SweRISC PISCES
A Swedish RISC-V Processor in Silicon Carbide for Extreme Space Environments

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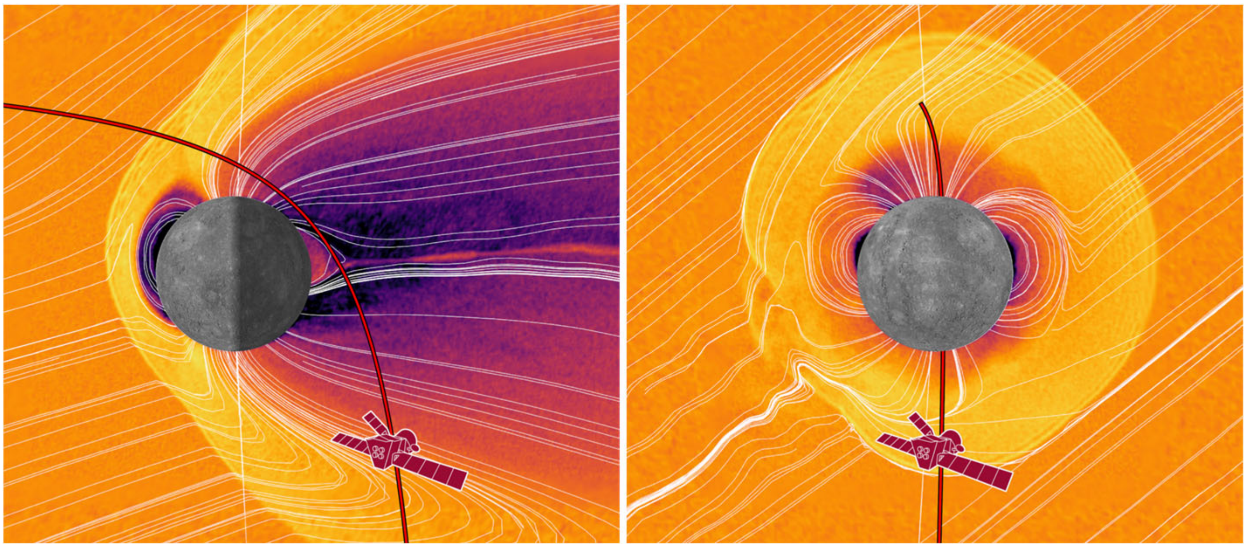


On 8 January 2024, BepiColombo will fly past planet Mercury for the sixth time. In doing so, it will pass through interesting regions of Mercury's magnetic field and the particles trapped within it. Attribution: Willi Exner – ESA & TU Braunschweig, CC BY-SA IGO 3.0 This mission does not use SIC electronics, but could have benefited from it.

For future space exploration both ESA and NASA have selected the RISC-V processor core. The RISC-V offers an open instruction set architecture (ISA), meaning that anyone can build a RISC-V without paying royalty. This makes it possible to add radiation hard RISC-V processors for space environments. KTH has experience in silicon carbide (SiC) integrated circuit design, with demonstrations of both high temperature operation and radiation hardness. In this project, we will demonstrate a RISC-V processor in SiC for extreme space environments.

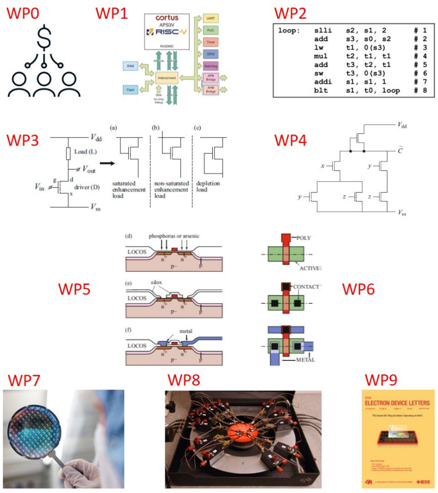
Motivation

Why us?
We have the basic process technology for SiC integrated circuits demonstrated for high temperature and radiation hardness, as well as experience in making process design kits for bipolar and CMOS processes. The entire needed infrastructure is in place at KTH.

Why now?
ESA and NASA has selected RISC-V for future space applications. Industry leaders have started the RISC-V Software Ecosystem (RISE) project including open tools and libraries.

Why this project?
Radiation hardness has always been a challenge for space exploration, and lately extended temperature ranges have come of greater interest. The wide bandgap semiconductor silicon carbide offers to be a game changer, being inherently radiation hard.

Why haven't this been attempted before?
KTH has previously demonstrated integrated circuits, but with RISC-V and RISE, the development can target processor architectures that can be easily exploited by space industry.



Experimental plan for a project to investigate a Swedish RISC-V Processor in Silicon Carbide:
0. Project management
1. Architectural design
2. Test program design
3. Device design
4. Circuit design
5. Process design
6. Mask design
7. Processing
8. Characterization
9. Dissemination and publication

Advantages of Silicon Carbide (SiC)

High Voltage Blocking
Bipolar junction transistors have been fabricated by KTH to block voltages of 15 kV, and Insulated Gate Bipolar Transistors have been fabricated by Wolfspeed for up to 26 kV. The Tesla Model 3 uses 1200 V SiC MOSFETs in the inverter. SiC MOSFETs are available from several suppliers in the range 600 to 3300 V breakdown.

High Temperature Operation
All SiC devices and circuits can operate at higher temperatures. Integrated circuits from KTH have been operated up to 600 °C and NASA has shown 800 °C operation.

Radiation Hardness (TID)
In several experiments with integrated circuits in SiC fabricated by KTH, at least ten times higher gamma ray doses were sustained for the same degradation.

Commercially Available
Previously SiC was mainly used in university research, now it is commercially available as discrete devices and substrate material.

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