Silicon Germanium Cryogenic Low Noise Amplifiers

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In this talk, we will review the state of the art in silicon germanium (SiGe) cryogenic low noise amplifiers (LNAs), how they are used in scientific applications, and the potential for their future use in scaled systems for radio astronomy and quantum computing. The talk will begin with a brief discussion of the system requirements of future instrumentation for THz radio astronomy and quantum computing. By considering the requirements of these systems, as well as a discussion of the limited heat-lift of cryogenic coolers, it will be shown that the power consumption of the cryogenic LNAs used in these systems must be reduced significantly if such instruments are to become a reality.

Next, after a brief review of cryogenic amplifier technology (e.g., InP HEMT amplifiers), we will discuss how silicon germanium (SiGe) heterojunction bipolar transistor (HBT) technology may be used in scalable scientific instrumentation. We will begin by discussing the unique properties of SiGe HBTs that make them particularly well-suited for operation at cryogenic temperatures. We will then briefly describe the recent development of discrete transistor and integrated circuit SiGe cryogenic LNAs. Next, we will discuss the potential for realizing high-performance cryogenic SiGe LNAs with power dissipations approaching 100 μW, which is over an order of magnitude lower than the amplifiers employed in todays systems. After discussing the performance implications of the low-power operation of SiGe HBTs at cryogenic temperatures, we will present a series of experimental results, including both discrete transistor and integrated circuit low noise amplifiers. The talk will conclude with a presentation of system results recently achieved using ultra-low-power SiGe LNAs, as well as a discussion of additional research that is required to further reduce the noise and power consumption of cryogenic SiGe LNAs.