Materials Testing for Hypersonic Environments

Plasma diagnostics enabling study of extreme temperature and reactive plasma effects on materials for hypersonic and spaceflight applications

The materials testing facility at Riverside Research provides significant diagnostic coverage of the plasma environment, dielectric property measurements, controllable sample heating methods in hypersonicrelevant conditions, and efficient atomic oxygen plasma generation.



Procedure

- Designed and procured components to develop state-of-the-art laser spectroscopic diagnostics
- Designed, procured, and developed custom compact vacuum compatible sample heaters to achieve hypersonic-relevant sample temperatures in vacuum environments without the need for plasma or arc heating methods
- Outfitted current vacuum facility with reactive plasma-compatible (e.g., oxygen) inductive plasma source
- Identified and designed electromagnet system to achieve full-scale operation of inductive plasma to helicon plasma source
- Developed free-space dielectric property diagnostic for X-band frequencies and confirmed operation using well-established benchmark materials

Observations

- Free-space dielectric property measurement system provides reliable, robust measurements of samples in ambient and hypersonic-relevant (high temperature, oxidizing) conditions
- Preliminary operation of laser diagnostic equipment is performing above specification, complete commissioning is in progress
- Preliminary operation of unmagnetized inductive plasma shows efficient plasma production with diagnostic characterization, plasma control, and environment manipulation in progress



Key Features

- Significant diagnostic coverage of plasma and neutral species to include species partial pressures and atomic-level plasmasurface interactions between a reactive plasma and a heated sample
- Capability to bring sample under test to temperatures up to 2000 °C in vacuumcontrolled environments to mimic hypersonic flight conditions
- Capability to expose compact, novel samples to inert and oxygen environments for all encompassing range of operating pressures to isolate unique effects reactive plasmas have on sample integrity and degradation
- Atomic oxygen plasma generation for examination of spacecraft charging in low earth orbit
- Capability to measure dielectric properties in critical communication and thermal bands (X-Band and Mid-IR) in extreme plasma environments

Materials Testing for Hypersonic Environments

We are developing a robust and costeffective hypersonic material test facility to identify key gaps in knowledge for plasma-material interactions at the atomic level for material samples in extreme environments. Our research team is creating a unique experimental test facility to investigate novel materials fabricated for hypersonic applications with rapid turnaround times without the need for large, expensive samples. Our suite of non-intrusive laser diagnostics and materials characterization equipment enable full coverage of plasma and gas dynamics, hypersonic



material surface chemistry alterations, and dielectric property resilience with results delivered to our customers faster, smarter, and cheaper.

Next Steps

- Implement electromagnets to enable full-scale operation of helicon plasma source at 2 $\rm kW$
- Commission full suite of laser spectroscopic diagnostic
- Commission Fourier transform infrared interferometer for dielectric property investigation at mid IR wavelengths
- Characterize plasma environment for various operating conditions to identify level of control we have over plasma and gas conditions
- Perform initial plasma-material interactions in reactive plasma environment
- Perform full scale investigation of plasmamaterial interactions for auxiliary heated novel sample in reactive, extreme environments for AFRL-RX





Critical Tech Areas



DoD Priorities

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- 1. Southwest Border Activities
- Combating Transnational Criminal Organizations in the Western Hemisphere
 Audit
- 3. Audit
- 4. Nuclear Modernization (including NC3)
- 6. Collaborative Combat Aircraft (CCA
- 6. Virginia-class Submarine
- 7. Executable Surface Ships
- 8. Homeland Missile Defense
- 9. One-Way Attack/Autonomous System
- 11 Priority Critical Cybersecurity
- 12. Munitions
- 13. Core Readiness, including full DRT funding
- 14. Munitions and Energetics Organic
- 15. Executable INDOPACOM MILCON
- Combatant Command support agency funding for INDOPACOM, NORTHCOM, SPACECOM, STRATCOM, CYBERCOM, and TRANSCOM
- 17. Medical Private-Sector Care