Who is Wolverine?

- A Rich History, A Solid Foundation, A Bold Future
  - Wolverine has 90+ years history with decades long customer partnerships
  - In 1935, Wolverine invented the first high performance heat transfer tubes and revolutionized the HVAC commercial chiller industry
  - Wolverine is the premier heat transfer design partner for OEM’s
  - Metal Joining and Brazing Products
Wolverine Targets

- **Waste Heat Recovery**
  - Technical Heat Transfer Tube

- **Electric Components**
  - Power Diodes, LED Arrays

- **Power Generation**
  - Nuclear and Wind Energy

- **Hybrid Vehicles**
  - Battery Cooling Systems

- **Catalysts**
  - Specialty Alloys for Gas Cracking

- **Servers & Computers**
  - Semiconductor Liquid Cooling

- **Water Purification**
  - Desalination and Antimicrobial
The Wolverine Difference

Engineering Thermal Innovation

Proprietary Heat Transfer Technology for Enhanced Performance
Industry With A Thermal Problem

- Increased micro-processor speeds and power generate more heat
- Continued demand to shrink package size
- Traditional heat sinks are performance and size limited
- Increased fan requirements generates excess noise
- Total system energy demand for cooling is excessive
- Continued pressure to reduce overall systems cost

“US Data Centers consume 2% of the nation’s total electrical power capacity”
MDT is a patented process which mechanically and plastically deforms the work piece to form finite and repeatable surface channels.

- Applicable to a wide range of materials (Cu, Al, Steel, Ti, Mo, Plastics)
- Flexible tooling for a variety of products
- Patented processes
- Rapid implementation (Minimal tooling and fixturing)
- No loss of base material
- Clean process – little to no lubrication needed
MicroCool Fin and Pin Options

- Fins per inch: 600-10
- Fin thickness to fin gap ratio: ~1:1
- Fin height to fin thickness ratio: 10:1
- Max fin gap: 1.2mm +
- Pins can be formed in either an in-line or staggered pattern.
- Fins or pins can be applied over surfaces up to 2x2 feet
- Fins or pins can be added in specific locations or on across entire surface.
- Materials available: Copper and Aluminum (aluminum geometries have some slight restrictions)

150 fins per inch
1mm tall

12 fins per inch
5 mm tall

Example
Pin array
MicroCool CFD Analysis and Optimization

Thermal performance optimization

Pressure drop calculation and optimization

Flow balancing and velocity
MicroCool Target Markets

- Blade Server – IBM
- CPU – CoolIt (Dell, Apple)
- LED – SolidUV
- Solar – Sunlight Direct
- Automotive Hybrid and EV
- Hybrid Truck – Arvin Meritor, International
- Wind - Clipper
- Military – DRS
- Industrial
Current Product Library

- Custom coldplates
- Small single phase coldplates
- 2 phase coldplates
- IGBT module coldplates
- Large multiple IGBT coldplates
- Enhanced surface baseplates
- Fabricated and assembled cooling loop
Baseplate w/ integrated cover used as a standard bolt on coldplate

- MDT baseplate w/ integrated cover
- IGBT held to coldplate with bolts
- Off the shelf IGBT
- Thermal grease or TIM
- MDT baseplate w/ integrated cover
Other IGBT Market Offerings

Application of MDT to existing IGBTS

MDT Baseplate for sale to module manufactures and integrators.

MDT Baseplate w/ integrated cover for sale to module manufactures and integrators.

*Can also be used as a standard coldplate
Different Cooling Methods

Standard Coldplate Method

- IGBT with standard flat baseplate
- Thermal grease (TIM)
- Coldplate

Direct Cool Method

- Smooth bottom Off the shelf IGBT
- IGBT with MDT enhanced baseplate

The direct cool approach eliminates the thermal resistance of the TIM and the thermal resistance of the top part of the coldplate. This is a significant **20-40%** reduction in thermal resistance. Further improvements can be made by enhancing the surface of the smooth bottom IGBT baseplate.
In order to form fins the MDT process will remove the nickel plating and at least 1mm of thickness from the 3mm thick baseplate. In this example we deform 2mm tall fins and end up with a resulting baseplate thickness of 2mm.
Comparing Baseline to MicroCool Enhanced Modules

- Baseline with flat bottom off the shelf IGBTs
- MicroCool MDT modified IGBTs with plastic tub pocket at same depth as fin height.
CFD Analysis Conditions

**Iterations:**

1. Baseline with flat bottom IGBTs (1.27mm water channel below IGBT)
2. 2mm tall fins 12 fins per inch
3. **2mm tall fins 25 fins per inch**
4. 4mm tall fins 25 fins per inch

- **3.7gpm (1.23gpm under ea IGBT)**
- **47.2 °C (117.4 ° F) water**

- **396 watts on each 30x22mm area (3 locations on each IGBT)**
- **1188 watts on each IGBT**
- **3564 watts total**
Thermal Analysis Results

Baseline: 87°C

2mm fin 25fpi: 65.9°C

2mm fin 12fpi: 71°C

4mm fin 25fpi: 63.3°C
Pressure Drop Results

Baseline
Pressure Drop: 1.00 psi

2mm tall 12 FPI
Pressure Drop: 1.46 psi
### Results Summary

<table>
<thead>
<tr>
<th></th>
<th>Max Temp (°C)</th>
<th>Coolant Temp (°C)</th>
<th>ΔT</th>
<th>Thermal Resistance (°C/W)*</th>
<th>Pressure Drop (psi)</th>
<th>Flow rate under each IGBT (GPM)</th>
<th>Temperature Reduction (°C)</th>
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</table>

- By enhancing the baseplate with MDT the thermal resistance can be reduced by 59.4% with no increase in pressure drop!

*Thermal Resistance is defined as max baseplate temperature minus inlet fluid temperature divided by the power of one IGBT module (1188 Watts)*
Pre-made baseplate w/ integrated cover sent to IGBT manufacturer

1. MicroCool™ produced MDT nickel plated copper baseplate and cover brazed together to make a full coldplate.

2. Coldplate sent to IGBT module manufacture for substrate attach and build up of module.

3. Finished IGBT module with MDT Baseplate with integrated cover.

- Stamped or machined copper cover
- Brazing temp to attach cover must be higher than substrate die attach temp.
Future R&D Activity

- CTE matching MDT baseplates
  - AlSiC
  - Metal Matrix Composites

- unique covers and manifolds

- 2 phase cooling – pumped refrigerant

- New fin and pin geometries
Thank You

IGBT Cooling
Jan, 2010