TBD

Variable Emittance Coatings

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EXECUTIVE SUMMARY

Variable emittance coatings (VECs) can reduce thermal control system mass and power by passively changing radiator heat rejection according to spacecraft and environment heat loads. VECs make establishing a lunar presence easier since this technology helps overcome challenges with harsh thermal environments on the lunar surface and in transit. This CIF focuses on creating testing capabilities to assess VECs from collaborators in academia and industry.

Two main testing capabilities were created. First, a set of temperature-dependent Fourier Transform Infrared Spectroscopy (FTIR) measurement accessories were designed, fabricated, and used to measure samples received from collaborators. These accessories are capable of measuring the transmittance and reflectance of semi-transparent and opaque samples. Second, a vacuum calorimetry experiment was designed and built to assess the variable heat rejection of larger coupons.

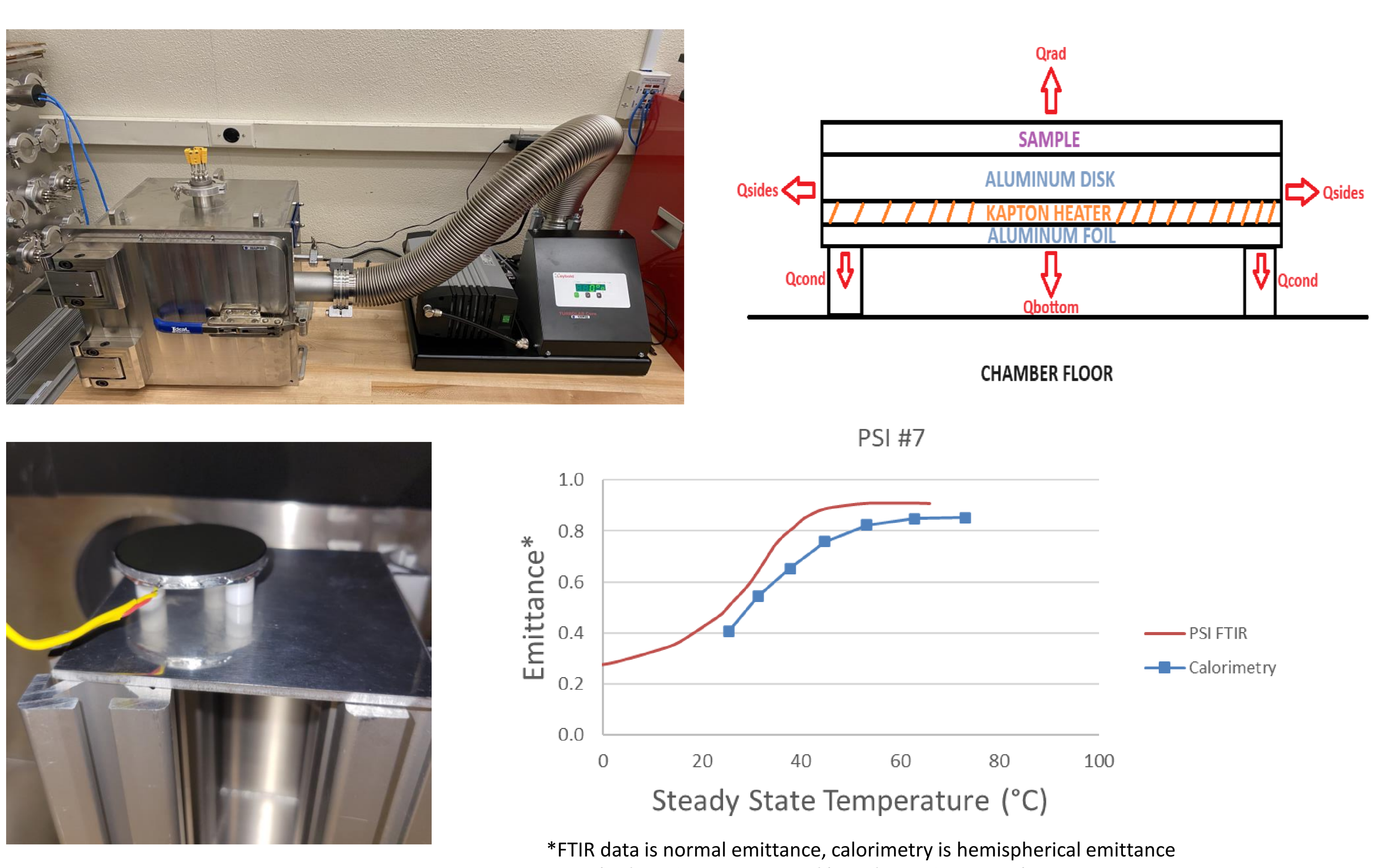
INNOVATION & BENEFITS

The innovation is a comprehensive metrology suite capable of evaluating VECs both to assist collaborators in their sample development, and to evaluate the state of the art in variable emittance. The suite of tools is capable of measuring the spectral total emittance of VECs from 5 °C to 100 °C in the wavelength range 2.5 to 20 µm. The other major component of this suite is the capability to measure larger area VECs with calorimetry. Variable heat rejection has been consistently identified as an enabling or enhancing technology in the NASA roadmaps. In crewed vehicles, VECs could eliminate the need for dual loop thermal control architecture, significantly saving on mass and power. In robotic spacecraft, VECs could reduce or eliminate the need for survival heaters. Many entities are developing VECs, however they are very variable in their ability to assess the performance of their samples.

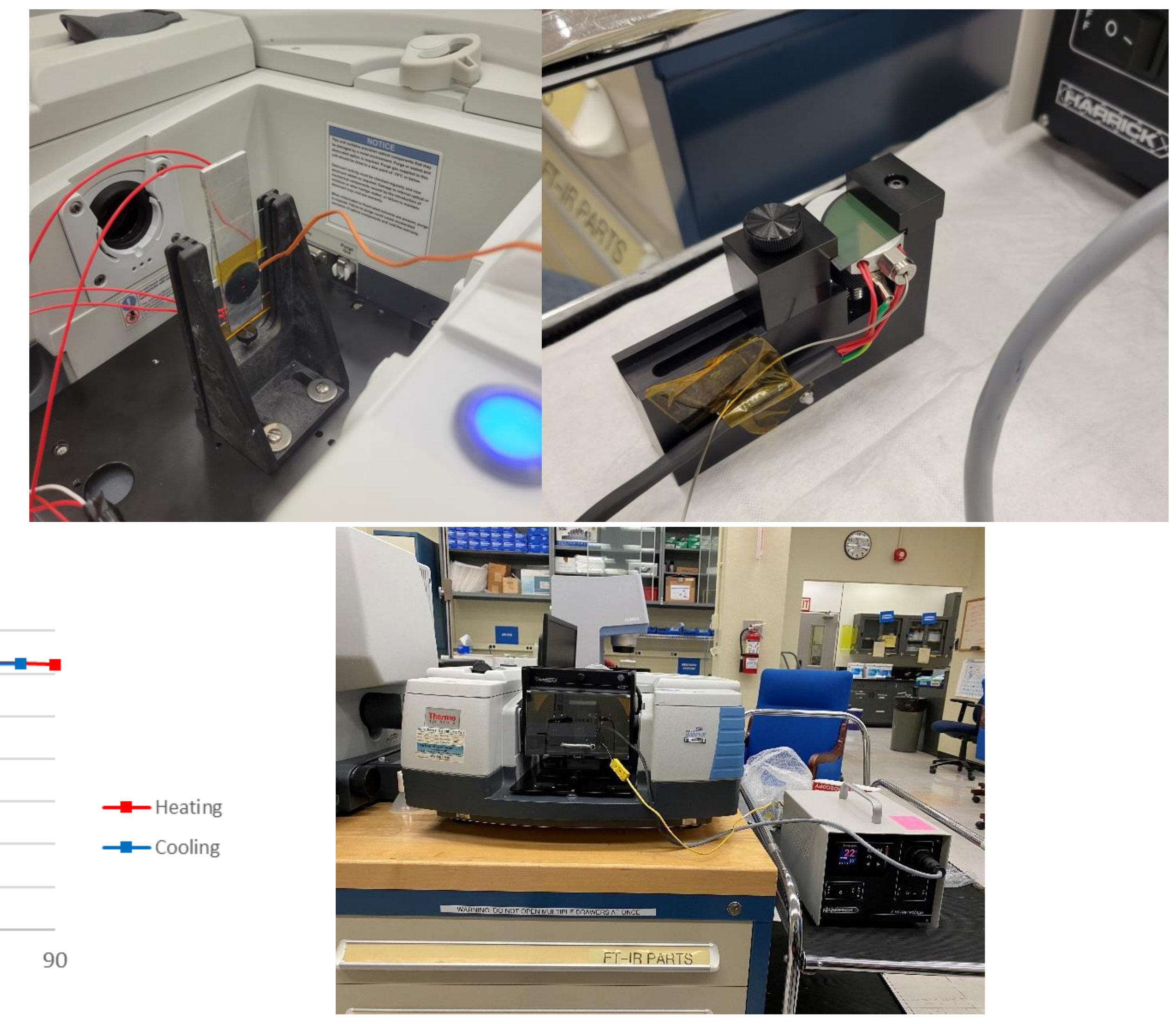
The suite developed during this CIF can also be used for other optical property studies such as lunar dust and other novel coating assessments.

COLLABORATION

1. Physical Sciences Inc. (Small Business supported by CCRPP)
2. University of District of Columbia – Supported by MUREP MIRO grant
3. University of North Texas – Supported by MSTAR grant (JSC as collaborator)
4. Arizona State University – Supported by CIF funds



VEC calorimetry experiment to measure total hemispherical emittance of larger area samples from ambient temperature up to 100 °C



FTIR Measurement Suite

OUTCOMES & INFUSION

Project Accomplishments:

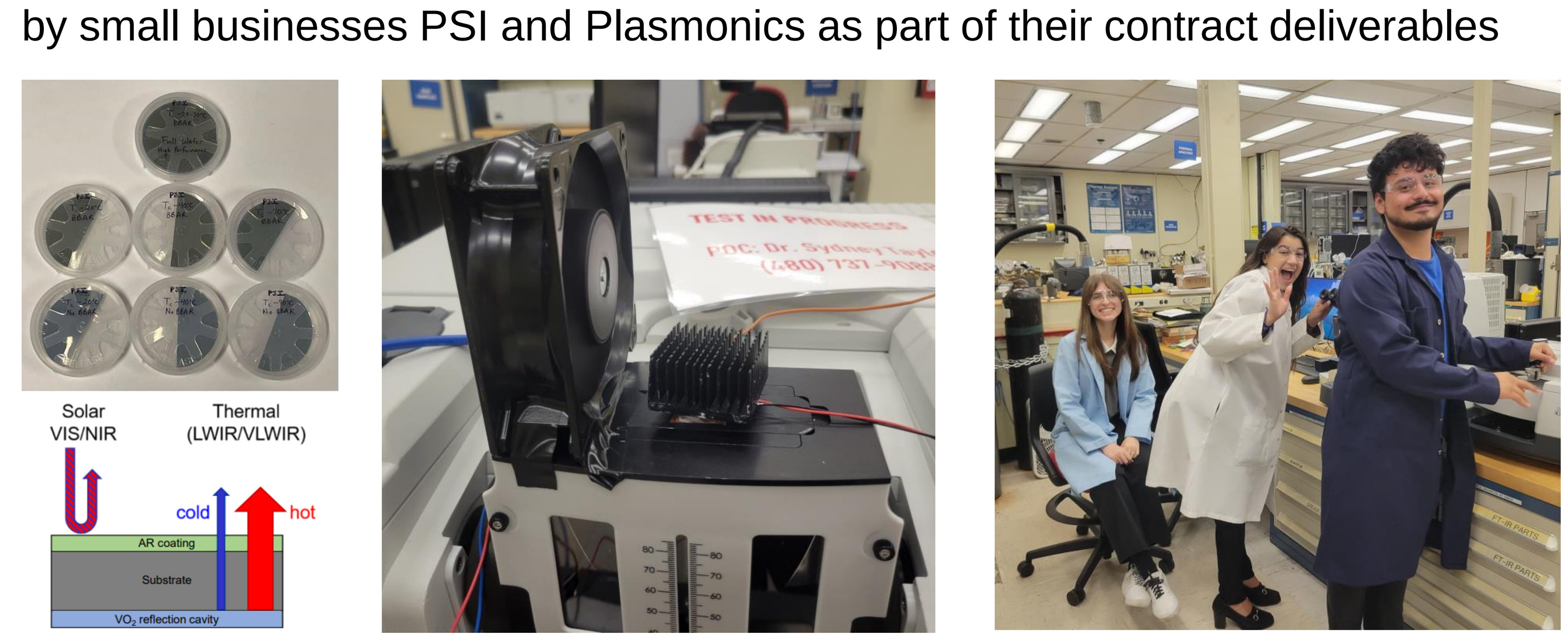
- Designed and built sub-ambient and above-ambient temp-dependent reflectance measurement accessories which can measure from 5 °C to 120 °C for wavelengths 2.5 to 20 µm
- Developed heating accessory to measure temp-dependent transmittance for IR semi-transparent samples (25 °C to 100 °C)
- Designed and assembled vacuum chamber system capable of reaching 4×10^{-6} Torr (empty), heating samples to 100 °C, and data collection to assess area average heat rejection of 2" coupons
- Developed post-processing scripts to calculate total emittance from measurement data, both FTIR and calorimetry
- Obtained and measured samples from four collaborators from academia and industry (small business)

Infusion Pathways:

- ICES2025 abstract in progress to disseminate results to spacecraft thermal community
- Hosted interns from UNT and UDC in summer 2024 to train them on metrology development so they can transfer the knowledge to their lab groups at school
- Working with VEC developers to increase their understanding of NASA's needs, providing guidance on how to improve sample fabrication and testing, and generating opportunities for tech talks for the collaborators to the NASA community
- Provide SoA assessment to NASA programs and provide foundation for large area prototype demonstration of the technology

NEXT STEPS

- Continue to build upon metrology suite developed during this CIF in FY25
- Pursuing ECI funding to design, build, and test a 1 m² prototype VEC radiator integrated with the Electrodynamic Dust Shield (EDS) in partnership with EX and EC
- Provide SoA assessment to NASA programs and provide foundation for large area prototype demonstration of the technology
- Obtain samples from other small businesses and universities to assess
- Continue collaboration on MSTAR/MUREP grants & assess samples provided by small businesses PSI and Plasmonics as part of their contract deliverables



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