InP HBT technologies for next generation mmWave and THz systems

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ABSTRACT

Indium Phosphide (InP) heterojunction bipolar transistors (HBTs) are an enabling device technology for next generation mmWave and THz frequency microsystems [1]. Highly-scaled InP HBTs demonstrate THz-class transistor bandwidth and InP HBTs have become the leading IC technology for power amplifiers (PAs) between 100-300 GHz [2]. We will review the operating characteristics and performance of advanced 250nm and 130nm InP HBT IC technologies with an emphasis on transistor and unit-cell design for mmWave and sub-THz PAs. InP HBT performance is strongly influenced by non-equilibrium (ballistic) transport effects in the collector and the modeling and impact of these effects on circuit operation will be discussed.

InP HBTs currently find application in high-frequency test and measurement systems. Power amplifiers covering full waveguide bands are used to increase test-port output power and system dynamic range either as system output stages or as drivers for multiplier chains. InP devices are also being investigated as front-end elements for future 6G/sub-THz communication systems at frequencies >100GHz. Large-element phased-array architectures envisioned for these systems will require high-efficiency frontend elements. State-of-the-art power added efficiencies (>20%) from 140-220 GHz have been reported in InP HBT technologies [3],[4]. Further improving the efficiency of InP ICs through advances in transistor design and back-end-of-line technology will be discussed and techniques for the heterogeneous integration of InP with Silicon electronics for phased-array applications will be reviewed.

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[3] A. Ahmed et. al., "A 140GHz power amplifier with 20.5 dBm output power and 20.8% PAE in 250-nm InP HBT technology," *Proceedings IEEE International Microwave Symposium*, Los Angeles, CA, August 2020.
[4] E. Lam et. al., "A 2-stage 140 GHz Class-B power amplifier achieving 22.5% PAE at 17.3dBm in 250nm InP HBT technology," *Proceedings 2022 IEEE International Microwave Symposium,* Denver, CO, June, 2022.