Device-to-Circuit Interactions in SiGe Technology: Challenges and Opportunities

John D. Cressler

Schlumberger Chair Professor
School of Electrical and Computer Engineering
777 Atlantic, Drive, N.W., Georgia Tech, Atlanta, GA 30332-0250 USA
cressler@ece.gatech.edu
http://users.ece.gatech.edu~cressler (research)
http://johndcressler.com (books)

Abstract—As an integrated circuit paradigm, SiGe BiCMOS technology has enjoyed great success over the 2+ decades of its existence. The seamless combination of SiGe HBTs, with their superior analog/RF properties (transconductance, output conductance, noise, gain, linearity), with standard CMOS in a 100% silicon-manufacturing compatible platform, has proven to be a compelling solution for a diverse variety of performance-constrained analog, digital and RF applications, for both wired and wireless systems, from DC to sub-mm-wave frequencies. Four distinct generations of technology presently exist in foundries in the US, the EU, and Asia, and small-signal intrinsic device performance (f_T and f_{max}) is rapidly approaching near-THz speeds, with useful breakdown voltages.

The coupling between the physics of SiGe HBTs with the circuits (and systems) in which they are utilized grows stronger as SiGe technology evolves, and in many instances represents the "final frontier" for research in technology optimization, device physics, compact modeling, circuit design, and system implementations. In this talk I address device-to-circuit interactions in three distinct realms: 1) our ability to tap achievable intrinsic device performance at the circuit level at the limits of scaling; 2) safe-operating-area limits of SiGe HBTs, the reliability physics of SiGe HBT stress mechanisms along complex, time-dependent dynamic load lines, and our ability to understand and predict resultant circuit-level reliability; and 3) the physics of the complex interactions between ionizing radiation and SiGe HBTs, and our ability to understand and predict digital/analog/RF circuit response under radiation exposure. In these three examples of complex device-to-circuit interactions in SiGe technology, the challenges we face (as a function of scaling) are addressed, and well as the potential opportunities presented.