HIGH TEMPERATURE ELECTRONICS, COMMUNICATIONS, AND SENSORS FOR VENUS MISSIONS

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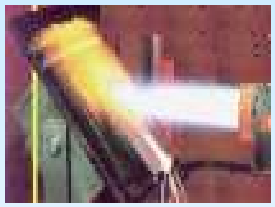
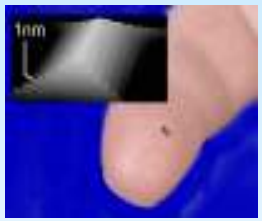
HARSH ENVIRONMENT ELECTRONICS AND SENSORS APPLICATIONS

- NEEDS:
  - OPERATION IN HARSH ENVIRONMENTS
  - RANGE OF PHYSICAL AND CHEMICAL MEASUREMENTS
  - INCREASE DURABILITY, DECREASE THERMAL SHIELDING, IMPROVE IN-SITU OPERATION



1998 R&D 100 Award



2004 R&D 100 Award

- RESPONSE: UNIQUE RANGE OF HARSH ENVIRONMENT TECHNOLOGY AND CAPABILITIES
  - STANDARD 500C OPERATION BY MULTIPLE SYSTEMS
  - TEMPERATURE, PRESSURE, CHEMICAL SPECIES, WIND AVAILABLE
  - HIGH TEMPERATURE ELECTRONICS TO MAKE SMART SYSTEMS

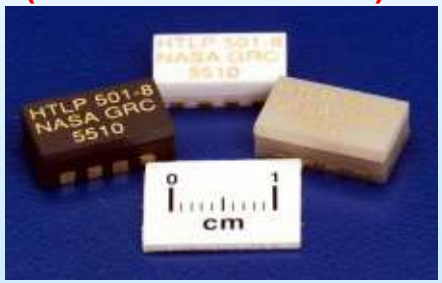
1995 R&D 100 Award

1991 R&D 100 Award

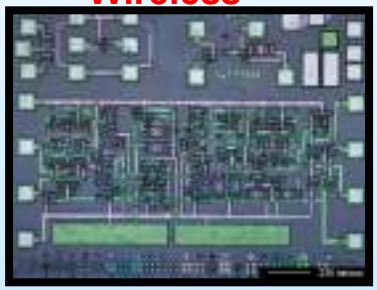
- ALL-IN-ONE SHOP FOR HARSH ENVIRONMENT SYSTEM APPLICATIONS
- ENABLE EXPANDED MISSION PARAMETERS/IN-SITU MEASUREMENTS

Range of Physical and Chemical Sensors for Harsh Environments

Harsh Environment Packaging (2000 hours at 500C)



High Temperature Signal Processing and Wireless



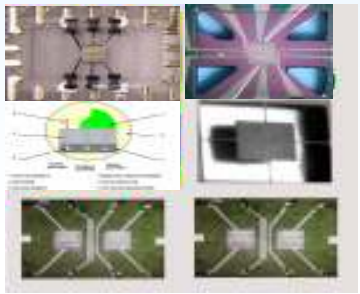
Long Term: High Temperature "Lick and Stick" Systems

SUMMARY

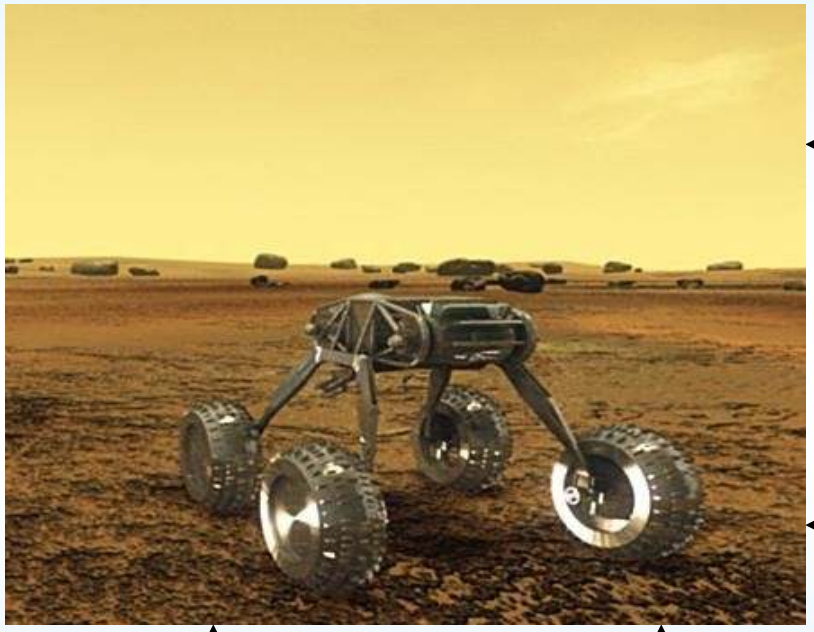
NASA GRC HAS THE TOOLS TO ENABLE NEW MISSIONS

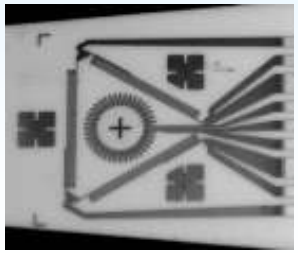
EXAMPLE POSSIBLE MISSION: Venus Integrated Weather Sensor (VIWS) System

Sensor Suite to Monitor Venus Weather Conditions including: Data Processing and Communication, Wind Flow, Seismic, Pressure/Temperature/Heat Flux, Chemical Environment



HIGH TEMPERATURE ELECTRONIC NOSE (Chemical Species)



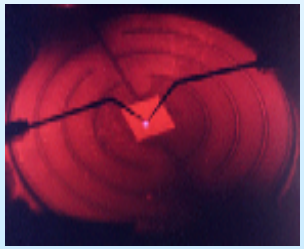


MULTIFUNCTIONAL PHYSICAL SENSOR ARRAY (Temperature, Heat Flux)

Hi-g SiC ACCELEROMETER (Seismic Activities)

HOTProbe (Wind flow, Pressure, Temperature)

PRESSURE SENSOR (Pressure)



SiC ELECTRONICS (Data Processing and Com)

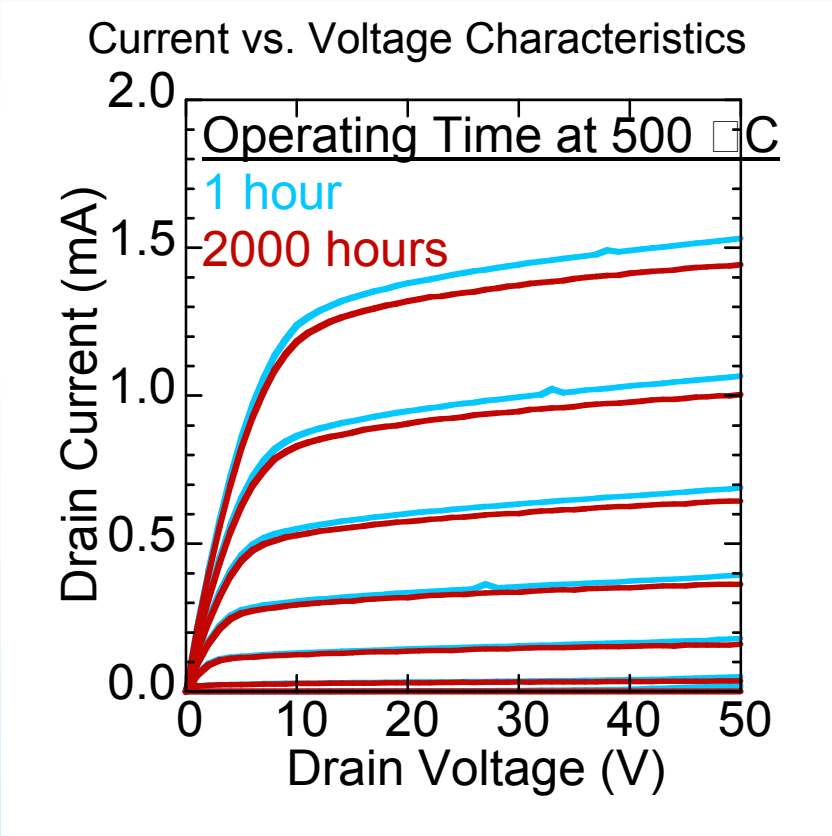
NASA Glenn SiC JFET : First Transistor to Surpass 2000 Hours of Stable Electrical Operation at 500 °C

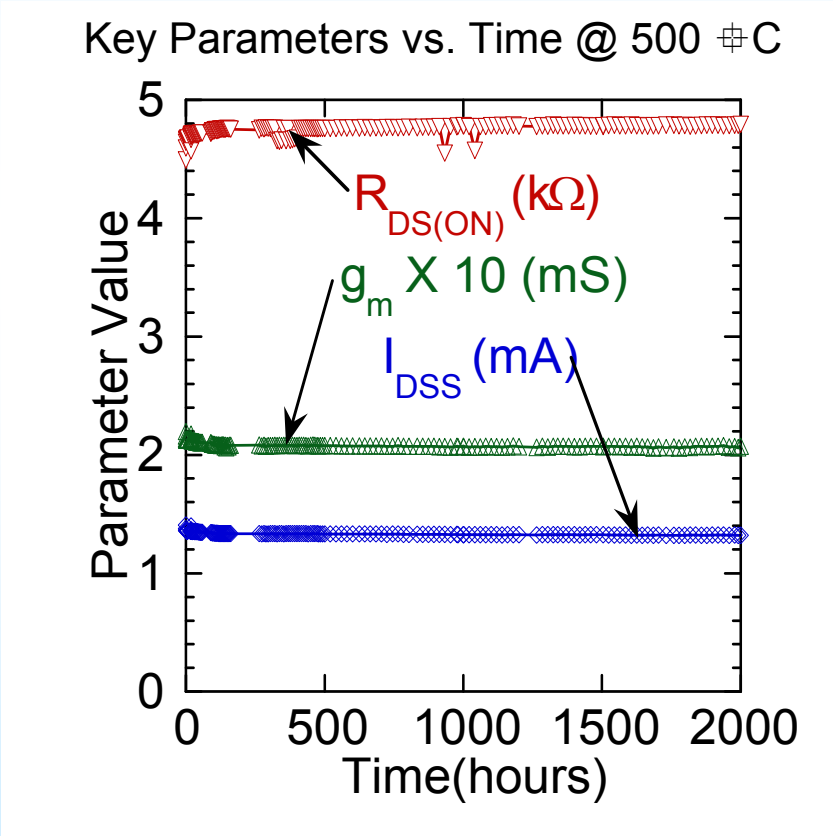
Current-voltage characteristics are very good and stable after 2000 hours.

- Enables realization of analog integrated circuits (amplifiers, oscillators).

Excellent turn-off characteristics, large ON to OFF current ratio (> 1000).

- Enables realization of digital logic circuits.





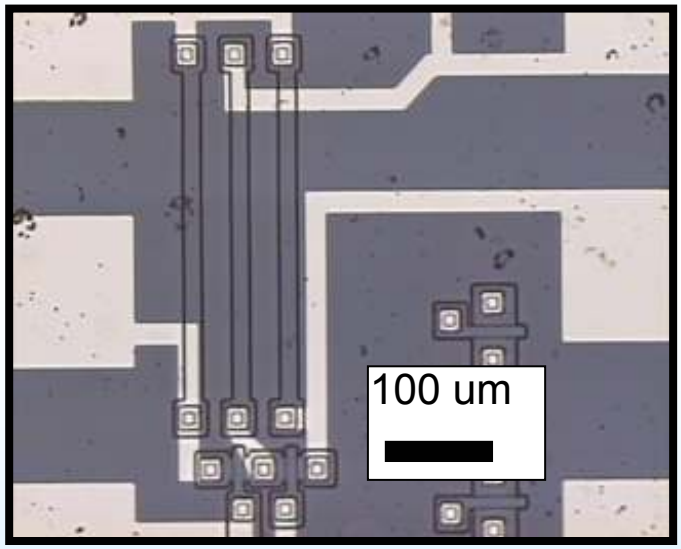
Less than 7% change occurs during 2000 hours at 500 °C (most during 1st 100 hrs).
- 7% change is smaller than listed on most silicon transistor spec. sheets.

NASA Glenn Silicon Carbide Differential Amplifier

World's First Semiconductor IC to Surpass
2000 Hours of Electrical Operation at 500 ⌗C

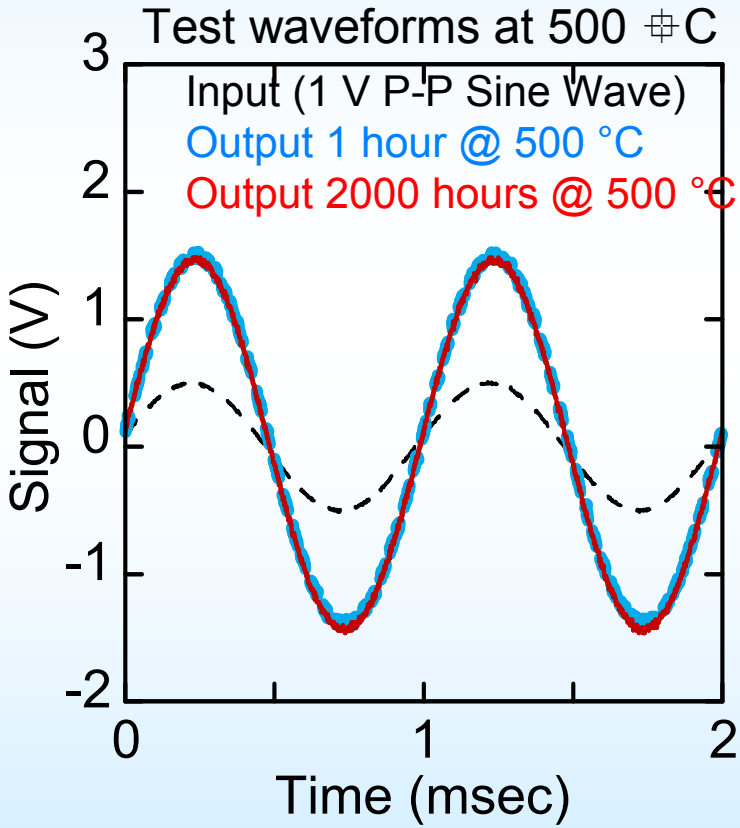
Demonstrates CRITICAL ability to interconnect transistors and other components (resistors) in a small area on a single SiC chip to form useful integrated circuits that are durable at 500 ⌗C.

Optical micrograph of demonstration amplifier circuit before packaging



2 transistors and 3 resistors integrated into less than half a square millimeter.

Single-metal level interconnect.

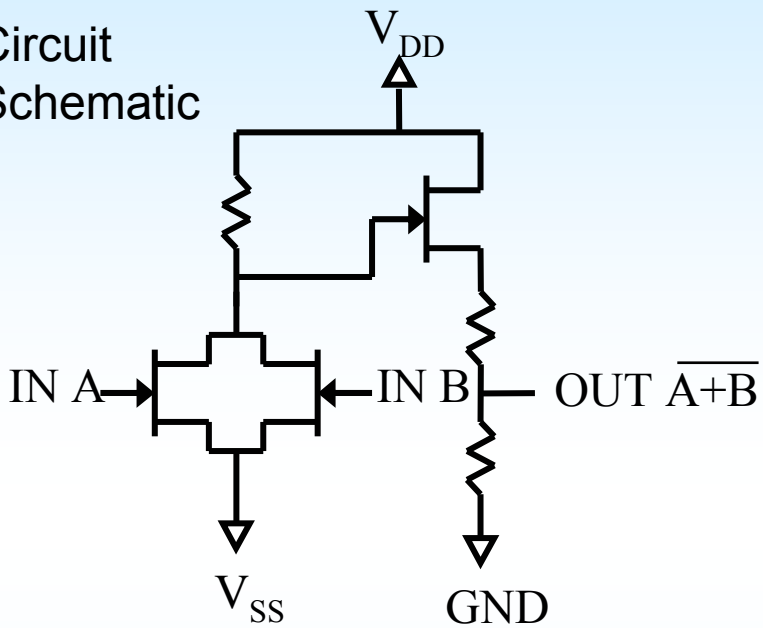


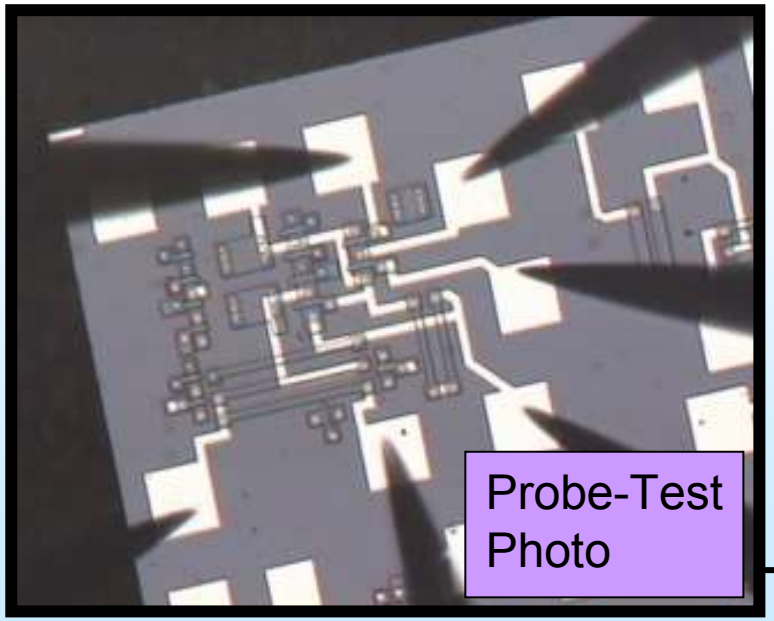
Less than 3% change in operating characteristics during 2000 hours of 500 ⌗C operation

NASA Glenn SiC JFET NOR Gate IC

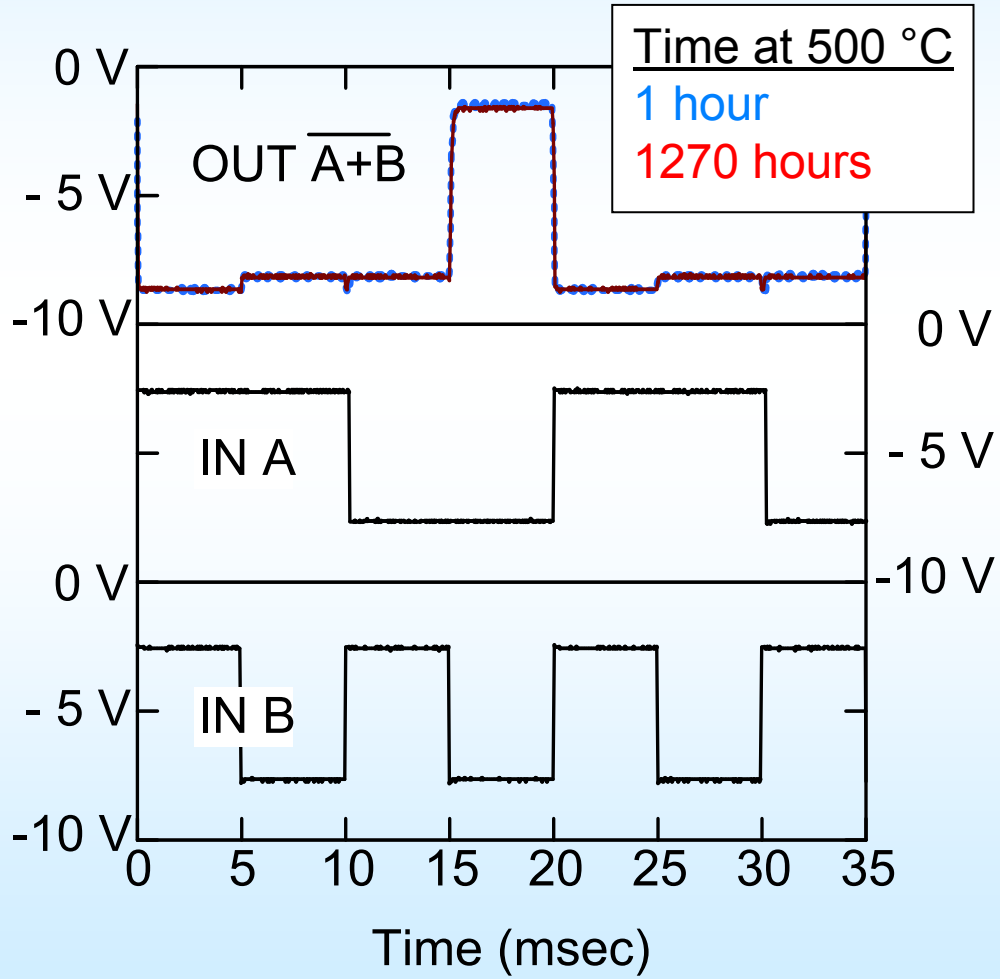
World's First Semiconductor Digital IC to Surpass 1000 hours of 500 ºC Operation

Circuit Schematic





Waveforms of **packaged** NOR (= "Not OR") gate at 500 ⌗C



SIGNIFICANCE OF RECENT ELECTRONICS RESULTS

THE BASIC COMPUTING TOOLS FOR VENUS MISSIONS HAVE BEEN FABRICATED

- **THIS DEMONSTRATION SHOWS THAT IT IS NOW POSSIBLE TO CONSTRUCT MORE COMPLEX CIRCUITS TO PROVIDE COMPARABLE FUNCTIONALITY TO THOSE USED DURING THE MERCURY/GEMINI ERA, BUT INSTEAD OPERATING AT 500 °C AND MINIATURIZED.**
- **LOGIC GATES GENERATE FLIP-FLOPS THAT CAN GENERATE STATE-MACHINES**
- **STATE MACHINES ENABLE:**
  - **CREATION OF CONTROL ELECTRONICS FOR AN "INTELLIGENT" FIXED OR MOBILE AGENT**
  - **THE CONFIGURATION OF INTELLIGENT DATA TRANSMISSION METHODS ALLOWING FOR UNAMBIGUOUS DEMODULATION OF SIGNALS UNIQUELY ASSOCIATED WITH EACH SENSOR/TRANSMITTER IN A NETWORK.**
- **OBJECTIVE OVER THE COURSE OF THE IVHM PROJECT: TO MOVE FROM MERCURY/GEMINI LEVEL CAPABILITY TO APOLLO LEVEL CAPABILITY**