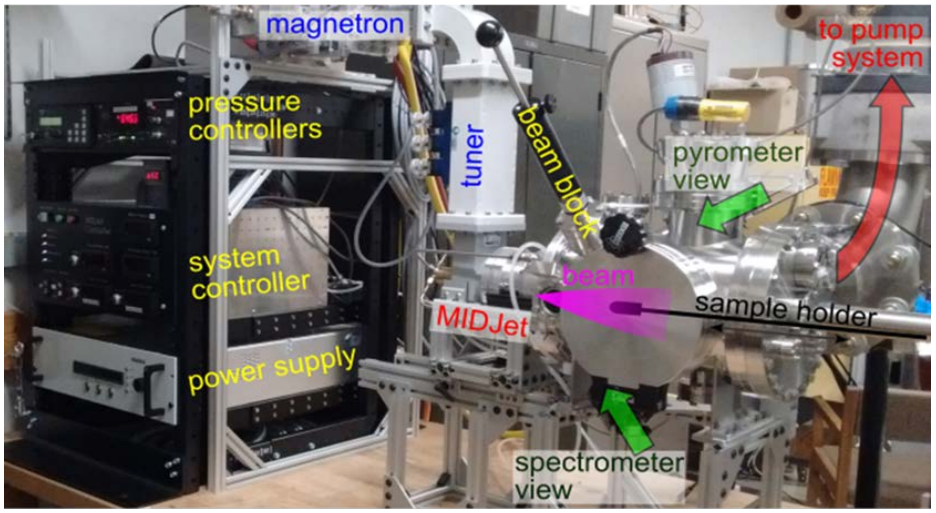
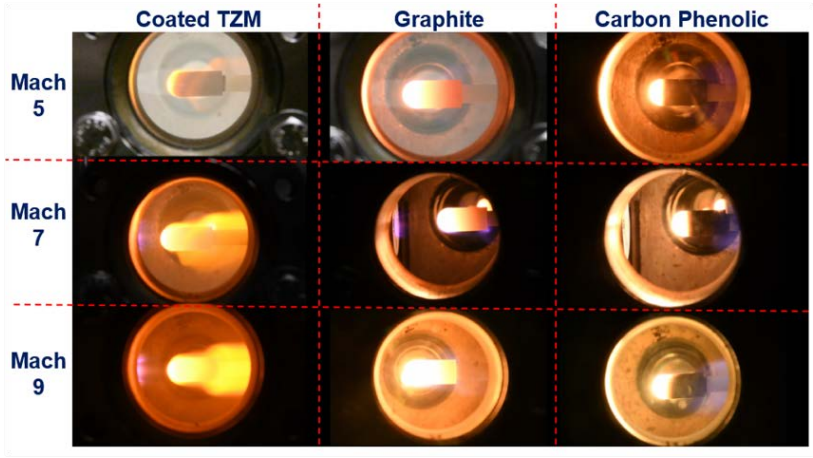
PSI's Hypersonic Materials Testbed



Example Test Matrix: 3 materials & 3 enthalpies



For over 40 years, PSI has provided technology solutions and innovative products to our government and commercial customers. Our employee-owners continue to grow the company across a range of markets applying emerging science to important problems. We play an important role in the development and transition of advanced technology from the laboratory to commercial and government use.

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Testing Services

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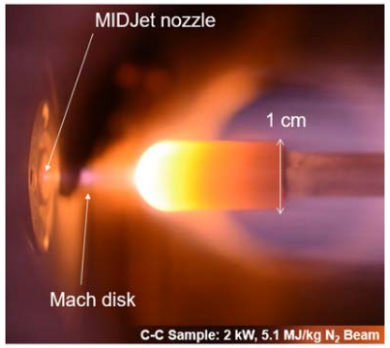
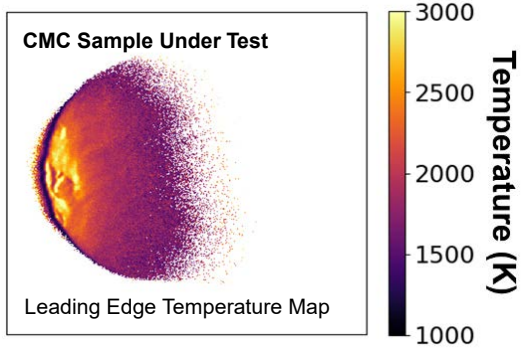
Hypersonic Materials Testing

Characterize the effects of the hypersonic environment on materials: Erosion rate, signatures, impact on surface and bulk properties.





Capability

Physical Sciences Inc.'s Hypersonic Materials Testbed provides accessible screening to evaluate thermal protection system (TPS) materials under high temperature, high heating rate, and strongly oxidizing reentry environmental conditions. This unique capability enables subscale testing of TPS materials and measurement of oxidation /erosion rate, changes in surface and bulk material properties and optical signatures enabling rapid material assessments and verification of CFD microphysics models.

Features

- **Lab-scale:** Rapid testing of material Thermal/Mechanical/Chemical response to high-enthalpy, high Mach number air flow
- **Clean:** Microwave Jet: No electrode erosion, no contamination
- **Relevant Enthalpies:** > 1-13 MJ/kg (Air) jet, 0.1 – 1.8 kW/cm2 heating
- **Simulated Flow Velocity:** Mach 3 to 17
- **Simulated Altitude:** 15 - 65 km

Physical Sciences Inc. is providing this clean, affordable testbed for hypersonic materials evaluation as a service or for sale
Please contact David Oakes (oakes@psicorp.com) for more details

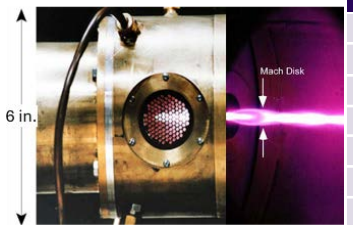
Testbed Capabilities

The testbed utilizes PSI's MIDJetTM microwave torch to deliver a high flux, high enthalpy jet of clean, heated air to the sample under test:

Primary Control Parameters:

- Source Gas: Air or Nitrogen (no diluent needed)
- Microwave power: 1 - 6 kW
- Enthalpy: 1 – 13 MJ/kg
- Stagnation Temperature: 1000 – 6000 K
- Simulated Altitude (pressure): 15 – 65 km (0.1 – 100 Torr)

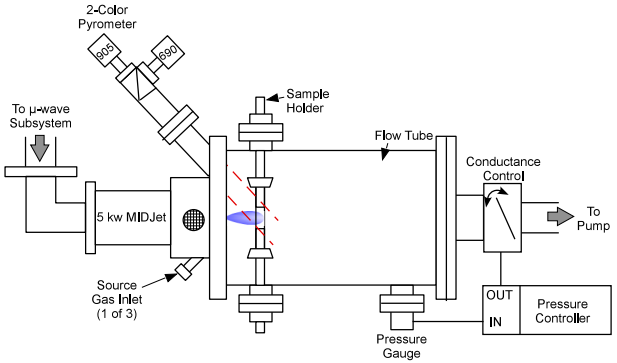
MIDJet^{TM}: Microwave Plasma Torch



MIDJet^{TM} Parameter	Capability	HMT
Microwave Power: kW	1 - 100	6
Microwave Frequency: MHz	2450/915	2450 MHz
Enthalpy: MJ/kg	1 - 17.5	1 - 13
Enthalpy Based Match #	≤ 20	≤ 17
Plenum Temperature: K	1000-6800	1000-6000
Plenum Pressure: atm	0.01 - 10	2 - 10
Jet Velocity: km/s	≤ 3.5	≤ 2.5

- **No electrodes**: Ultra-clean processing, Highly scalable (up to 100 kW), High efficiency /reliability
- **Thermal Source**: Equilibrium output
  – Set enthalpy to tune heating rate and composition: O/O_2

Testbed System and Diagnostics



In-situ tensile testing

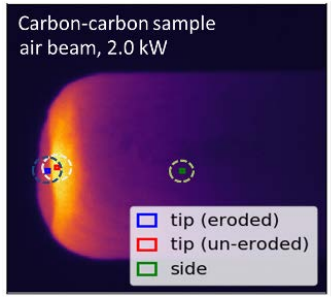
Diagnostics:

- **2-color Imaging pyrometer:** Spatially (50 μm) and Temporally (10 Hz) resolved map of leading edge temperature
- **Process Pressure:** Simulated altitude
- **Jet Enthalpy:** Flow rate & coupled microwave power: Calorimeter & Pitot probes
- **Bulk Sample Temperature:** Imbedded thermocouple
- **Optical:** UV-Vis, Near-IR and FTIR spectrometers
- ***New:*** Instron 34-TM for *In-situ* mechanical strength measurement during heating

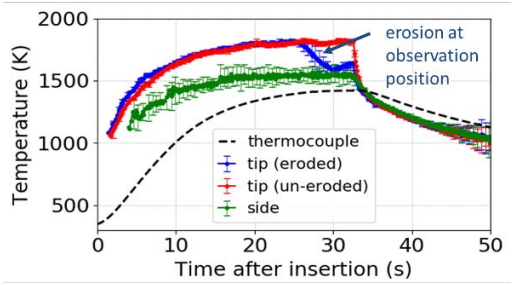
Materials Testing

Two-color Pyrometer: Sample Heating

- Spatial and temporal heating measurements



Apparent local surface cooling as erosion occurs at the observation point



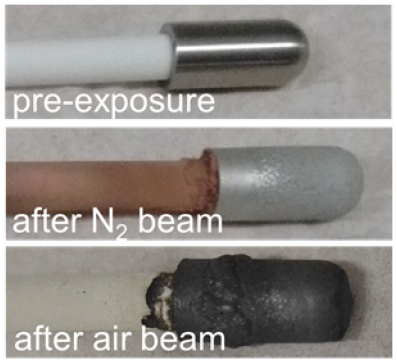
Material Analysis

Capabilities:

- Sample mass loss: erosion
- SEM, surface profiling
- Raman spectroscopy

Additional analysis:

- In-situ tensile strength and modulus
- Surface Analysis: ESCA, XRD, etc

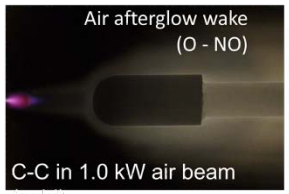


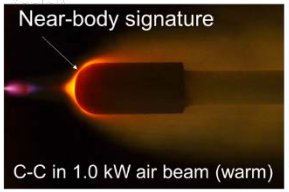
Tungsten samples showing extensive surface changes

Signatures

Emission Spectroscopy: UV - IR

- Atomic and molecular emission from erosion products
- High-enthalpy beam emission
- Reflected thermal emission





Selectable Field-of-View:

Leading edge stagnation zone, direct sample emission, wake

- Physical process investigation
- Relative emissivity spectral variation
- Re-entry signature simulation