A novel approach to improving the radiation hardness of SiC Power Devices, Phase I Project

SBIR/STTR Programs | Space Technology Mission Directorate (STMD)

ABSTRACT

Silicon Carbide Technology for power semiconductors offers a significant improvement in capability that will allow systems to operate at higher voltages and temperature and offer greater efficiency. However, the current state of the art for this technology proves to have significant issues that prevent its use in the space environment. Specifically the susceptibility to heavy ion damage that requires significant derating of the devices to a point that makes their use not practical. The problem for SiC MOSFET?s appears to make these devices unusable in space system due to the extremely low operating voltage where damage occurs within the device. This proposal will focus on SiC MOSFET and propose a novel approach to significantly improve the heavy ion performance to a level where the use of SiC MOSFET?s constructed using this approach would be feasible in most space applications. Semicoa is teamed with General Electric Global Research Center (GEGR) to solve this issue and provide a pathway to bring these devices to the space market fully qualified to military specifications. The focus of this effort will be to further optimize the hardening techniques being investigated by GEGR and develop a novel approach to depositing the gate oxide with Atomic Layer Deposition (ALD) techniques. This approach will allow the use of a much thicker gate oxide, while maintaining the total dose hardness characteristics, and provide significant improvement to the heavy ion performance. The challenge will be addressing the interface between the dielectric and the semiconductor. It is believed that the ALD process using a High-K dielectric material will lower the interface state density to achieve the total dose hardness while at the same time provide for a significant improvement in the heavy ion performance.

ANTICIPATED BENEFITS

To NASA funded missions:

Potential NASA Commercial Applications: The development and

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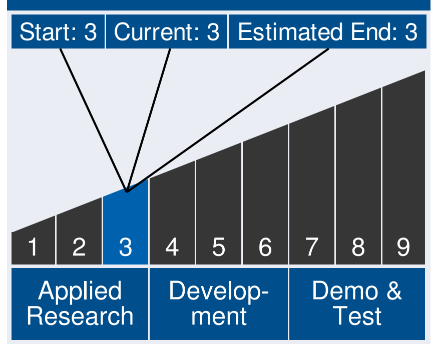
Technology Maturity



Management Team

Program Executives:
- Joseph Grant
- Laguduva Kubendran

Program Manager:
- Carlos Torrez

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integration of high voltage/high temperature components that can be space qualified will lead to increases in system level performance as they will tend to increase efficiency and decrease mass at the system architecture level. Such performance improvements are necessary if NASA is to realize several operational concepts such as very high power Solar Electric Propulsion (SEP). In a simplistic but specific realization, higher voltage parts allow power generation at higher voltages on the arrays themselves, this higher voltage allows for the same power to be transferred at lower current thereby reducing cable mass at the system level.

To the commercial space industry:

Potential Non-NASA Commercial Applications: Silicon MOSFET?s seem to be reaching the ?end of the road? as far as improvements to the technology for power, speed and performance. SiC MOSFET technology offers high-temperature and high-power operation far superior that that of Silicon MOSFETs. It is generally felt that SiC is early in its life cycle and there are many applications that could benefit from this technology. SiC extreme high electron mobility and low temperature coefficient enables a very low RDS(ON). This device would have superior switching characteristics due to the high critical field, high electron mobility, high saturation velocity and low gate-drain capacitance of the SiC device. This also allows for short delay times and excellent controllability in low duty-cycle applications. SiC devices also have significantly lower output capacitance when compared to Silicon MOSFET?s of similar RDS(ON). SiC offers the benefits of the least power consumption while providing for the lowest energy loss at extremely high temperatures requiring limited external cooling.

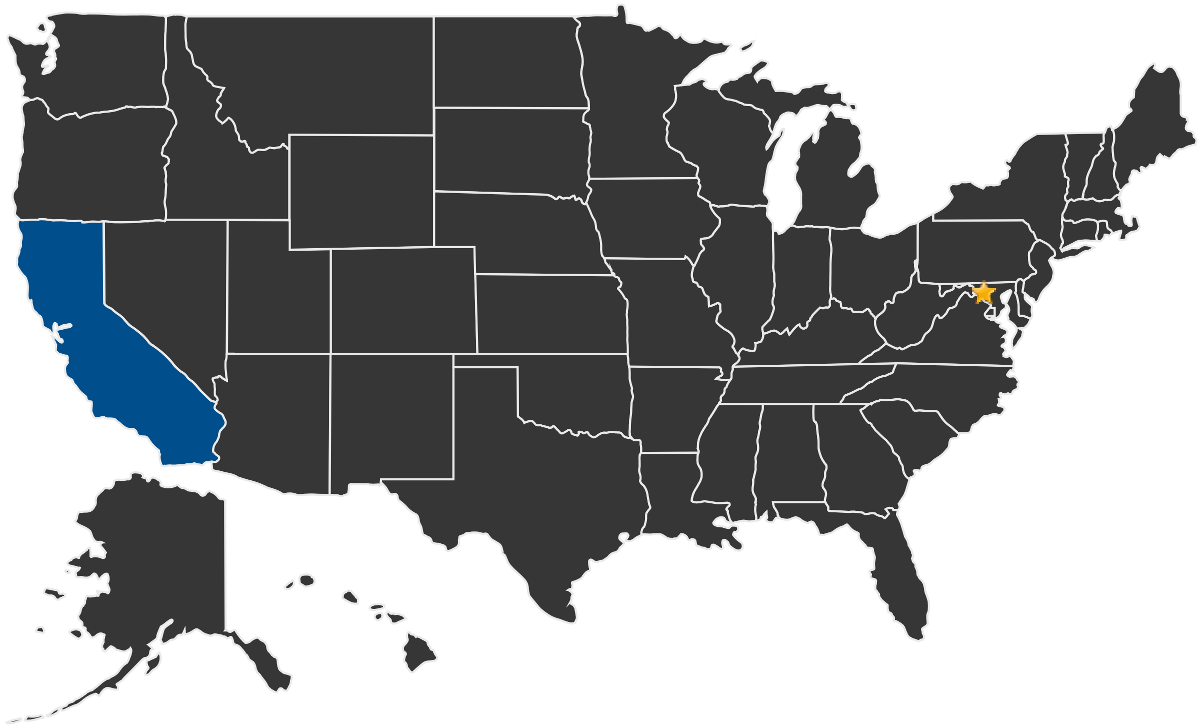
Management Team *(cont.)*

Principal Investigator:
- Brian Triggs

Technology Areas

Primary Technology Area:
Space Power and Energy Storage (TA 3)
└─ Power Management and Distribution (TA 3.3)
  └─ Distribution and Transmission (TA 3.3.3)

U.S. WORK LOCATIONS AND KEY PARTNERS



U.S. States With Work

Lead Center:
Goddard Space Flight Center

Other Organizations Performing Work:

- Falkor Partners, LLC dba: Semicoa (Costa Mesa, CA)

PROJECT LIBRARY

Presentations

- Briefing Chart
  - (http://techport.nasa.gov:80/file/23521)

IMAGE GALLERY

A novel approach to improving the radiation hardness of SiC Power Devices, Phase I

DETAILS FOR TECHNOLOGY 1

Technology Title

A novel approach to improving the radiation hardness of SiC Power Devices, Phase I

Potential Applications

The development and integration of high voltage/high temperature components that can be space qualified will lead to increases in system level performance as they will tend to increase efficiency and decrease mass at the system architecture level. Such performance improvements are necessary if NASA is to realize several operational concepts such as very high power Solar Electric Propulsion (SEP). In a simplistic but specific realization, higher voltage parts allow power generation at higher voltages on the arrays themselves, this higher voltage allows for the same power to be transferred at lower current thereby reducing cable mass at the system level.