Additively Manufactured (AM) Heat Exchangers

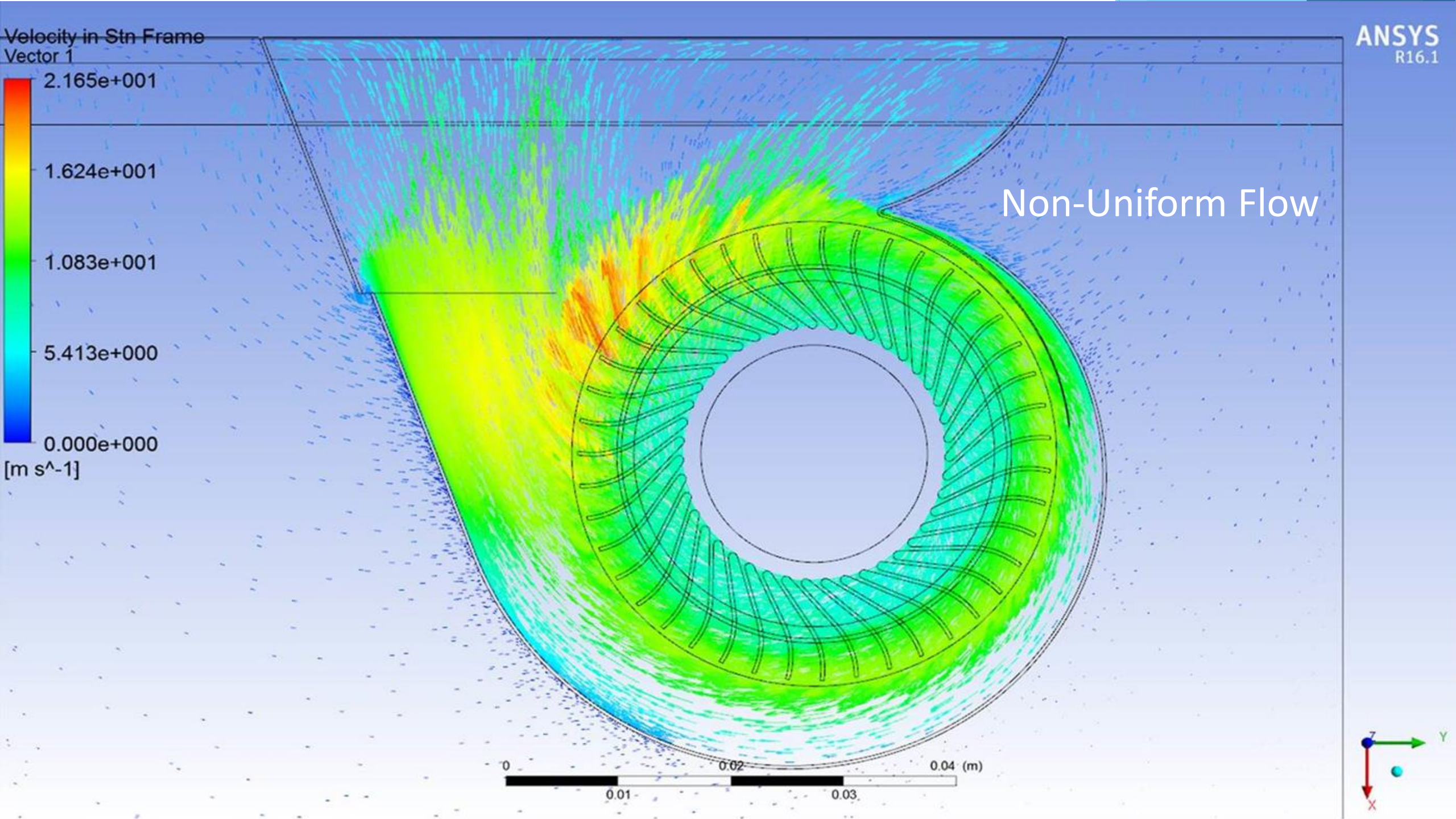
Microsoft Applied Sciences

December 2016

Microsoft

Increasing Heat Load

- Surface Book 2015:
  - 16 Watt GPU
  - Straight Fin Architecture
  - Single Fan
- Surface Book with Performance Base 2016:
  - 35 Watt GPU
  - Dual Fan


Velocity in Stn Frame
Vector 1
2.165e+001
1.624e+001
1.083e+001
5.413e+000
0.000e+000
[m s^-1]
ANSYS
R16.1
Non-Uniform Flow
0
0.02
0.04 (m)
0.01
0.03
Y
Z
X

Laser Powder Bed Fusion

- Powder Metallurgy
- Full Melting of Metal Powders
- Net Shape Parts
- Cast to Wrought Material Properties
- Several Manufacturers (we picked 2)

Materials

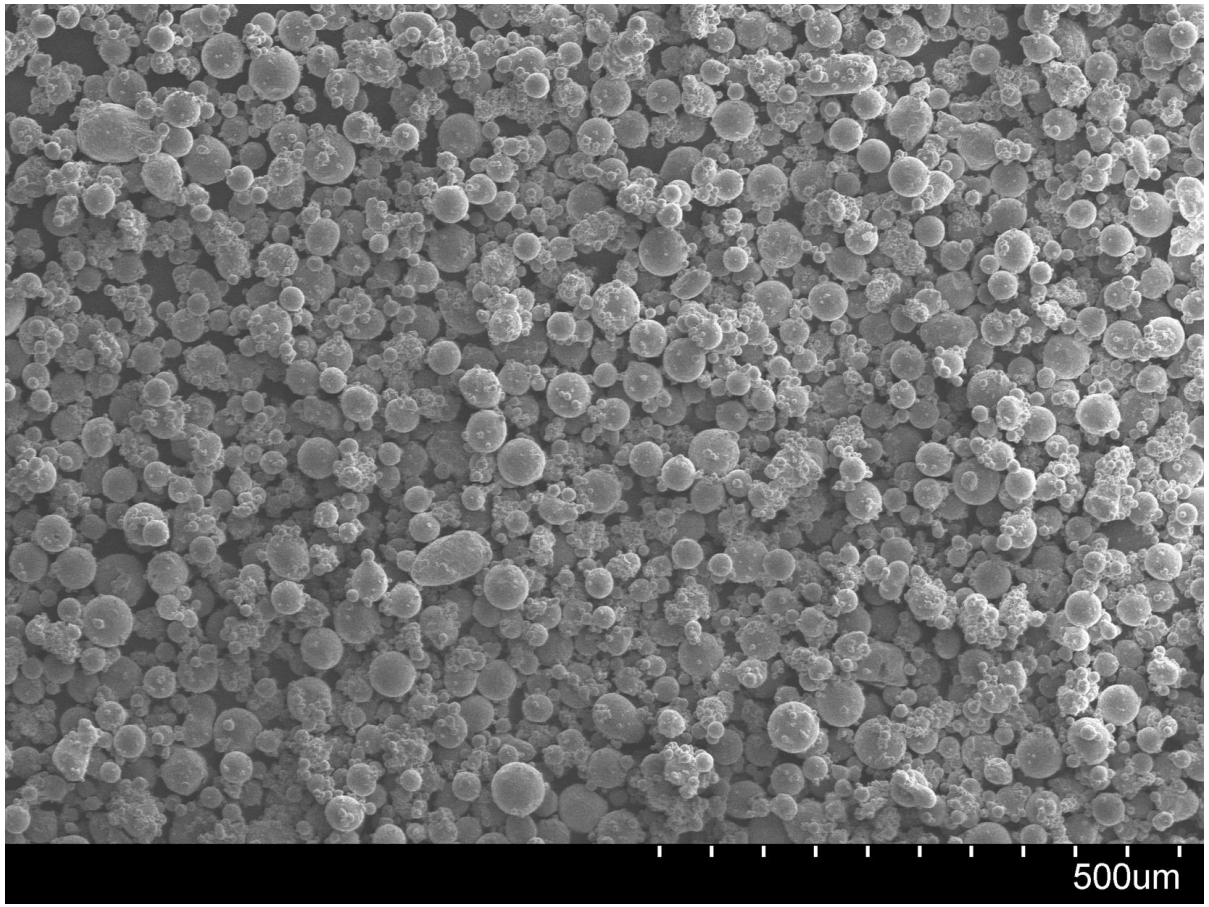
Typical heat exchanger material: Copper

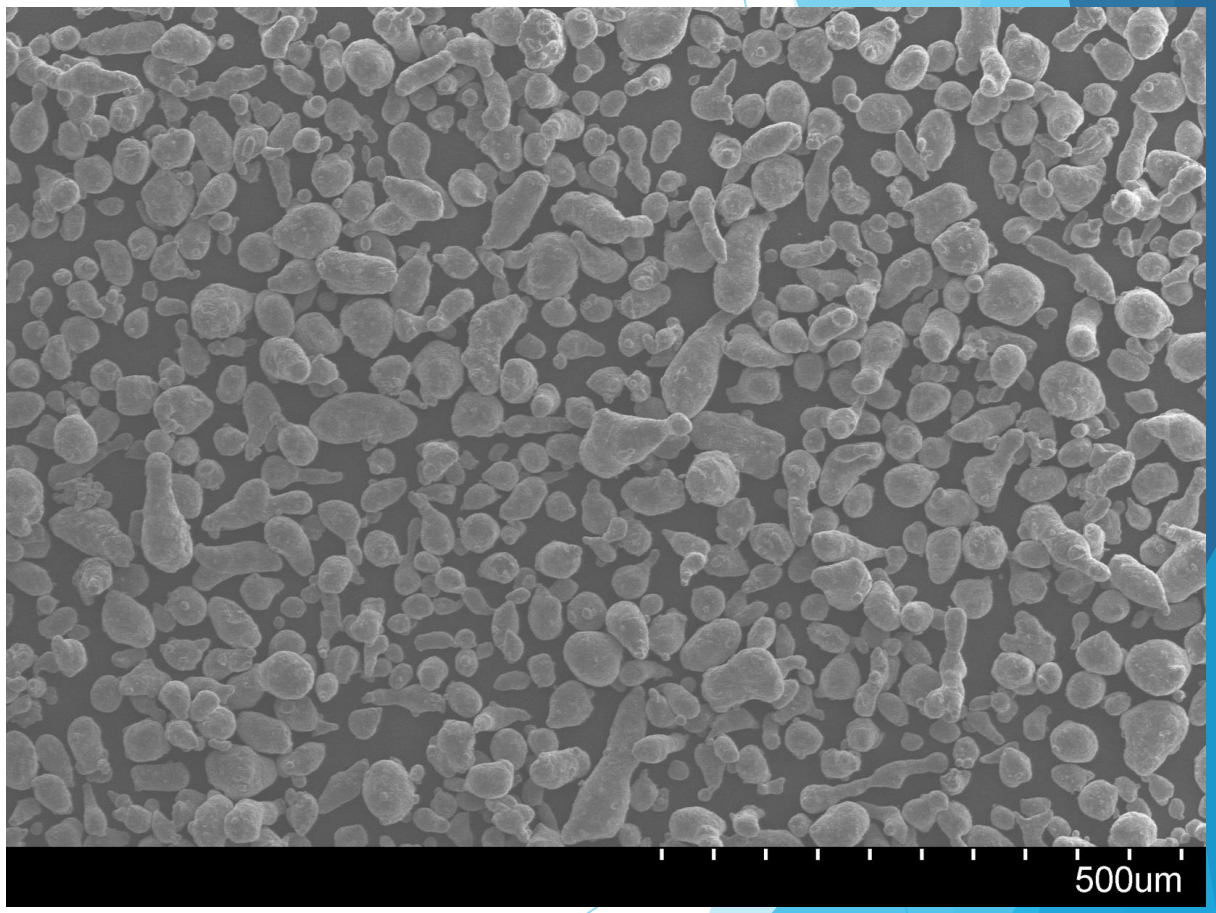
- Thermal conductivity 400 W/mK
- Density 8.96 g/cm^3

Highest thermal conductivity of readily available printable materials: AlSi10Mg

- As-Printed Thermal Conductivity 110- 150W/mK
- After heat treatment 175-240 W/mK
- As-printed density ~2.69 g/cm^3

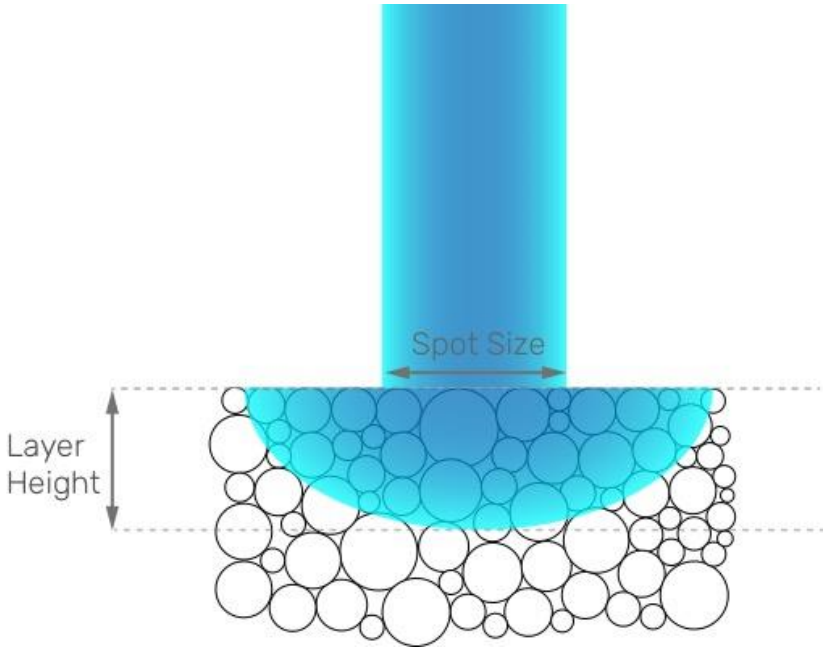
Powder Morphology



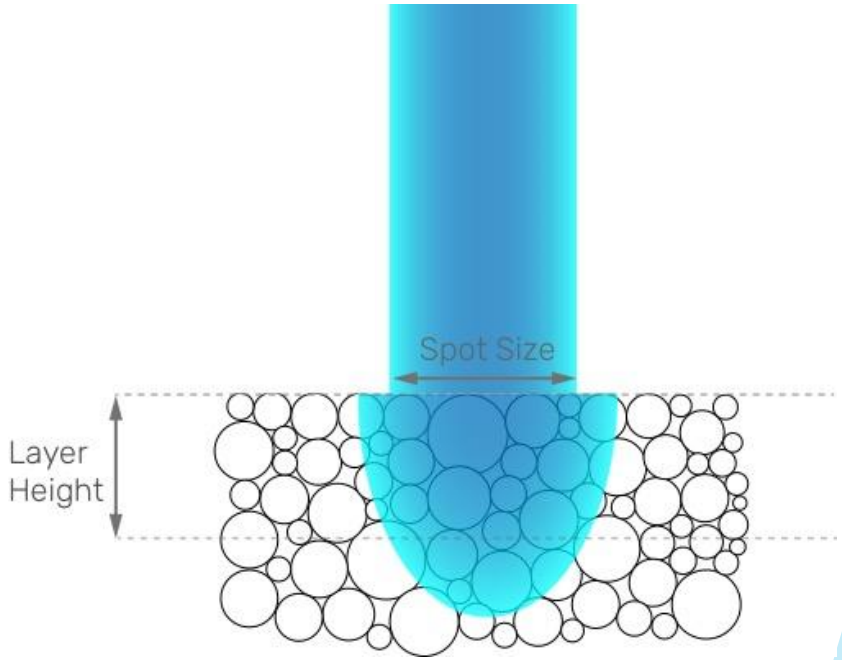


AlSi10Mg

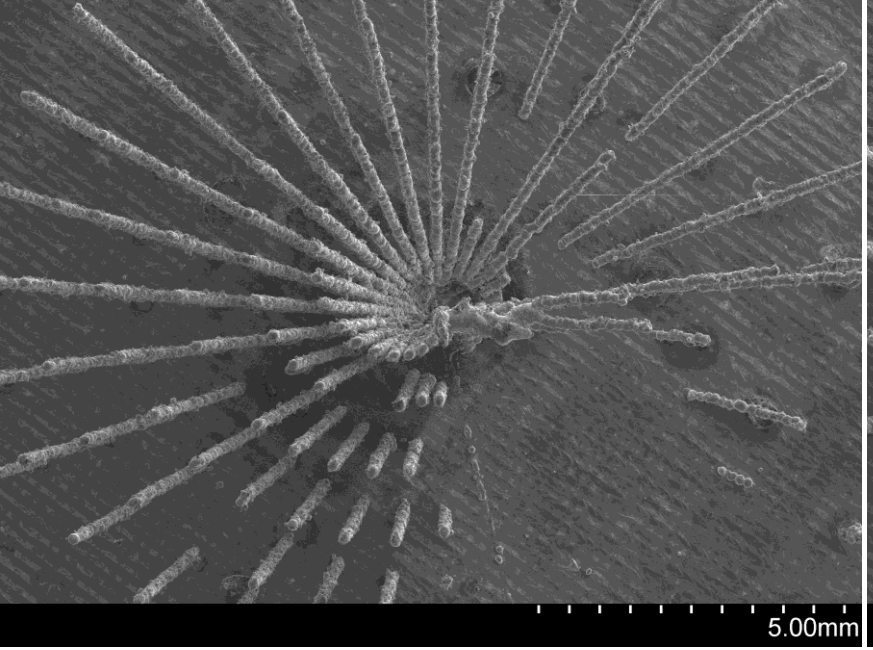
Melt Physics: Energy Delivery & Powder Morphology

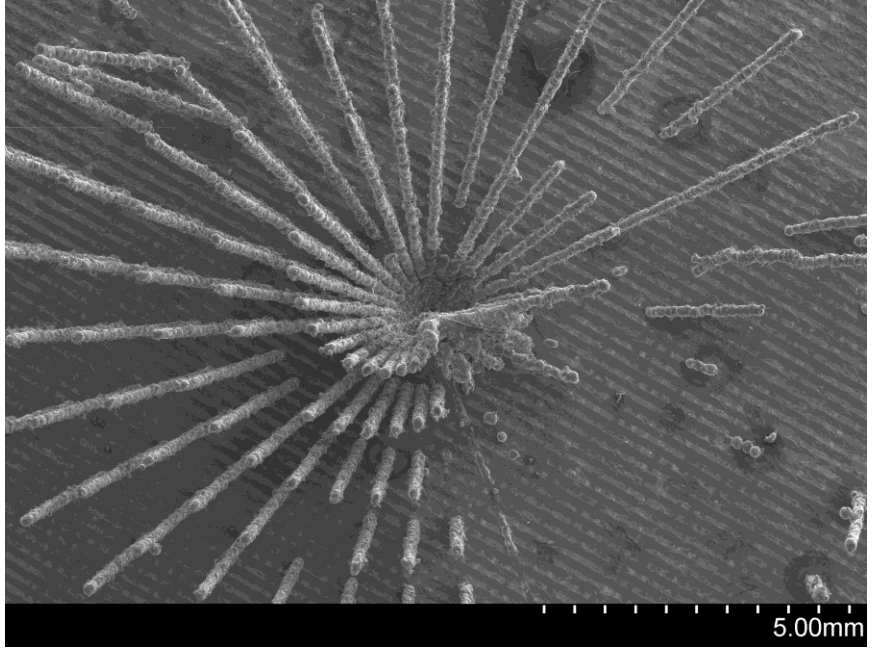


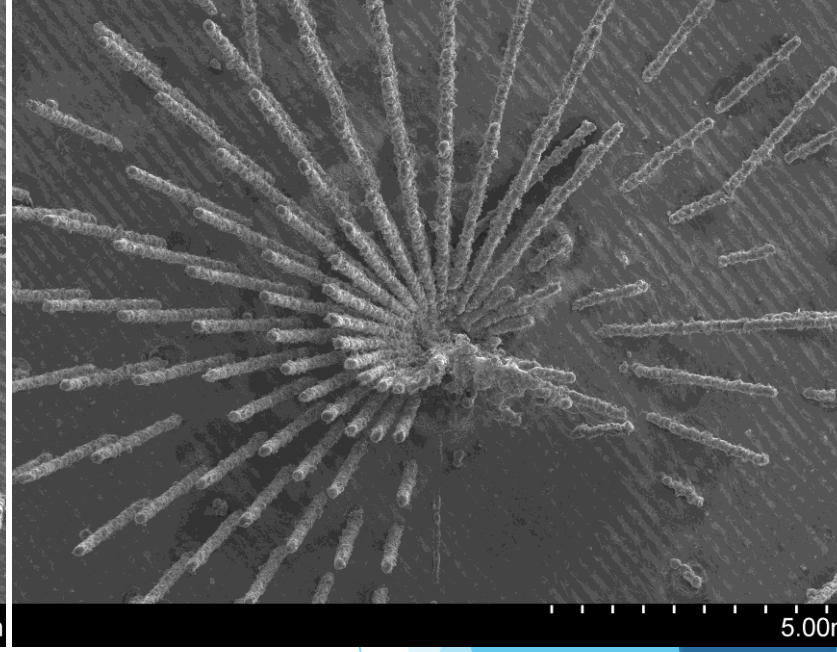
Low Power / High Energy Requirement

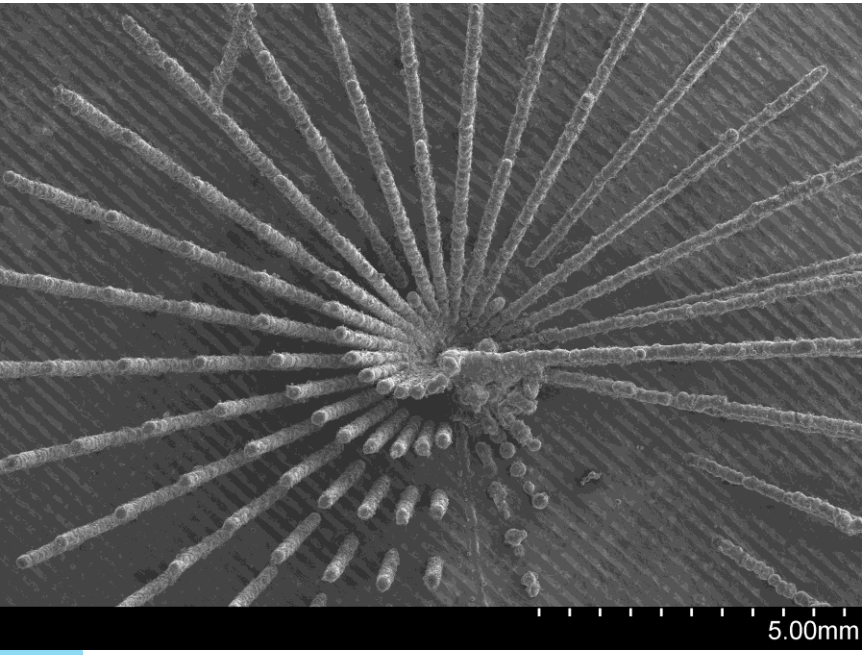


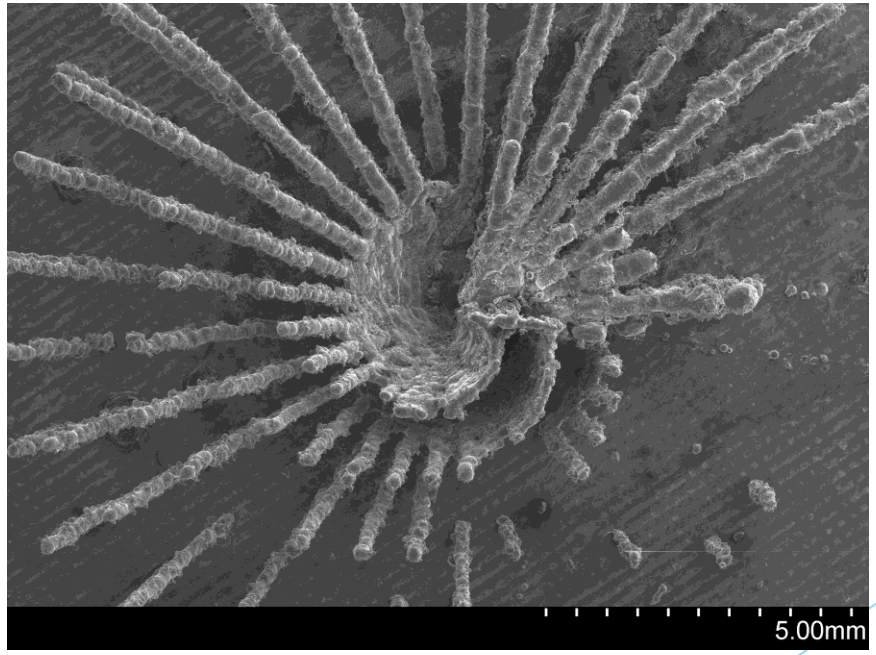
High Power / Low Energy Requirement

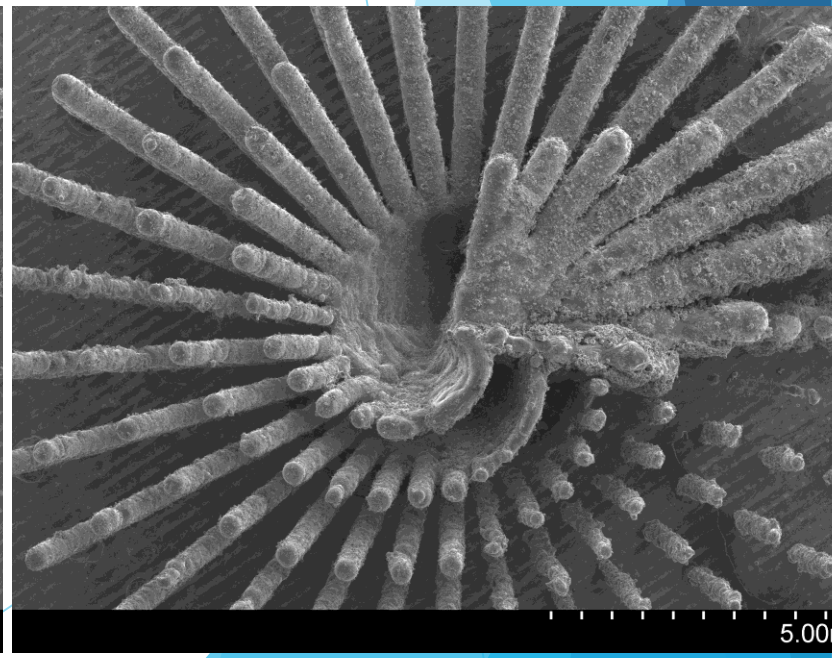

5.00mm


5.00mm

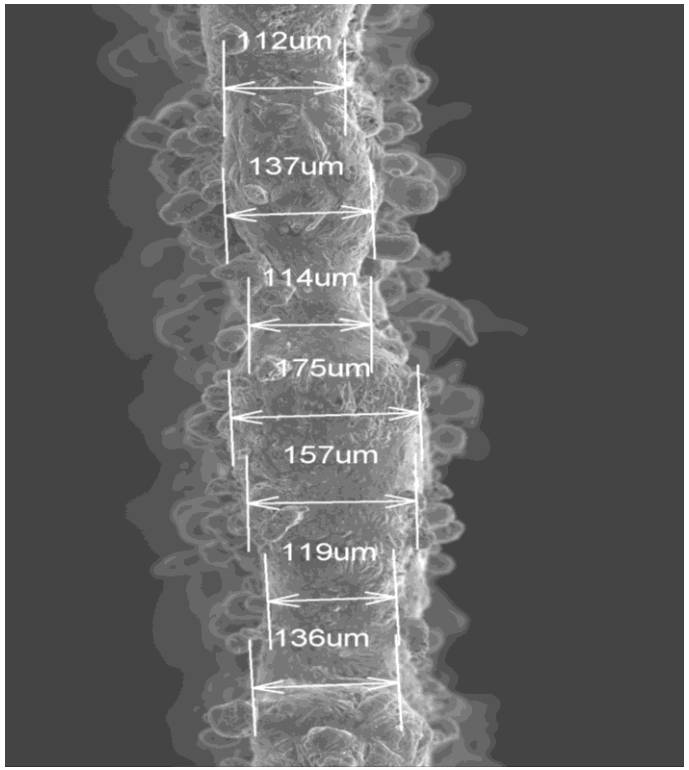

5.00m

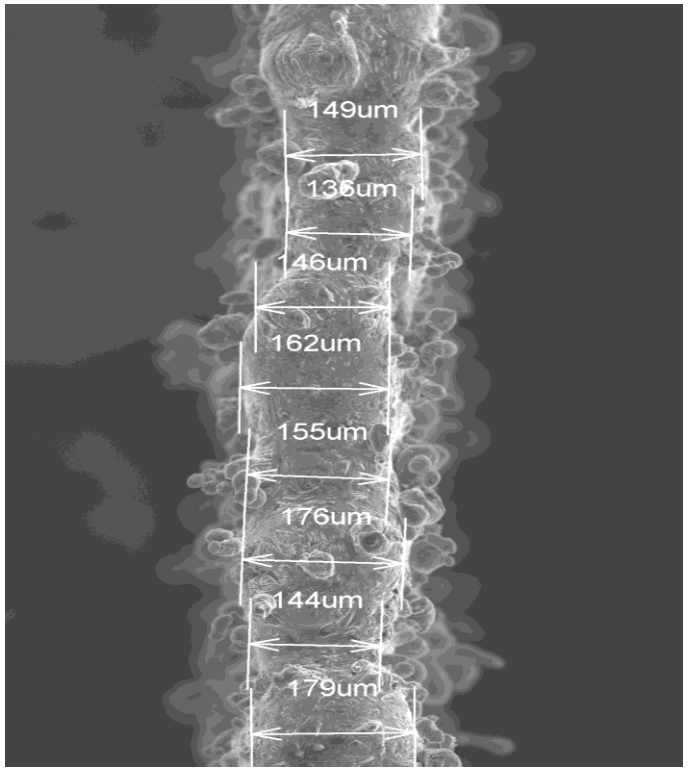

5.00mm

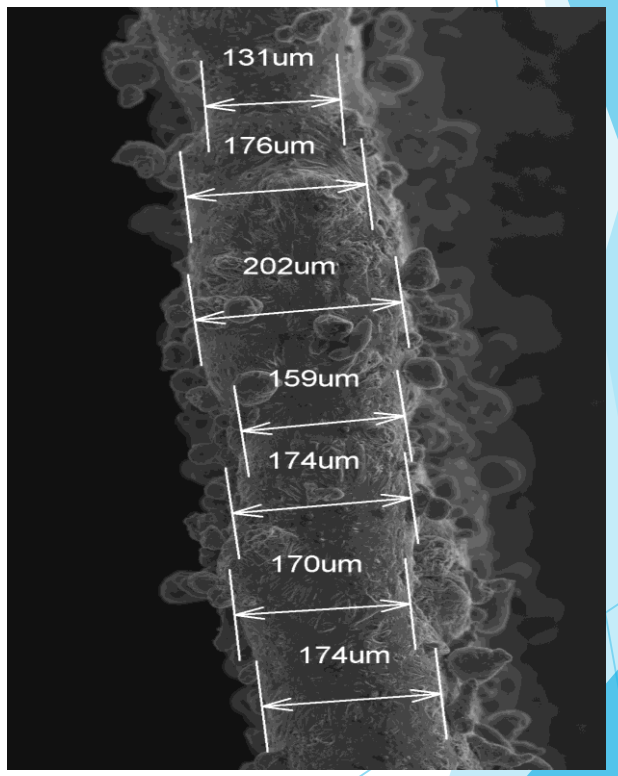

5.00mm


5.00

Wall thicknesses and surface particles

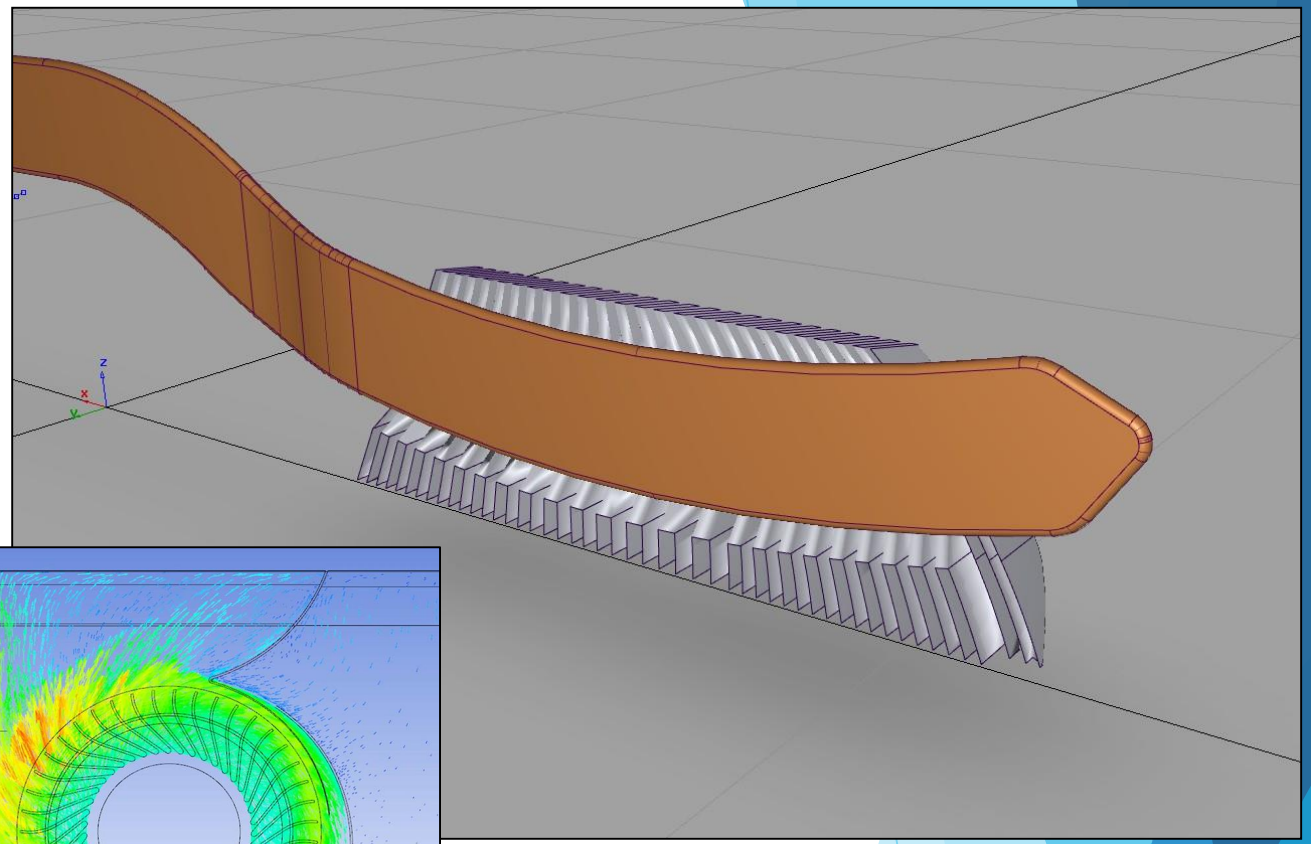


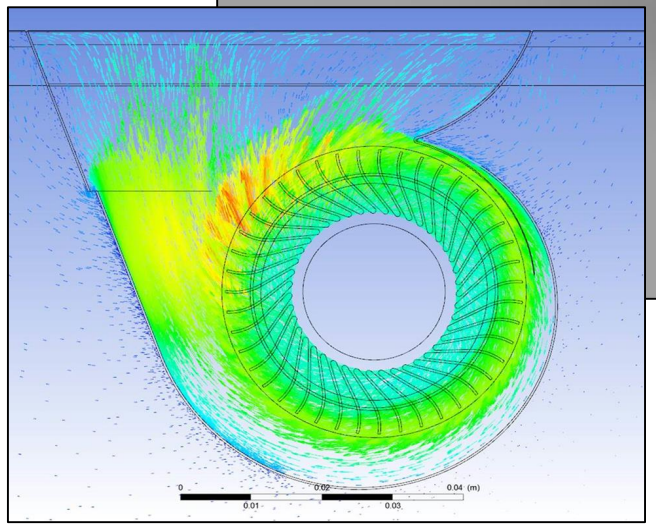


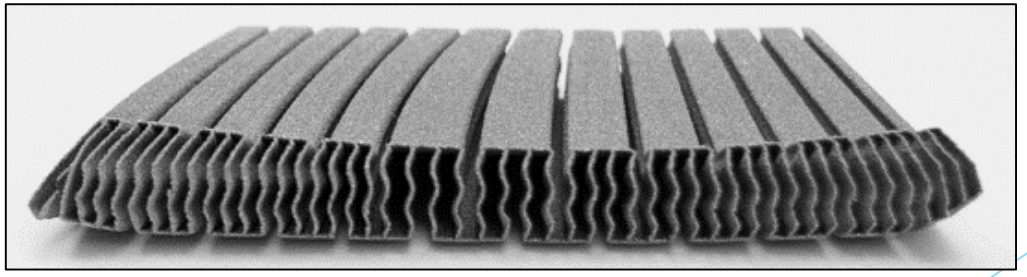


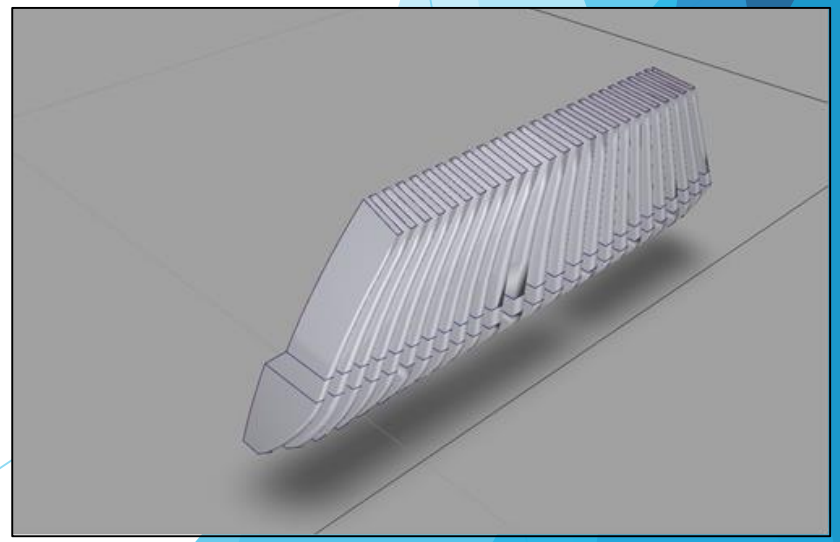
New Design Freedom

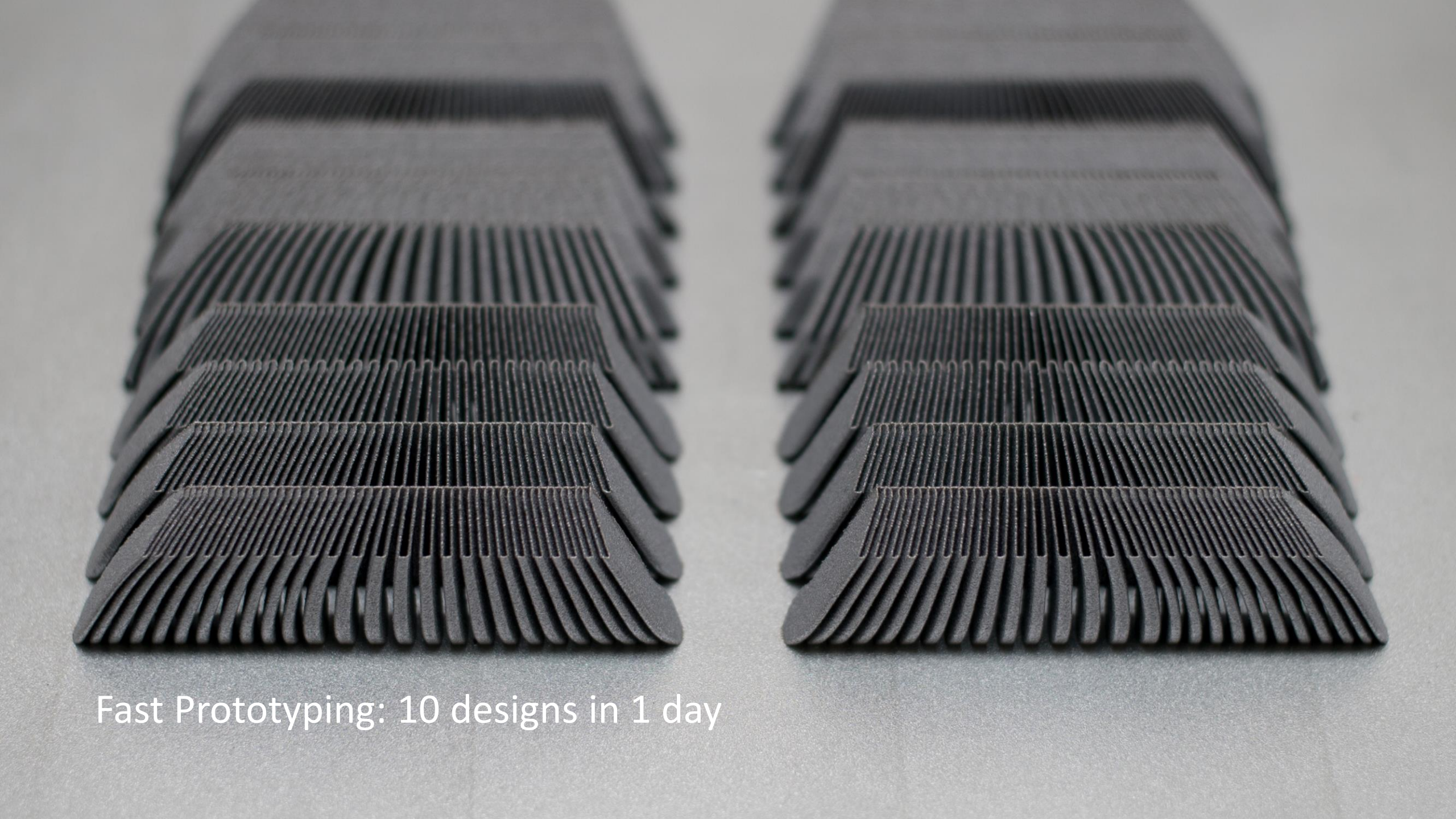
- Fin shape tailored to match air flow vectors
- Fin spacing adjusted for equal pressure distribution
- Increased surface area and flow rate at the same time



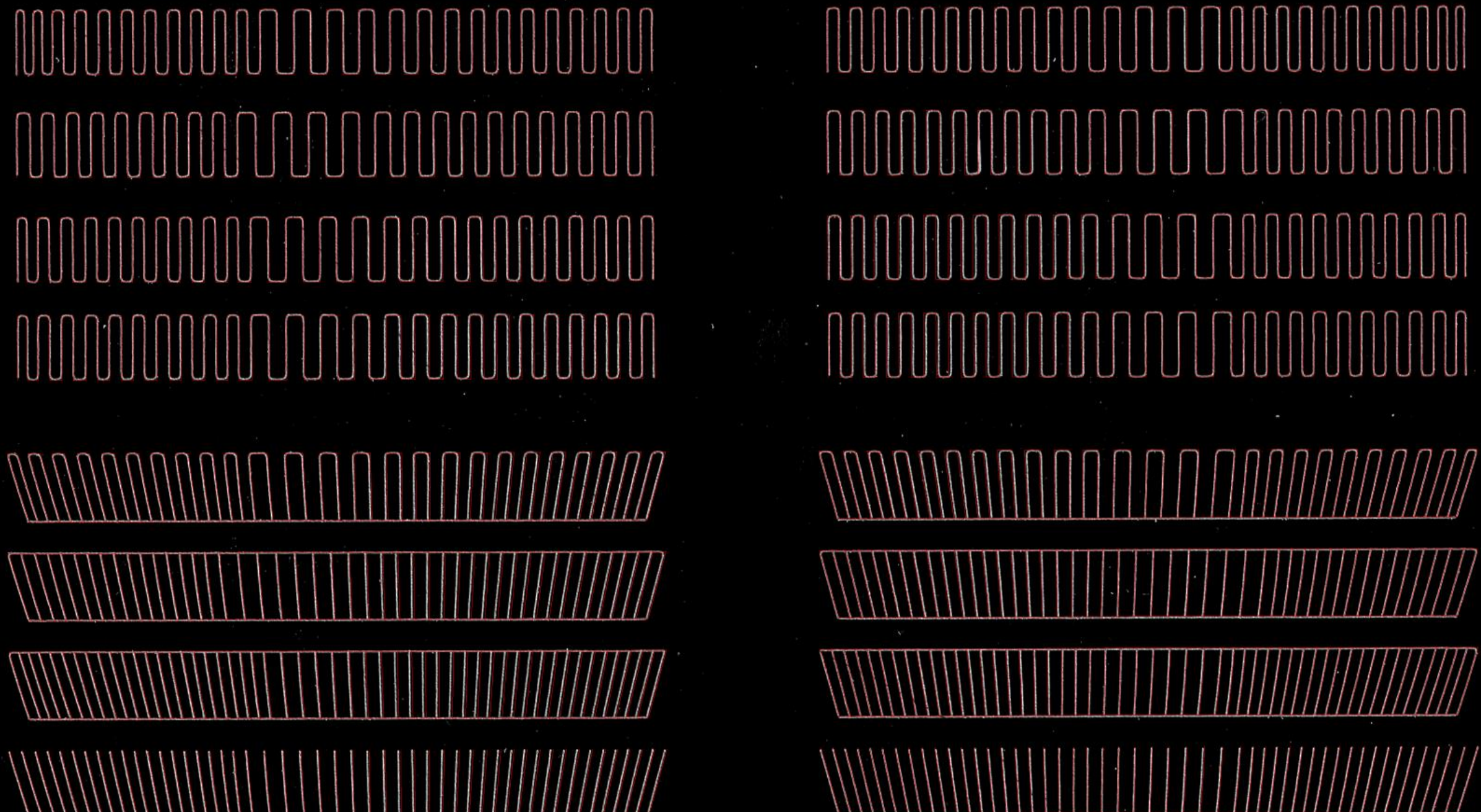


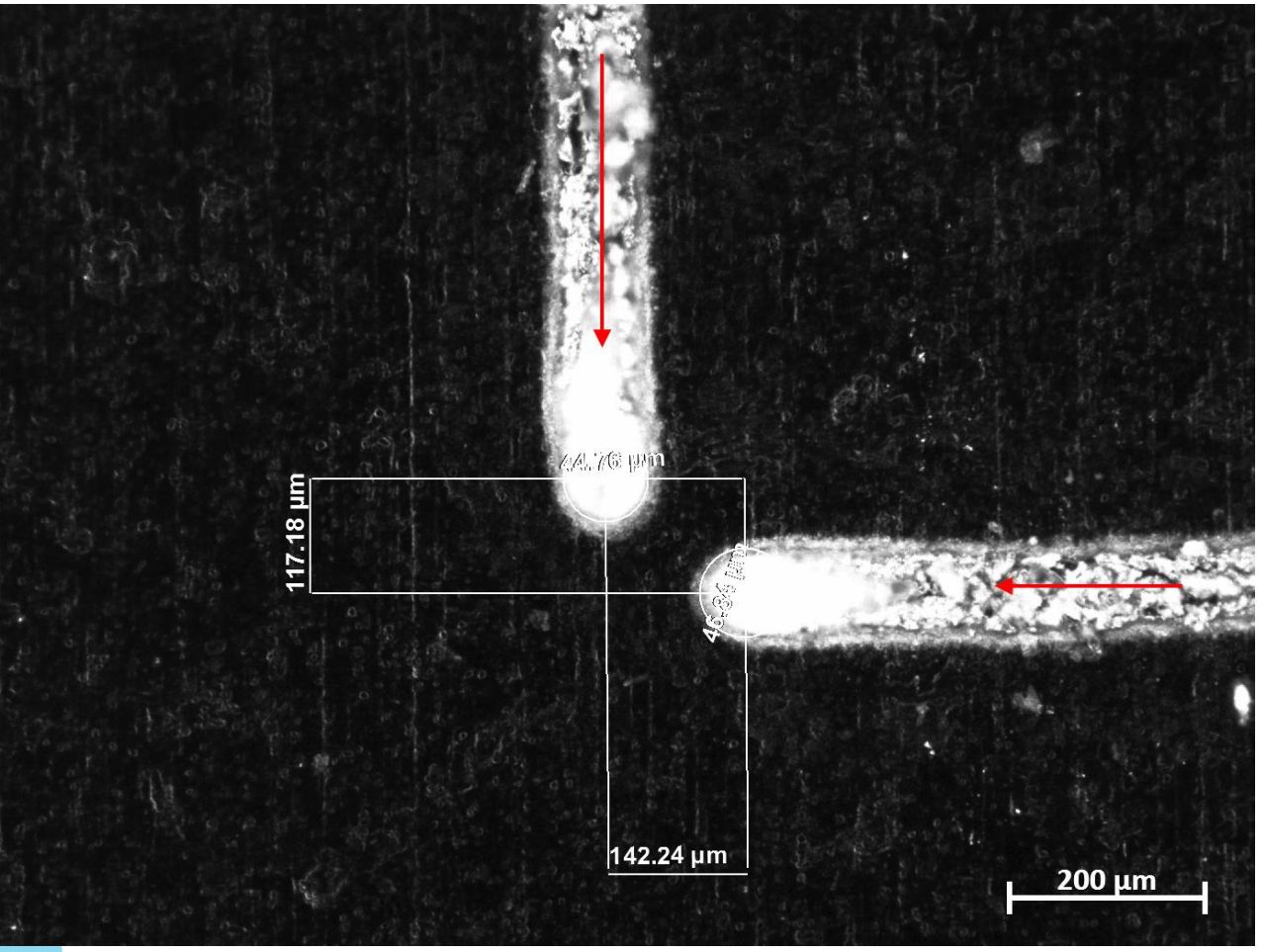


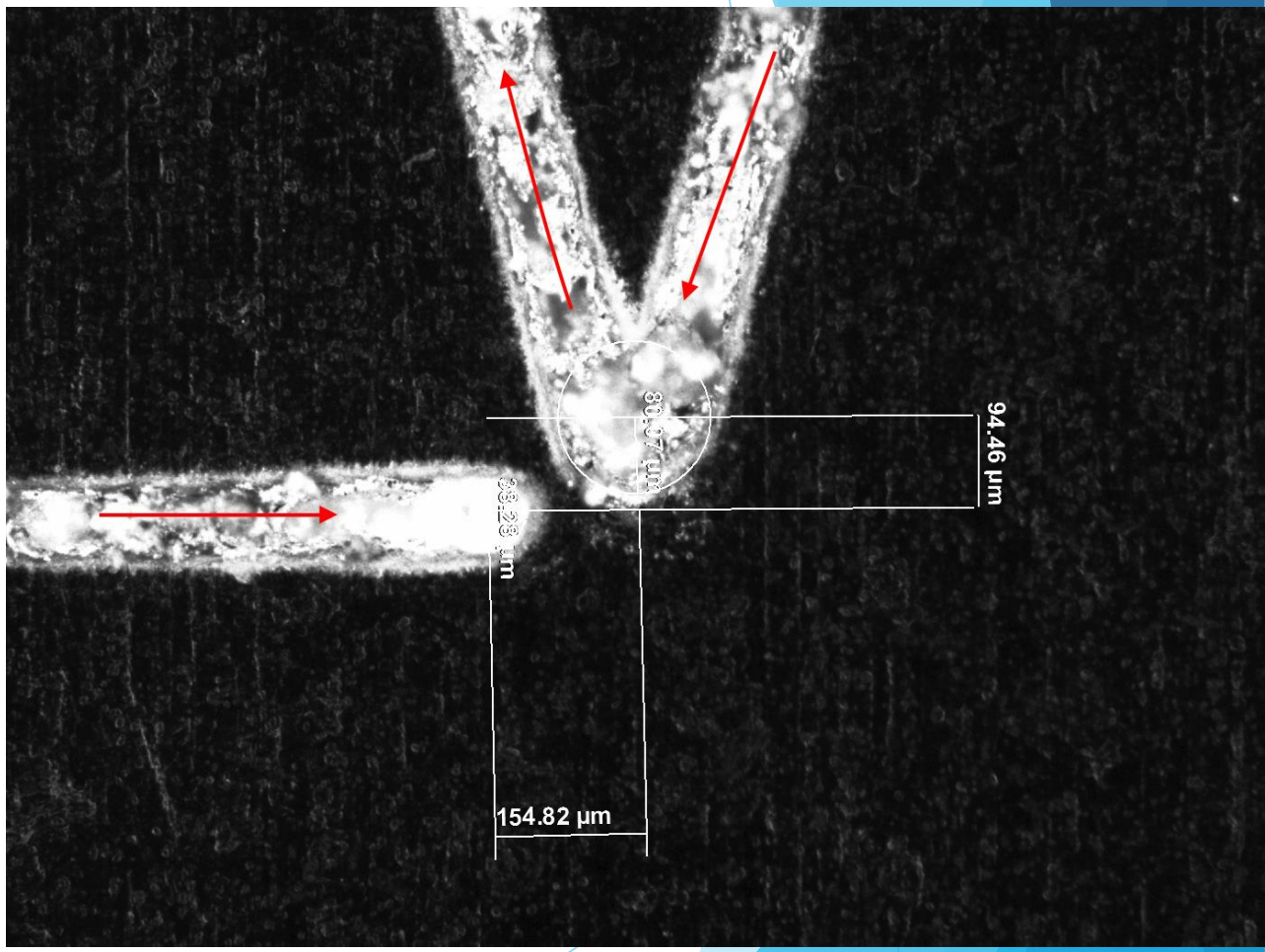


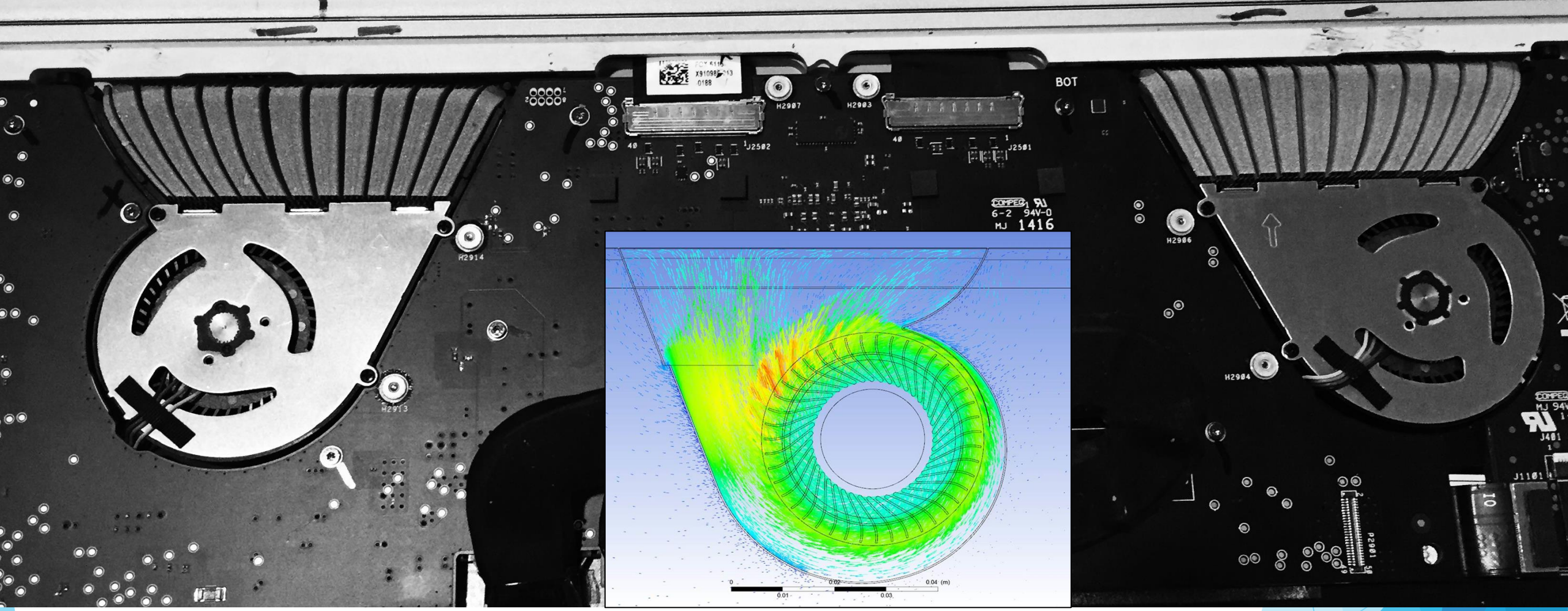


Fast Prototyping: 10 designs in 1 day




44.76 µm
117.18 µm
142.24 µm
200 µm


94.46 µm
154.82 µm



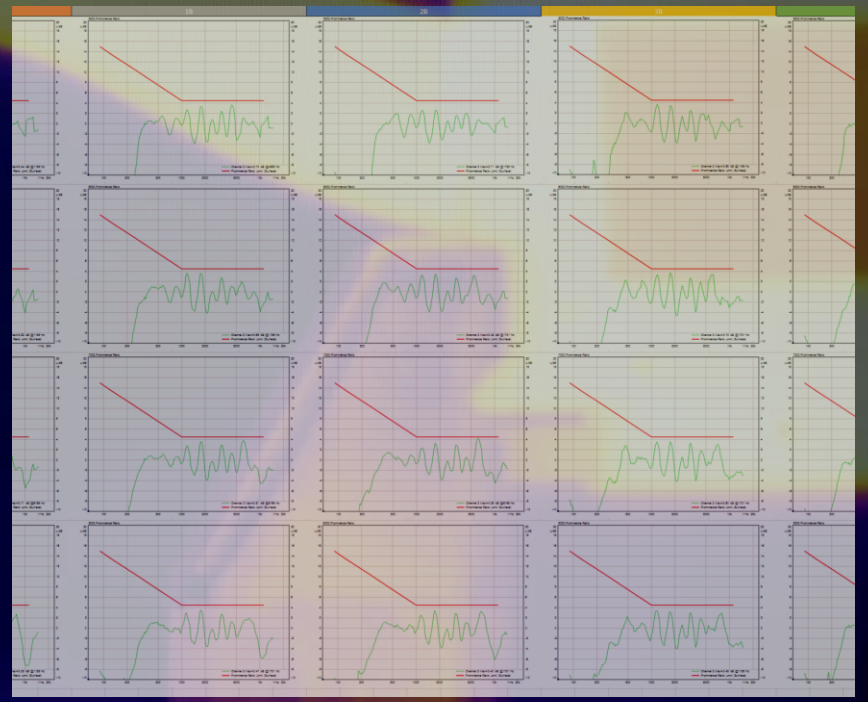
Form

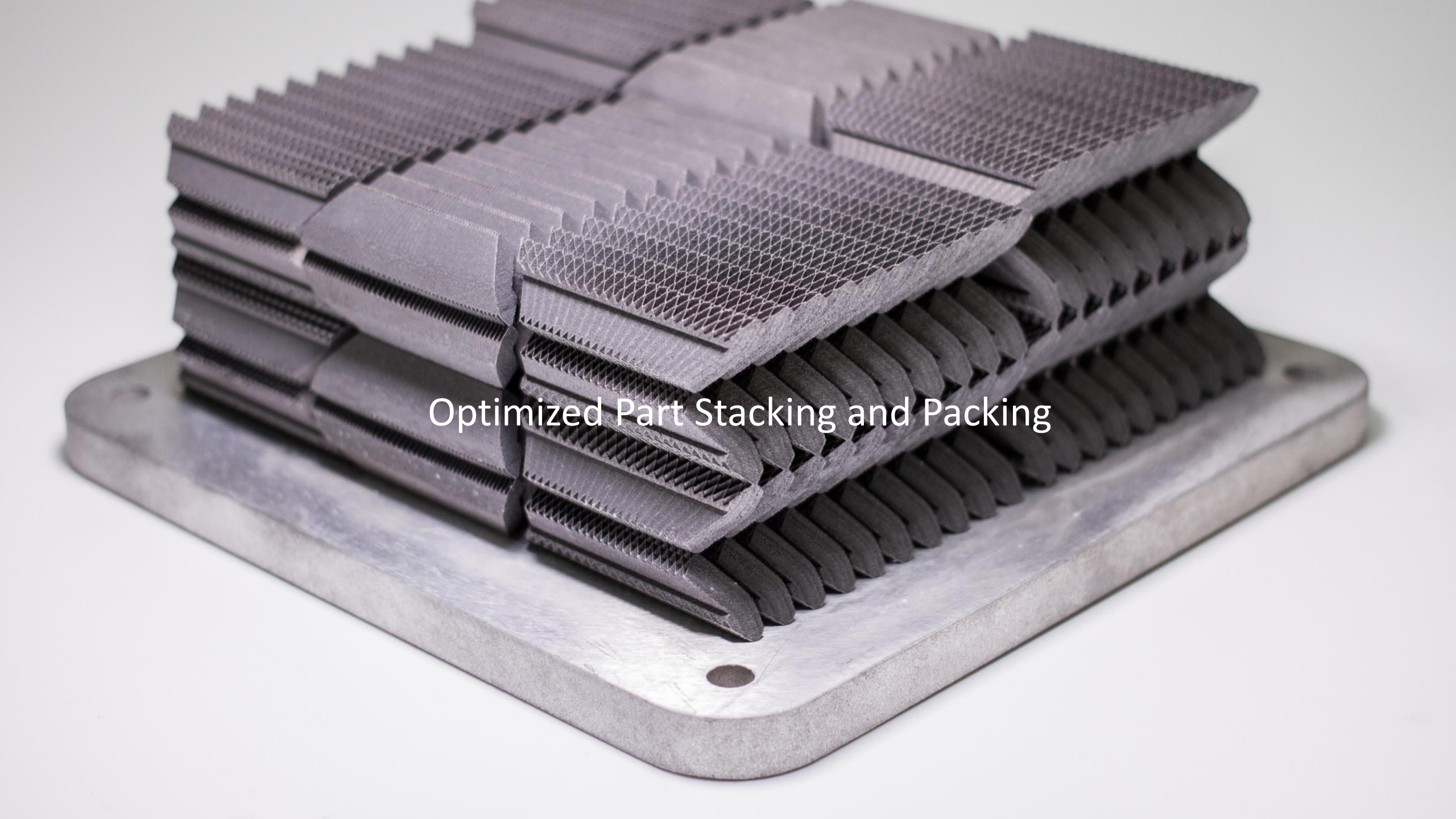
Fit

Function

Performance Results

- Reduced Weight by 55% (2.5g per side)
- Increased Air Flow (CFM)
- Improved Acoustic Performance
- Lower Junction temperature




Optimized Part Stacking and Packing


Production Qualification

Production Qualification Results

- **60,000** parts built to date
- Average mass = **2.57 g**, Cpk = **1.3** (2 machines)
- Thickness = **6.00 mm**, Cpk = **3.8**
- **8%** Build volume utilization
- Mass and thickness variation between machines **< 1%**
- Maximum possible build size = **1,824** components
- Build time per part **90 seconds** (down from 840s)

- Process is **stable** and can be **cost competitive**