High Performance, Energy Efficient Compact Liquid Cooling Technology for Effective Thermal Management in Defense Applications

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The Problem

- Miniaturization of defense equipment

While,

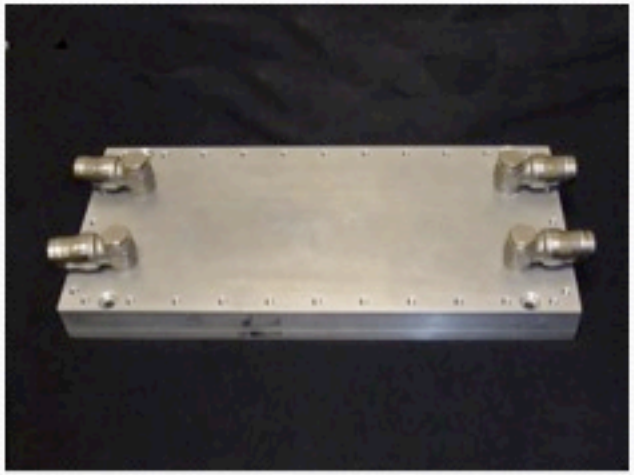
- Increase of power in equipment

 Larger heat flux from equipment

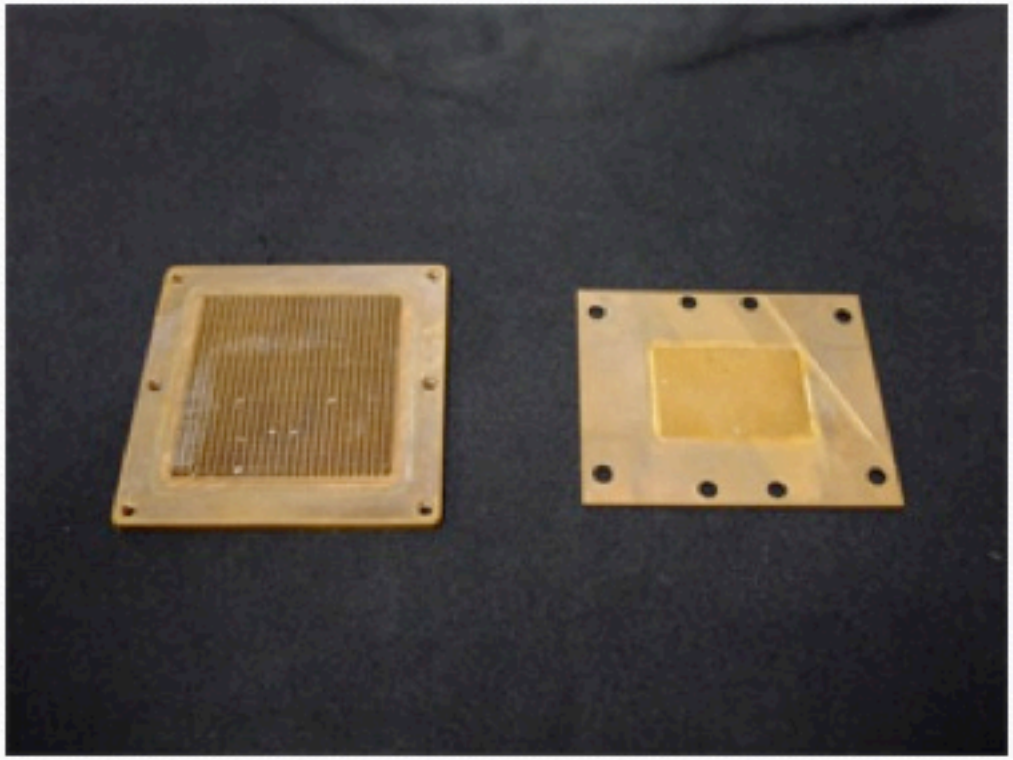
Which causes overheating of equipment!!!

Solution - Novel Oblique Fin Technology

- Presenting GCoreLab's Liquid Cold Plates with Oblique Fin Technology.

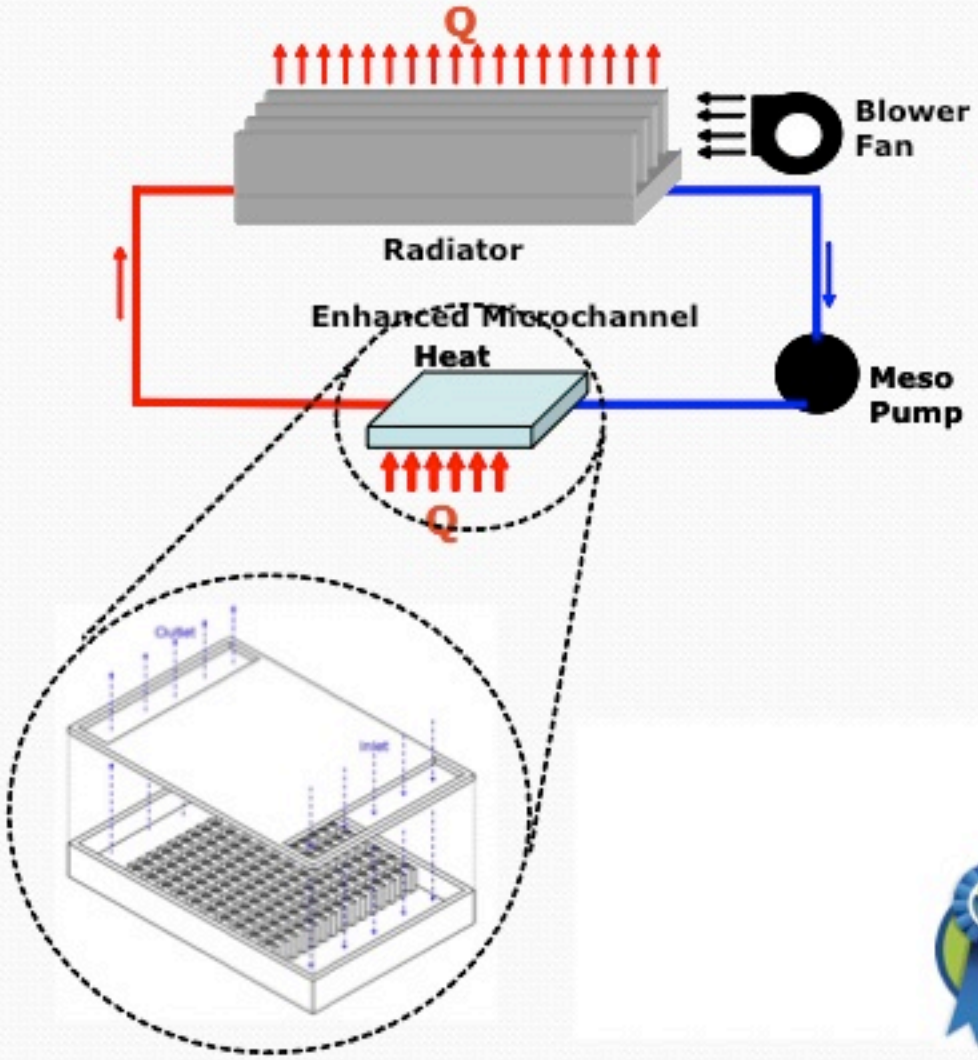


Larger footprint applications



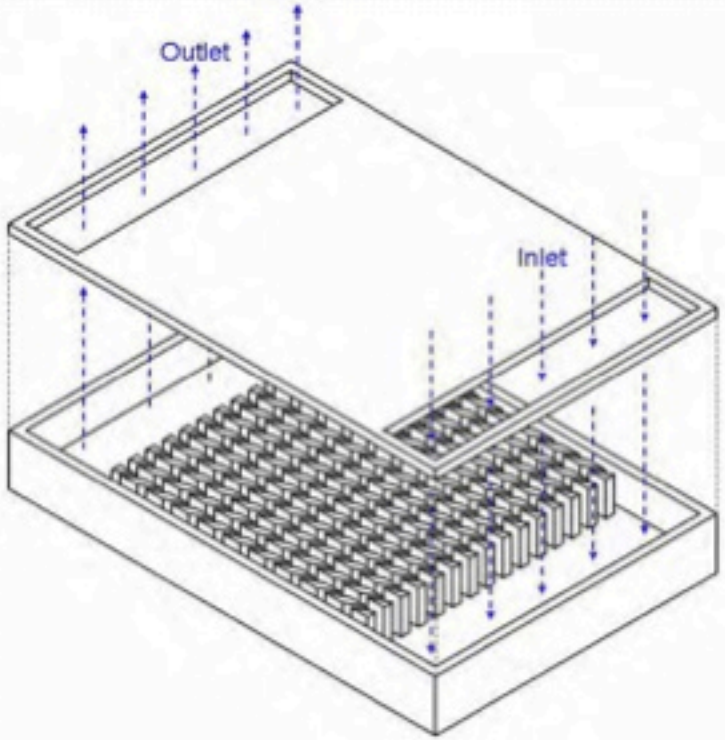
Chip-level applications

Novel Oblique Fin Technology

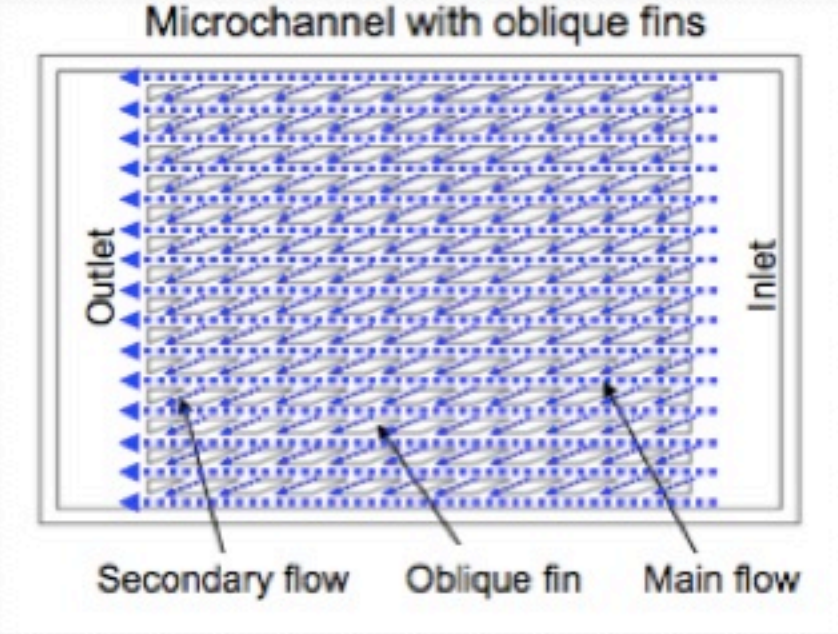


- **Award Winning, Patent-Pending Cooling Technology**
  - Integrated liquid cooling solution
  - Cooling liquid absorbs heat from the target heat flux
  - Heat is released from the cooling liquid to the ambient air via the radiator

Solution - Novel Oblique Fin Technology

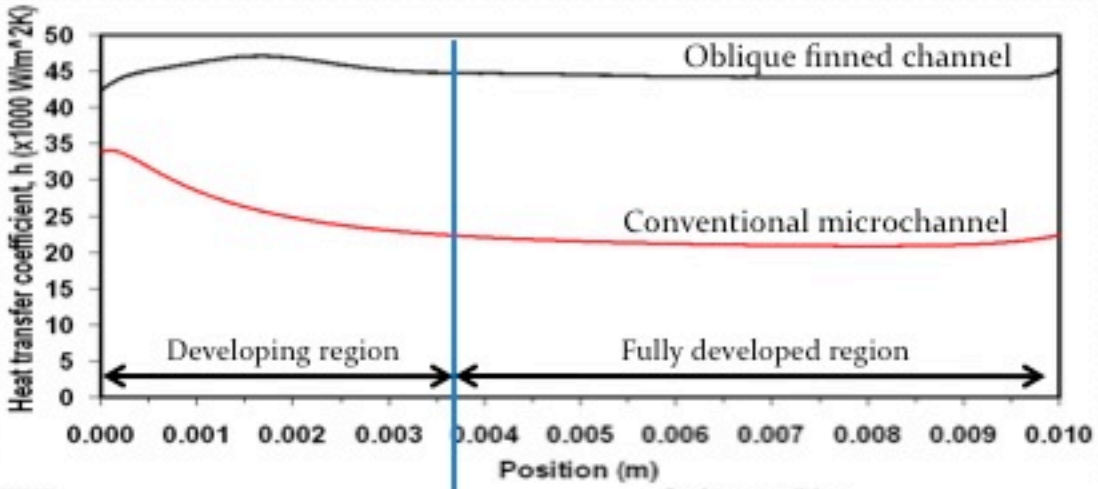


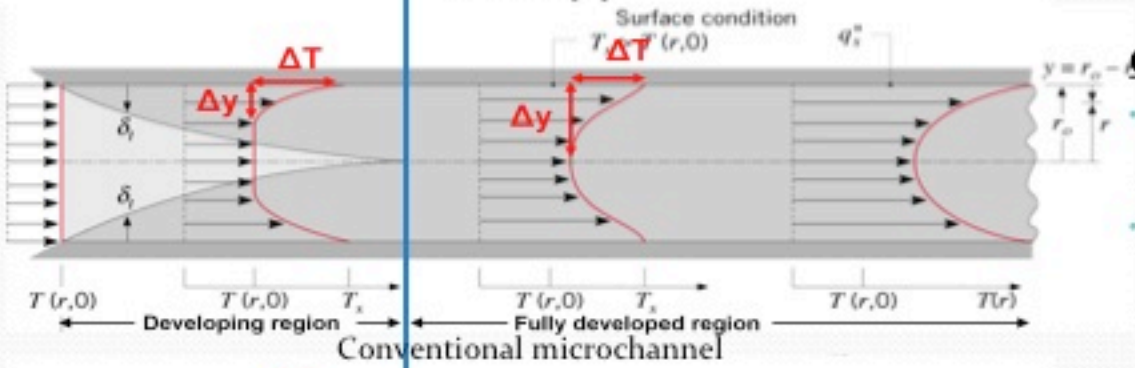
3-D view



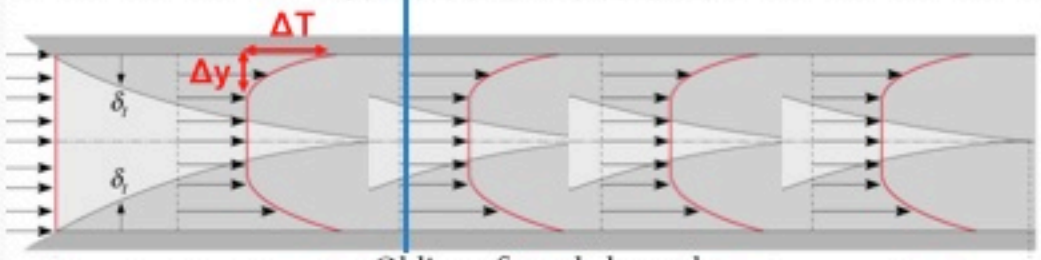
Top view
(showing oblique fin structure)

Novel Oblique Fin Technology





Conventional microchannel



Oblique finned channel

- Thermal boundary layer thickness increases as flow develops in a channel.
- The thicker the thermal boundary layer, the larger the thermal resistance.
- This in turn, results in a smaller heat transfer coefficient, which means less effective heat transfer.

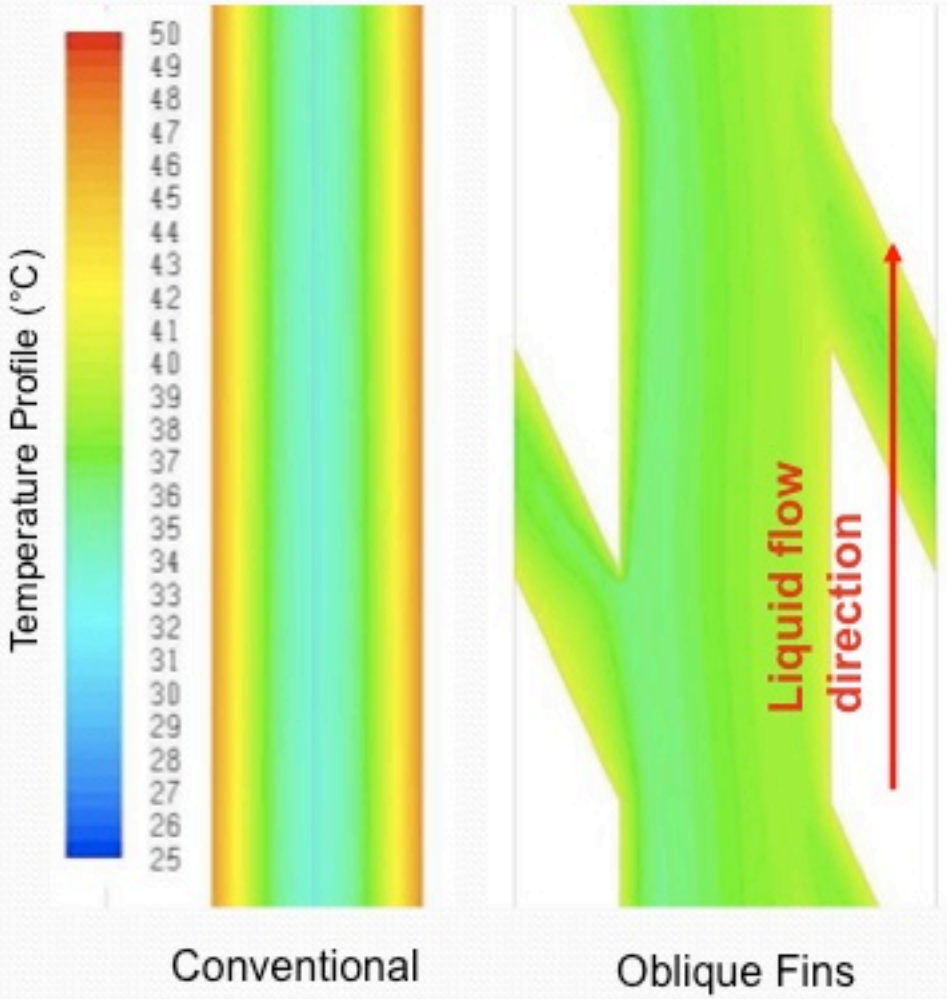
Conventional microchannel:

- Flow develops quickly to give a thick boundary layer
- Thicker thermal boundary layer results in less effective heat transfer – smaller heat transfer coefficient.

Microchannel with oblique fins:

- Flow redevelops due to secondary channels and fluid mixing, resulting in more effective heat transfer – larger heat transfer coefficient.

Novel Oblique Fin Technology



Conventional microchannel:

- Non-uniform temperature profile from microchannel wall to fluid core.
- This is the result of less effective heat transfer due to the thick thermal boundary layers..

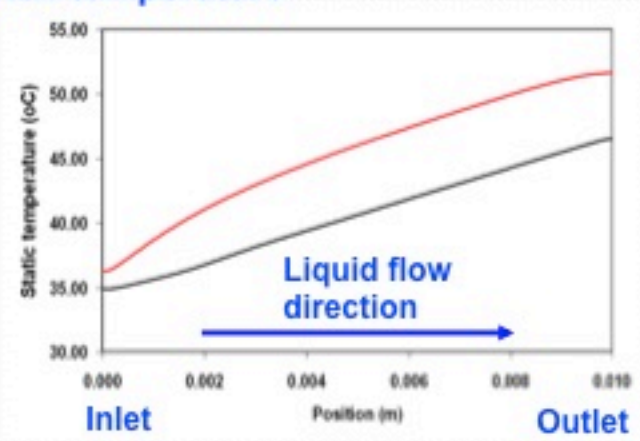
Microchannel with oblique fins:

- More uniform temperature profile due to better fluid mixing.
- Result of thinner thermal boundary layer that enables more effective heat transfer.

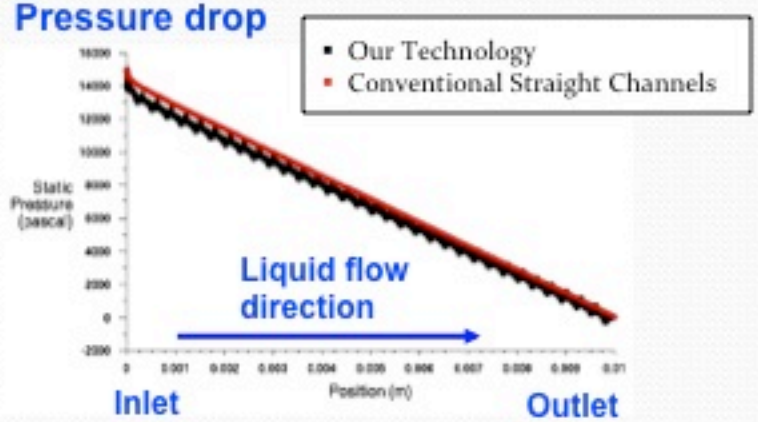
Comparison of results

Experimental results - Conventional straight channels vs. Our technology

Wall temperature

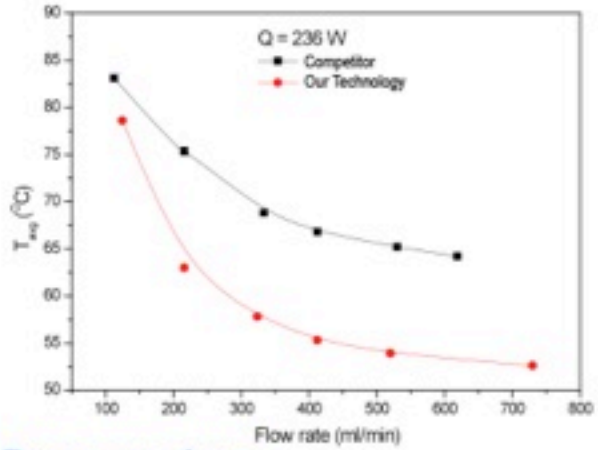


Pressure drop

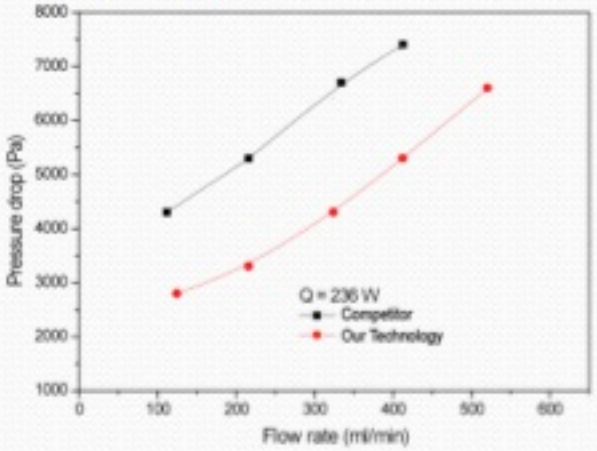


Benchmarking results against competitor

Wall temperature

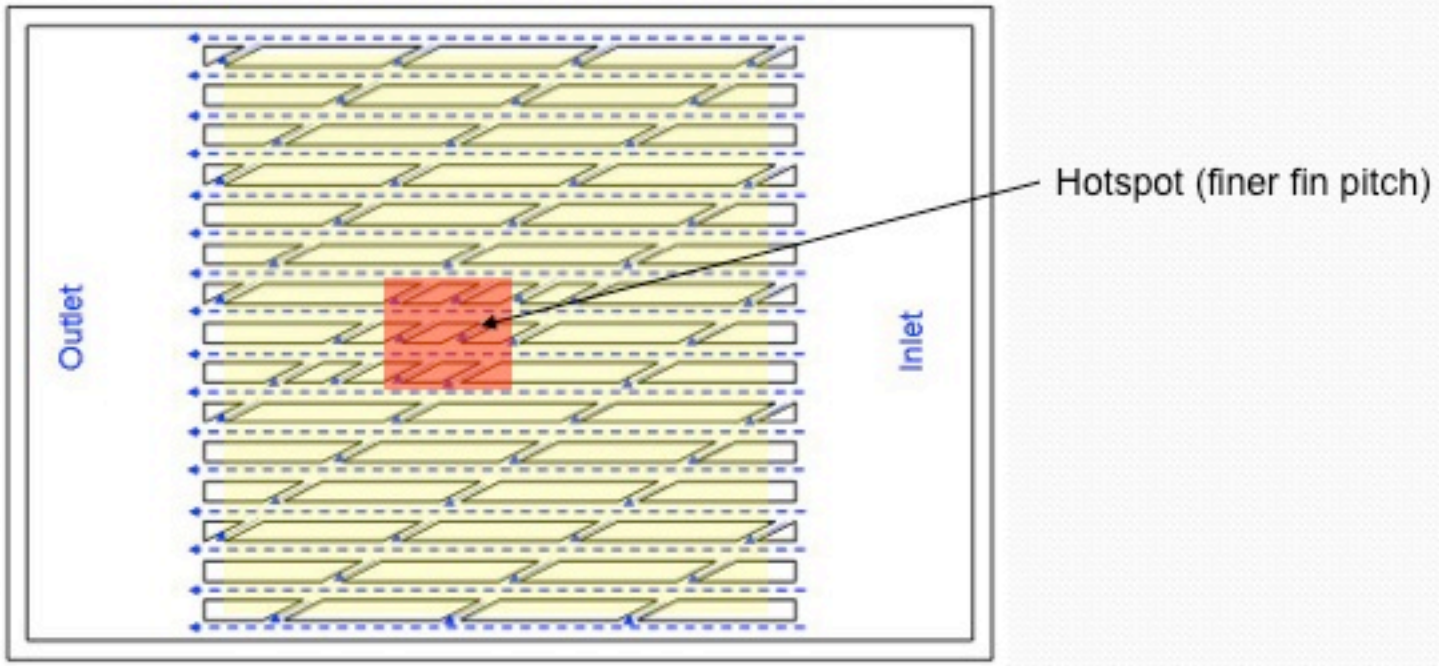


Pressure drop



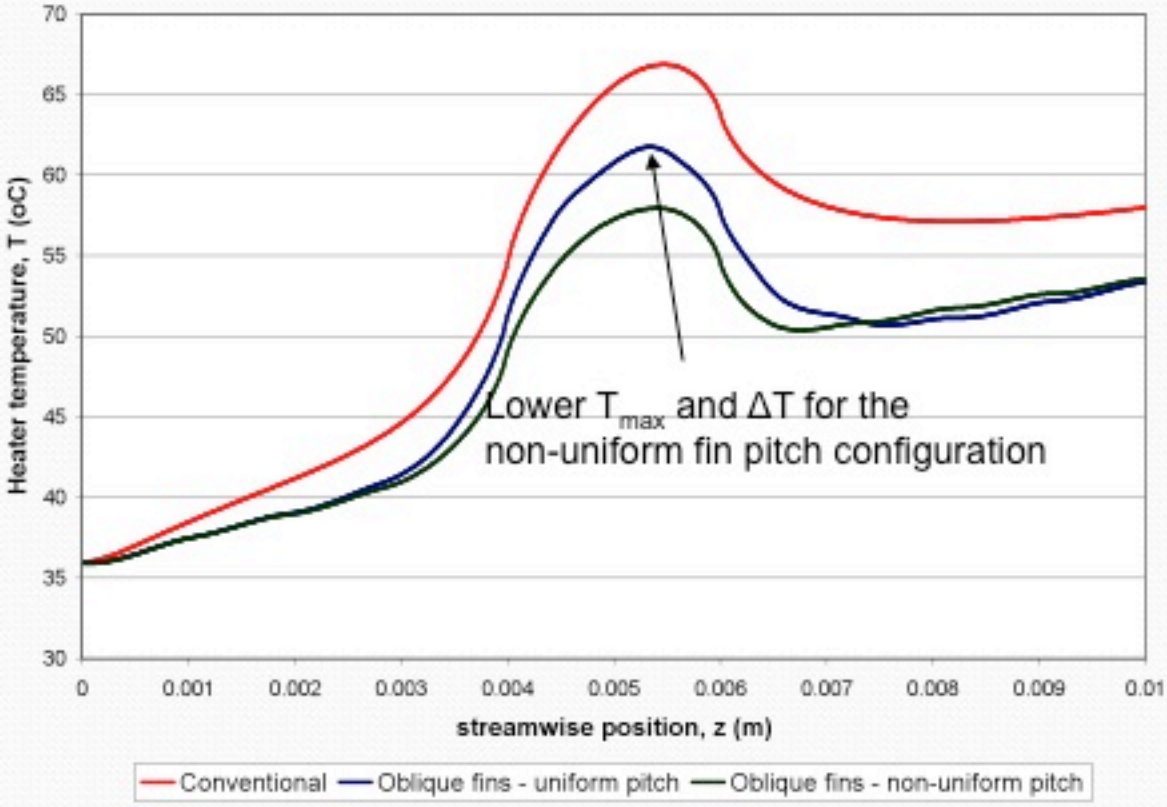
More innovations: Hotspot mitigation

- Hotspot is a common issue in current electronics due to the integration of multifunctional chip.
- Localized hot spots induce higher thermal stresses and further compromise the reliability of the product.
- Conventional thermal management solution is unable to address the hotspot issue appropriately.
- The proposed concept is unique as the oblique fins characteristic can be tailored to address the hotspot issue.



More innovations: Hotspot mitigation

- Finer fin pitch leads to more frequent thermal boundary layer and secondary flows generation
- => higher heat transfer performance compared to conventional microchannel and coarser fin pitch configuration.



Potential applications

Defense applications

Laser diodes
Rangefinding
Optical target detectors

Aviation systems
Avionics

GaN electronics
Electronic warfare
Radar systems

Commercial applications

Microprocessors
Integrated circuit (IC)
3D ICs

Electric vehicle
Hybrid electric vehicle
High power battery pack

Windmill gear box
Wind turbine waste heat recovery

Concentrate photovoltaic
Solar energy collector

Why use Our Technology?

- **High performance thermal management**
  - ✓ **Safer operation** - lower component temperature.
  - ✓ **Longer product life/better reliability** – lower component temperature
  - ✓ **Better product performance** – over-clocking and battery fast charging.
  - ✓ **Compact system** – smaller pump required and thinner liquid cold plates.
  - ✓ **Lower maintenance/power cost** – less power needed to drive, smaller and less costly equipment.
  - ✓ **Waste heat recovery system** – able to harness higher quality waste heat.

Why use Our Technology?

✓ Suitable for a wide range of applications

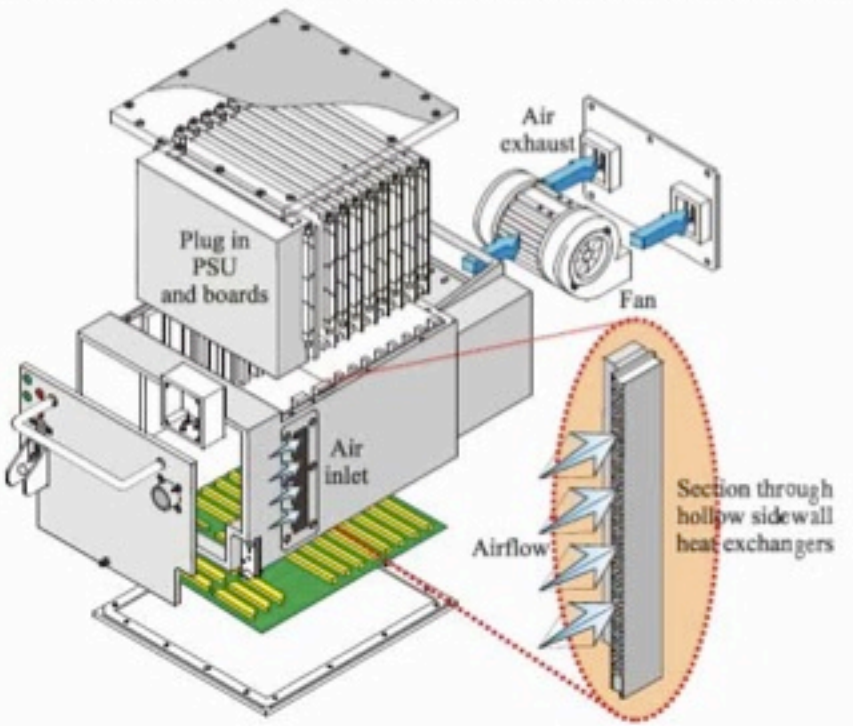
- **Wide heat flux dissipation range (10~1000 W/cm²)**
- **Highly scalable (few mm² ~ few hundred cm² footprint)**
- **Technology works on cylindrical shapes**

✓ Suitable for replacing original systems/ equipment with space constraint

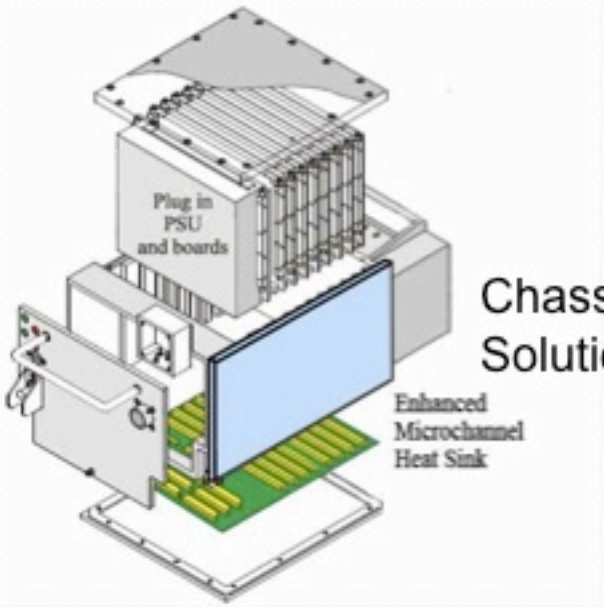
- **Negligible pressure drop penalty**
- **Compact system**

Case study 1: Avionics

- The footprint of the card (6U) is governed by IEEE 1101.2-1992, the only way to have a more complex card is to make a thicker card.
- Conventional means of cooling is via forced convection by fins within the side wall.
- To allow for an increase in thickness of the card, a more effective heat thermal management solution is needed.

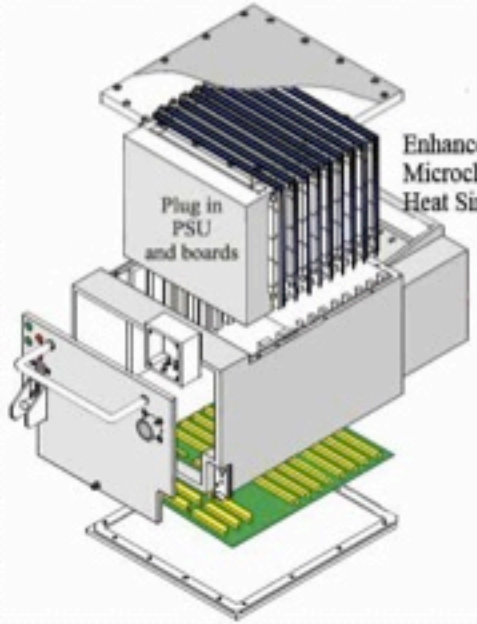


Case study 1: Avionics



Chassis-level Solution

- Replacing the air-cooled system with a chassis-level liquid cooled system
- Increase of effective heat transfer – liquids have higher heat capacities, thus they are able to remove more heat



Board-level Solution

- Further increase in effective heat transfer when liquid cold plates are placed directly on high heat flux regions.

Our Team

- Collaboration between National University of Singapore (NUS) and GCoreLab.
  - NUS to focus more on research
  - GCoreLab on the development and implementation of the technology

- GCoreLab
  - Founder/CSO – Dr. Lee Poh Seng
  - CEO – Mr. Ray Kung
  - GM of North America – Mr. Bob Lyons
  - Technical Advisor – Mr. Quek Poh Seng

- NUS
  - Micro Thermal System Group

Our Products

- Sub-licensing of our technology to OEMs
- Development of our technology for use in various applications
- Consultancy for thermal management solutions

Current Projects

- Signed an MOU with a leading automaker and currently developing thermal management solutions for battery packs in their EVs.
- Working on a project from a defense agency.
- Collaborating with a radiator manufacturer to develop a radiator using our technology.
- In talks with several companies, ranging from biomedical to wind energy.

Funding

- Awarded Spring Singapore's Technology Enterprise Commercialisation Scheme – SGD$500,000 (USD$415,000)
- In talks with government agencies, incubators and VCs.

Partners

Thank You