Additively Manufactured (AM) Heat Exchangers
Microsoft Applied Sciences
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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
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/cm³

Highest thermal conductivity of readily available printable materials: AlSi10Mg
- As-Printed Thermal Conductivity 110-150 W/mK
- After heat treatment 175-240 W/mK
- As-printed density ~2.69 g/cm³
AlSi10Mg

Powder Morphology
Melt Physics: Energy Delivery & Powder Morphology

Low Power / High Energy Requirement

High Power / Low Energy Requirement
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
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