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

• 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

• 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

Glenn Research Center at Lewis Field
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)

Hi-g SiC ACCELEROMETER (Seismic Activities)
PRESSURE SENSOR (Pressure)

MULTIFUNCTIONAL PHYSICAL SENSOR ARRAY (Temperature, Heat Flux)
HOTProbe (Wind flow, Pressure, Temperature)

SiC ELECTRONICS (Data Processing and Com)
**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.

**Current vs. Voltage Characteristics**

Operating Time at 500 °C

- 1 hour
- 2000 hours

**Key Parameters vs. Time @ 500 °C**

- $R_{DS(ON)}$ (kΩ)
- $g_m \times 10$ (mS)
- $I_{DSS}$ (mA)

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.

Test waveforms at 500 °C

- Input (1 V P-P Sine Wave)
- Output 1 hour @ 500 °C
- Output 2000 hours @ 500 °C

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 °C Operation

Waveforms of packaged NOR (= “Not OR”) gate at 500 °C

Time at 500 °C
1 hour
1270 hours

Probe-Test Photo
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