NASA SBIR/STTR Technologies

S4.04-9709 - Radiation-Hardening of Best-in-Class SiGe Mixed-Signal and RF Electronics for Ultra-Wide Temperature Range

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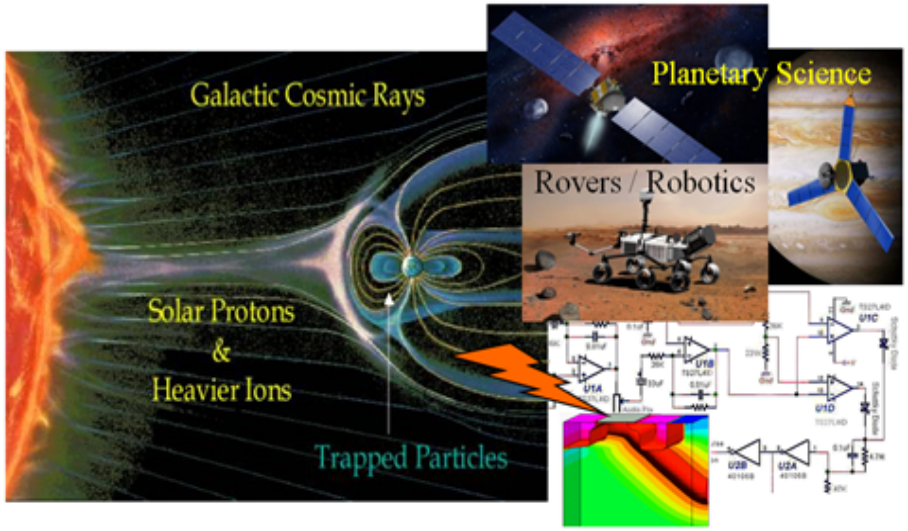
Identification and Significance of Innovation

NASA space missions need reliable, low-power, low-noise, RF electronics that can operate over a wide temperature range (wide-T, -230 to +130 deg C) and high radiation. Silicon-germanium (SiGe) - a robust IC technology with superior electronic properties, resilience to harsh environments, and moderate cost - can dramatically reduce mission size, weight, power and cost. The newest IBM 9HP SiGe platform enables highly integrated (sub) mm-wave applications not possible with earlier SiGe technologies. However, 9HP is yet to be tested in detail for wide-T and radiation effects and few data or simulation models exist.

Innovations: (1) Detailed characterization of best-in-class IBM 9HP SiGe RF electronics for extreme temperatures & transient radiation response. (2) New, validated physics-based 9HP SiGe models for wide-T. (3) Novel Rad-Hard designs of mixed-signal/RF circuits, tested for extreme/low temperatures: will not require Warm Box and will decrease weight/cost of missions.

Estimated TRL at beginning and end of contract: (Begin: 2 End: 4)



Technical Objectives and Work Plan

Technical Objectives:
- Design, validate, and demonstrate innovative RHBD devices and mixed-signal/RF circuits fabricated in the newest, best-in-class SiGe BiCMOS technology (IBM 9HP), verified for environmental extremes.
- Provide reliable mixed-mode CAD tools and physics-based device models, enhanced and validated for the wide temperature range from -230 to +130 deg C, to enable design and verification of rad-hard mixed-signal/RF circuits in the IBM 9HP SiGe platform.

Work Plan:
Phase I:
1) Upgrade and validate CFDRC TCAD/mixed-mode tools with new models for extreme temperatures (low and high) and for the newest 9HP SiGe technology.
2) Develop better understanding of complex transient phenomena due to heavy ion strikes in mixed-signal and RF electronic circuits and systems in extreme environments, by experimental laser-based and heavy ion irradiation testing on 9HP SiGe HBT devices and circuits, and by numerical mixed-mode simulations utilizing the new models and TCAD tools.
3) Based on the gained knowledge and experimental data, develop new RHBD concepts.

NASA Applications

Per OCT TA08, radiation-hardened and wide-temperature mixed-signal/RF circuit technology development is aligned with the major flight programs within the Planetary Science Division (PSD): Discovery, New Frontiers, Lunar Quest, Mars Exploration, and Outer Planets Programs, including EJSM. Electronics operating in extreme environments without bulky and power inefficient protective shielding and heating/cooling infrastructure will make possible new investigations of the Solar System.

Non-NASA Applications

Various critical analog, mixed-signal, RF, and digital circuits used in all space-based platforms, including DoD space systems (communication, surveillance, ballistic missiles, missile defense), and commercial satellites. Also, cryogenic electronics for high-sensitivity, low-noise analog and mixed-signal applications, such as metrology, infrared (IR) imagers, sensors.

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NON-PROPRIETARY DATA