber Optic Telecommunications

InP HBT technology is particularly well suited for high-speed fiber-optic circuits including single channel SONET OC-768, 40 GBPS for Internet backbone broadband data transmission. InP HBTs have advantages for several key front-end component blocks including transimpedance amplification, gain control, clock and data recovery, modulator drivers, and high speed MUX and DMUX functions. A key parameter is digital clock frequency and we have demonstrated frequency dividers operating to 69 GHz with 70mW-power dissipation and 66 GHz at 45 mW of power dissipation. This frequency performance beyond the OC-768 SONET standard provides both manufacturing margin and improved decision circuit sensitivity which increases the distance capability between transmitter and receiver.

Millimeter Wave Telecommunications

A third application area for InP HBT technology is in the millimeter wave point-to-point and point-to-multi-point transceivers for local multi-point distribution systems (LMDS). InP HBT technology provides both high efficiency and high linearity capability for these digital networks. We have demonstrated a compact millimeter wave circuit of 1 mm x 1.1 mm which produces over 300mW of power at K-Band. This demonstrates InP HBT's functional implementation efficiency.

Summary

The ability to produce cost-efficient high-volume InP microelectronics enables a wide range of insertion opportunities for InP HBT products for government and commercial applications. These applications include ultra-efficient ultra-linear power amplifiers ideally suited for digital communication systems, and highly integrated high-speed 40GBPS fiber-optic networks. The rapidly expanding demand for broadband telecommunications provides a strong market pull for the enabling performance provided by InP microelectronics.

Acknowledgements

This work is partially funded by the Air Force Research Laboratory under the Technology Investment Agreement F33615-99-2-1471 and F33615-98-2-1238.

This work is partially funded by the Office of Naval Research, "Ultra High Speed DDS for Electronic Beam Steering Program.

The authors would like to acknowledge the contributions of the many engineers and technicians at TRW including Donald Umemoto, Tim Naeole, Stacey Bui, Matt Hoppe, Y.C. Chen, Rich Lai, Mike Barsky, Ron Grundbacher, William Jones, Peter Chou, Rosie Dia, Hung Nguyen; John Scarpulla, David Eng, Edwin Sabin, and Denise Leung, the researchers and project managers at DARPA, Air Force, Army, and Navy research laboratories, and our partners at RF Micro Devices, and Multilink Technology Corporation.