HARSH ENVIRONMENT ELECTRONICS AND SENSORS APPLICATIONS

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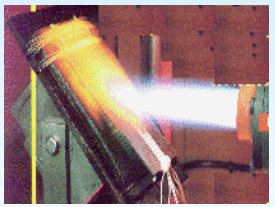
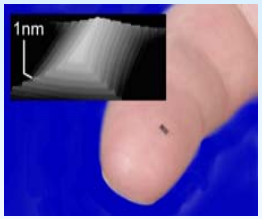
NASA GRC HAS VAST RANGE OF HIGH TEMPERATURE EXPERIENCE

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

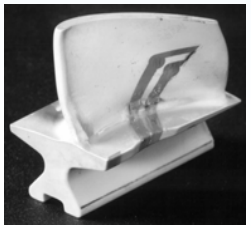


1998 R&D 100 Award



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**

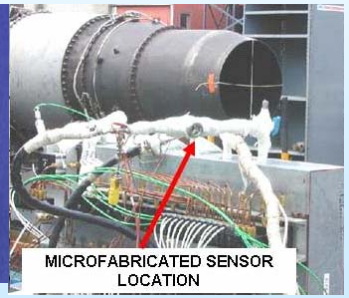


1995 R&D 100 Award

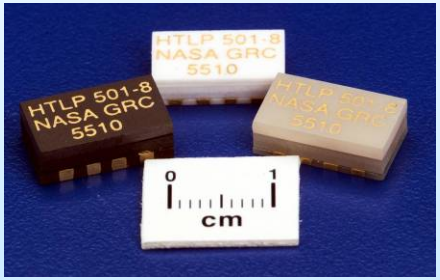
1991 R&D 100 Award

- **ALL-IN-ONE SHOP FOR HARSH ENVIRONMENT SYSTEM APPLICATIONS**

Range of Physical and Chemical Sensors for Harsh Environments

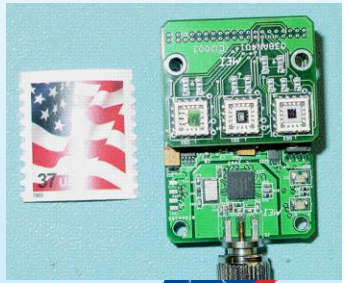


Harsh Environment Packaging (2000 hours at 500C)



High Temperature Signal Processing and Wireless

Long Term: High Temperature "Lick and Stick" Systems

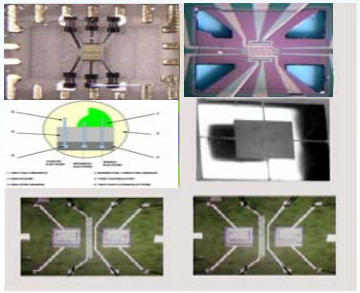


VENUS SCIENTIFIC MISSIONS LIMITED BY AVAILABILITY OF HARSH ENVIRONMENT SENSORS AND ELECTRONICS

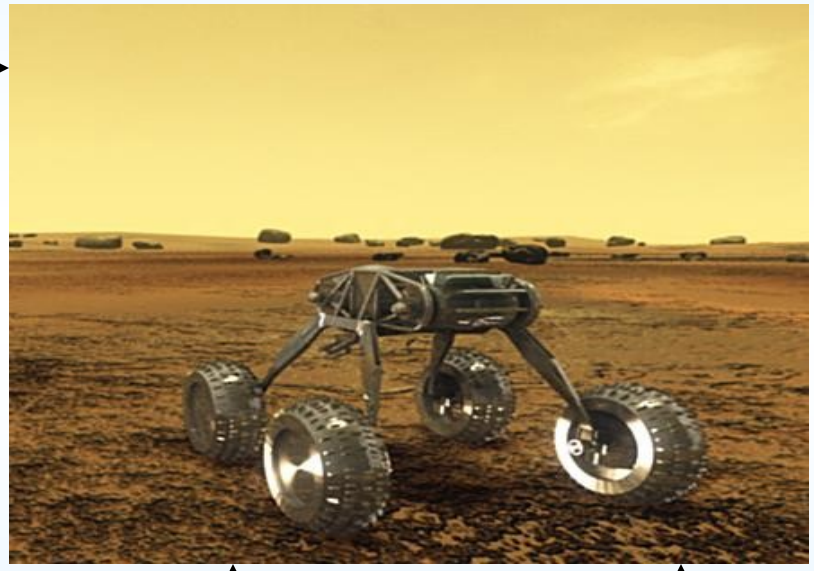
NASA GRC HAS THE BASIC TOOLS TO HELP ENABLE NEW MISSIONS

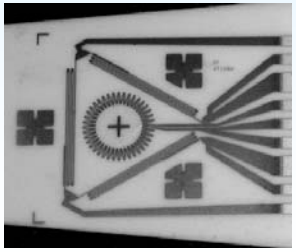
EXAMPLE POSSIBLE MISSION: Venus Integrated Weather Sensor (VIWS) System

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

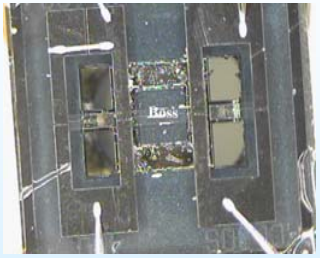


HIGH TEMPERATURE ELECTRONIC NOSE (Chemical Species)





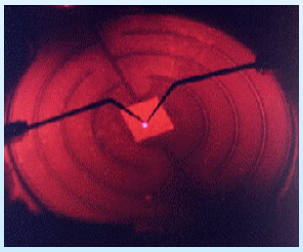
MULTIFUNCTIONAL PHYSICAL SENSOR ARRAY (Temperature, Heat Flux, Strain)



Hi-g SiC ACCELEROMETER (Seismic Activities)

HOTProbe (Wind flow, Pressure, Temperature)

PRESSURE SENSOR (Pressure)



SiC ELECTRONICS (Data Processing and Com)

BACK UP SLIDES

NASA Glenn Microsystem Development Facilities

- Significant In-House Capabilities for a Range of Micro/Nano Sensor and Electronics Development
- Capabilities Range From Semiconductor Material and Device Fabrication to Packaging and Testing
- State-Of-The-Art Facilities Leading to World Leading Technologies

SiC Chemical Vapor Deposition (CVD) Epitaxial Growth Laboratory

World's Most up-to-date Facility of Its Type

Microsystems Fabrication Clean Room

3000 Square Foot Clean Room Space for Electronic-Grade Oxides and MEMS

Microdevices Characterization Facilities

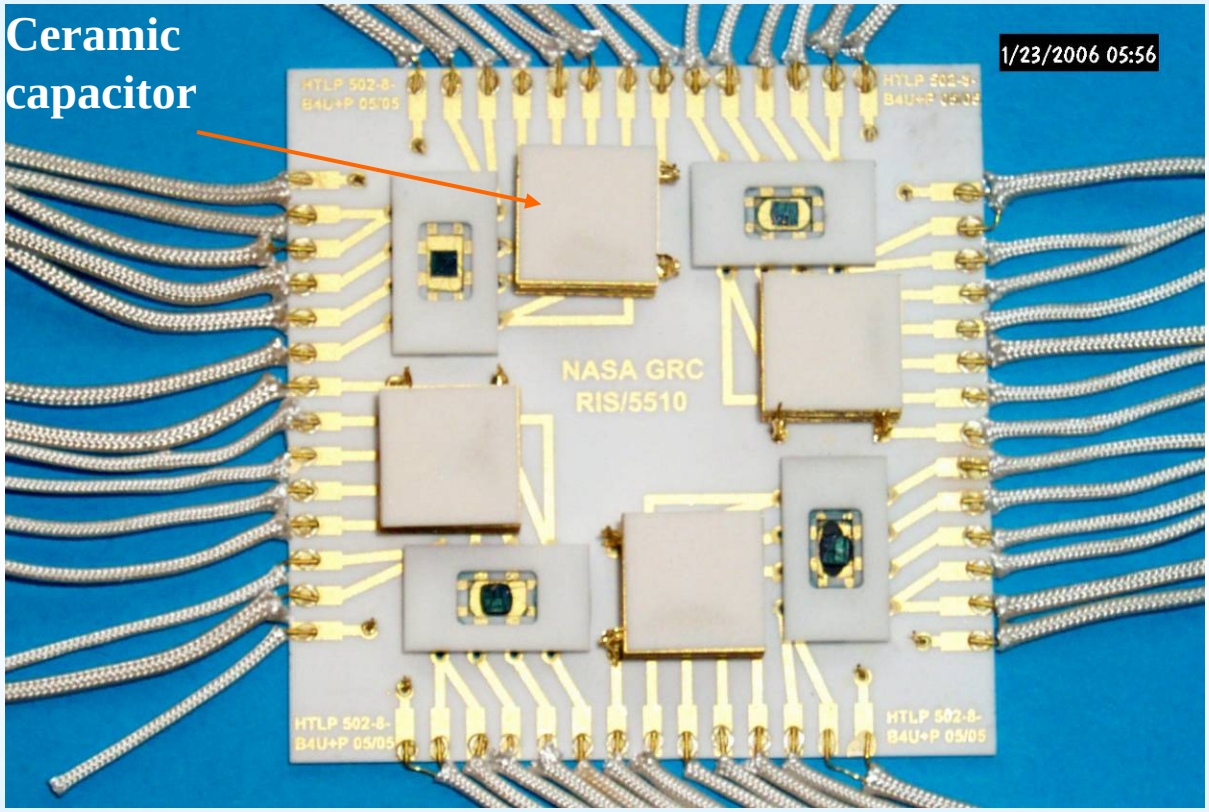
A Range of Characterization and Testing Equipment For Device Development

HARSH ENVIRONMENT VENUS MISSION REQUIREMENTS

- **SURFACE CONDITIONS**
  - **TEMPERATURE: 450-500 C**
  - **PRESSURE: 90 bar PREDOMINATELY (~100 TIMES EARTH)**
  - **SULFURIC ACID PARTICLES IN CLOUD DECK**
  - **96.5% CO_2 and 3.5% N_2; Trace Gases include H_2O, SO_2, CO, HCL, H_2, and HF**
- **SOME PARAMETERS OF INTEREST: TEMPERATURE, PRESSURE, CHEMICAL SPECIES, FLOW (WIND)**
- **TEMPERATURE CONTROL INCREASES SYSTEM COMPLEXITY/RISK TO MISSION**
- **NEED TO SHIELD SYSTEM FROM EXTREME ENVIRONMENTS YIELDS INCREASE IN SIZE AND WEIGHT**
- **LIMITED INFORMATION AVAILABLE FROM IN-SITU SYSTEMS DUE TO HARSH ENVIRONMENTS INVOLVED**
- **SCIENTIFIC COMMUNITY: LACK OF VIABLE HARSH SENSOR SYSTEMS SENSORS AND ELECTRONICS FOR IN-SITU CHARACTERIZATION**
- **IN SOME AREAS, NASA GRC HAS ALREADY TECHNOLOGY SOLUTIONS ISSUES NEEDED BY SMD FOR HARSH ENVIRONMENT APPLICATIONS**

Demonstration of 500°C AC Amplifier Based on SiC MESFET and Ceramic Packaging – Test assembly 2006

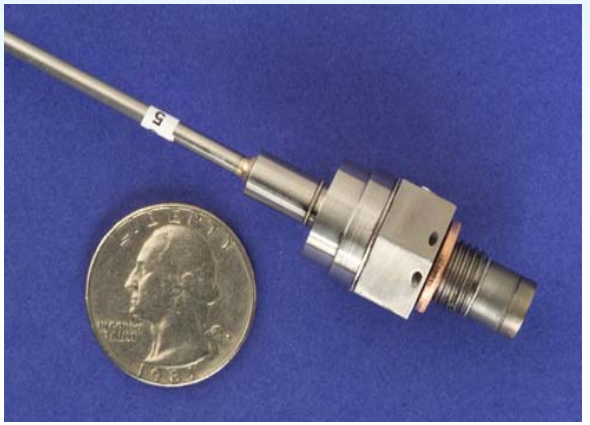
Optical Picture of the Test Assembly



- The test assembly includes four testing circuit units
- Common - Source AC amplifier tested at 500 C for over 1100 hours

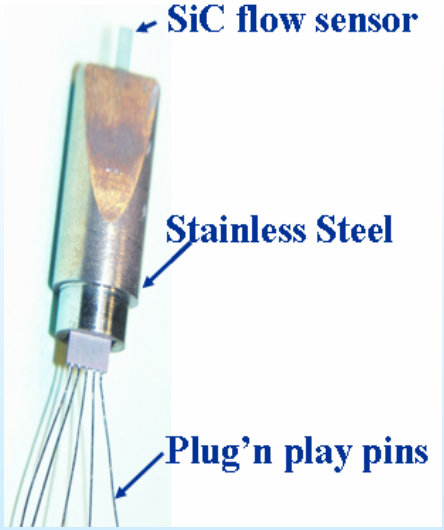
SiC-BASED PRESSURE SENSORS

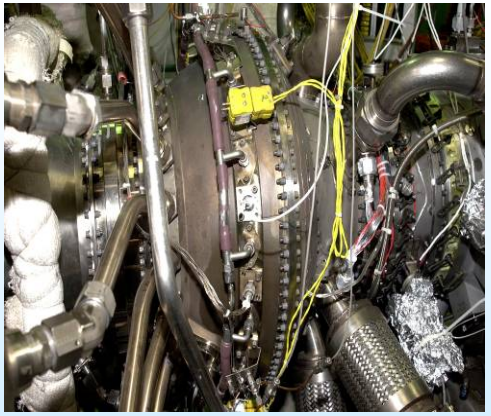
- SiC HAS EXCELLENT MECHANICAL PROPERTIES FOR USE AS A HARSH ENVIRONMENT PRESSURE SENSOR (T > 500 °C, SILICON UNDERGOES PLASTIC DEFORMATION)
- FORM DIAPHRAM OF SiC AND INTEGRATE WITH ELECTRONICS
- WIDE RANGE OF APPLICATIONS
  - AERONAUTIC ENGINE APPLICATIONS
  - AUTOMOTIVE APPLICATIONS
  - MATERIAL PROCESSING
- ENGINE OPERATION DEMONSTRATED AT 500 C
- CAN BE INTEGRATED WITH FLOW VELOCITY AND TEMPERATURE FOR A VENUS HIGH TEMPERATURE WEATHER MONITORING DEVICE



500 °C SiC pressure sensor

SiC High Operating Temp. Probe (HOTProbe): SiC chip to simultaneously measure flow velocity, pressure, and temperature;

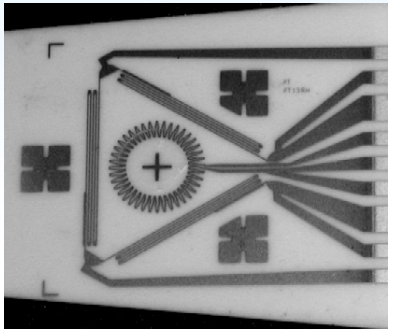




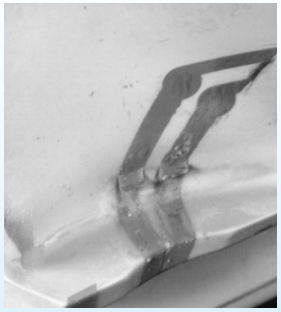
Real World Application: Pressure Sensor Installed in Engine Test

Thin Film Physical Sensors for High Temperature Applications

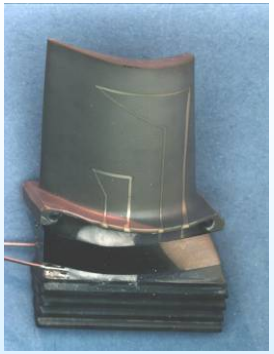
- **Advantages for temperature, strain, heat flux, flow & pressure measurement:**
  - Negligible mass & minimally intrusive (microns thick)
  - Applicable to all materials including ceramic based materials
  - Minimal structural disturbance
  - Intimate sensor to substrate contact & accurate placement
  - Multiple sensor fabrications, full-field measurement
  - High durability
  - Capable for operation to very high temperatures (> 1000°C)
- **Multifunctional smart sensors being developed**
- **Can Be Used To Measure Venus Surface Conditions as well as Monitor Vehicle Conditions**



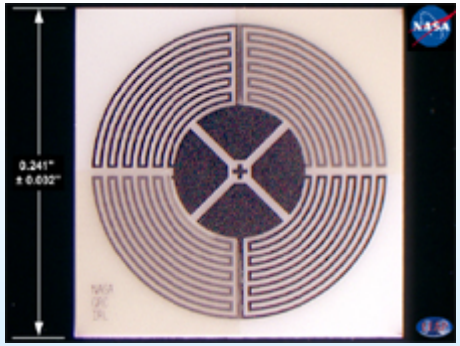
Multifunctional Sensor Array



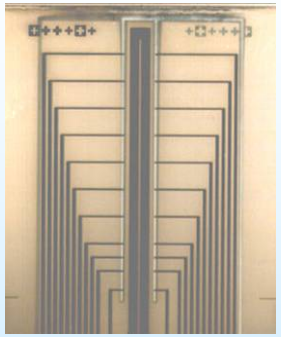
PdCr strain sensor
On Alloy to T=1000°C



Pt- Pt/Rh temperature sensor to T=1200°C



Heat Flux Sensor Array to T=1000°C



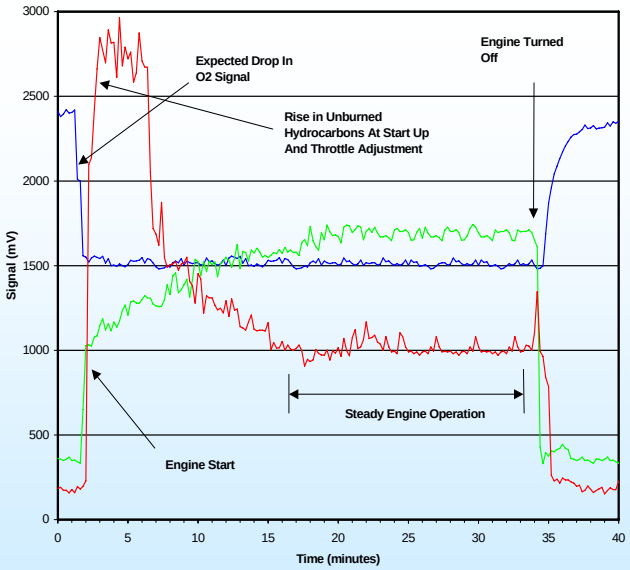
Flow sensor to T=1000°C

HIGH TEMPERATURE GAS SENSOR ARRAY
HIGH TEMPERATURE ELECTRONIC NOSE

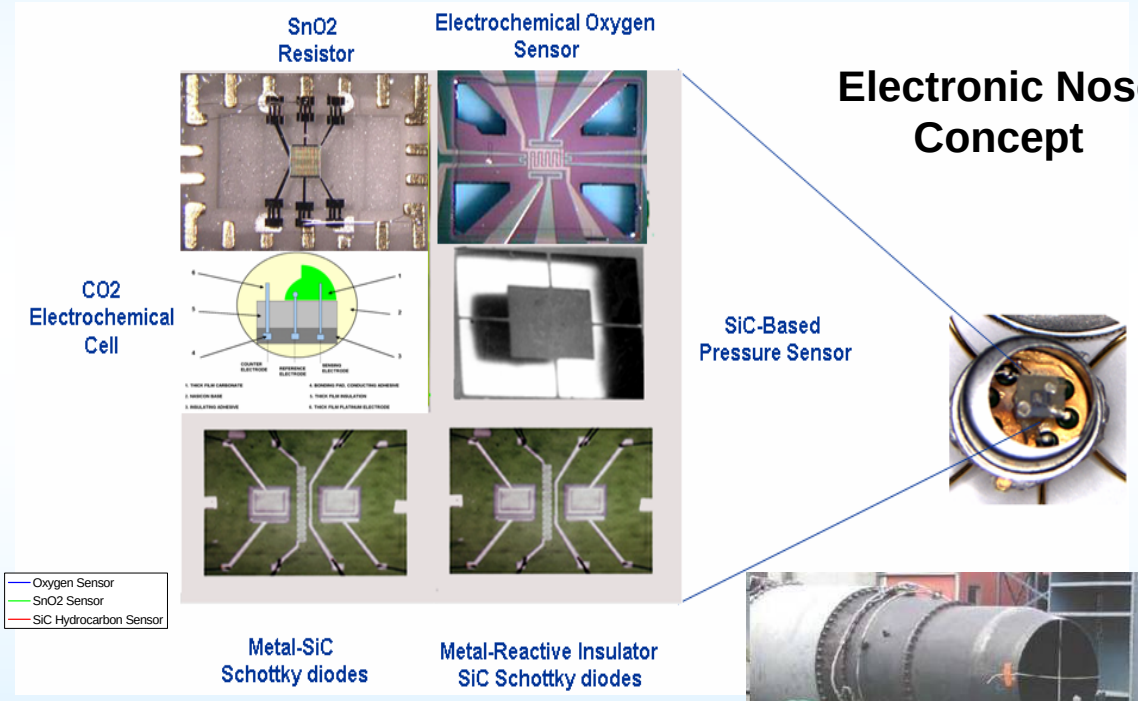
Makel Engineering Inc.

- **High Temperature MEMS Based Gas Sensors Designed for Selective Detection**
- **Multiple Chemical Species Can Be Measured/Sensors Can Be Tailored for the Application**
- **Multiple Species of Interest To Venus Applications Can Be Detected**

Automotive Engine Sensor Testing



Electronic Nose Concept



Jet Engine Sensor Testing