Evaluation of the Radiation Tolerance of SiGe Heterojunction Bipolar Transistors Under Gamma and Neutron Exposure

J. Metcalfe, D.E. Dorfan, A. A. Grillo, A. Jones, F. Martinez-McKinney, P. Mekhedjian, M. Mendoza, H.F.-W. Sadrozinski, A. Seiden, E. Spencer, M. Wilder
University of California Santa Cruz
J.D. Cressler, G. Prakash, A. Sutton
Georgia Institute of Technology
R. Hackenburg, J. Kierstead, S. Rescia
Brookhaven National Laboratory

Abstract—For the potential use in future high luminosity applications in High Energy Physics (HEP) (e.g. the Large Hadron Collider (LHC) upgrade), we evaluated the radiation tolerance of a candidate technology for the front-end of the readout Application-Specific Integrated Circuit (ASIC) for silicon strip detectors. The devices investigated were first, second and third-generation IBM Silicon-Germanium (SiGe) Heterojunction Bipolar Transistors (HBTs).
The current gain as a function of collector current has been measured at several stages: before and after irradiation with gamma rays from a Co60 source up to a total dose of 100Mrad and with neutrons up to a fluence of $6x10^{15}$1MeV n_{eq}/cm^2. The effects of bias conditions during irradiation were also measured in the case of the gamma irradiation.
The analog section of an amplifier for silicon strip detectors typically has a special front transistor, chosen carefully to minimize noise and usually requiring a larger current than the other transistors, and a large number of additional transistors used in shaping sections and for signal-level discrimination. We discuss the behavior of both kinds of transistors, with a particular focus on issues of noise, power and radiation limitations.