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DESIGNING AN ADDITIVE MANUFACTURED MICRO PUMP FOR SPACE APPLICATIONS

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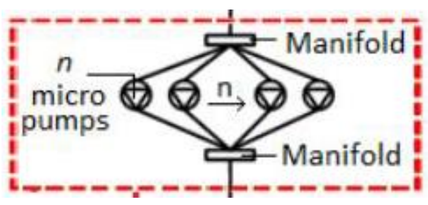
Introduction

- ✓ Pumped two-phase loops are essential to handle future thermal power densities in space applications (50-300 W/m^2 is expected).
- ✓ But, space pump reliability is *the* reason not to apply pumps in space on commercial satellites.
- ✓ Single-point of failure: pump failure is spacecraft failure.
- ✓ Robust space pump technology is required.

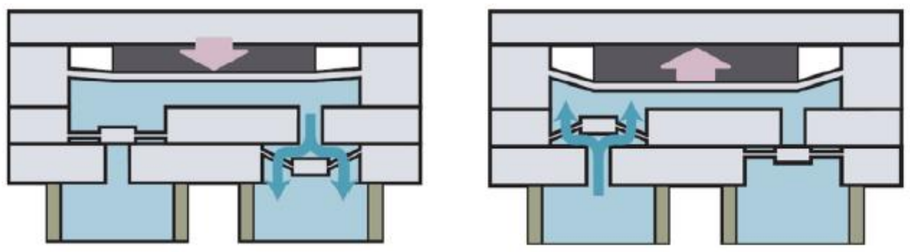
Concept solution

- ✓ Multi-parallel micro pump



- ✓ Many micro pumps operate together in a pump assembly.
- ✓ One pump failure is not an issue anymore. $\frac{n-1}{n}$ Pump capacity is still available.
- ✓ The number of micro pumps in the pump assembly is tailored to the flow and pressure head requirements.

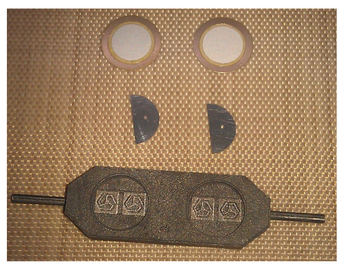
Micro pump working principle

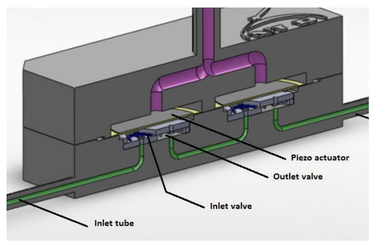


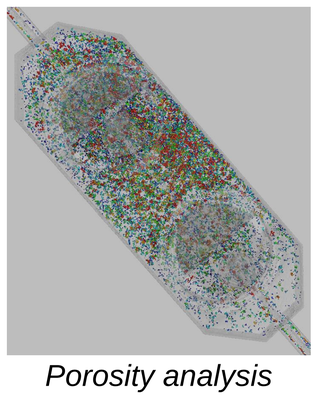
- ✓ Discharge stroke (left) and suction stroke (right) through a reciprocating diaphragm motion.
- ✓ Piezo electric disk actuates the micro pump.
- ✓ Passive check valves control the flow direction.

Micro pump prototyping using SLM

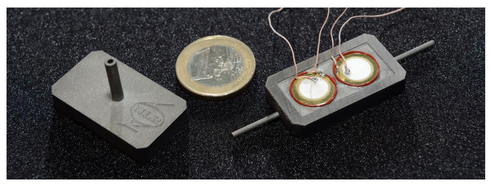
- ✓ SLM parts that are laser welded are leak tight < 1·10^{-9} mbar·l/s.
- ✓ Quality control using X-ray micro-CT.

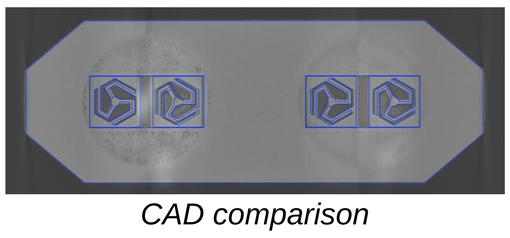






Porosity analysis

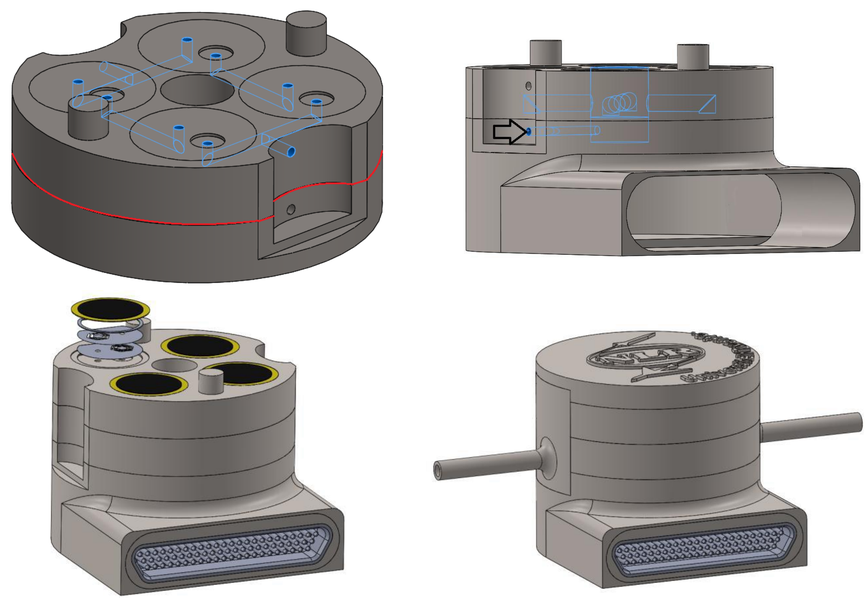




CAD comparison

Design optimized for SLM

- ✓ Modular design with stackable disks.
- ✓ Bottom part with standardized 51 pins electronics connector.
- ✓ This concept has 6 micro pumps in 3 layers.
- ✓ Targeted flow rate = 20 ml/min and pressure head = 250 mbar.
- ✓ Total weight is 103g; each additional disk add ~25g.



SLM production of parts

- ✓ Parts are produced with selective laser melting.
- ✓ Local post processing to enable laser welding.

Conclusions

- ✓ Live testing is on-going.
- ✓ Concept is patent pending.
- ✓ One design fits all.
- ✓ Tailorable to meet various flow and pressure head requirements.
- ✓ Non-destructive testing using micro-CT can also be used for automated quality control.

- ✓ Additive manufacturing is a game changer for space applications.
- ✓ SLM can meet the stringent requirements for this application.
- ✓ Novel robust pump technology only manufacturable using SLM.
- ✓ 90% overall weight reduction is projected.

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