White Paper

Radiation-Hardened SiGe BiCMOS for Space – Enabling COCHISA's Core-Chips

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Introduction

At the heart of modern satellites lie microchips engineered to operate in some of the most extreme conditions known: vacuum, radiation, temperature swings, and mechanical stress. A special class of these microchips — beamforming core-chips — is fundamental to COCHISA's mission: providing European-made, radiation-hardened X-band and Ka-band chips for satellite technology. But before these chips can be designed, they need to be built on a technology platform that can survive space. This is where SiGe BiCMOS technology, developed at the research center IHP, comes into play.

Why SiGe BiCMOS Matters for Space

Resilience in Harsh Environments

Silicon-Germanium Heterojunction Bipolar Transistors (SiGe HBTs) are well-known for their durability under radiation. This makes them suitable for space — where particles from cosmic rays can disrupt standard silicon chips. Research shows that these devices continue to operate reliably even after high doses of radiation.

Integrated, Efficient Design

SiGe BiCMOS combines high-frequency analog components (the SiGe HBTs) with digital CMOS logic on a single chip. This enables highly integrated, efficient designs that save space and power — critical for small satellites.

IHP's Space-Qualified SiGe BiCMOS Technologies

IHP, a European microelectronics institute, has developed two key process design kits (PDKs) tailored for space:

1. SGB25RH (250 nm process)

- Includes radiation-hard design elements, such as special transistors and logic cells that resist radiation effects.

- Demonstrated success in rigorous tests, meeting European Space Components Coordination (ESCC) standards.

2. SG13RH (130 nm process)

- Offers significantly higher performance (up to ~340 GHz transistors), suitable for future, even higher-frequency applications.

- Also undergoing radiation qualification.

These PDKs include Radiation-Hardened By Design (RHBD) techniques — such as enclosed-layout transistors and fault-tolerant flip-flops — to maintain functionality after prolonged exposure to space radiation.

Proven Performance in Radiation Tests

IHP's chips have passed major space-qualification hurdles:

- Total Ionizing Dose (TID) Resistance: Both SGB25RH and SG13RH maintained functionality and stability even after sustained radiation exposures exceeding 800–1,200 krad(Si).

- Single Event Latch-up (SEL) and Upsets (SEU): Extensive heavy-ion testing found no catastrophic failures in digital elements, demonstrating resilience against radiation-induced glitching.

- Long-Term Reliability: Extended stress tests—running for thousands of hours at elevated temperatures—indicate excellent longevity.

From Technology to Application: The COCHISA Connection

The verified success of IHP's SiGe BiCMOS platforms directly supports COCHISA's objectives. Here's how:

- Radiation-hardened chips for satellites: SiGe BiCMOS with RHBD features and proven stability under TID and SEL/SEU tests.

- High-frequency operation (X-band, Ka-band): SG13RH reaches ~340 GHz — sufficient for both X- and Ka-band applications.

- Complex, integrated design: Combines analog (RF) and digital logic in one chip, enabling compact beamforming electronics.

- Reliability and longevity: Multi-thousand-hour endurance tests show stable behavior over time.

By building COCHISA's core-chips on these trusted foundations, the project ensures that Europe's beamforming solutions will be robust, performant, and reliable for space missions.

Broader Perspective and Future Paths

Beyond COCHISA, this technology has even broader implications:

- Industry Accessibility: IHP offers access to these PDKs via Multi-Project Wafer (MPW) services, democratizing development for academic and industry innovators across Europe.

- Leading Edge Prospects: Earlier demonstrations indicate that SiGe BiCMOS transistors may reach performance in the terahertz (THz) range, setting the stage for future ultra-high-frequency satellite systems

Conclusion

IHP's radiation-hardened SiGe BiCMOS technology provides the technical backbone for COCHISA's ambition: building European-made, space-ready beamforming chips in X- and Ka-bands. With proven performance in harsh environments, integration capability, and long-term reliability, these technologies ensure that COCHISA can deliver on its promise of autonomy and high performance in European satellite subsystems.

Sources

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