

IMAPS HiTEC 2025 Ozark Integrated Circuits, Inc.

Ozark

**OZARK
INTEGRATED
CIRCUITS INC**

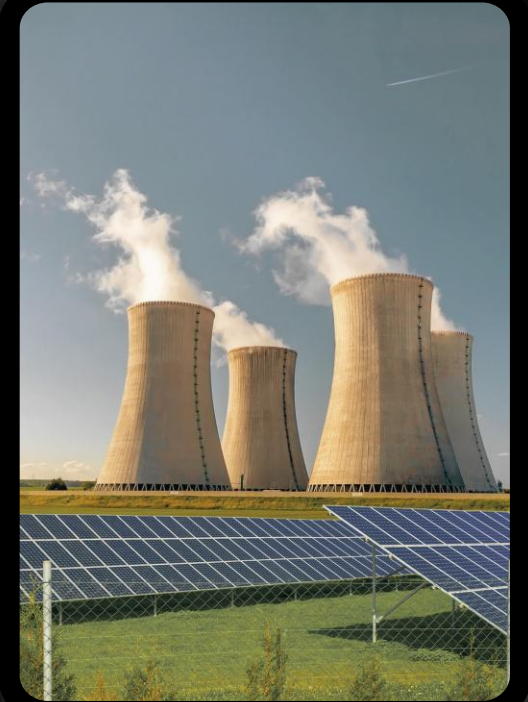
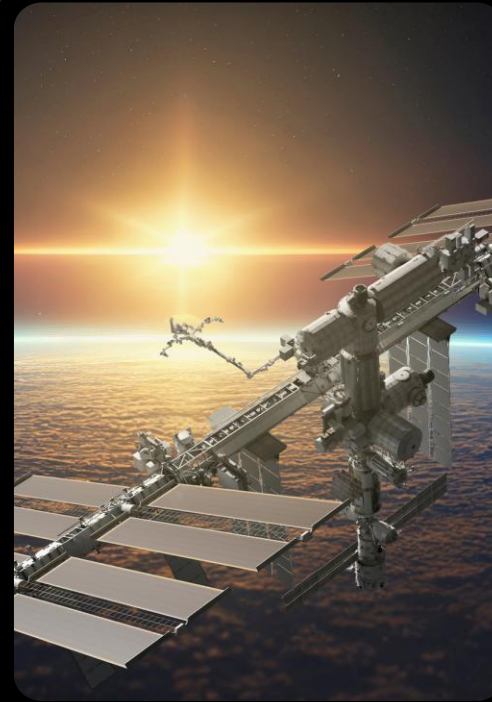
Solutions for Extreme Environments using XNodes®

Paul Minor, PhD, Program Manager
minor@ozarkic.com

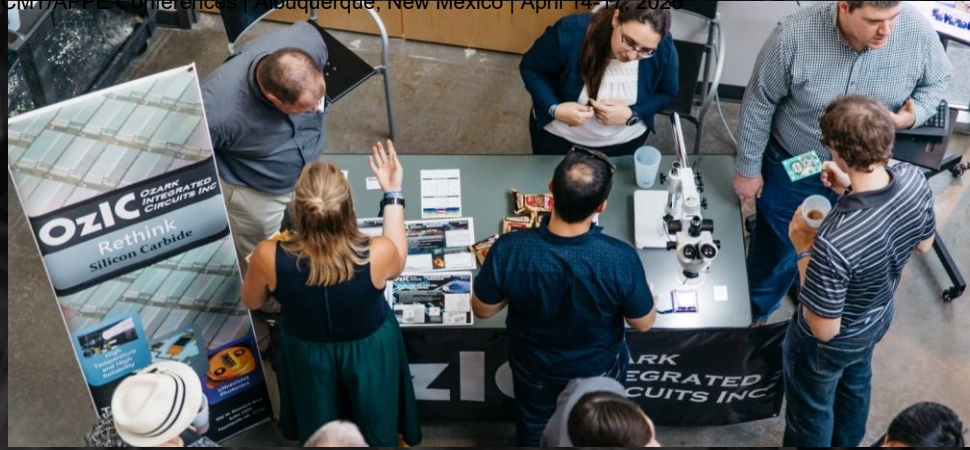
Ozark IC is a fabless semiconductor company that delivers best-in-class analog & mixed-signal integrated circuits for remote sensing and actuation under extreme environment conditions, rapidly and right-first-time

THE RUGGED CIRCUIT SPECIALISTS

WWW.OZARKIC.COM



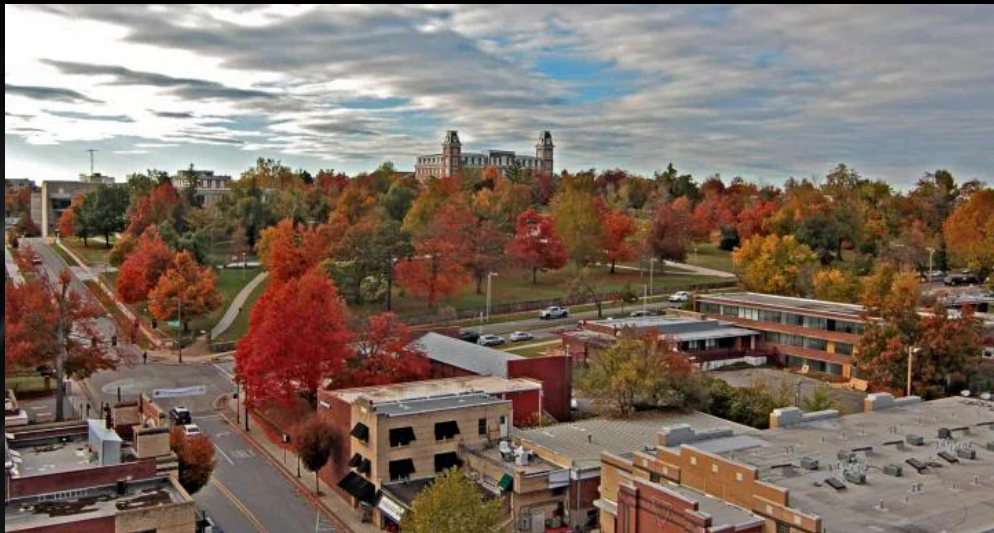
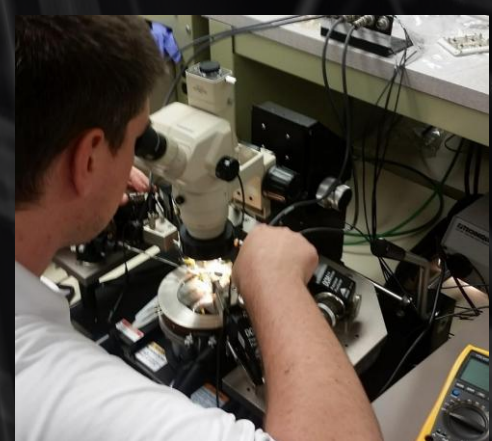
Ozark Integrated Circuits Inc



Who We Are

Ozark IC uses advanced semiconductors and packaging to deliver best-in-class analog & mixed-signal solutions for remote sensing and actuation under extreme environment conditions, rapidly and right-first-time

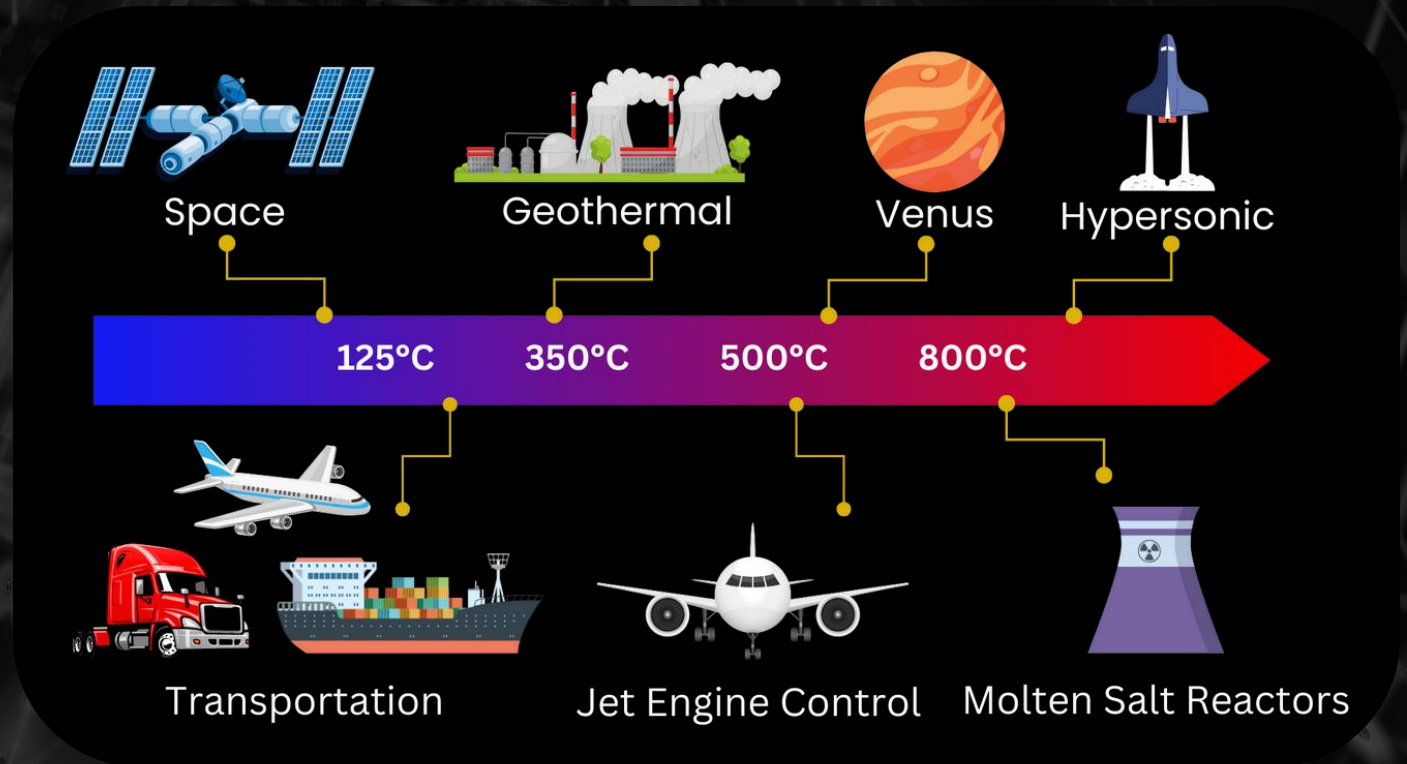
- Founded in February 2011
- Located in Fayetteville, Arkansas Technology Park
- 26 Employees



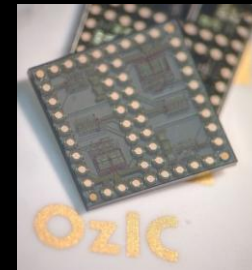
The Challenge

Acquiring Operational or Situational Data & Exerting Digital Control in Extreme Environments is Difficult

- **Electronics Lifespan** - Traditional Electronics are Unable to Survive
- **Limited** Observability & Controllability
- Current "Solutions" are **Custom, Expensive, & Ineffective**
- **Critical Defense and Energy Applications Require Operation of Electronics in Extreme Environments**



Ozark IC Provides Extreme Environment Solutions:



Semiconductors



Packaging



Integration

Ozark IC Solution: The eXtreme Node[®]

XNode[®]: A single-board, rugged computer module with one or more integrated functions designed to operate in an extreme environment

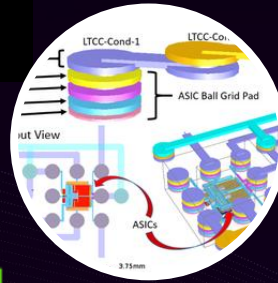
Acquisition: Remote signal acquisition (sensing) and digitization

Actuation: Remote control of a motor, linear actuator or other electromechanical device

Closed-loop control: Local sensing and actuation with local decision making (e.g. PID)

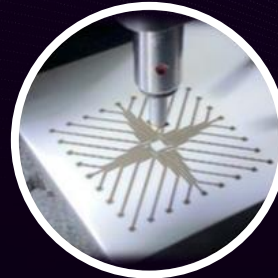
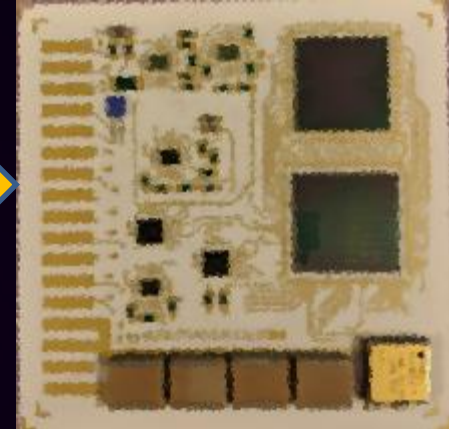
Communication: Wired, wireless communication to a remote location

XNODE[®]

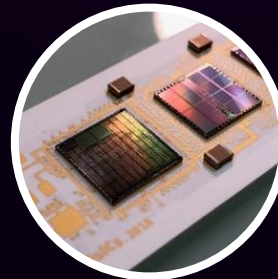


IC/Package
Co-Design

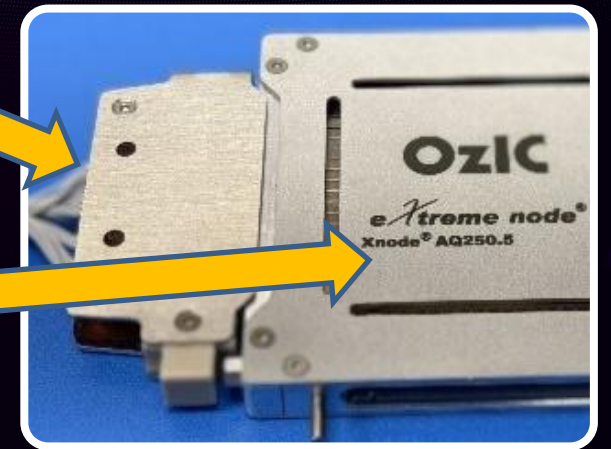
AQ250
XNode[®]



Additive
Technologies
for 3D
Integration



Advanced
Semiconductors-
Operate at Any
Temperature!

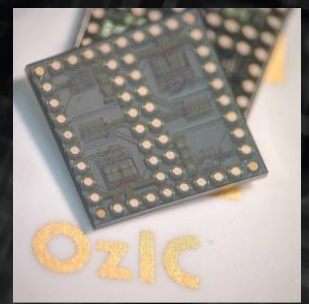


Where do you start?

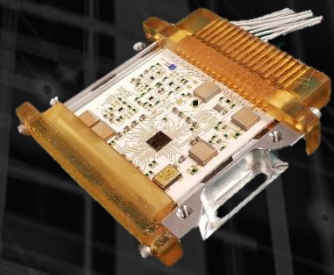
- Standard ranges are out the window
- What materials work?
 - Temperature survivability
 - Temperature reliability
- Consider everything
 - Semiconductor
 - Package
 - Integration

Know your application, and map to materials

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2025 Joint HITEC/CIDM OzIC(R) and XNode(R) are registered in New Mexico | April 14-17, 2025
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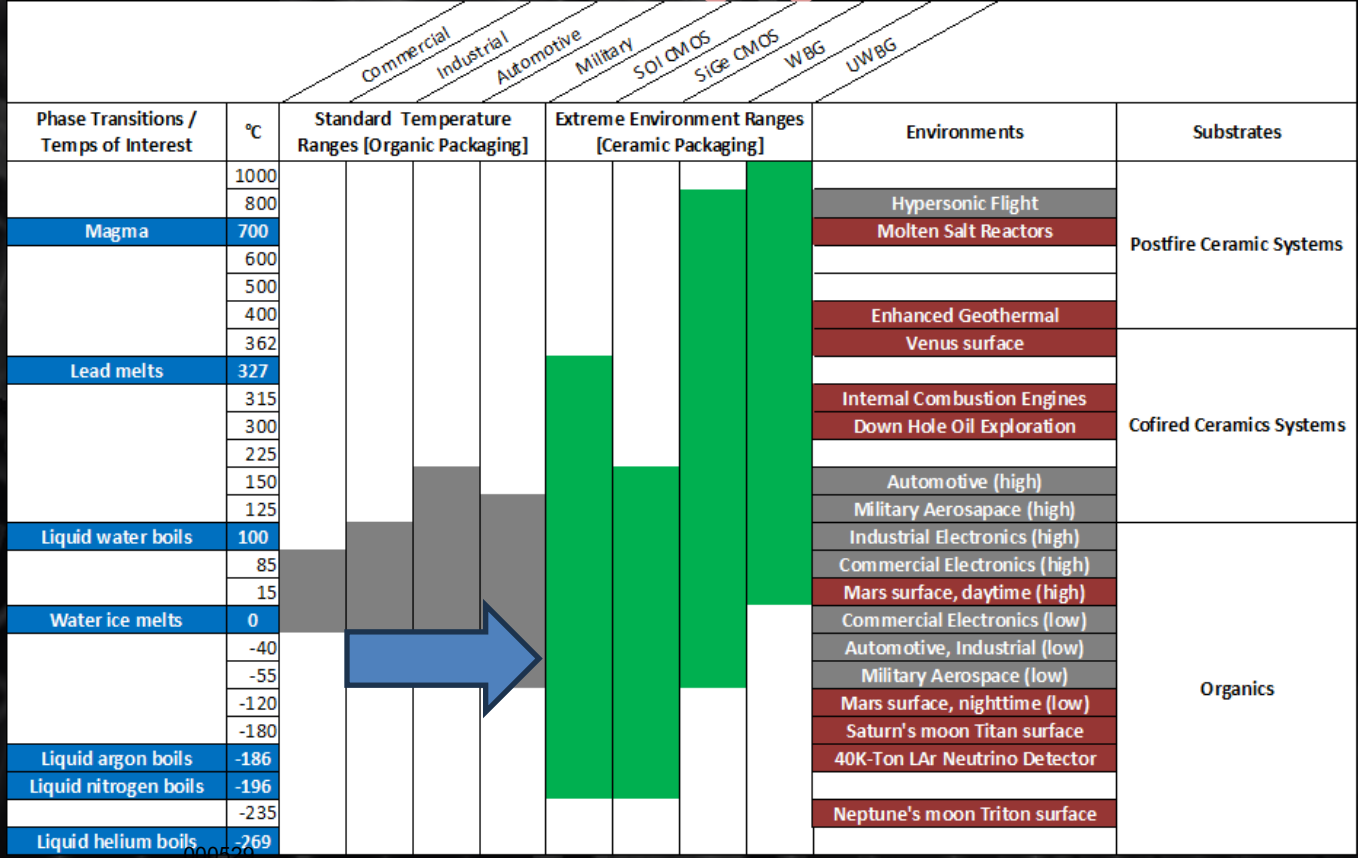
Semiconductors



Packaging

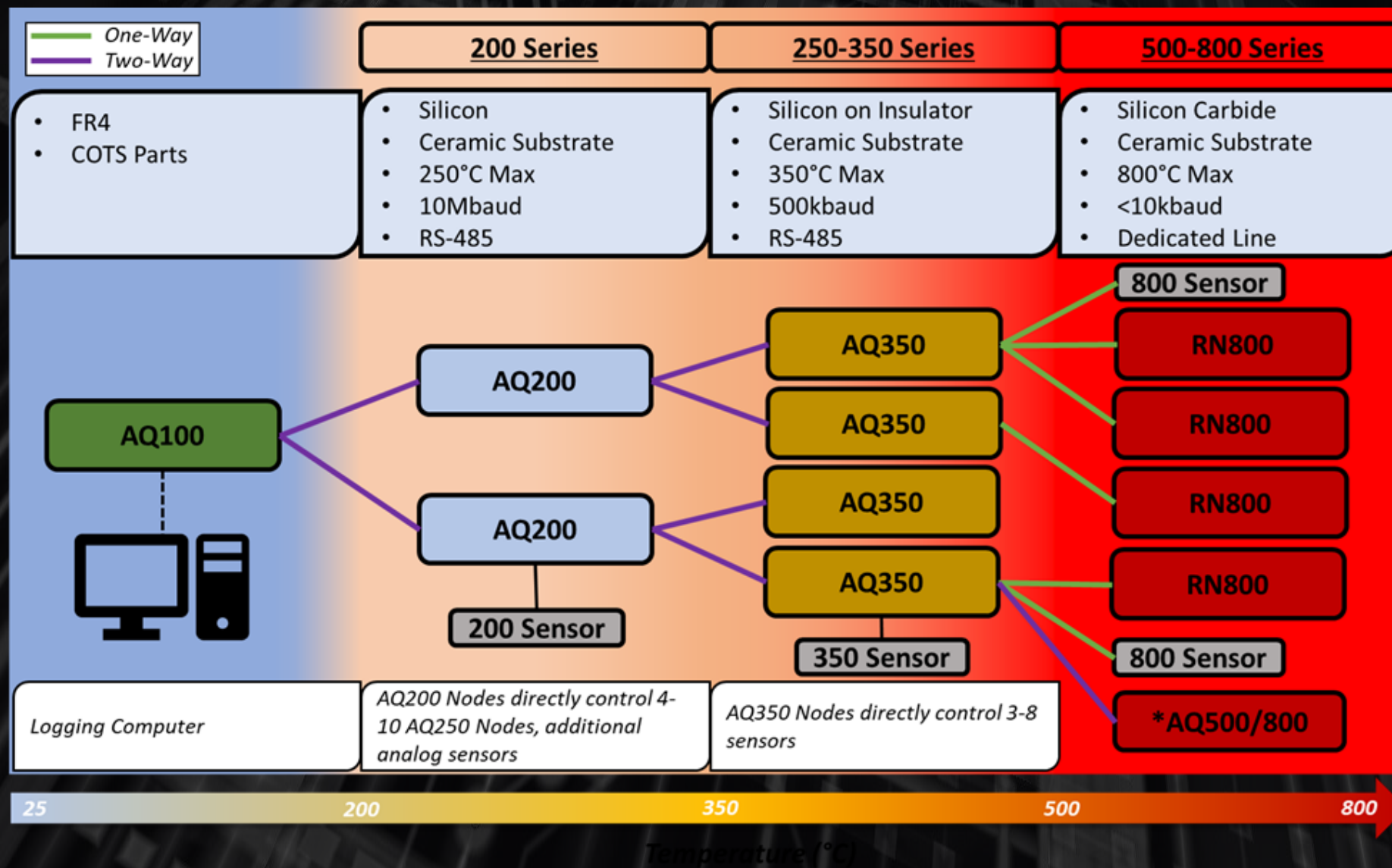


Integration



Networked Topologies

2025 Joint HITEC/CICMT/APPE Conferences | Albuquerque, New Mexico | April 14-17, 2025



Ozark IC High Temperature Products

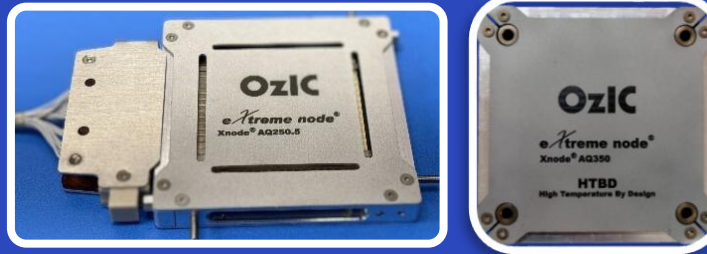
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X NODE[®] 200



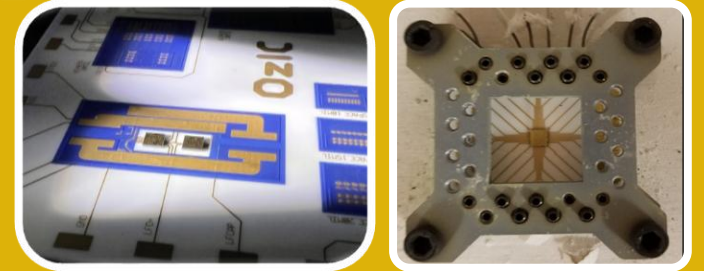
- 32 Bit Processing Core with 12-bit ADC, on-chip Flash

X NODE[®] 250/350



- 32-bit Processor Core
- Memory options 4k up to 32k

X NODE[®] 500/800

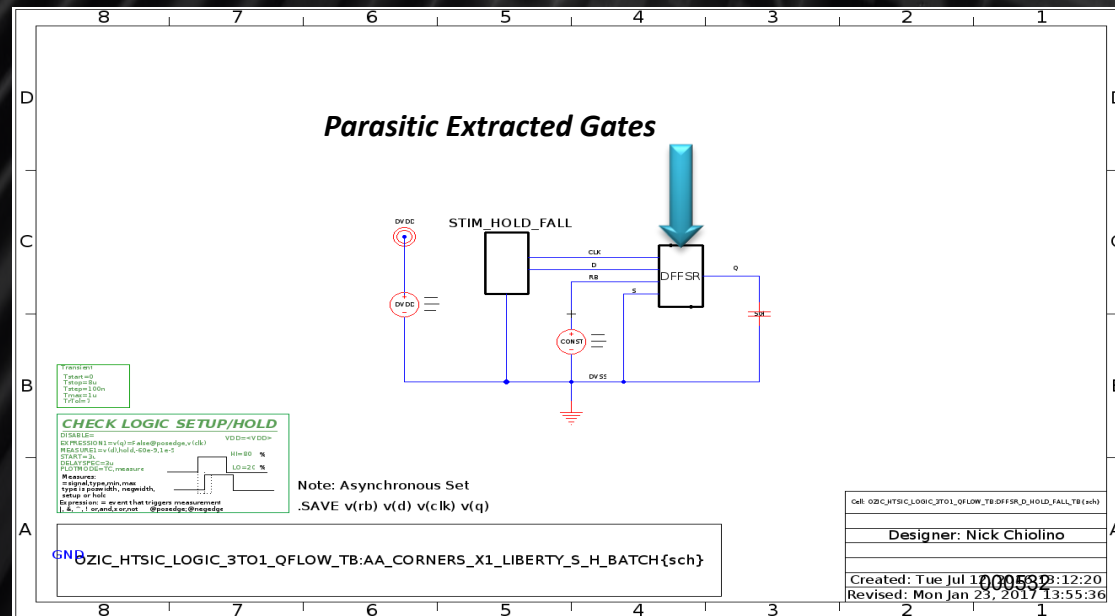


- **In Development**
- SiC technologies validated to 800°C
- Multiple iterations and form factors

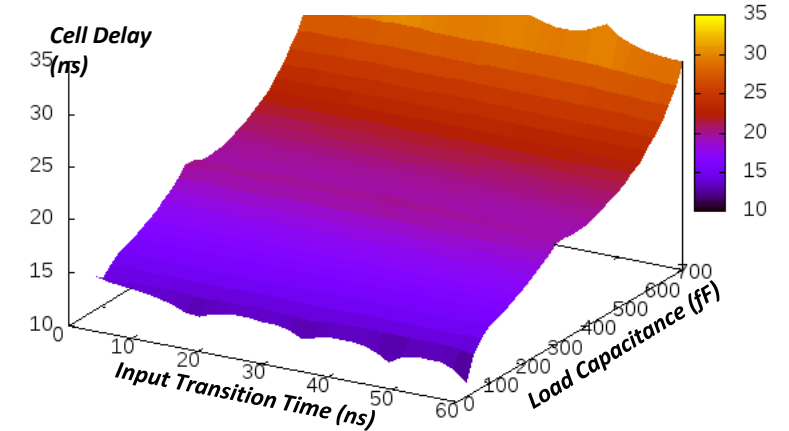
Bespoke Digital Designs for H1

- Supporting automated digital flows
 - Rapid Iterations
 - Flexible design space dependent on target corners
 - Low cost (open source)
- Challenges for an eXtreme Environment (XE) digital flow
 - Tailoring traditional CMOS place & route tools for XE applications (emerging technologies)
 - Creating all of the necessary inputs for a rule-based placement & signal routing tool
 - Optimization over large PVT space

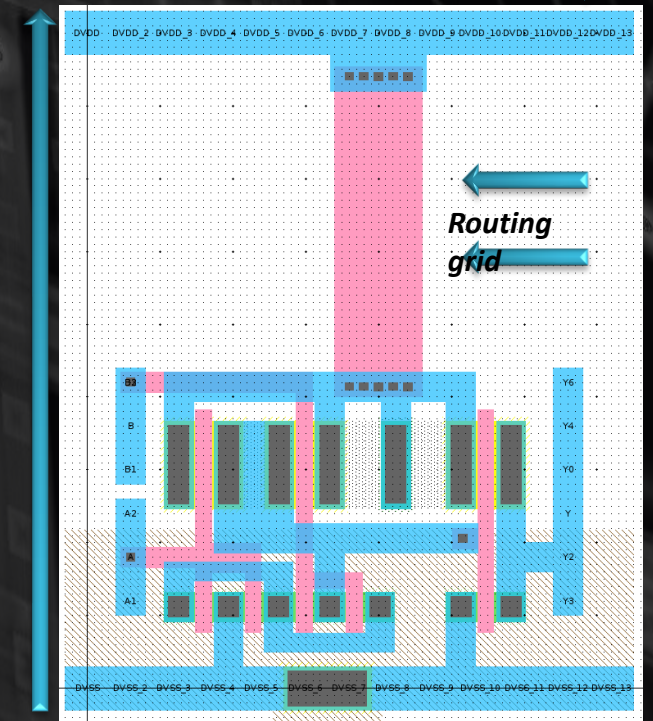
Timing test bench for DFFSR



Timing surface of cell delay during rise time of input A to output Y of a AND2X1 at 470 °C



Width snapped to uniform grid



Uniform rail

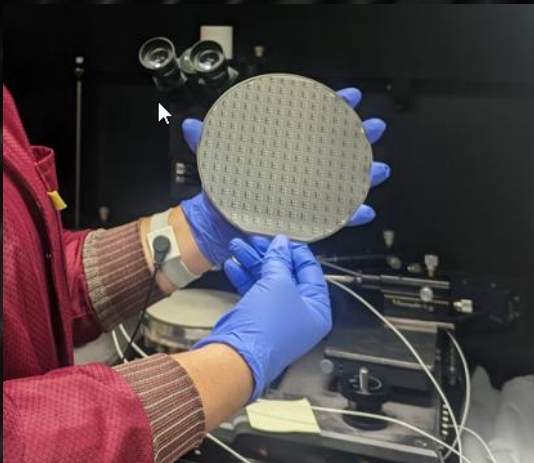
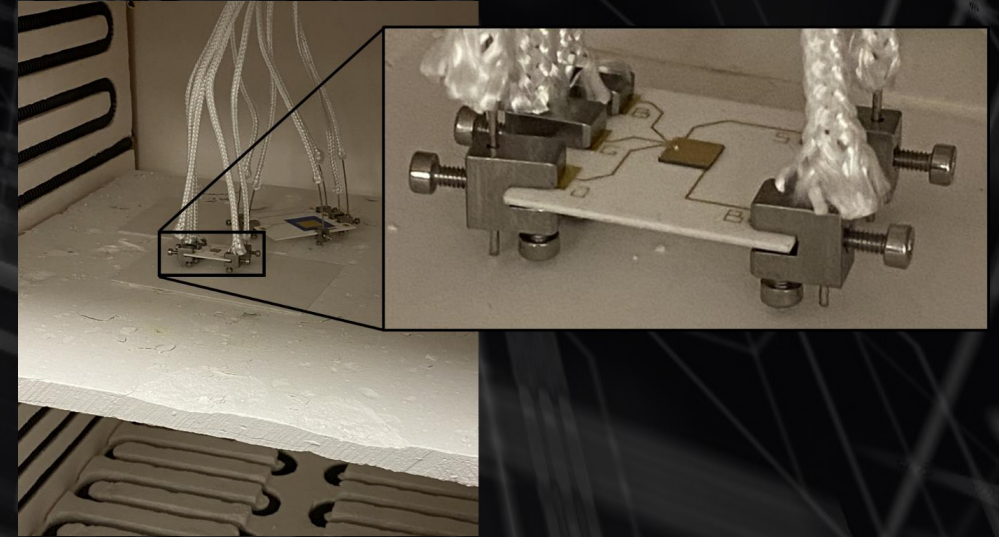
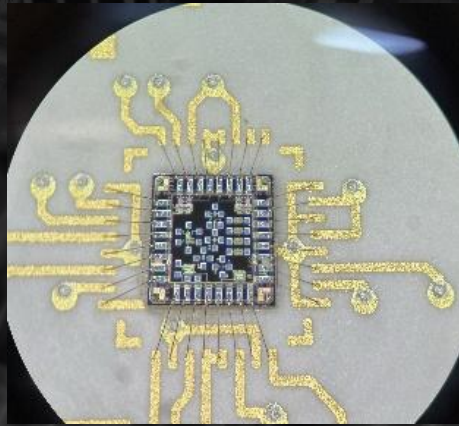
How we do it: Advanced Devices, Advanced Packaging

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- Qualified semiconductors
- Qualified materials
- High density integration
- High performance, high reliability

State of the Art



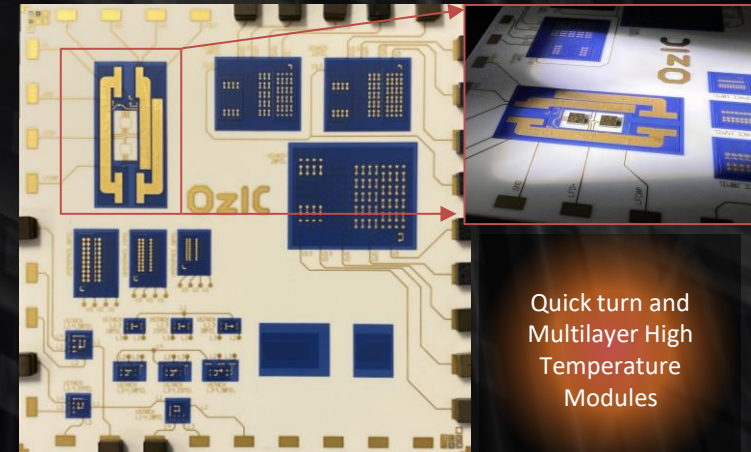
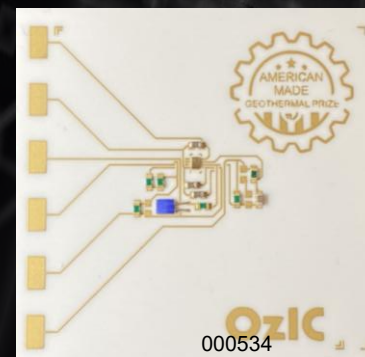
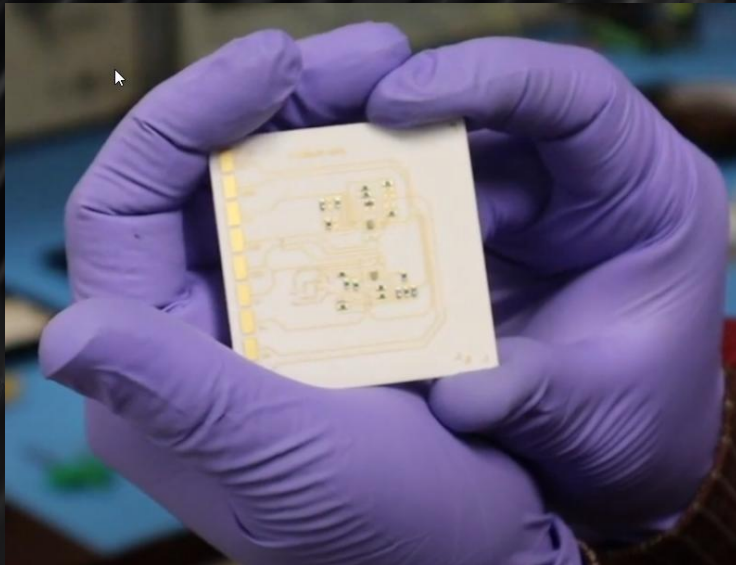
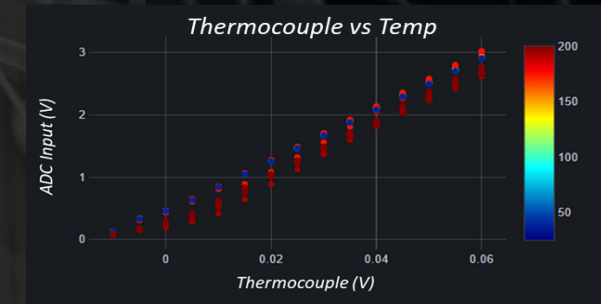
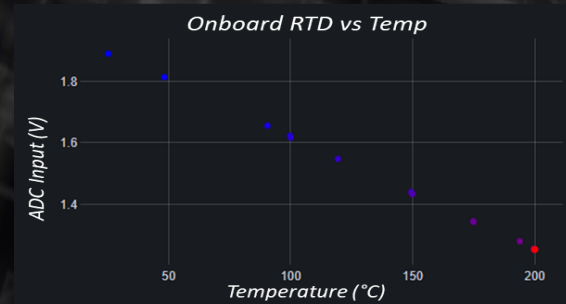
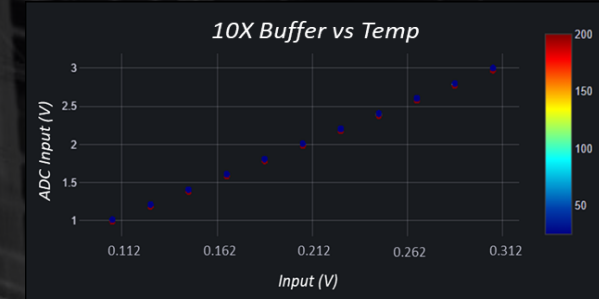
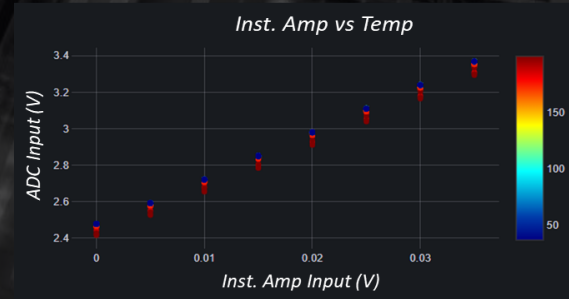
How we do it: Rapid Prototyping

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Additive-based Packaging:
Quick-turn packages for test and qualification in as little as a week to temperatures as high as 800°C!

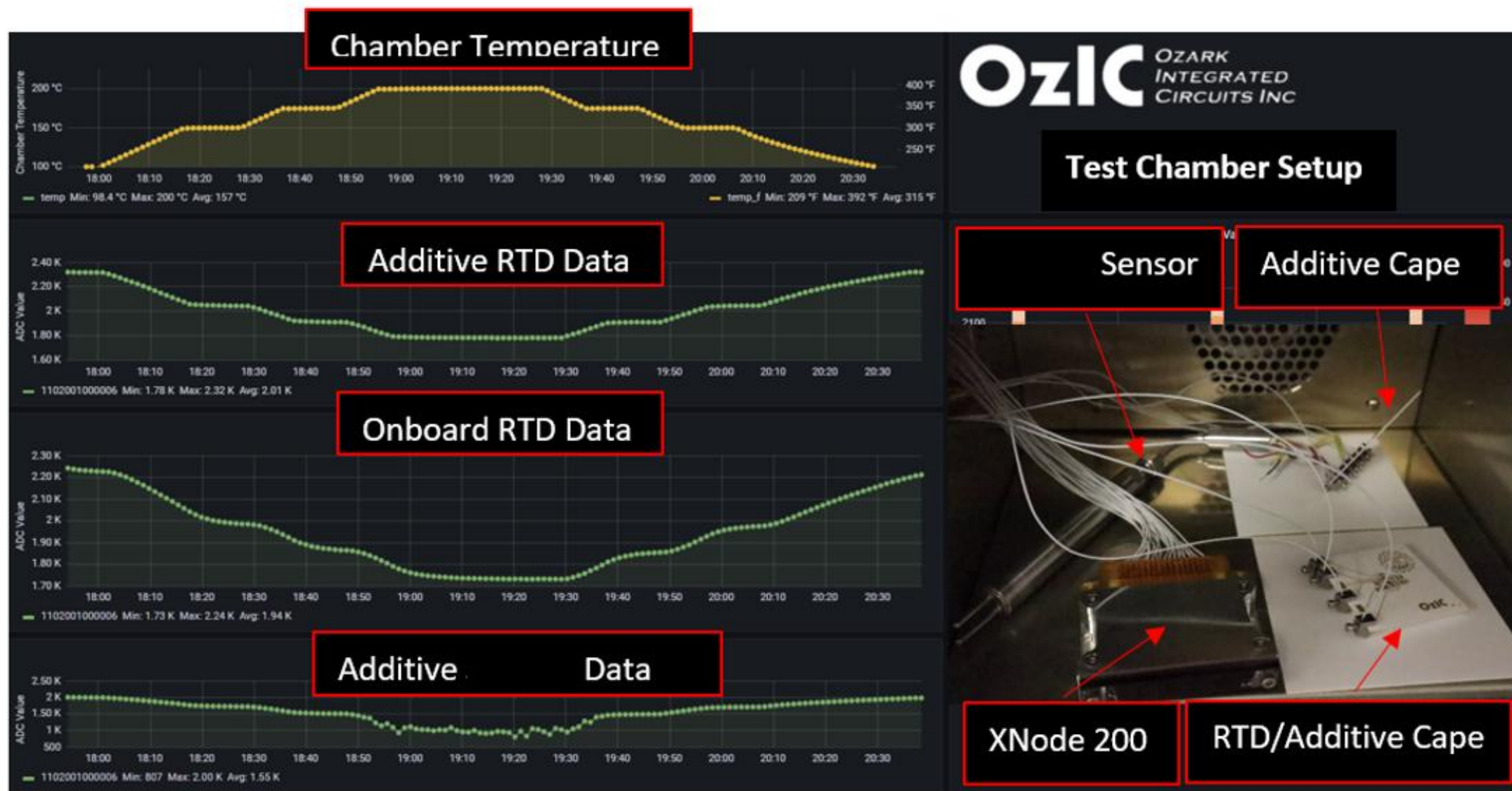
State of the Art

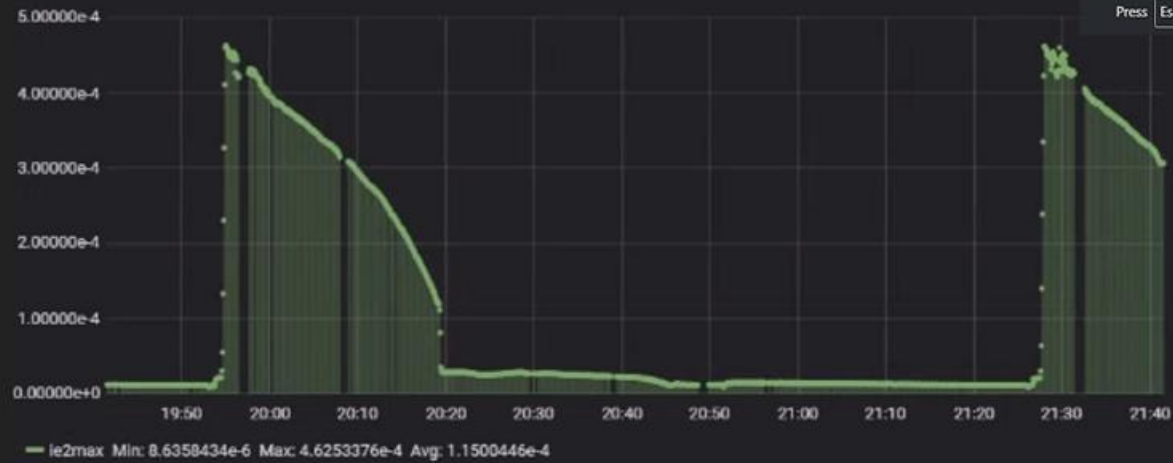


Quick turn and Multilayer High Temperature Modules

Rapid Prototype XBlock Testing

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Time to/from last command

-12 days -08:40:08.145322 :
resume operations (spacewalk
complete) at 2020-01-16
13:00:00-06

Recorded Max (all channels)



WAKE (APID 1521)



Sweep Curve - 1533

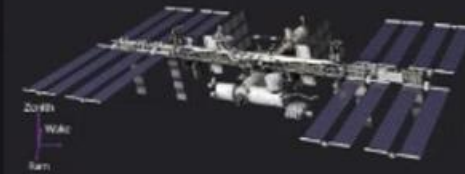


Ozark IC UV-100 SmartNode

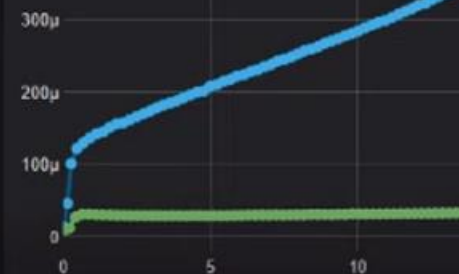
Receiving and reporting data from the
International Space Station

Views of UV from space

Ultraviolet Response correlates with 90 minute
orbit, Measures ultraviolet radiation present in
low earth orbit



Sweep Curve - 1521



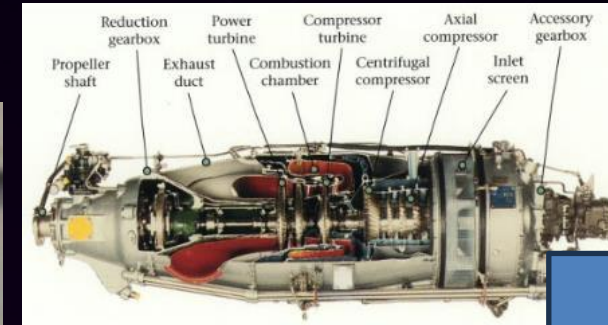
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Networked Topologies – PT-6 Turboshaft Engine

350°C to 500°C+



AQ350

- 4MHz
- 12 bit
- Local Digitization
- RS-485 Data Stream

RN500/800

- Local Temperature sensor

RN500/800

- Local Pressure Sensor



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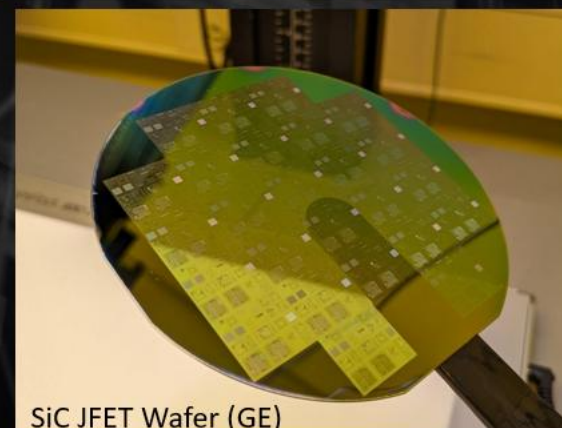
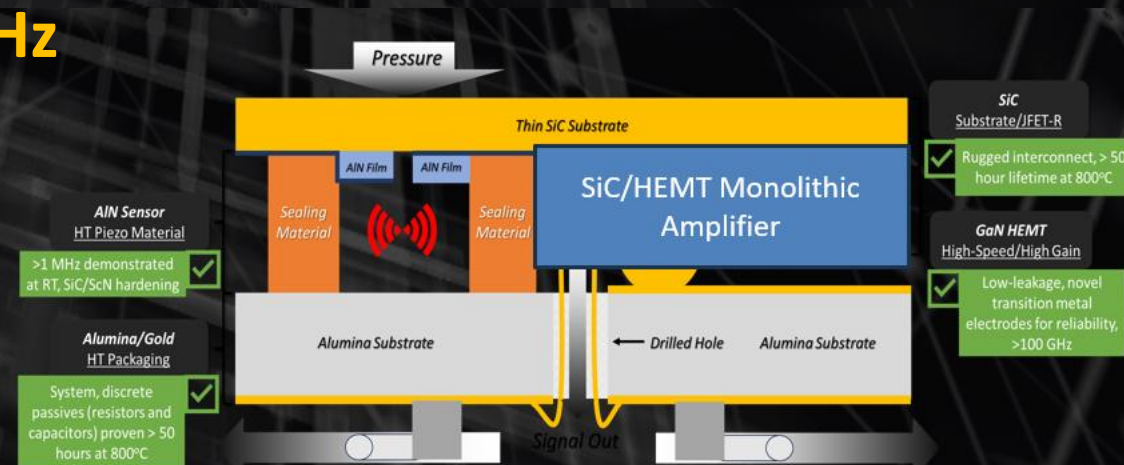
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The Future – Monolithic Integration

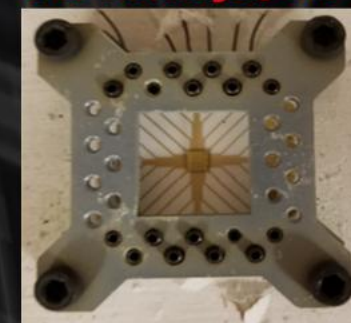
1 MHz Pressure Sensor, with 100 MHz Analog Electronics

800°C Single-Chip Pressure-Transducer System on a Thermally-Hardened Heterogeneous SiC/JFET:GaN/HEMT Platform (SPoTS)

- Building from a base of Proven Supply Chains and Materials
- Combining technologies
 - AlN technology already demonstrated at 1 MHz from IC2.
 - Proven NASA SiC JFET-R technology installed at GE Research
 - Ceramic packaging by Ozark IC.
 - Hardened HEMT grown by Raytheon (RTX)
- Best of all worlds
 - High performance
 - High reliability
 - High density
 - Solving a wide variety of challenges – analog, sensing, etc.



JFET & Package @ 800°C

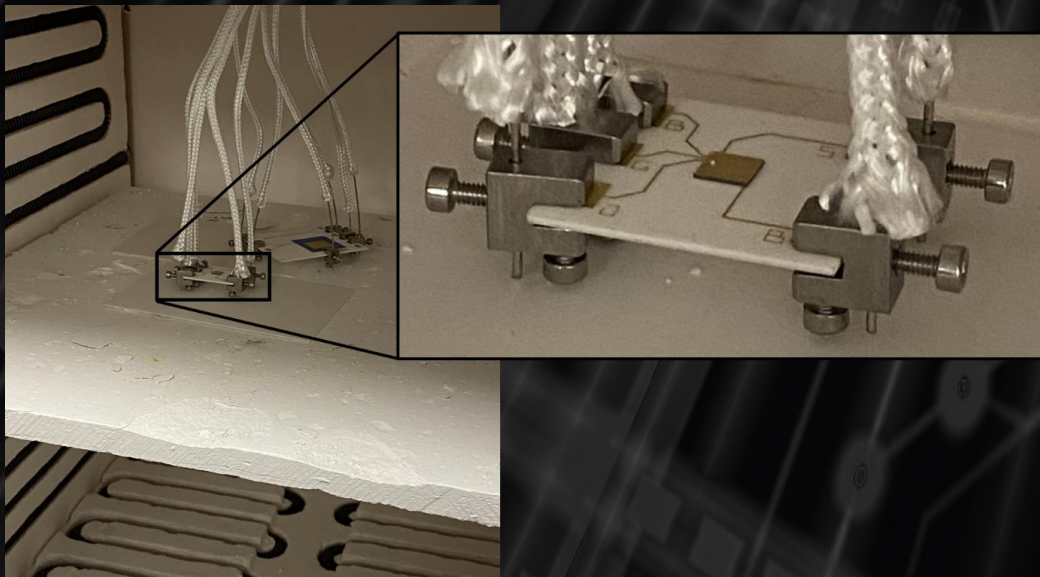
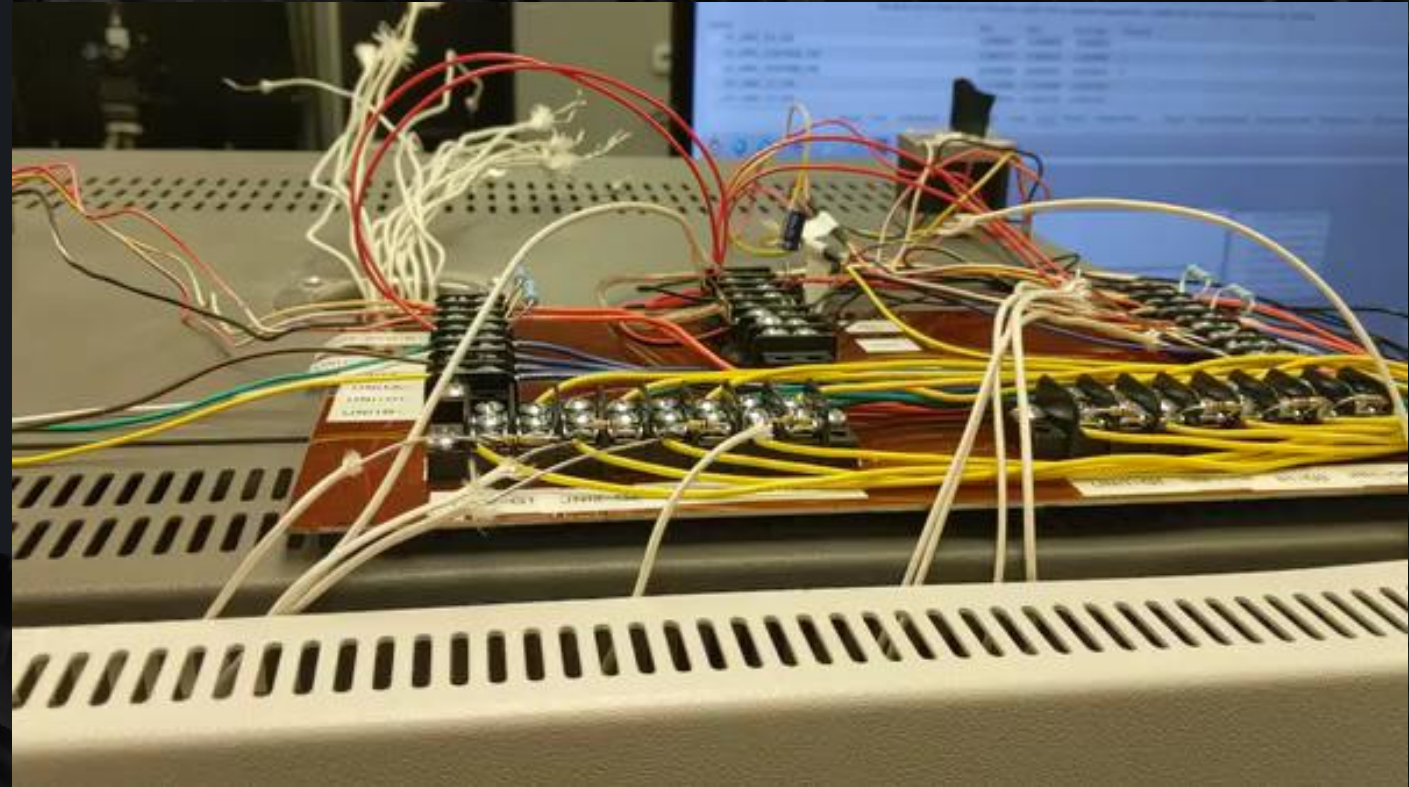
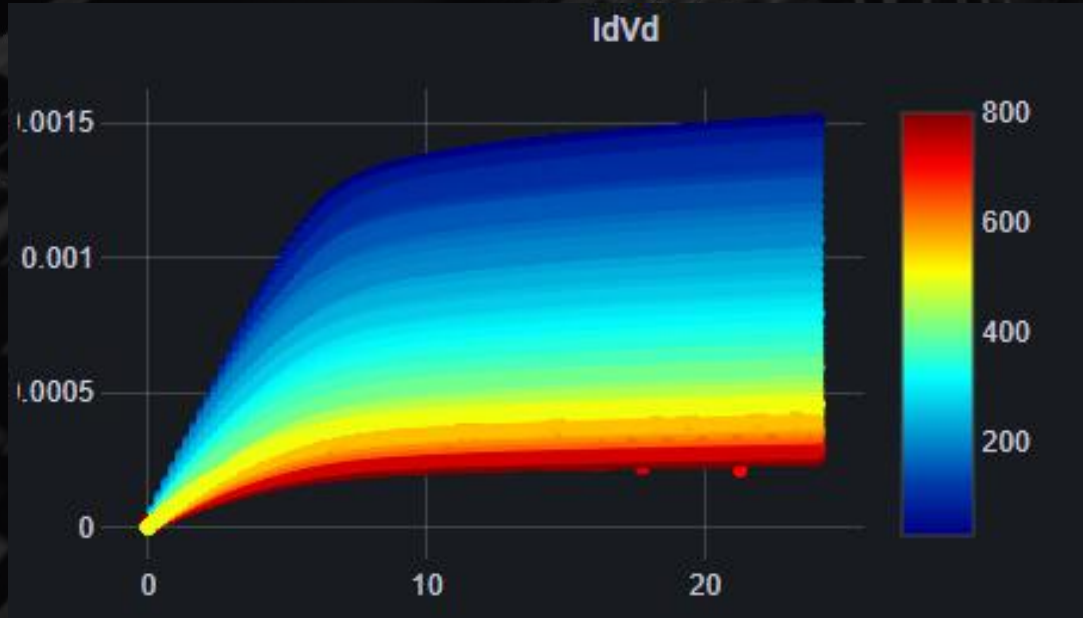


Utilizing NASA JFET Technology
Invented at Glenn Research Center

High Temperature Actuation

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Using NASA JFET-R Technology (Gen 10)

Example: Silicon



Temperature:

- 200°C
- Sinusoidal input (1Hz)
- Over 300 days
- Grade 3 (SOA is Grade 5)

XNode® AQ200

32 Bit Processing Core with 12-bit ADC, on-chip Flash

- Internal 2.5V Reference
- Internal ADC: 16x12-bit Channels with 1MSPS (Default)
- (Standard) Three external sensor channel types
 - RTD, Strain or Thermocouple, General Purpose Gain Limited
- 8-Bit R2R, GPIO Driven DAC
- RS-485

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Hours Run

7443.25

Days Run

310.14

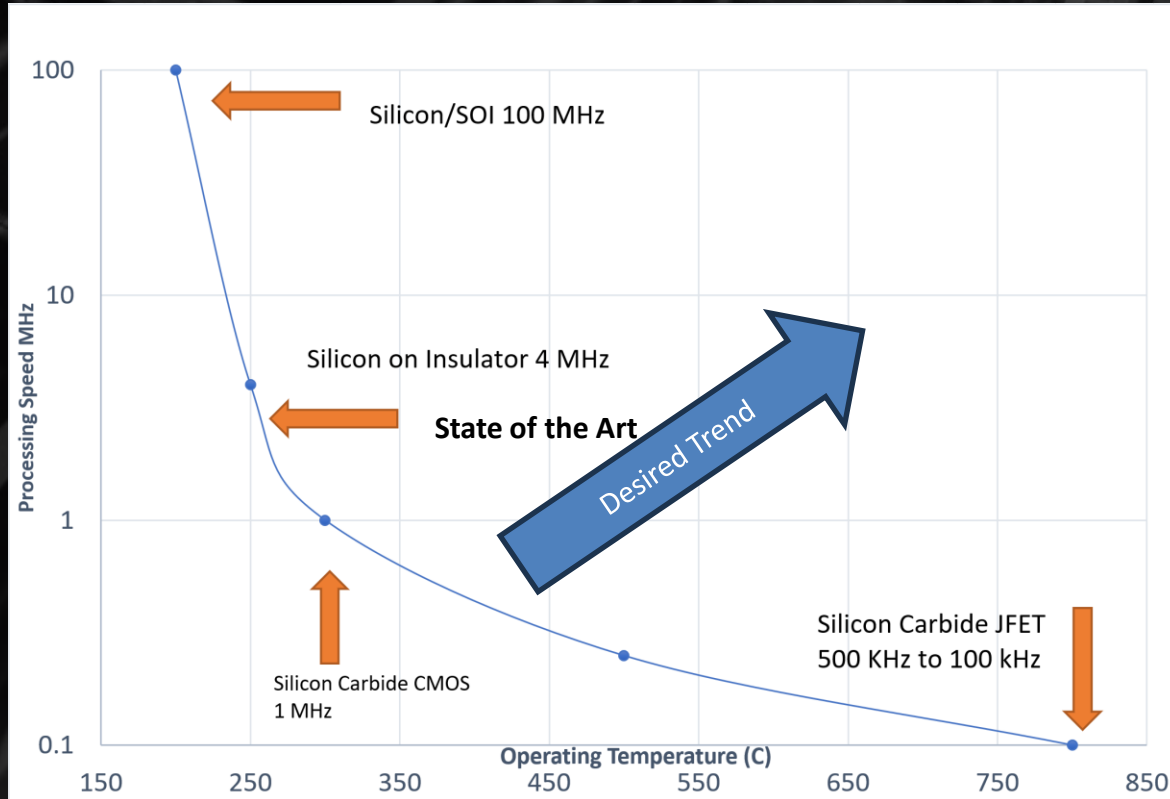
Years Run

0.85

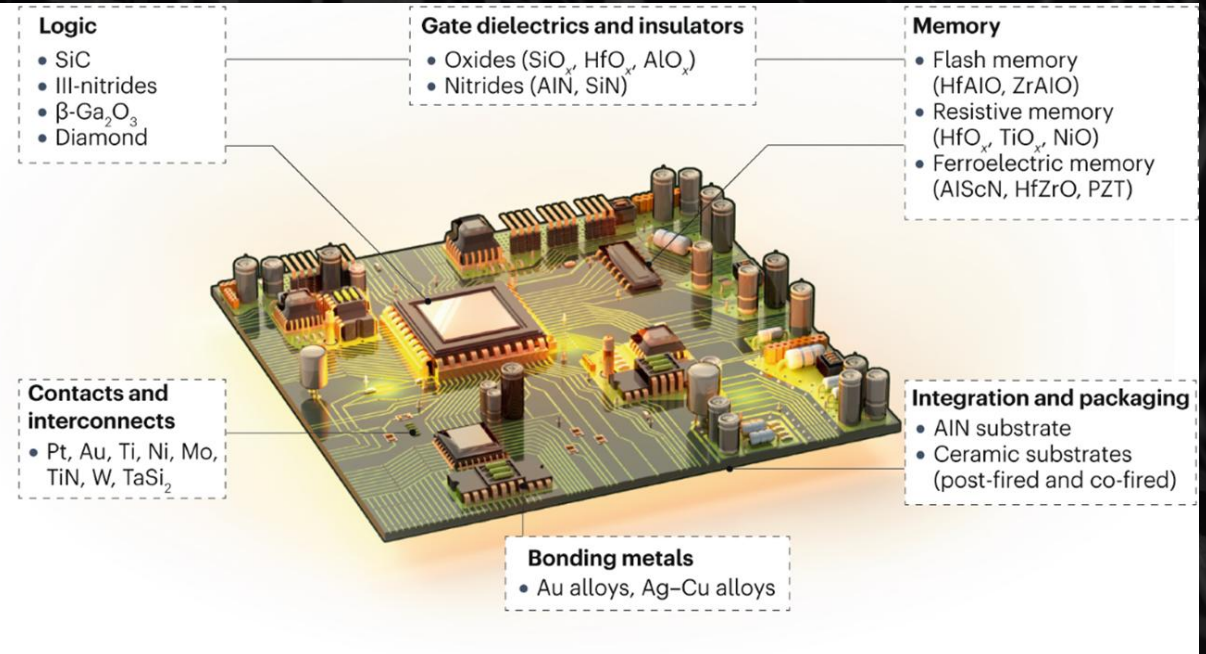


Materials

Challenge Performance vs Temperature



Material Considerations at High Temperature



Pradhan, Moore, Francis, Kupernick, Kennedy, Glavin, Olsson, and Jariwala, *Nature Materials* (2024)

- Important to consider application requirements for lifetime, there is a trade space for lifetime and performance at a given temperature!



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Ozark INTEGRATED CIRCUITS INC

Bringing IoT to the Edge in Extreme Environments

ADVANCING
MICROELECTRONICS
EVERYTHING IN ELECTRONICS BETWEEN THE CHIP AND THE SYSTEM!
2024 • Vol. 51 No. 2

Advanced
Packaging for
Power & High
Temperature



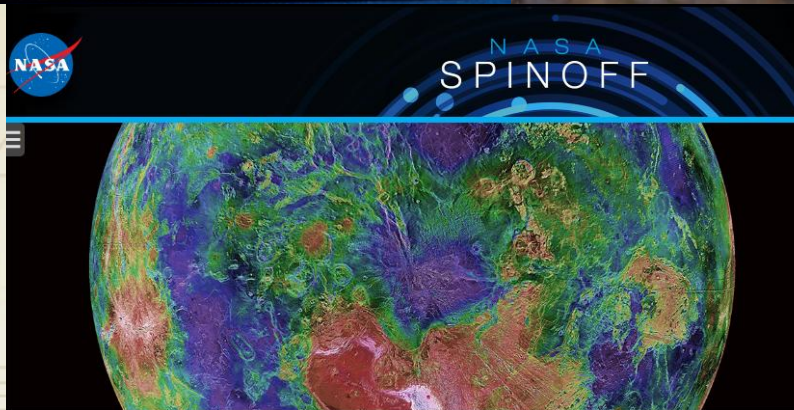
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Additive Prototyping...
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From the APPE Chairs
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Earth's Twin Helps with Extreme Electronics

Plans to explore Venus give rise to new computer chips for high-heat conditions on Earth

Originally published 01/31/2023

Venus and Earth, often called twins for their comparable size and density, have something else in common – extreme heat. Exploring our closest planetary neighbor will require technology for a corrosive, high-pressure atmosphere and surface temperatures around 900°F. Geothermal engineers tapping heat deep within the earth as a renewable energy source encounter similarly punishing temperatures. Both need compact, rugged electronics to power sensors and collect data without a bulky cooling system. All-in-one, single-board electronics modules that benefited from NASA expertise now offer that capability on this planet.

To support missions to the surface of Venus and elsewhere, NASA's Glenn

An all-in-one, single-board computer module can withstand 900°F conditions without a cooling system thanks to Glenn Research Center expertise in extreme-temperature technology. SBIR funding also helped Ozark Integrated Circuits Inc. of Fayetteville, Arkansas, create its eXtreme Nodes modules to support geothermal drilling, nuclear power plants, and other industries on Earth, as well as, perhaps, a future Venus lander.



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