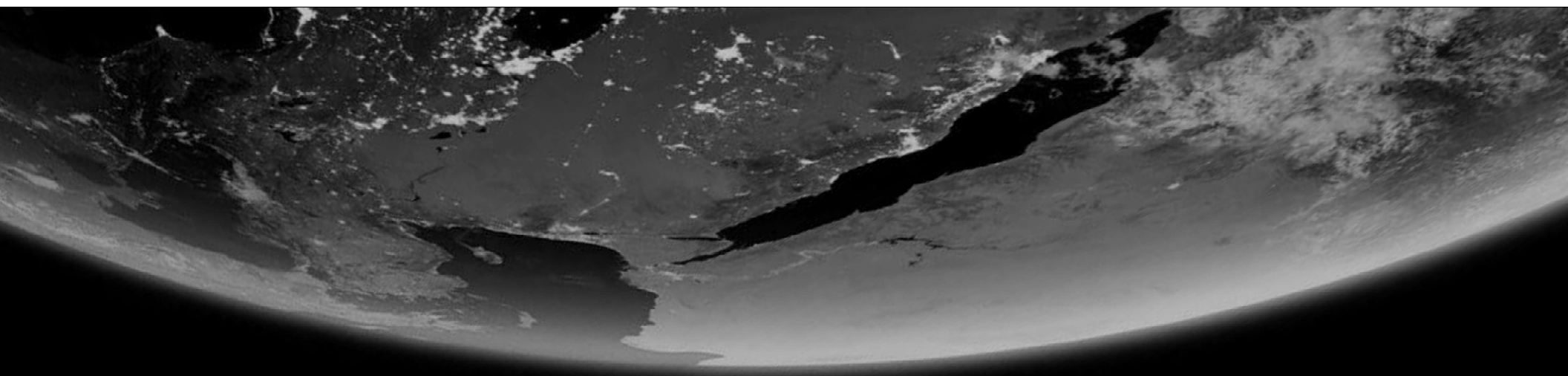




mott

MISSION CRITICAL PRECISION

SOLUTIONS FOR SPACE PROGRAMS

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Who We Are: A Proven Leader in Filtration, Flow, & Thermal Technology

- Over 60-year track record of designing precision filtration, flow, and thermal technologies for spacecraft with Government, Primes, Sub-system OEMs, and Space Start-ups.
- Ironclad reliability qualified and flying on thousands of spacecraft including rockets, satellites, and manned spacecraft. 100% guaranteed.
- Wide range of customization options as we team up with you on exacting specifications – vacuum to high pressure ratings, cryogenic to extreme heat, & conventional to exotic materials – to meet mission requirements.
- Complete on-site fabrication, welding, and manufacturing with ISO Class 5 and 7 clean room environments. ISO9001, AS9100 certified.
- Based in the USA (Farmington, CT) with ability to supply programs globally. A 100% Employee-Owned company.



Wide Range of Fluid Application Expertise

**GAS & LIQUID
FILTRATION**

**FLOW
CONTROL**

**OXYGEN
SERVICE**

**GAS
DIFFUSION**

**FLOW
SPLITTING**

**PHASE
SEPARATION**

FLUIDIZING

**FLAME
ARRESTING**

SPARGING

WICKING

**GAS
PURIFICATION**

SAMPLING

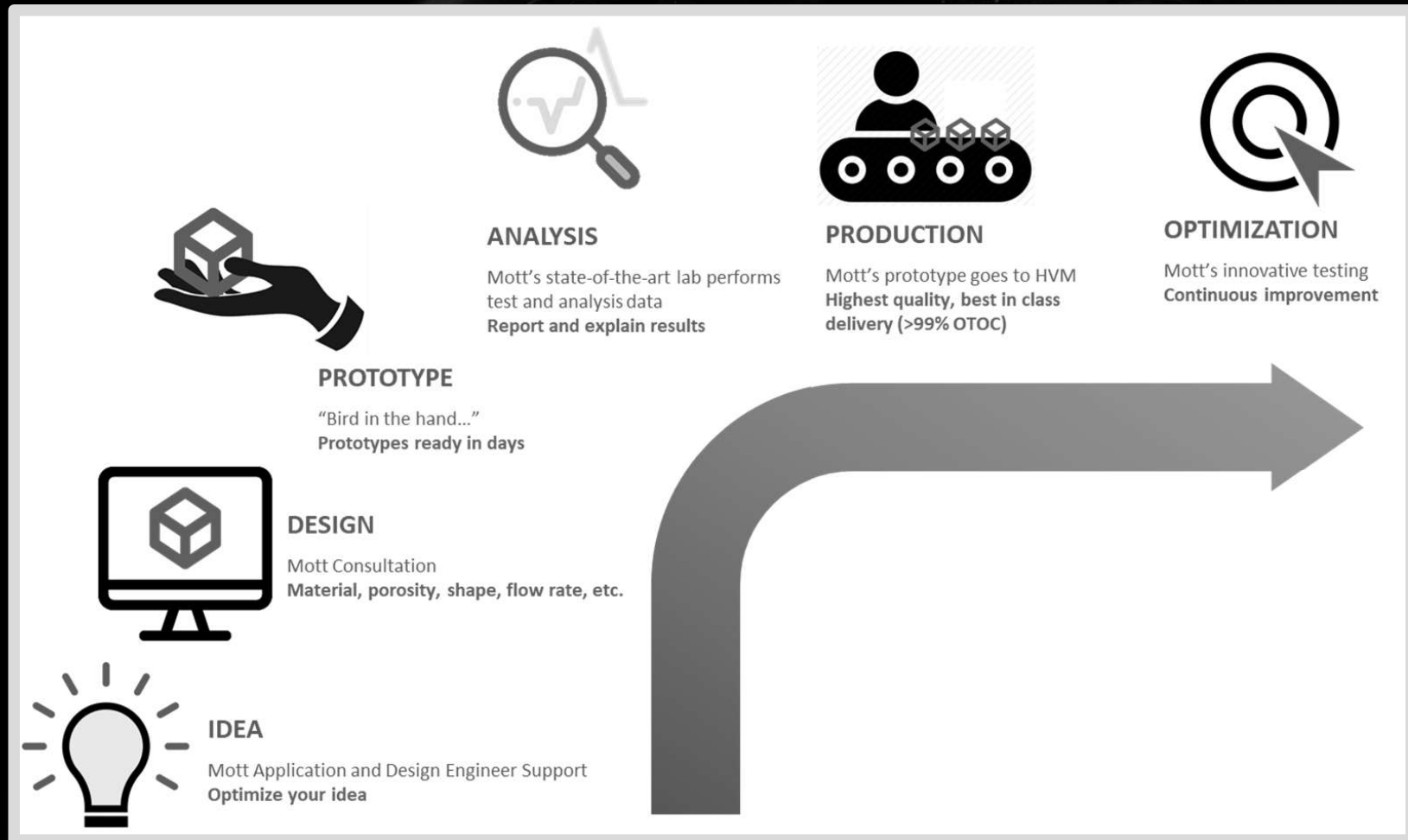
**INSULATION &
SHIELDING**

**POROUS
TRANSPORT**

MIXING

**HEAT
EXCHANGE**

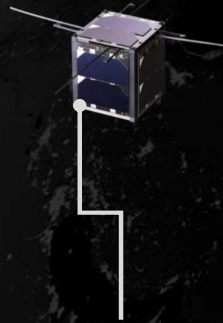
Collaboration Model



Snapshot of Space Applications & Products Provided



Nitrogen Filter for First Stage Propulsion System



Xenon Flow Control for Constellation Satellite



Hydrazine Propellant Filter for Large Weather Satellite



Oxygen Filter for ECLSS System on Spacecraft

Space Applications

- Rocket Propulsion & Actuation Systems
- Small Satellites (Femto to Small)
- Large Satellites (Medium to Extra Heavy)
- Manned Spacecraft / Crew Cabin ECLSS
- Spacesuits
- Long-Distance Probes
- Landers & Rovers
- Hypersonic Craft
- Military Applications



Products Provided (and counting...)

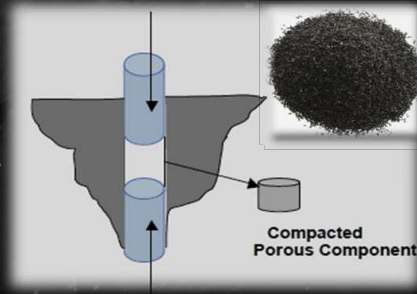
- Chemical Propulsion Filtration
- Electric Propulsion Flow Control & Electrodes
- Valve Protection Filters & Flow Setters
- Gas System & Actuation Filtration
- Cold Plates, Vapor Chambers & Other Heat Exchangers
- Two-Phase Loop Heat Pipes
- 3D Printed Thruster Componentry
- Fuel Cell Stack Components
- Other Custom Integrated Porous Metal Assemblies

Our Manufacturing Processes: (1) Conventional & (2) Additive

1



Design Specifications



Powder Compaction & Furnace Sintering



Welding, Assembly, & Post Processing

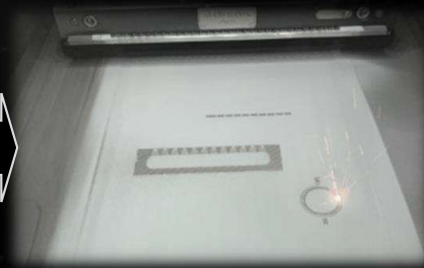


Finished Product

2



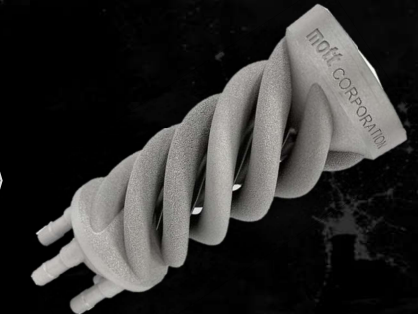
Design Specifications
(3D CAD Model)



Laser Sintering



Powder Removal & Post Processing



Finished Product

Our 3-Step Engagement Process

Step 1

Requirements Review & Statement of Work Proposal

- Thorough engagement to review specification requirements
- Meet directly with engineers and scientists to discuss technical parameters
- Mott will provide proposal that meets performance requirements and program schedule

Step 2

Design Confirmation & Qualification

- Our team updates you on statement of work status
- Delivers design for formal review and approval
- Provides regular cadence update on schedule and qualification progress (both lab analytical and destructive testing)

Step 3

Production & Delivery

- We deliver your component on-time and to specification
- Teams confirm all quality parameters and reports are accepted once at your site
- As your program schedule progresses, call us anytime if any additional needs are required



Technologies to Support Your Mission

Propellant and Gas Filtration

Filtration, Flow, and Footprint Optimization

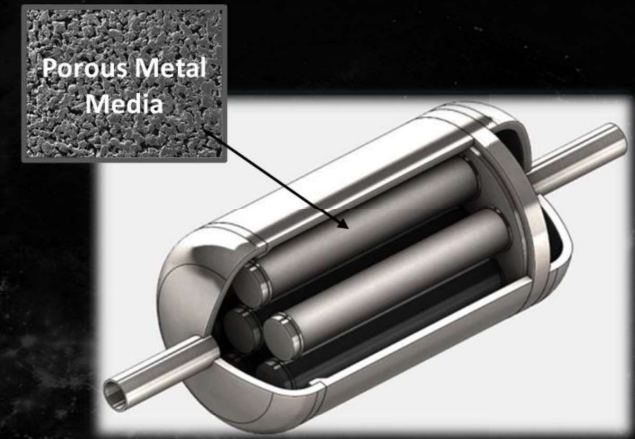
- Custom Particle Filtration ratings & capacity
- Custom Flow Ranges including bi-directional flow from cryogenic to hot temperatures
- Filter Media and hardware material and size flexibility

Wide, Customizable Operating Range

- Operating pressures -14.7 to 10,000 psig (-1 to 689 barg)
- Operating temperatures -100F to 700F (-73C to 371C)
- Virtually limitless liquid and gas material compatibility (from standard 316L stainless steel or Titanium Grade 5 to exotics like Niobium C103 or Tungsten).

Fast Delivery to Program Schedules

- Lead times in weeks vs. months

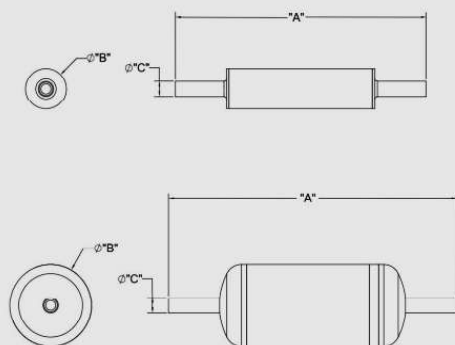


Example Propellant Filter

Typical Applications

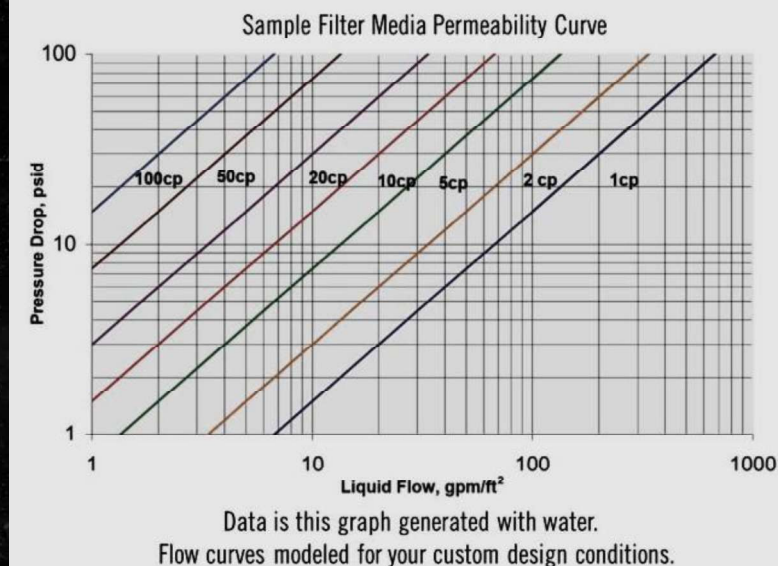
- First Stage Propulsion
- Second Stage Propulsion
- Hydrazine Thrusters
- GHe Valve Actuation

Propellant Filtration – Typical Design References



Application Size	Media Grade Range	Fitting Type	A Inches (mm)	B Inches (mm)	C Inches (mm)	Clean Flow Rating lbm/s (kg/s) PSI (bar)	Mass Ounce (Gram)
Micro: less than 10 kg	0.2 to 100	Tube Stub	Custom micro scale designs available upon request				
Small: 10 to 100 kg	0.2 to 100	Tube Stub	2 to 5.5 (50.8 to 139.7)	.75 (25.4)	0.375 (9.5)	Up to 1.0E-3 (4.5E-4) to 2.0E-2 (9.1E-3) @ < 1 (.07)	2 to 7 (56 to 198)
Med: 500 to 1000 kg	0.2 to 100	Tube Stub	6 to 7.5 (152.4 to 190.5)	1 (25.4)	0.375 (9.5)	Up to 2.0E-3 (9.1E-4) to 4.0E-2 (1.8E-2) @ < 1 (.07)	5 to 10 (141 to 284)
Large: greater than 1000 kg	0.2 to 100	Tube Stub	7 to 8.5 (177.8 to 215.9)	2 (50.8)	0.375 (9.5)	0.15 (.07) to 2.5 (1.13) @ < 5 (.34)	15 to 20 (425 to 567)

*Custom designs and connections available. Contact a Mott representative for more information.



High-Flow Engine Mesh Filtration

Filtration, Flow, and Footprint Optimization

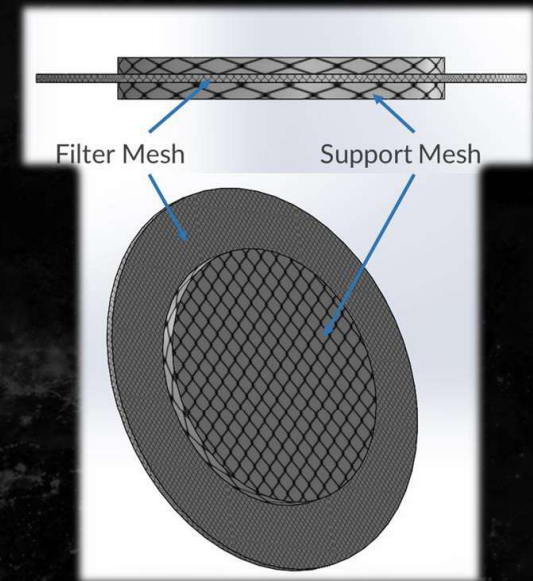
- Custom Particle Filtration ratings & capacity
- Custom Flow Ranges including bi-directional flow from cryogenic to hot temperatures
- Filter Media and hardware material and size flexibility

Wide, Customizable Operating Range

- Operating pressures -14.7 to 10,000+ psig (-1 to 689 barg)
- Operating temperatures -238 F to 700+ F (-150 C to 371+ C)
- Virtually limitless liquid and gas material compatibility

Fast Delivery to Program Schedules

- Lead times in weeks vs. months
- Capable of full flight qualification, compliance matrix & data packages



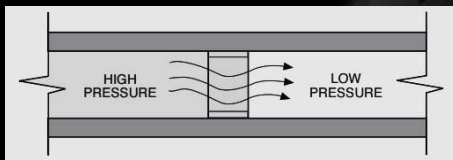
Typical Applications

- Rocket Main Engine
- Aircraft Last Chance Filtration
- Booster Stages
- Collaborative Combat Aircraft

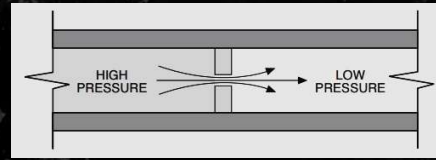
Electric Propulsion Flow Control – Xe, Kr, and other flow setting

Key Benefits

- Accurate flow splitting to anode and cathode, without risk of FOD clogging ultra-small orifices
- Laminar flow: Gas flow uniformly distributed across media for laminar flow avoiding resonance vibration caused by supersonic flow through orifices



vs



Example Xenon Flow Setter

Wide, Customizable Operating Range

- Flows from <1 SCCM to high flow 40,000+ SCCM with tight tolerances
- Pressure to pressure, pressure to vacuum, and other upstream/downstream configurations
- Virtually limitless gas material compatibility: Xenon, Krypton, Argon, and others available

Fast Delivery to Program Schedules

- Lead times in weeks vs. months

Typical Applications

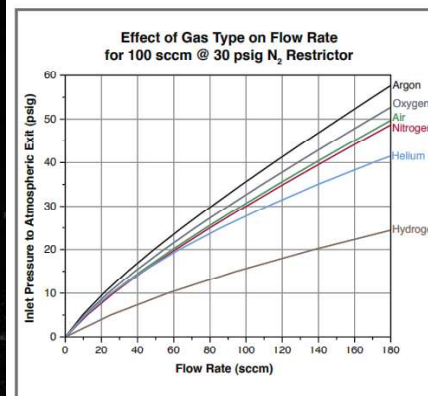
- Propellant Flow Control
- Gas Actuation Flow Setting
- Valve Protection

Electric Propulsion Flow Control – Configuration & Flow Data

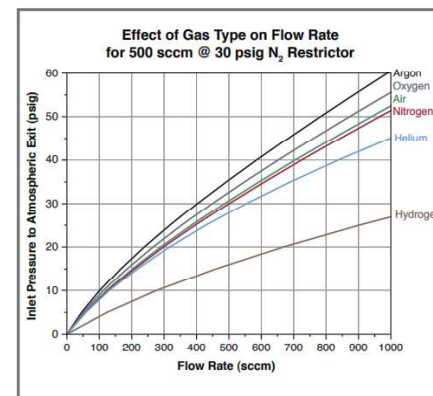
Typical Specifications

Flow Ranges Available	0.1 sccm to 40 slpm *
Max Inlet Pressure / Max Differential Pressure	1500 psig
Accuracy	+/- 7.5% Base**
Repeatability	+/- 0.1% of reading
Operating Temperature	Up to 450°C
Warm-up Time	N/A
Wetted Hardware	316L Stainless Steel, contact Engineering for Full List
Wetted Surface Finish	To 10Ra (average)
Leak Integrity (External)	1 x 10 ⁻⁹ atm cc/sec Helium Leak Rating
Fittings (compatible with)***	Virtually any configuration
* Condition specific ** Up to +/-2% of reading available *** Fittings Available on Request	

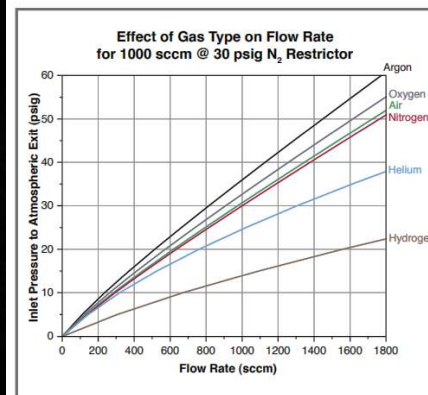
SAMPLE FLOW DATA



100 SCCM N₂ @ 30 psig

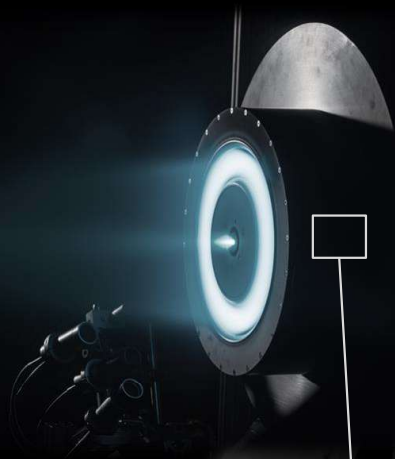


500 SCCM N₂ @ 30 psig



1000 SCCM N₂ @ 30 psig

Refractory Substrates, Thermo-Structural, & Flow Elements



Hall Effect Thruster
(Photo Credit: NASA)

Uniform Porosity

- Impregnable custom pore sizes for emissive compounds in hollow cathode element
- Tantalum, Tungsten, Niobium, Molybdenum and other refractory elements available
- Integration with hardware to orifice plates and other components available



Example precision Molybdenum-Molybdenum weld



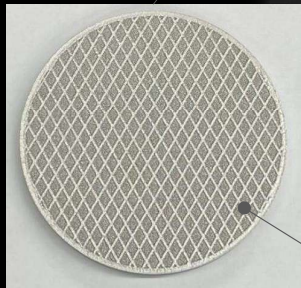
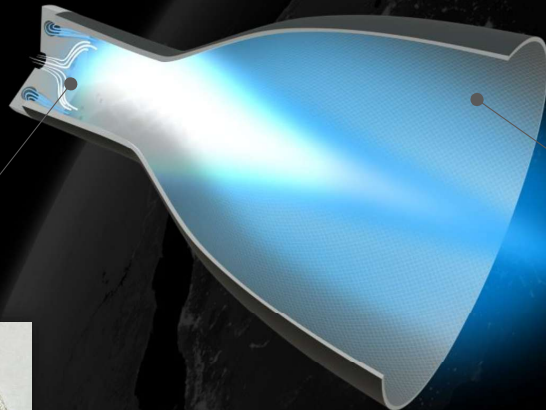
Typical Applications

- Electric Propulsion Systems
- Hypersonic Programs
- Kinetic Weapons & Energetics

Integrated Rocket Injectors, Chambers, & Motors

DurAMesh Controlled Porosity Rocket Technology – All In One Print and 100% made in the USA:

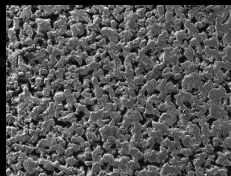
Through improved cooling flow we can design for improved efficiency, reduced weight & size, and even less exotic materials allowing propulsion systems to last longer, go farther, and cost less. Additionally, improved design strength can be achieved through the solid lattice integration with the porous media.



DurAMesh faceplate to replace conventional mesh



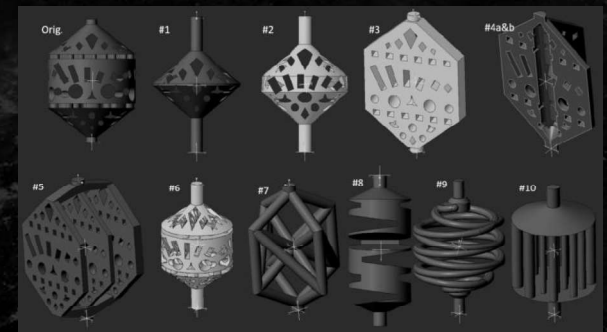
Solid-to-Porous Interface



Porous Media Close-up



DurAMesh Porosity Incorporated into a Chamber Design



Custom Fluid Channel Designs for Loading, Mix and Flow Efficiency

Ground Filling Inert and Noble Gas Purification & Oxygen Service

Included Features

- Gas Purification <100ppt of impurities from tank Xe or Kr
 - H₂O, O₂, CO₂, CO, Hydrocarbons, Organics, etc
- Nickel Media options compatible for Oxygen particulate filling down to 0.1 micron
- <10 Ra Internal Electropolish on wetted surfaces
- 0 – 2500 psia Operating Pressure

Potential Benefits for Efficient and Reliable Thrust:

- Reduced Ion Beam Instability – More Precise Thrust Vectors
- Protects Hall Effect Thruster from Debris and Impurities
- Increased Thruster Efficiency
- Reduced Erosion and Debris Damage
- Last Line of Filtration and Purification Defense



*Microbulk Purifiers and Nickel Filters
for Ground Assembly Fueling*



ECLSS Oxygen Filtration and Moisture Protection

Laminar Flow

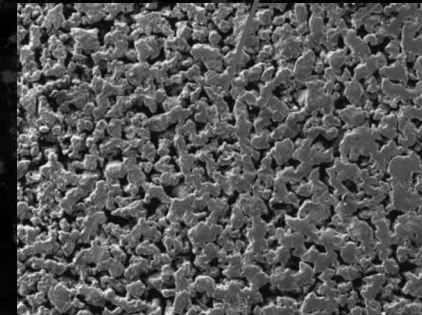
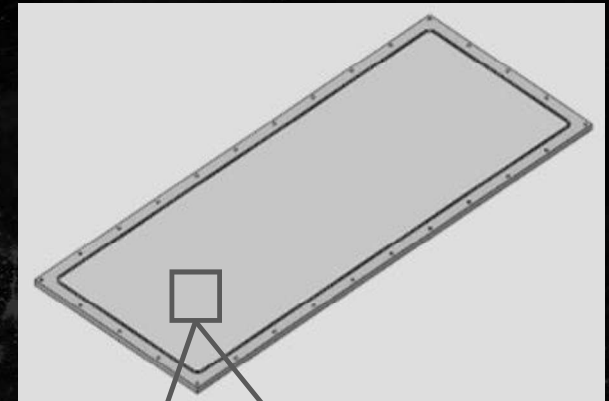
- Gas flow uniformly distributed across media for laminar flow to ECLSS componentry

Wide, Customizable Operating Range

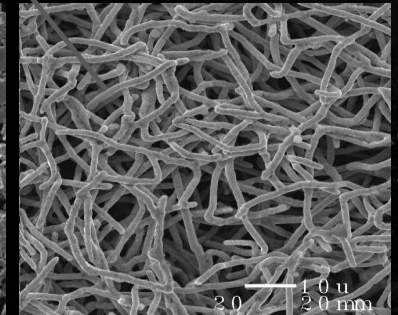
- 0.1-to-100-micron media grade; thickness depending on Flow/dP and strength tradeoff
- Typical 316L Stainless or Titanium; Nickel for Oxygen units
- Complete welded assembly with optional sectioned structure

Flame Arrestor Rated Media

- Dual purpose flame arresting to prevent fire spread in case of adverse event
- Typical configurations in qualified systems per ATEQ and UL requirements



Porous Metal
(particulate)

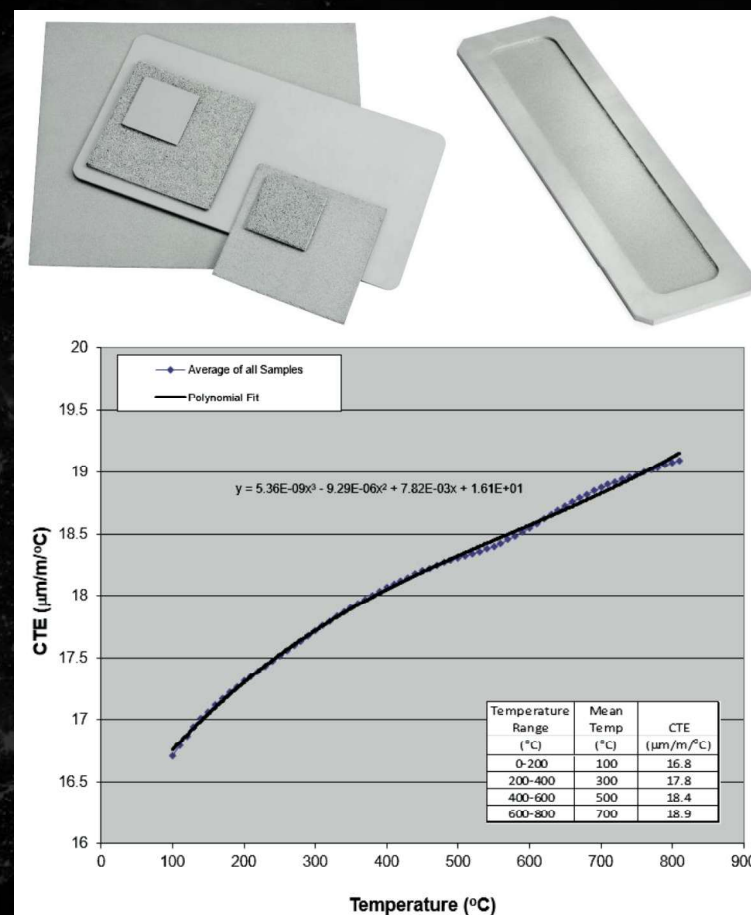


Porous Fiber
(moisture)

Fuel Cell Stack Technology

- Uniform porosity for even distribution of gas flow across a broad selection of corrosion materials to support all operating temperatures including Niobium and Zirconium.
- We customize to micron pore size, dimensions, and hardware with diffusion layers as thin as 0.25mm
- Designs are high strength even under compressive loads, ductile, and electrically conductive as well as coatable offering strong substrate support capability.

Available Materials	316L SS, Titanium, Nickel 200, 430SS, and various other corrosion resistant alloys
Porosity	16% to 40% open
Thickness Variation	Typically +/- 0.001" (0.025 mm)* *Custom development options available
Dimension	Dependent of configuration and manufacturing method selected



Thermal expansion for Mott porous materials is equivalent to solid materials of the same composition

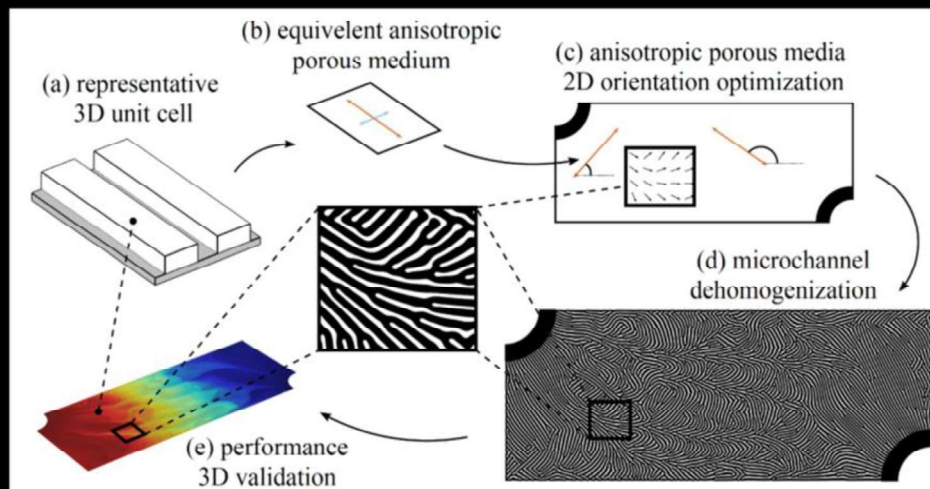
Example 3DP Fuel Cell Project with Toyota Motor North America



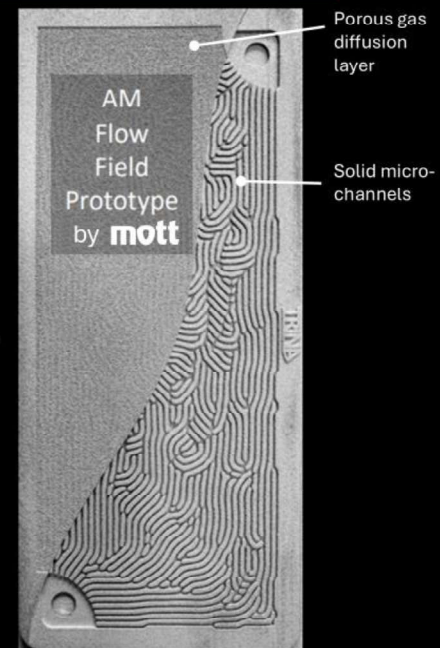
Research & Development
Toyota Research Institute of North America

Microreactor Flow Field Design Example

- Inverse design via the homogenization method



*Ref.: Zhou, et al. (2022) Chem. Eng. J.



*Ref.: Zhou, et al. (In preparation)
Additive Manufacturing Overview - Mott Corporation

20

E.M. Dede

High Efficiency Phase Separation & Coolant Recovery

Key Driver – current thermal sub-systems are:

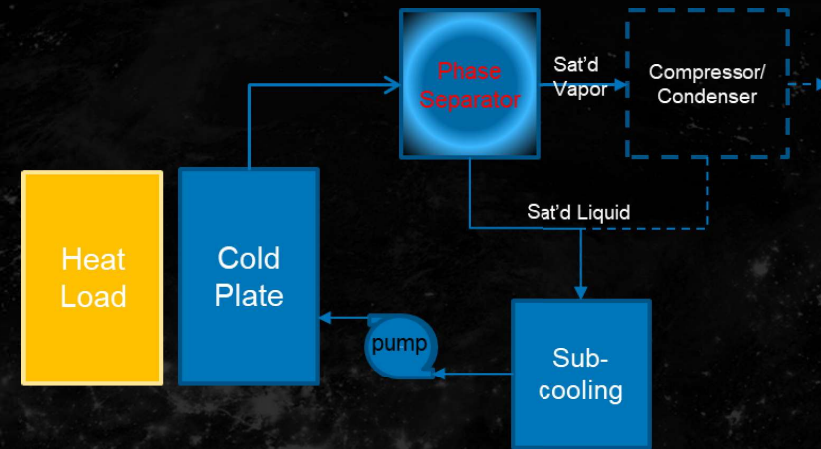
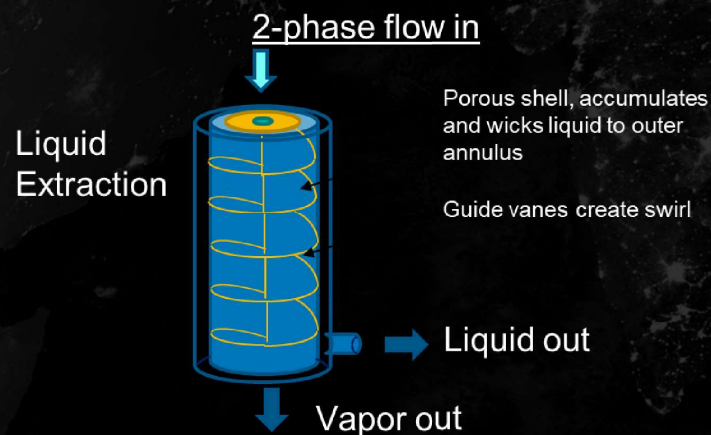
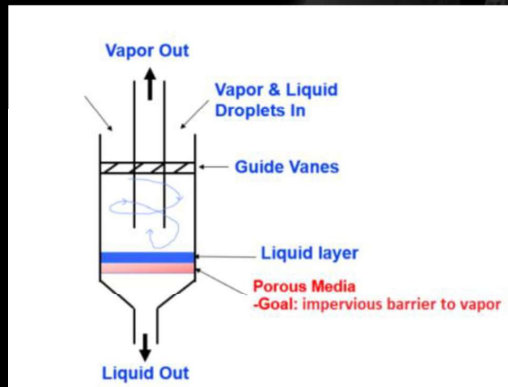
1. Power-limited – Coolant capacity limited to 1 min. at 100kW with at less than 50% return quality (once-through system)
2. Size & Weight-limited – Existing separation (land-based) systems large and heavy
3. Gravity Dependent – Current tech uses gravity as a primary means to separate and recirculate liquid coolant

Phase Separator Solution:

- A novel, modular, gas-liquid phase separation technology that recovers 93%+ coolant, weighs <100 lbs, is <2cu-ft that can reach 1MW scale and works in ground, High-G, and micro-G environments for airborne-based mission sets.

Two Primary Designs For Specific Programs:

Reverse Flow



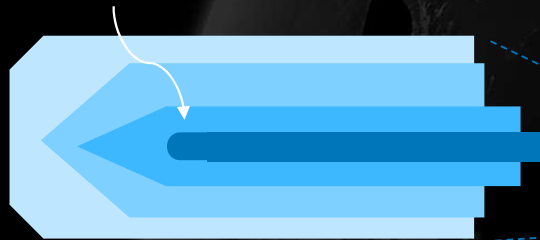
Design	Parameter*	Quality** 50%
Design 1 Reverse Flow Cyclone	Liquid Pressure Drop (PSID)	< 1
	Gas Pressure Drop (PSID)	< 1
	Liquid Capture Efficiency (%)	93

* All performance testing using Water/Air mixtures at 2% scale.
 ** Quality is the ratio of air mass to total mass of the water & air mixture

Hypersonic Thermal Designs: Intercooled Aeroshell & Leading Edge



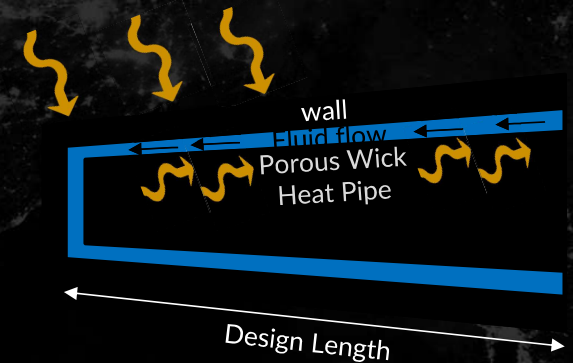
Porosity gradients drive flow to critical regions in the sublayer



Schematic Top View of External Structure

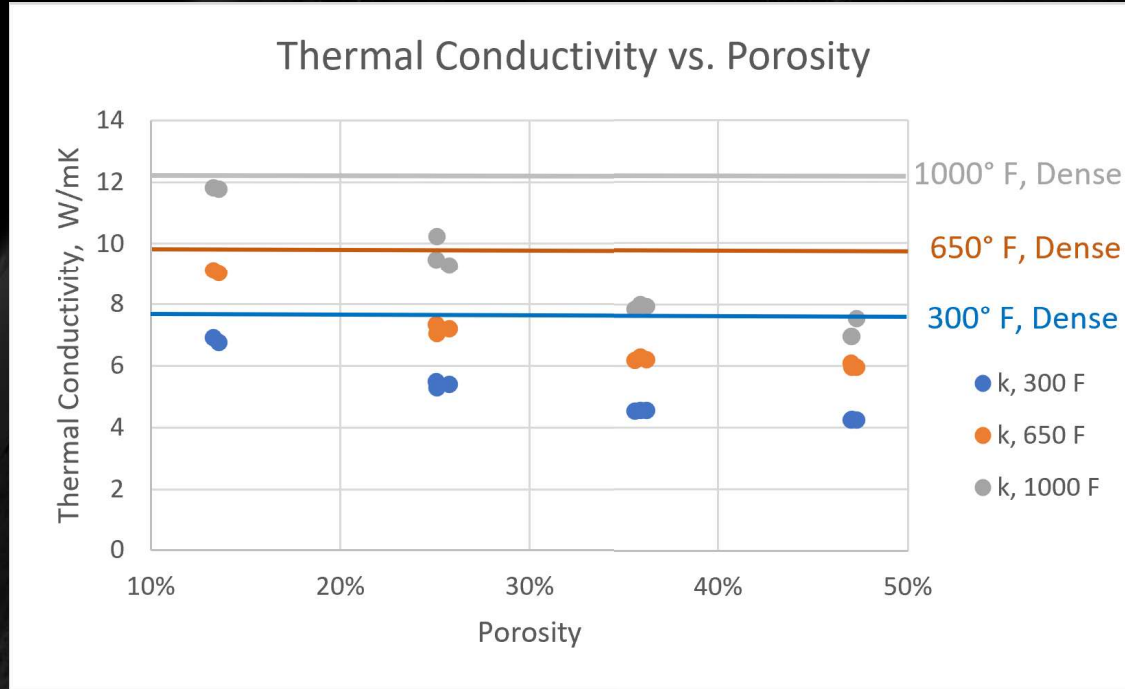


External Fin Structure Example



Integrated Wicking Sublayer on Forward Aeroshell

Hypersonics: Thermal Conductivity Control with Porosity



Thermal Conductivity of additively manufactured porous Ti6Al4V at 300°F, 650°F, and 1000°F measured by laser flash as a function of porosity. Literature values for dense metal (0% porosity) are plotted as horizontal lines.

Correlations to 4000F proprietary and testable through partnerships.

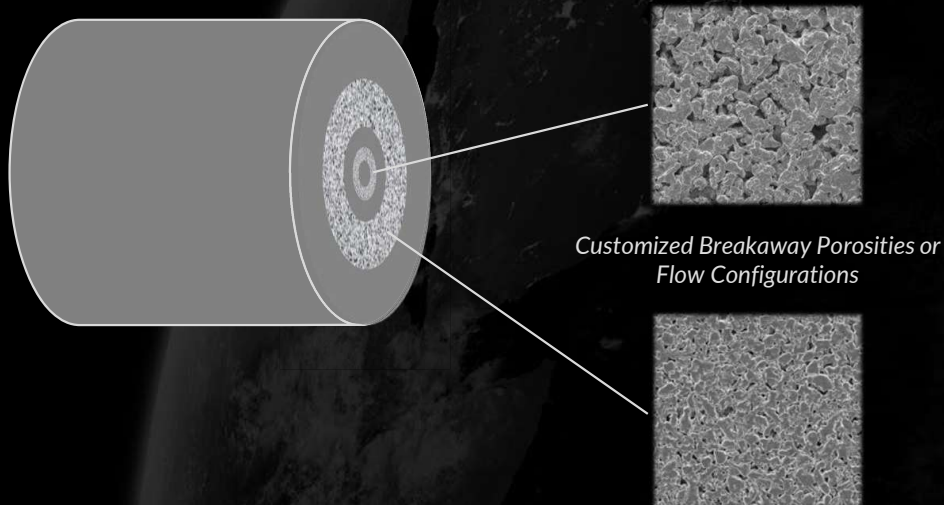
Kinetic Weapon & Energetic Custom Designs

Key Features & Benefits

- Customized breakaway strength with assigned solid/porous hardware configurations
- Additive options capable up to ~12" prototypes and larger builds for production for complete design freedom & supply chain robustness
- Material options in both conventional metals (316L SS, Ti-64, Inco-625) and high temperature refractories (Tungsten, C103, etc.)



Concept Weapon System



Typical Applications

- Kinetic Weapons & Energetics
- Hypersonic Programs
- Missile Systems
- Unmanned Aircraft

High-Powered Electronics Cryocooling Componentry

Key Features & Benefits

- Optimized phase separation with multiple or gradient porosity integrated down to cryogenic conditions
- Conventional or completely additive bill of material options available
- Reduce footprint, weight, and/or improve efficiency in same or reduced footprint

Wide, Customizable Operating Range

- 0.1-to-100-micron media grade; thickness depending on Flow/dP and temperature tradeoffs
- 316L Stainless, Titanium, or Inconel designs in addition to other materials

Fast Delivery to Program Schedules

- Lead times in weeks vs. months
- Capable of full flight qualification, compliance matrix & data packages

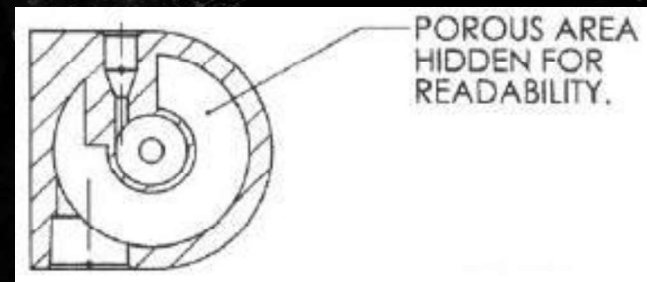
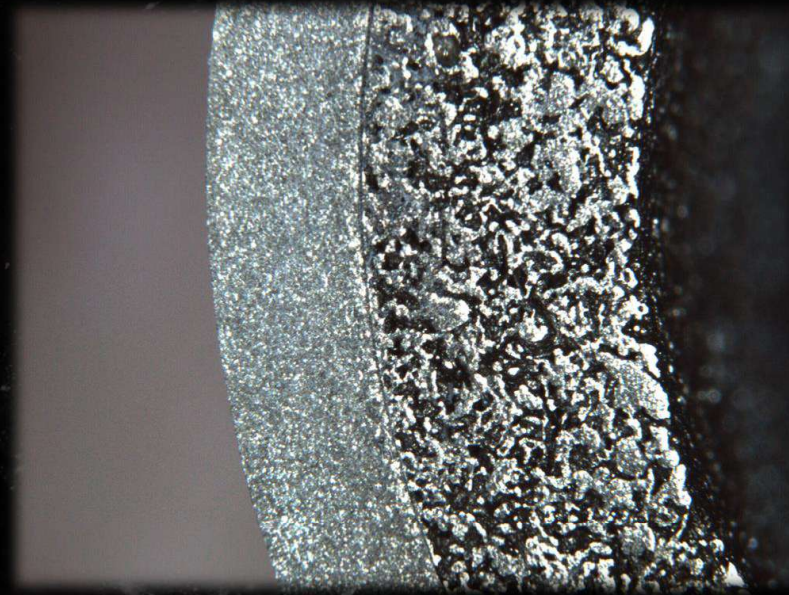


Example Cryocooling Component Design for Aircraft Electronic Systems

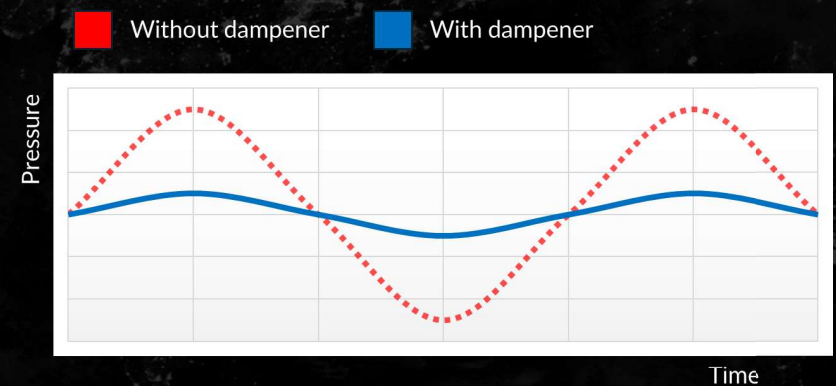
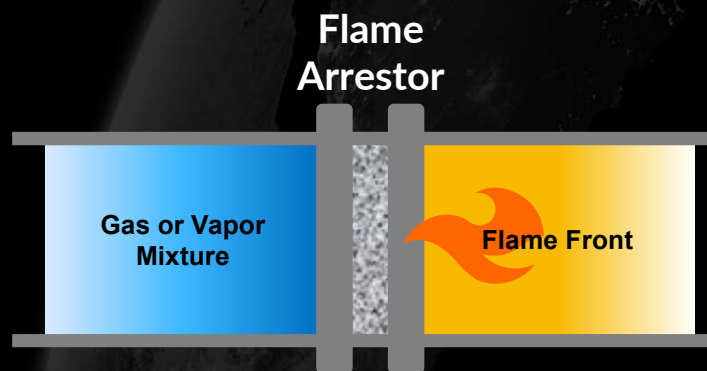
Wicking, Loop Heat Pipe, & Vapor Chamber Componentry



Titanium Porous Wicks



Other Applications: Flame Arresting & Internal Sound Attenuation



Custom Integrated Porous Assemblies

Materials (Powder)

- Tungsten (>99% pure)
- Niobium (>95% pure)
- Molybdenum (>95% pure)
- Zirconium (>95% pure)
- Tantalum (>95% pure)
- Titanium (all grades)
- 316L Stainless Steel
- Nickel
- Hastelloy
- Gold, Silver, Platinum
- **Any alloy, challenge us**

Materials (Fiber)

- 316L SS
- Hastelloy C-22

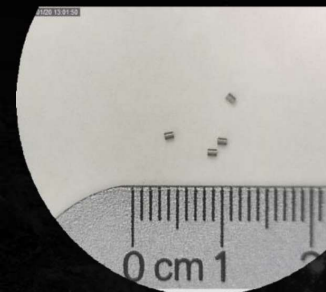
* High purity ceramics & polymers under development

Form Factors

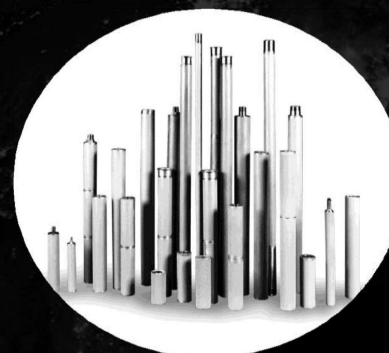
- Discs and rods,
 - Diameters from 0.020" to 10.0"
 - Thicknesses from 0.020" to 1.0"
- Bushings, Cups
 - Diameters from .125" to 2.0"
 - Lengths from .25" to 3.0"
- Seamless Tube/Tube assemblies
 - Diameters from .170" to 8.0"
 - Lengths from 0.25" to 120"
- Sheet
 - Lengths from 1" to 12" wide
 - Thicknesses from 0.013" to 0.100"
- Rolled & Welded Cylinders
 - Diameters from 1.0" to 12.0"
 - Lengths from .25" to 120"



Gas diffusers for vacuum applications



Sub-.030" parts for sensor protection



Welded Options for Larger Systems

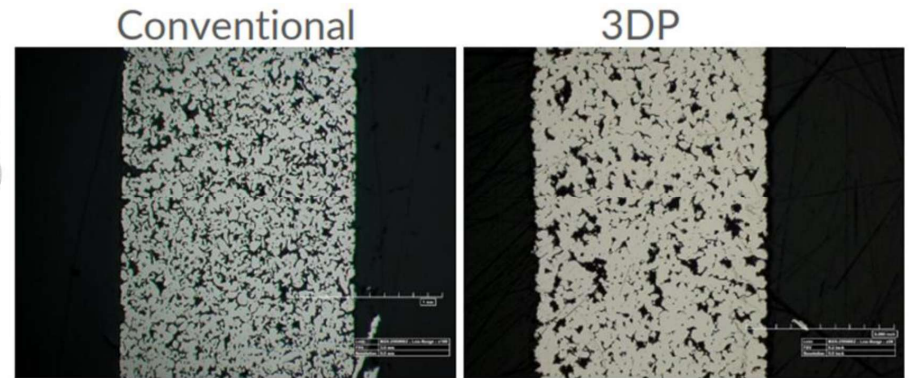


Customized designs for any configuration

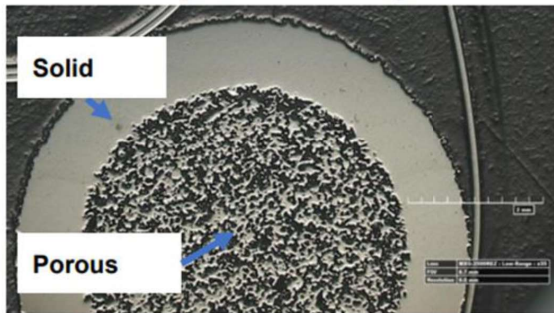


Controlled Porosity Additive Manufacturing

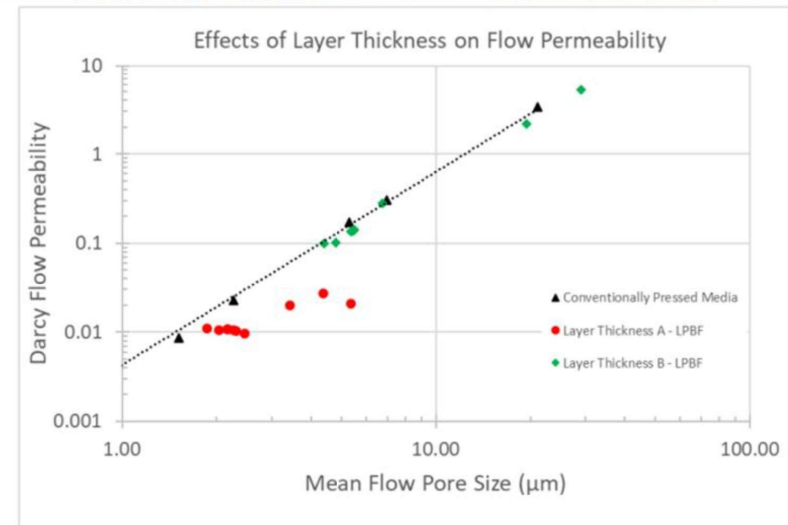
Next-Gen Additive Thermal Technology for Rockets & Satellites



Dual density structures (porous-solid)



*Avoids secondary operations such as assembly, welding, press-fitting and sinter-bonding



Build Feature Tolerances (Production Build Box Sizes Expanding!)

Build volume: Prototype 9.7" x 9.7" x 13.0" (L x W x H) –
Expansion to 39" production build height with investment

Build materials: 316L Stainless Steel, Titanium, Inconel, other high
temp alloys like C103 in development

Solid feature size resolution: +/- 0.015"

Porous feature size resolution: +/- 0.02"

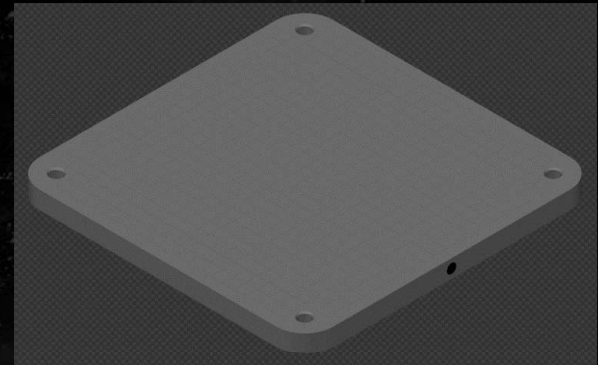
Porosity range: 1 to 100+ micron pore size (for custom porosity
consult engineering)

Part-part dimensional consistency: +/- 0.001-0.002"

Density consistency: +/- 0.07-0.1 g/cc

Solid printed surface finish: 350 Ra μ in

Machined surface finish: 5 to 32 Ra μ in



Build plate



Laser Powder Bed Fusion

Next-Gen Additive Thermal Technology for Rockets & Satellites

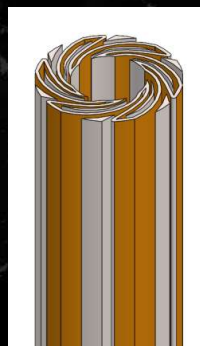
Conventional Design

Ex. Space Filter
(5-element design)



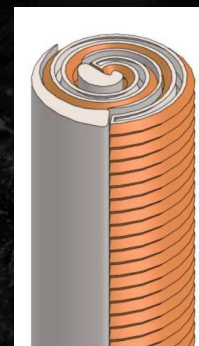
3DP Concept 1

"SPIRAL"



3DP Concept 2

"SWISS ROLL"



3DP Concept 3

"HONEYCOMB"



Design

Surface area (cm ²)	271	1,161		1,032		389
Clean dP (psid)**	1.966	0.089	-95%	0.117	-94%	0.354
Dirt Capacity (mg)	800	TBD		TBD		TBD
Envelope (cm)	same profile	same profile		same profile		same profile
Weight (kg)	0.34	0.35		0.36		0.29

* All data presented are modeled and calculated estimates and would need proven by building actual prototype units to test.

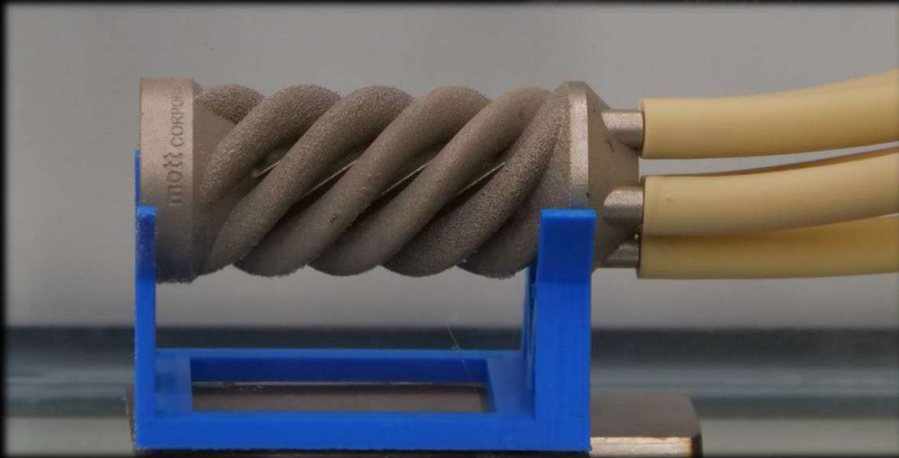
** Clean dP modeled using analogous conventional media comparison with max flow rate 0.14 lb/s using H₂O. Testing would need to confirm these values.

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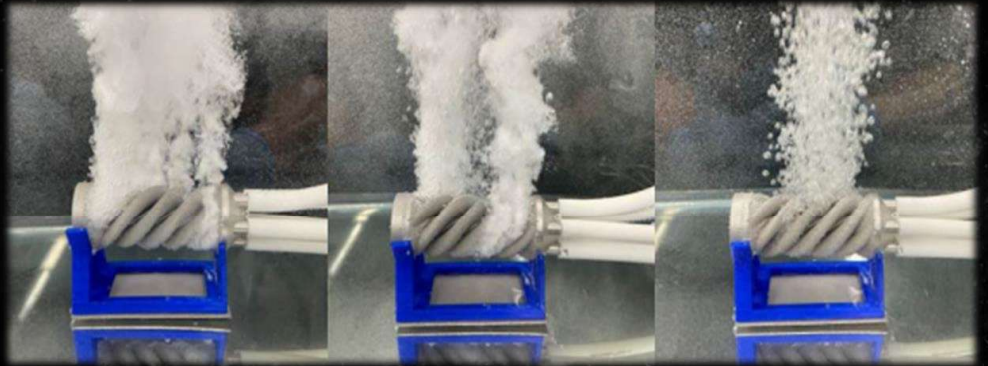
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Example Porosity Variability in a Single Print



Example 3D Printed Component with Multiple Porosities Integrated

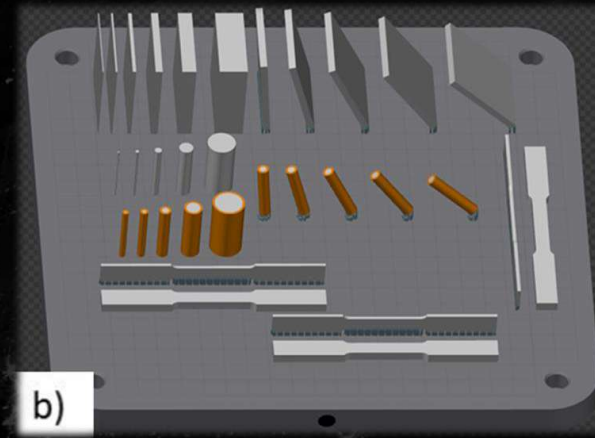


Representative images showing impact of different pore sizes (Media Grades) increasing from left to right

Transitioning to Production – Machine & Build Validation



a) Typical layout for testing a variety of parameters settings on standard discs.



b) Parameter matrix build layout. Fixes one parameter set while adjusting thickness, build angle and solid wall to porous media ratio (orange). Additionally, tensile bars are printed to understand mechanical properties of each parameter set.

Contact Us

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