High-Temperature Lightweight Radiator Panels with 3D-Printed Titanium Loop Heat Pipes

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Research Objectives:

- Develop and demonstrate a lightweight spaceflight radiator to simultaneously improve thermal performance and mechanical robustness.
- Improve power density with 3D-printed titanium LHP. Reduce radiator area density with Ti-encapsulated graphite.
- Eliminate CTE mismatch and reduce joint thermal resistance using homogeneous welding.

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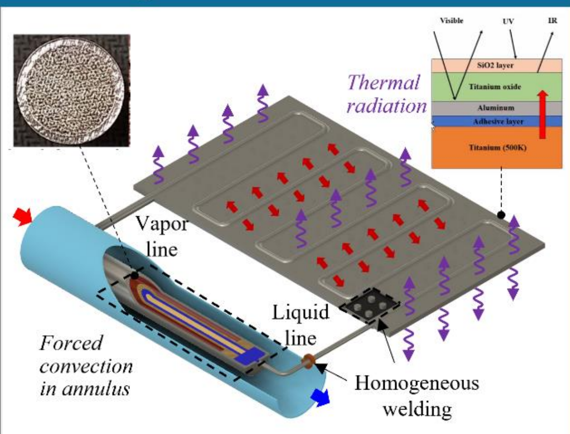
Improving both Thermal Performance and Mechanical Robustness

Integrated Titanium Radiator Panel



Innovative Claims

Innovations:

- 3D-printed titanium loop heat pipe
- Titanium-encapsulated pyrolytic graphite fin with spectrally selective coating
- Homogeneous welding
- Annular heat exchanger

Metrics:

- Power density ~ 3,000 W/cm^2
- Aerial density ~ 2.0 kg/m^2
- In-plane k ~ 1,750 W/m-K
- Out-of-plane k ~ 18 W/m-K

- Start TRL 1 with principles observed
- Projected end TRL 3 with experimental proof-of-concept.

Approach

- Titanium 3D printing to significantly increase loop heat pipe power density and robustness.
- Encapsulation of ultra-high-conductive graphite with Ti matrix for lightweight radiator fins.
- Thermo-mechanical and thermofluidic characterizations: bending, tensile, and fatigue tests, IR thermography, heat transfer and pressure drop measurements, radiative property measurements, CFD simulations.

Potential Impact

- Enable sustainable heat dissipation for nuclear propulsion systems.
- Produce lighter and more robust radiators than the SOA.
- Train graduate and undergraduate students for space applications.
- Accelerate technology transfer by teaming with Advanced Cooling Technologies, leading manufacturer of thermal management products for space applications.