# “SiGe Technology: New Research Directions and Emerging Application Opportunities”

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## Abstract

The silicon-germanium heterojunction bipolar transistor (SiGe HBT) is the first practical bandgap-engineered device to be realized in silicon, and effectively combines transistor performance competitive with III-V technologies with the economy-of-scale of conventional silicon IC manufacturing. Since the first demonstration of a functional transistor in 1987, SiGe technology has entered manufacturing across the world, and is currently making in-roads in a number of venues associated with the global electronics infrastructure.

In many ways SiGe HBTs represent *the* ideal mixed-signal device. SiGe HBTs possess: excellent frequency response at useful breakdown voltages, extremely large transconductance per unit area, very high gain, very low output conductance, very low broadband noise, very low 1/f noise, very low phase/jitter noise, good RF linearity, excellent power handling capability, extremely high current drive, good thermally stability, the ability to operate across very wide temperature ranges (4K to 300C), and inherent tolerance to ionizing radiation. All at very conservative lithographic nodes (typically with a two-generation advantage over CMOS at fixed performance). Importantly, SiGe HBTs can also be easily integrated into core foundry-compatible CMOS platforms to address an optimal HBT/CMOS division of labor for highly-integrated electronic systems. At the state-of-the-art, SiGe HBTs exhibit frequency response above 300 GHz at 300K (at 130 nm), and above one-half TeraHertz (500 GHz) at cryogenic temperatures, with significant untapped performance remaining.

After an introduction to the field, this presentation will focus on new research directions and emerging mixed-signal application opportunities enabled by SiGe technology, including: complementary-SiGe (C-SiGe = *npn* + *pnp* SiGe HBTs) for analog, SiGe radar systems, SiGe for high-frequency wireless and wireline communications, SiGe for extreme environment electronics, and SiGe for wideband, enhanced dynamic range systems.