



CANOPY

INDUSTRIAL OVERMATCH FOR DEMOCRACY

April 2025 – Technical Ceramic Products Enabled through Next-Gen
Materials and Manufacturing

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Vision: Canopy is a materials engineering company advancing next-gen ceramics for space, defense, power, and computer systems.



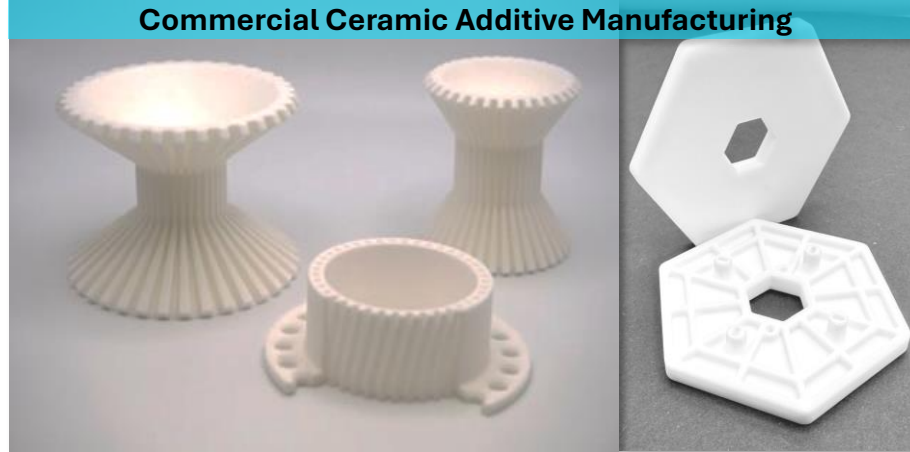
Mission: We're building the factories of tomorrow to rapidly iterate, scale, and underwrite the next industrial revolution.

Canopy HQ in Denver, CO

18k sq-ft Office and Manufacturing Facility



Commercial Ceramic Additive Manufacturing



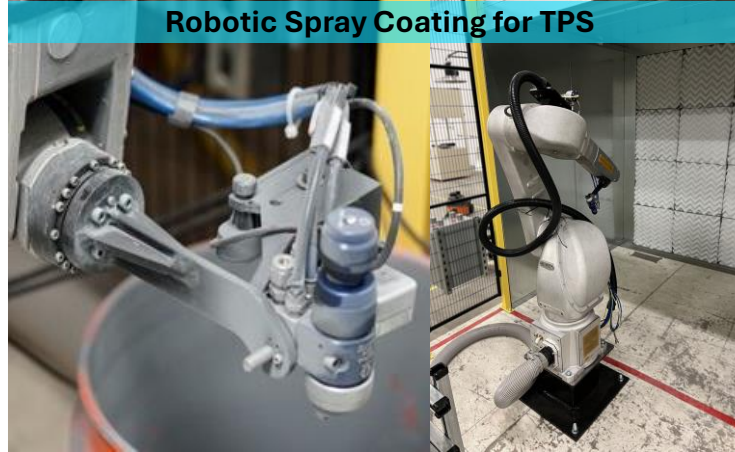
New Materials Development



Reusable TPS Manufacturing



Robotic Spray Coating for TPS



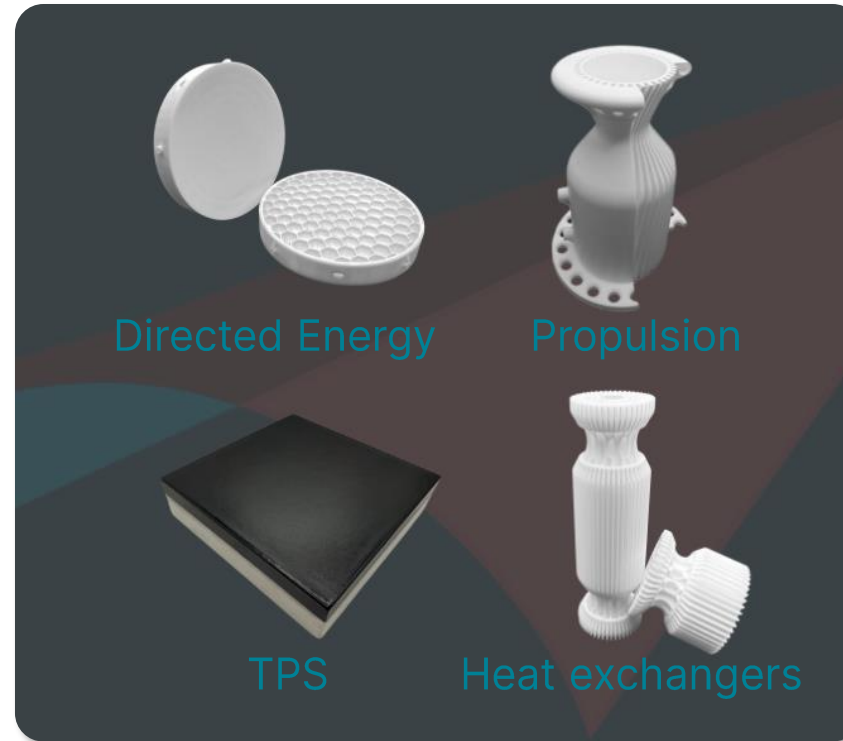
Materials Testing and Qualification



Canopy Next-Gen Factory: Solving the Thermal Management Problem for Extreme Missions

Materials Engineering

- Better performance; initial focus on ceramic material systems
- Developed for advanced manufacturing processes



Manufacturing Excellence

- Predictable manufacturing outcomes
- Best-in-class knowledge on materials processing parameters
- Expert supply chain knowledge



High-performance, end-use components

Product Spotlight: Thermal Protection Systems

Status: initial sales established to pilot customers

Many of the flight-proven thermal protection systems (TPS) consist of advanced ceramics, including the famous “Shuttle Tiles”

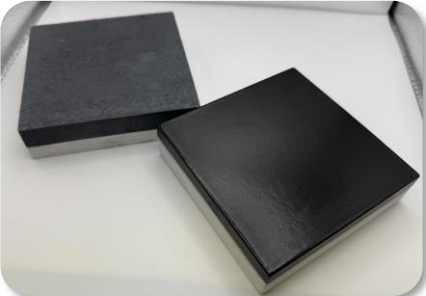
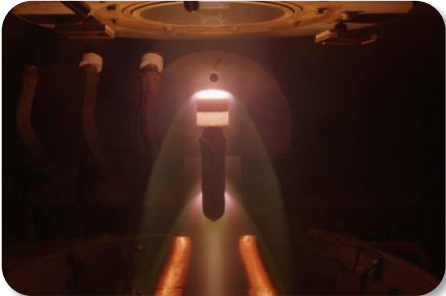
Today’s thermal protection systems are produced by an army of master technicians, highly skilled in their step of the process but presenting key man risk. As a result, supply chains have been rebuilt multiple times due to knowledge drain and vendor churn.

Canopy has developed key partnerships with the NASA ARC and JSC TPS groups, transitioned out key technologies, mastered traditional production, and secured funded USG programs to adapt TPS to ceramic AM.

LEGACY

Canopy has established a pilot production line for “Shuttle Tile” and secured an initial sale to Stratolaunch.

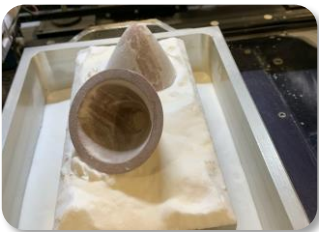
Pilot production allows Canopy to establish early sales to Stratolaunch, Sierra, and LMCO to help define requirements for future AM materials



Canopy reusable TPS testing in simulated high-Mach re-entry environment at NASA Ames Arc Jet Facility

ADDITIVE

Same printer used to print reusable and ablative materials, scalable to 1 m³ build volume



Canopy’s RHAM TPS with properties rivaling AETB



Canopy ablative TPS under development for USAF hypersonics

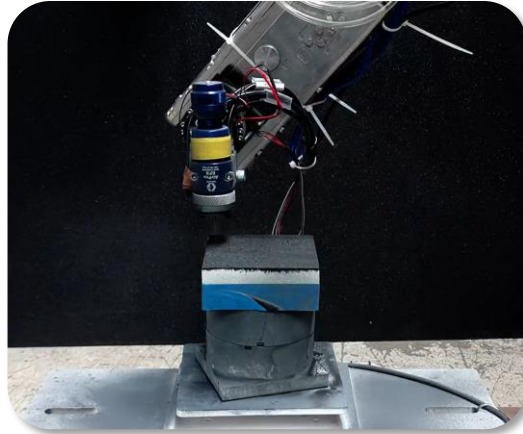
TPS Materials and Manufacturing Innovations

Reduced cost and labor requirements through additive manufacturing and robotics



Additively-Manufactured
Ablative TPS

- Directly printed low density carbon phenolic ablator
- Tailorable porosity and ablation rates through design and manufacturing



Autonomous Robotic Spray
Coating Application

- Independent, geometry-agnostic path planning through computer vision
- In-situ monitoring of deposition providing feedback to closed loop control system



Reusable Heat Shields Through
Additive Manufacturing

- Sintered, silica based material system with tunable properties akin to AETB
- Near net shape geometries as-printed reduce machining time and scrap rate

Product Spotlight: Thermal Management Devices

Status: developmental parts produced and currently under evaluation for production

- Ceramics increase performance for thermal management systems including heat pipes, exchangers, and sinks
- Complex geometries are critical to enhance efficiency and tailor thermal properties for specific application requirements
- Ceramics are compatible with a broader set of working fluids and allow higher temperature operation compared to metals
- High-demand materials include alumina and silicon carbide

Canopy has completed multiple manufacturing runs in alumina to support customers within aerospace and defense



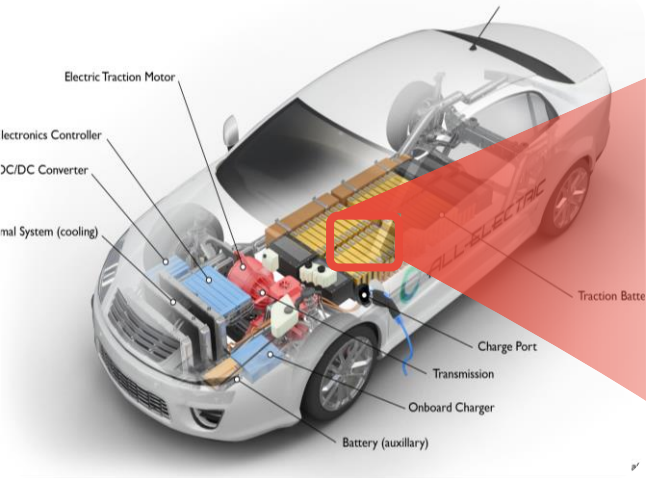
Product Spotlight: Power Electronics

Focus on enabling high-density power

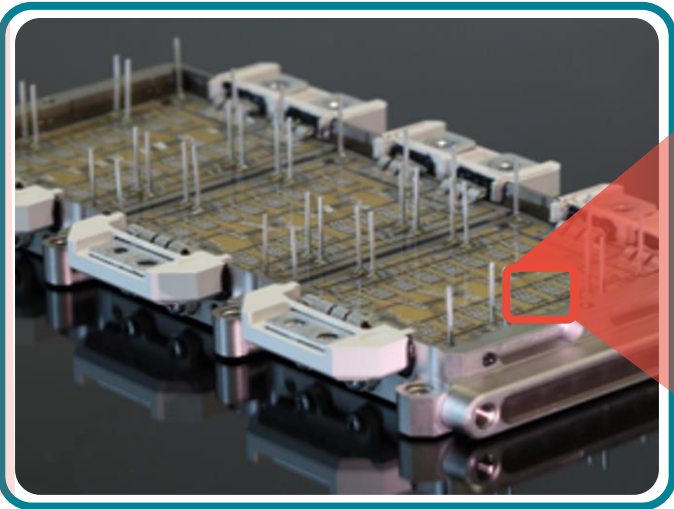
Better thermal management is necessary in all EV cars, power inverters for energy storage, and power generation

- ✓ Unlocks higher performance
- ✓ Enables higher efficiency
- ✓ Allows part consolidation to reduce weight, cost, and systems integration complexity

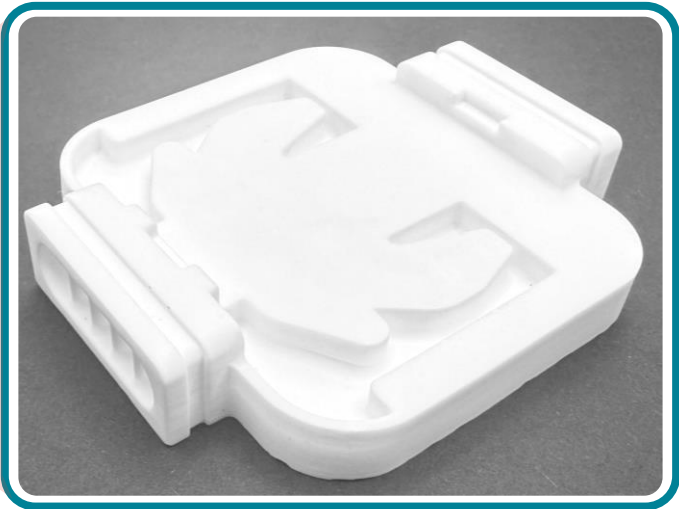
Canopy is a manufacturing and design partner on developing new parts for the power and clean tech industries



ELECTRIC VEHICLE



POWER CONTROL MODULES



ADVANCED HEAT SINK SUBSTRATE

6-24 power modules per vehicle

Canopy has delivered multiple part orders for evaluation

Product Spotlight: High Temperature Connectors

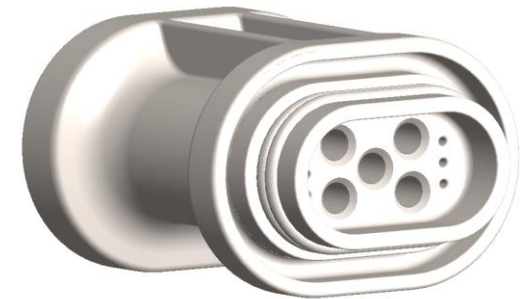
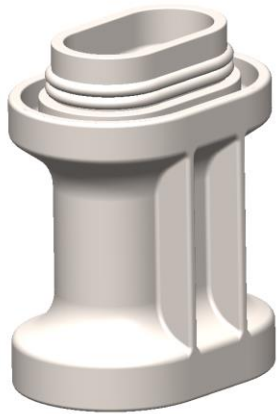
Complex Shapes, Rapid Iteration, No Tooling Cost

Alumina connectors

- ✓ 99.2% alumina
- ✓ Unique cleaning process allows hole designs that others cannot achieve
- ✓ Reduce sealing requirements by incorporating multiple connectors into one unit

Custom material compositions are also feasible.

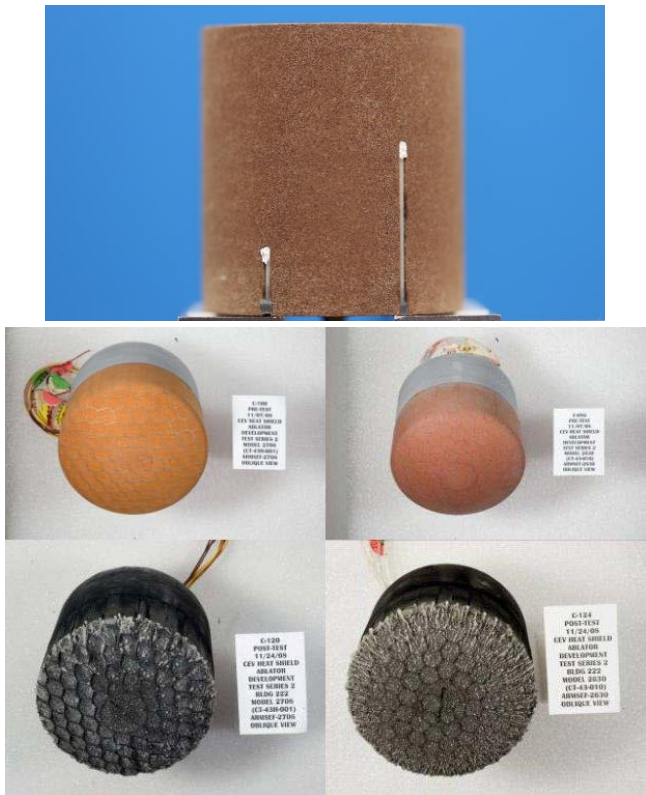
Designs are proprietary.



Problem Focus: TPS Sensor Technologies

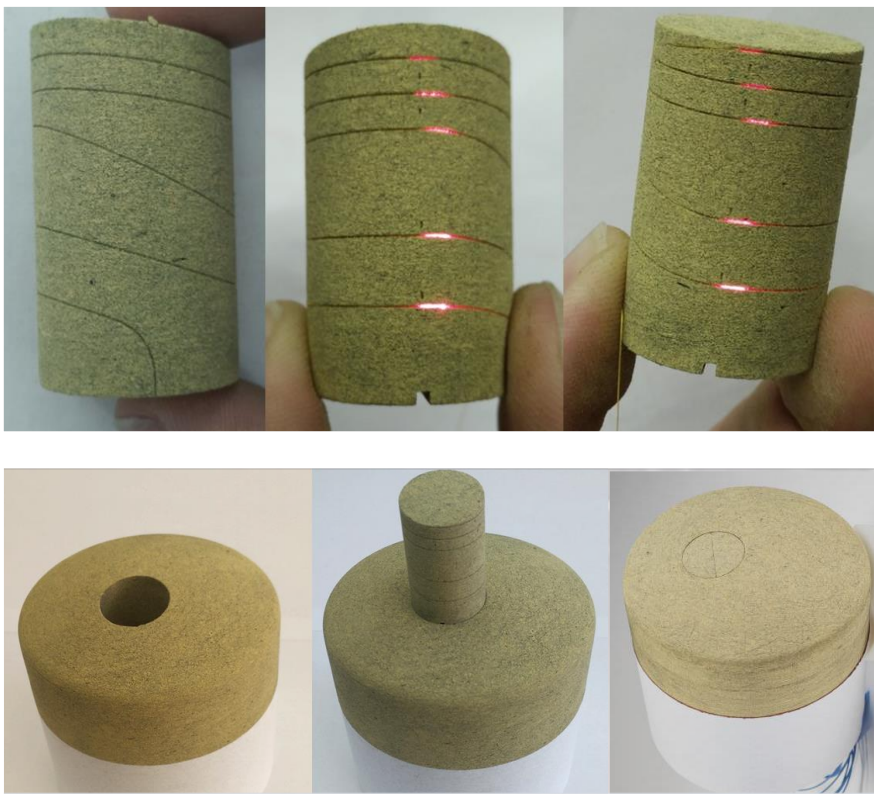
Difficult integration and limited temperature range

Thermocouples



Miniature thermocouple probes require elaborate machining and individual wiring

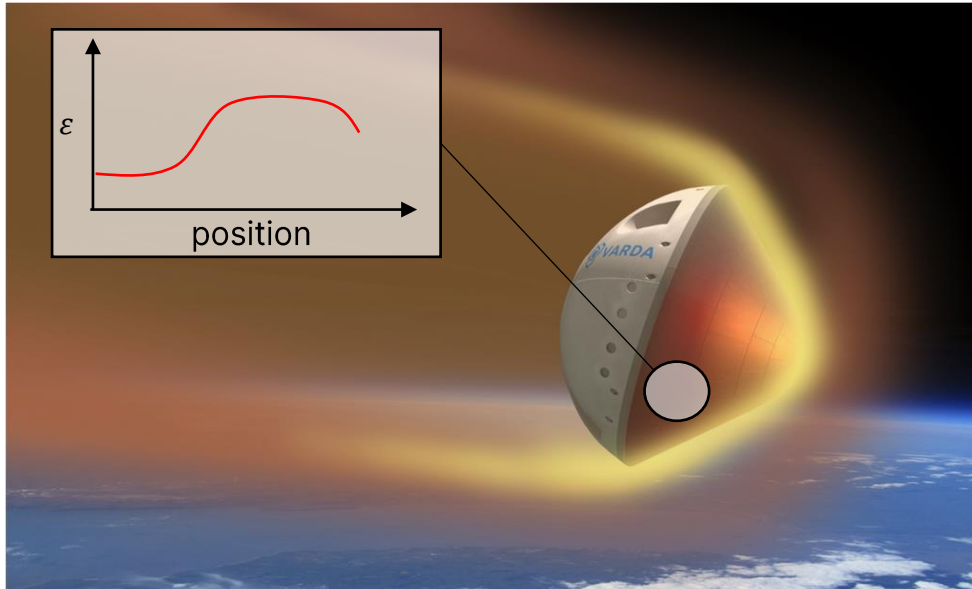
Fiber Bragg Gratings



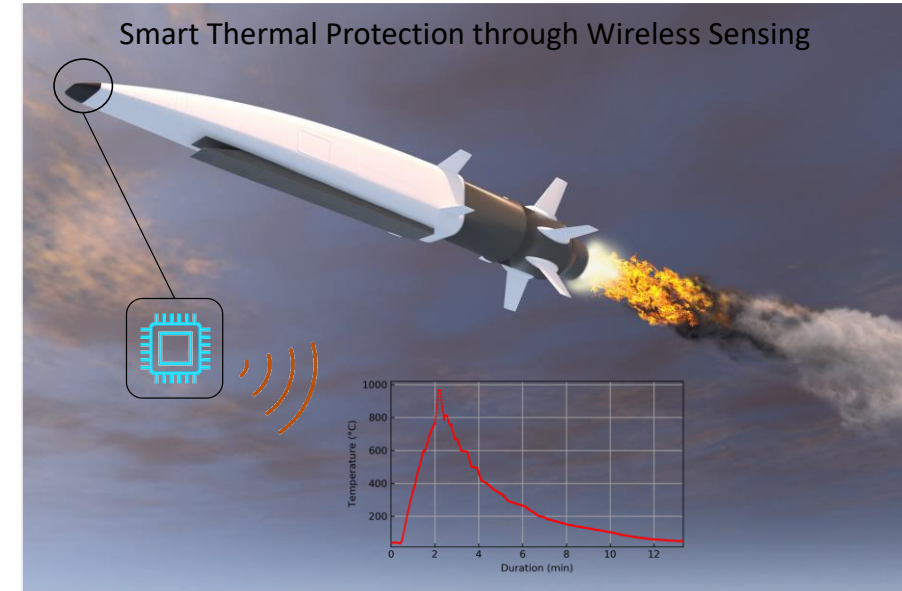
FBGs allow multiplexed measurements but are difficult to integrate with limited temperature range

Solution: Smart Thermal Protection Systems (Smart TPS)

Canopy using multiple sensor modalities to enable real-time data collection at the edge



- ✓ Real-time strain data enables structural health monitoring and prognostics of critical TPS components
- ✓ Reentry data to calibrate aerothermal models and refine TPS safety margins
- ✓ Underlying sensors can operate $>1500^{\circ}\text{C}$ for short durations and 1100°C sustained
- ✓ Single fiber optic cable can house 100s of sensors that can be read simultaneously
- ✓ Sensor read hardware is easily extensible to more sensors and/or additional fiber optic channels



- ✓ Real-time temperature data enables structural health monitoring and prognostics of critical TPS components
- ✓ Reentry data to calibrate aerothermal models and refine TPS safety margins
- ✓ Underlying sensors can operate up to $>1700^{\circ}\text{C}$ for short durations and 1250°C sustained
- ✓ Single antenna can read multiple sensors
- ✓ Passive sensors reduce cabling and simplify vehicle maintenance