15th IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Novel Concepts and Technologies to Enable Future Building Blocks in Space Exploration and Development (3)

Author: Prof. Christer Fuglesang
KTH, Sweden, christer.fuglesang@esa.int

Prof. Carl-Mikael Zetterling
KTH, Sweden, bellman@kth.se
Prof. Mikael Östling
KTH, Sweden, mostling@kth.se

# WORKING ON VENUS AND BEYOND – SIC ELECTRONICS FOR EXTREME ENVIRONMENTS

**Abstract**

Venus is our closest planet, but we know much less about it than about Mars. The main reason for this is the extreme conditions, with a dense atmosphere of mainly CO2 at 92 bar atmosphere and 460 C temperature at the surface. Only six spacecraft have succeeded to land on Venus and transmit data back to Earth; however none survived for long due to the high temperature. Venera-13 has the record, with 127 minutes at the surface of Venus in 1982. There are many compelling reasons to learn more about the sister planet of Earth, which requires measurements over months rather than minutes on the surface of Venus. Perhaps the single-most challenging task for long-term data taking on the surface of Venus is to build electronics that can operate at temperatures up to 500 C without cooling. It seems that such technology must be based on wide bandgap semiconductors, such as GaN, SiC or diamond. At KTH, research with SiC devices and integrated circuits has been done for more than 20 years, demonstrating high voltage devices and digital integrated circuit operation at 600 C. In 2014 the project Working On Venus launched, with funding from Knut and Alice Wallenberg Foundation. The goal is to demonstrate all the electronics for a complete working lander, with all electronics from sensors through amplifiers and analog-to-digital converters to microcontroller with memory and radio, including power supply. The particular sensors the project has in mind are seismic, gas and image sensors. So far, a 200 device level integration has been demonstrated at 500 C and a 5000+ device level 4 bit microcontroller is being fabricated in an in-house bipolar technology. As for all devices for space, radiation is another concern. SiC integrated circuits have survived exposure to 3 MeV protons with fluences of $10^{13}$ $cm^{-2}$ and gamma rays with doses of 332 Mrad. The dedicated project SUPERHARD IC will study manufacture methods for radiation hardened instrument components that could go beyond Venus, for example for Jovian system exploration. Members of Working on Venus are discussing with scientists seeking opportunities for a Venus Long-Life Surface Package (lander). In 2016 a response was submitted to ESA's Call for New Scientific Ideas.