Fujikura Thermal Technology Overview

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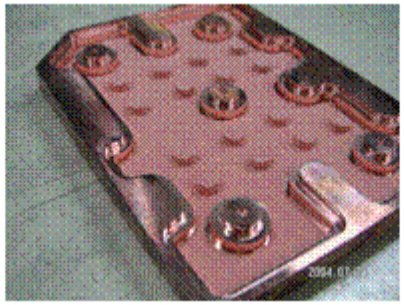
Key Technology of Thermal Product

Heat Pipe

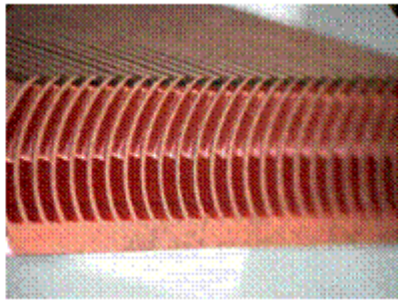
Merits:
→Passive system
→Two phase heat transfer
→One directional heat flow

Vapor Chamber



Merits:
→Passive system
→Two phase heat transfer
→Two directional heat flow

Micro-channel

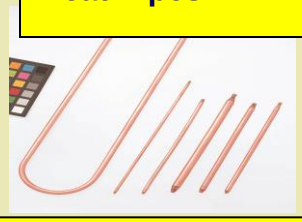


Merits:
→Active system
→Single phase heat transfer
→Multi directional heat flow

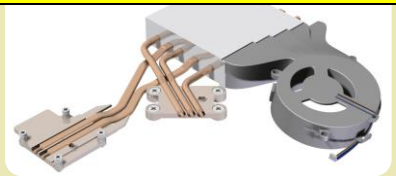
Applications Areas

Cooling Electronics


Heat Pipes



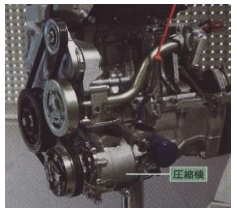
Heat Pipe Module



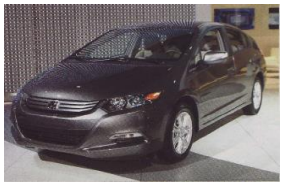
Vapor Chamber

Heat Sinks

Energy

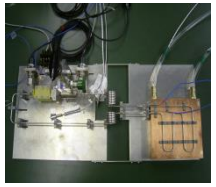



Automotive Application

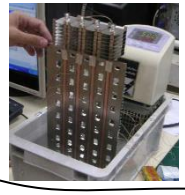



Global Warming & Environment


Aviation

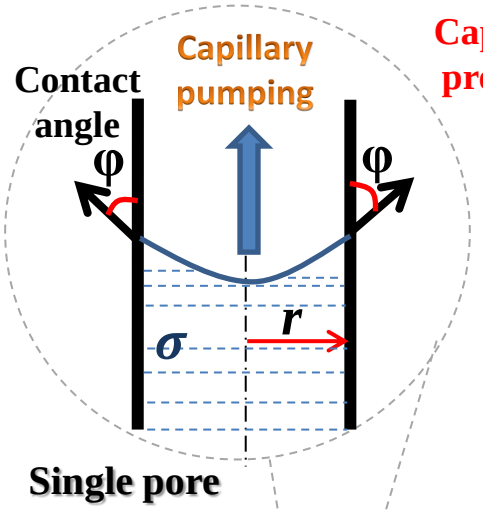
Healthcare




Fujikura

Heat Pipe

Heat Pipe Operation Principle



Surface tension

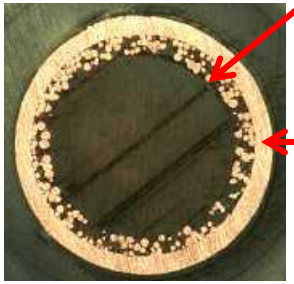
$$\text{Capillary pressure} = \frac{2\sigma\cos\varphi}{r} = \rho g h$$

Pumping height

Pore radius

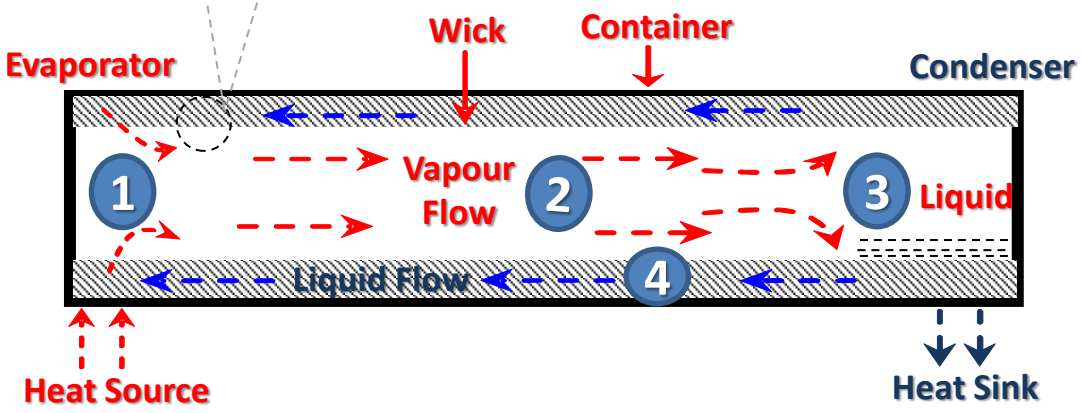
Operating Principle

1. Evaporation
2. Heat transfer by vapour
3. Condensation
4. Capillary or gravity pumping



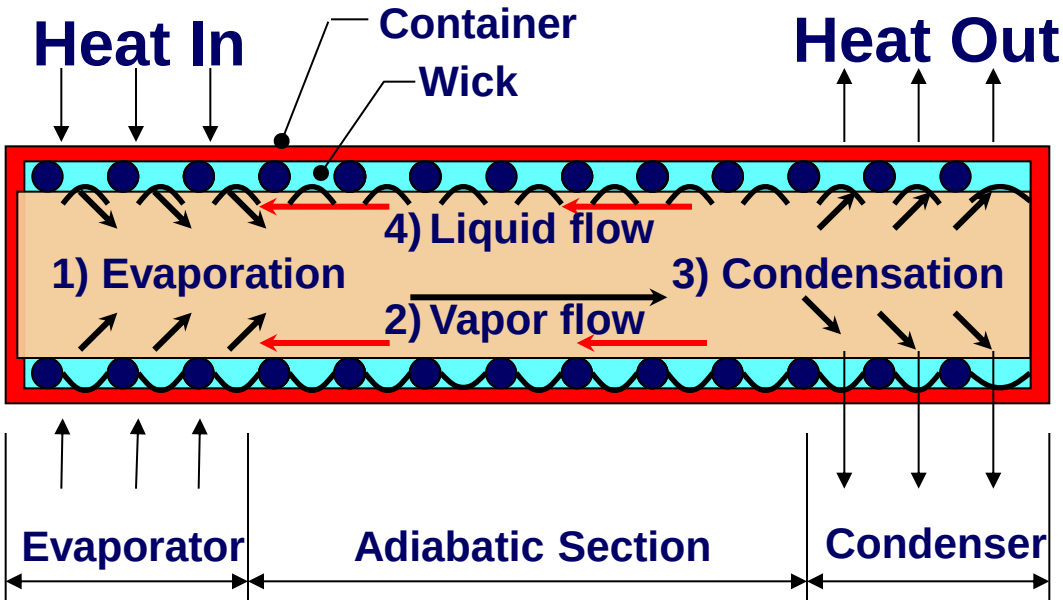
Cross section

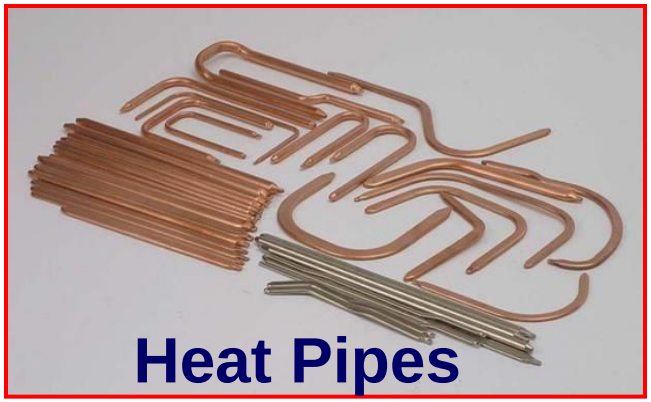
Heat Pipe



Heat Pipe Thermal Module

Superior Heat Transfer Element! Heat Pipes!

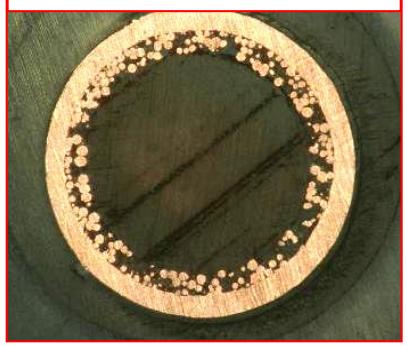




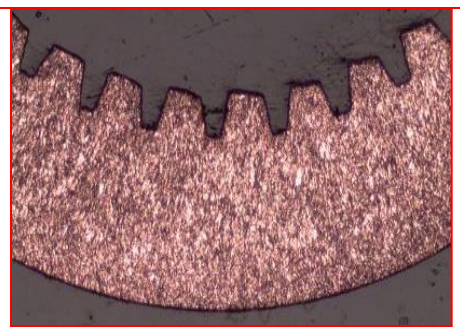
Heat Pipes have been become popular and consumer products now. Approx. 13 Mil. Pcs / a month heat pipes are produced in the world.

Composite Wick

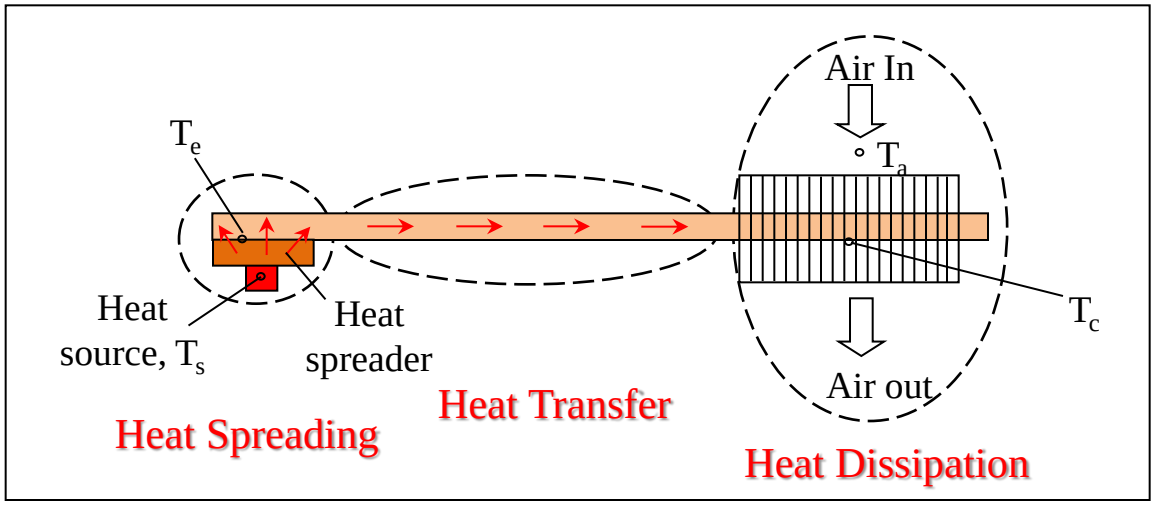
Sintered Wick

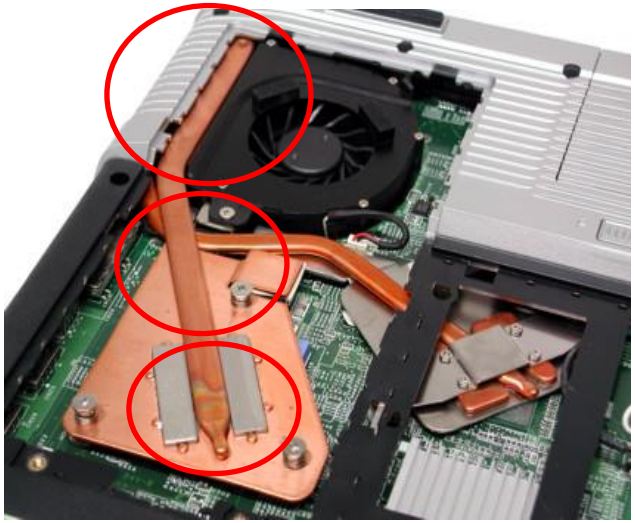


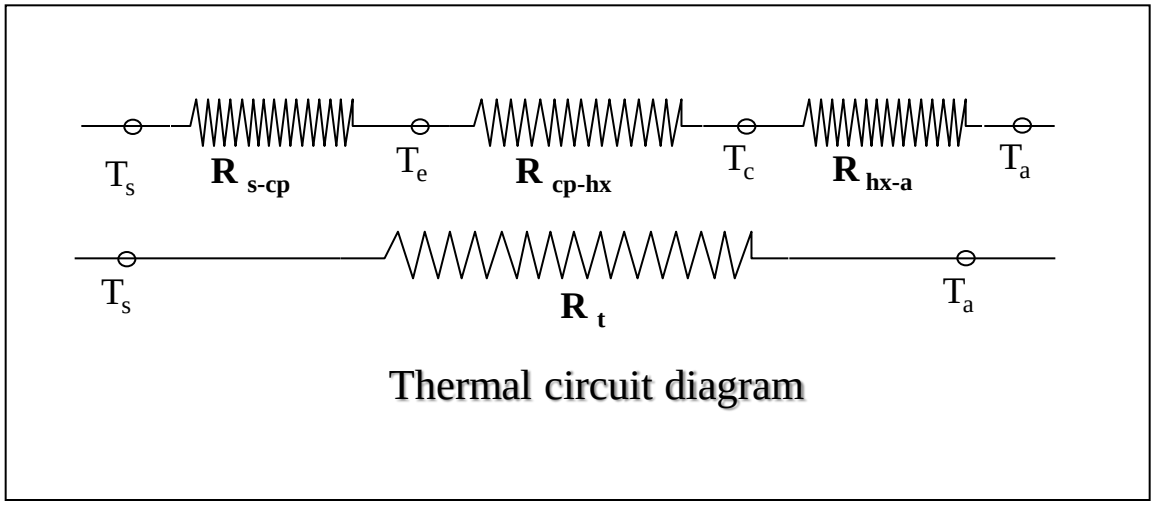
Axially Grooved



Functions of thermal control device in cooling







Thermal circuit diagram

Summary of Cooling Design Trend for Desktop PCs

PGA ←

TYPE 2
High aspect extrusion parallel fins with copper embedded base

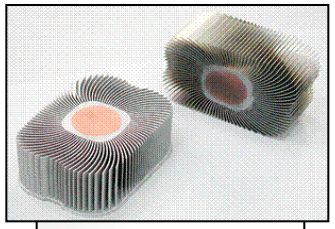
TYPE 3
High aspect extrusion radial fins with copper insertion core

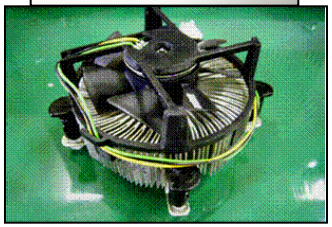
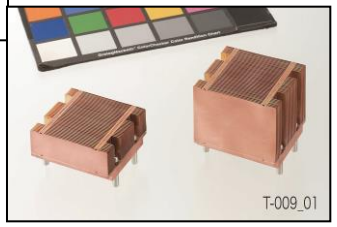
TYPE 4
Fine pitch stacked fins soldered heat sink

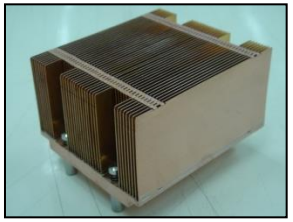
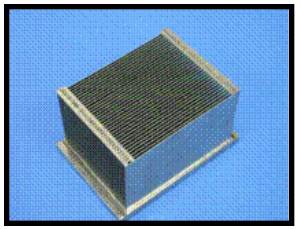
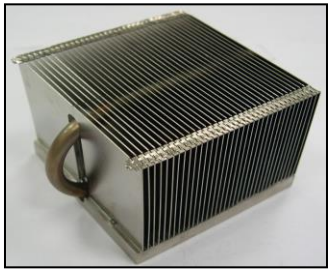
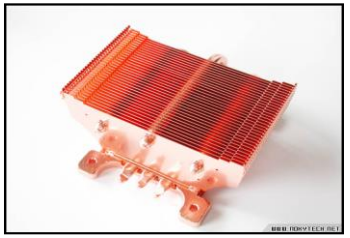
TYPE 5
Heat pipe heat sink

TYPE1
Extrusion parallel fins



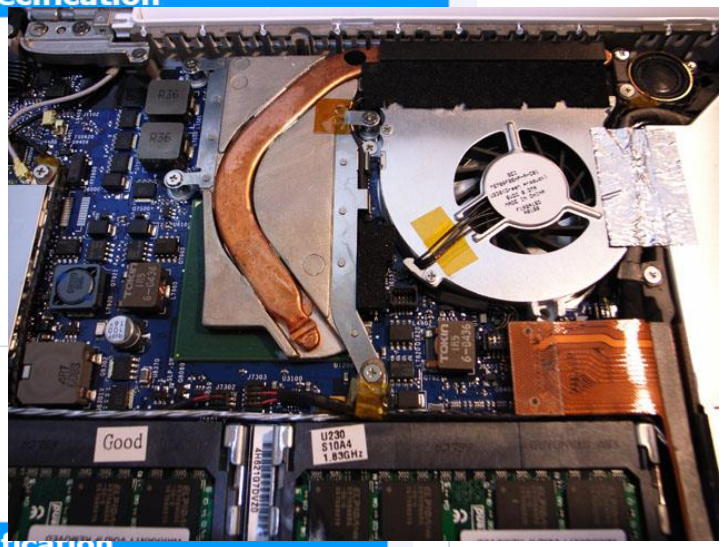

Rca: 0.5 ℃/W
Low Performance

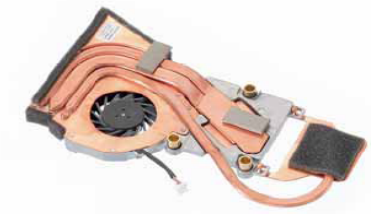
→ LGA

Rca: 0.2 ℃/W
High Performance

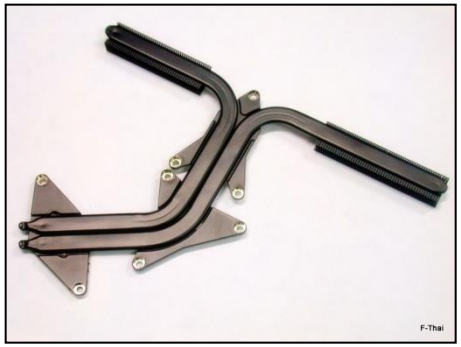
Various Heat Pipe Remote Heat-Exchanger for Laptop PC

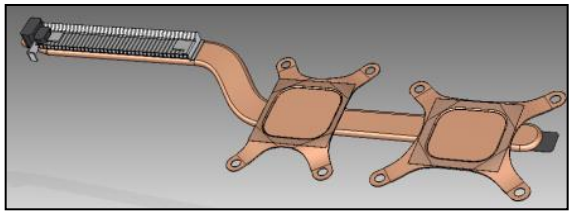
Picture	Specification
	Heat pipe dia. 6.0mm x 1pc *CPU 35 W (Rja < 1.25 °C/W)
	Heat pipe dia.6.0mm x 3pcs *CPU 25W (Rja < 2.20°C/W) *GPU 10W (Rja < 5.50°C/W)

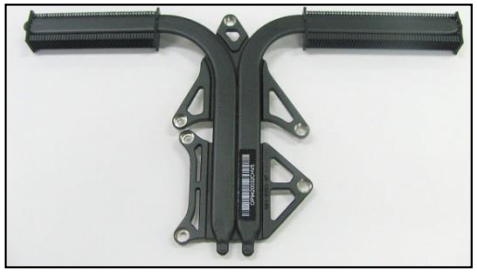


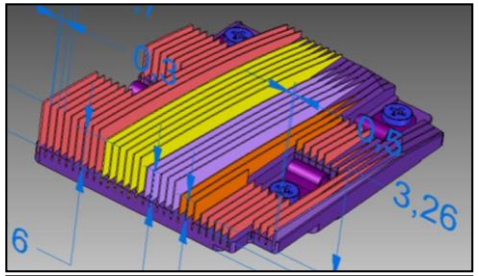
Picture	Specification
	Heat pipe dia 6.0mm 1pc Heat pipe dia 5.0mm 1pc Heat pipe dia 4.0mm 1pc *CPU 27W (Rja < 1.75°C/W) *GPU 7 W (Rja < 5.55°C/W)
	Heat pipe dia 6.0mm 1pc *CPU 25W (Rja < 1.70°C/W)

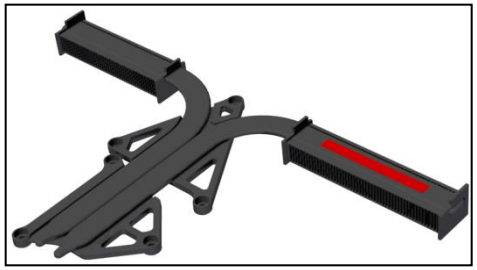
Current Thermal Solution Trend for Thin Laptop-PC

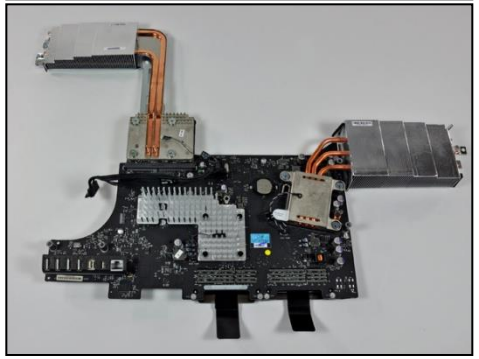








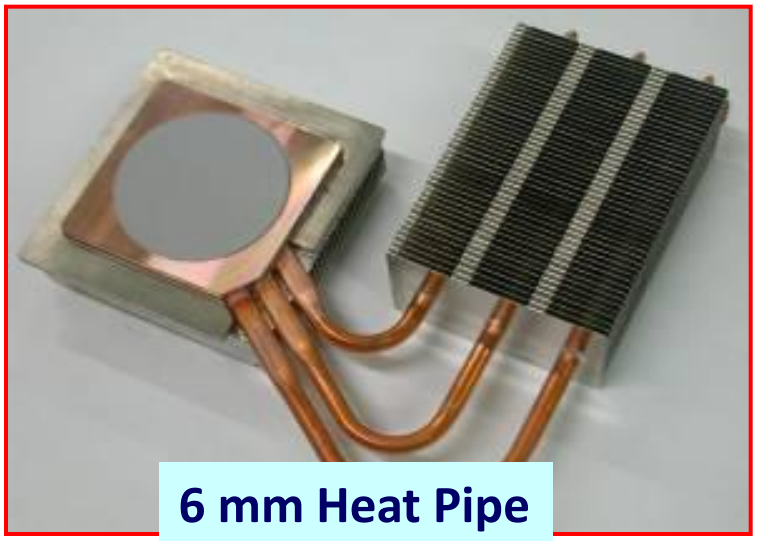




Thin and Light Solution combination of 2mm thick or thinner heat pipe with Aluminum fins are applied in current Laptop PC.

Typical Consumer Products of Heat Pipes for Cooling PC

4 mm Heat Pipe

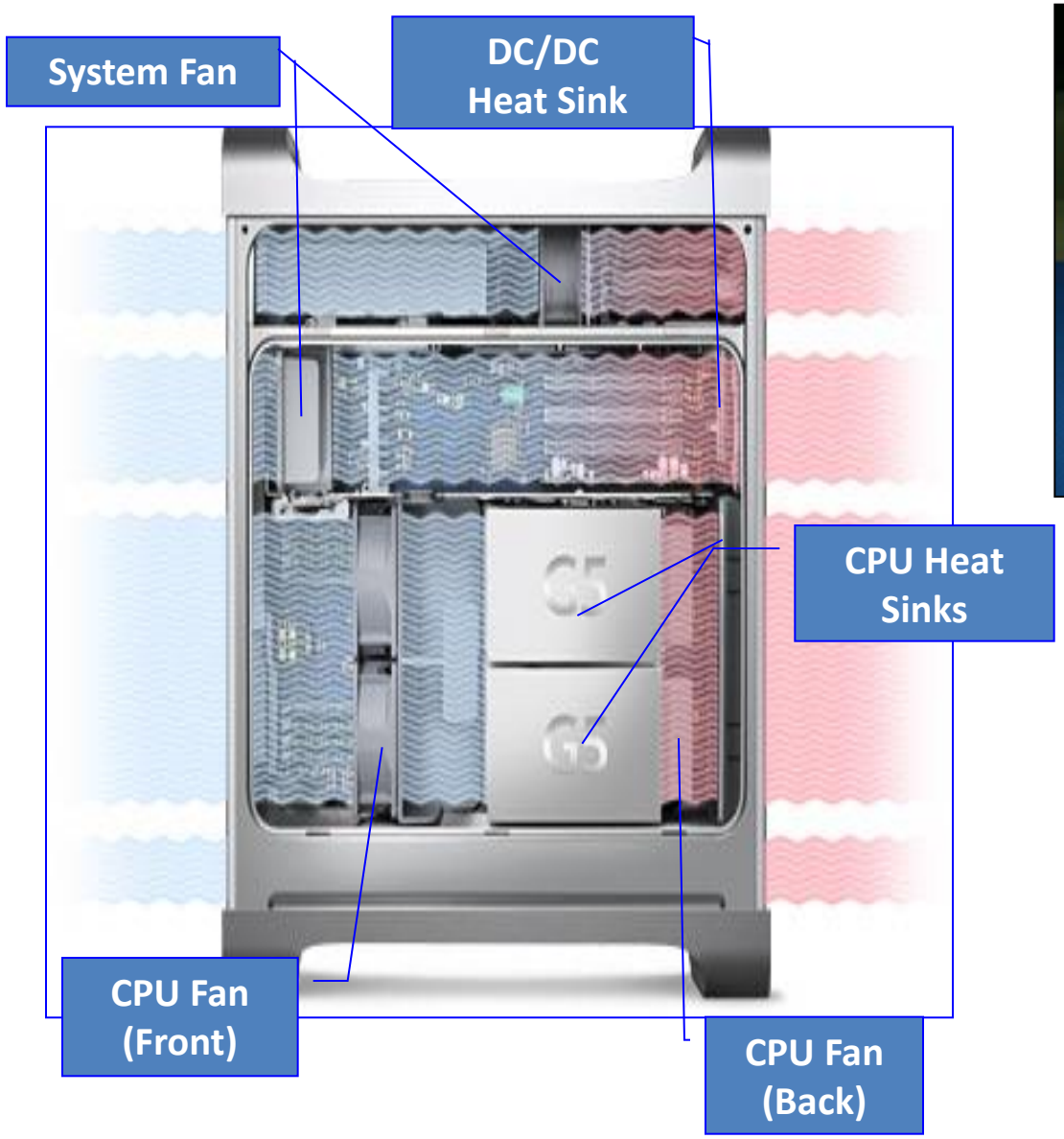


6 mm Heat Pipe

1 inch Heat Pipe

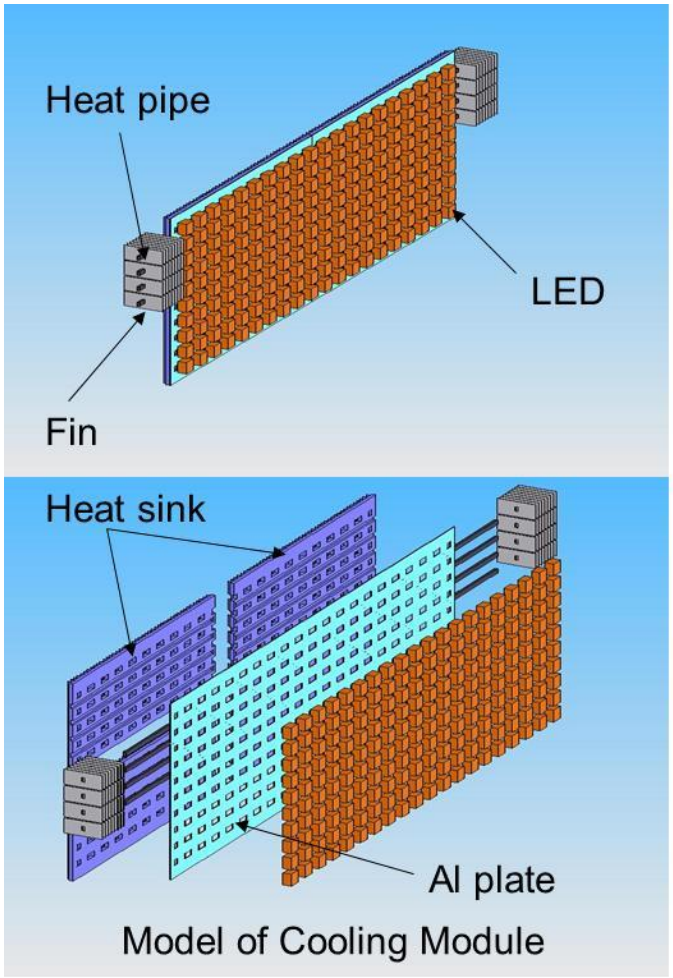
Vapor Chamber

High Power Heat Pipe Heat Sink for Desktop PC

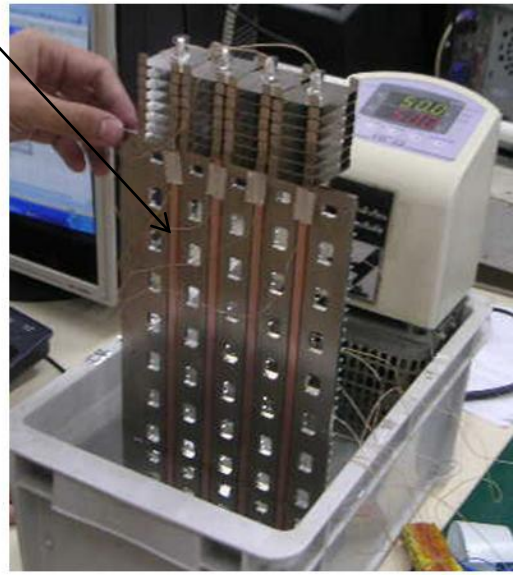


130W/CPU x 2 CPUs

TV LED BACK LIGHTS THERMAL MANAGEMENT



Heat Pipe



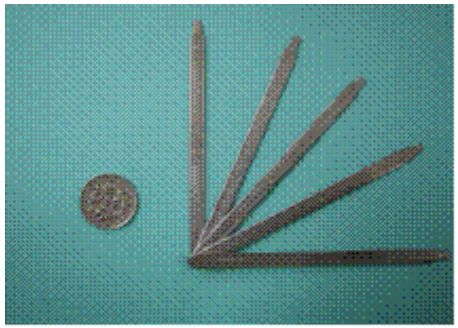
Heat Pipe Cooling Module Sample

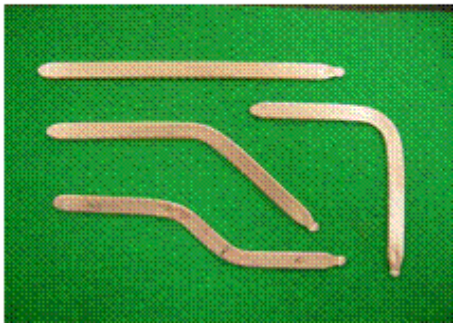
TV LED Back Lights

Thinner Heat Pipes

◆1.5 mm thick : Qmax:25 W

Rhp: 0.2-0.3 K/W

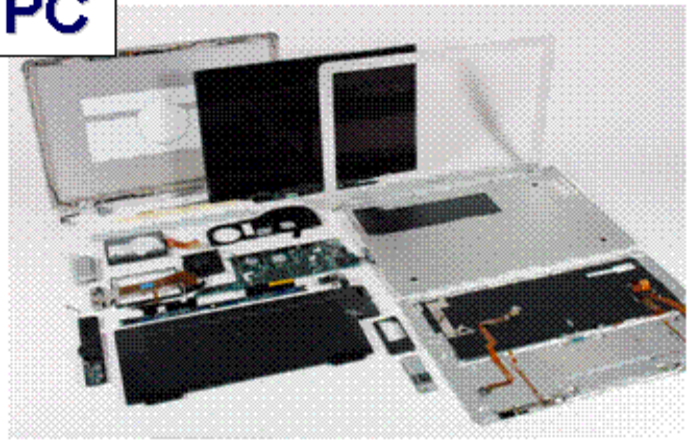




◆1.0 mm thick : Qmax: 10 W

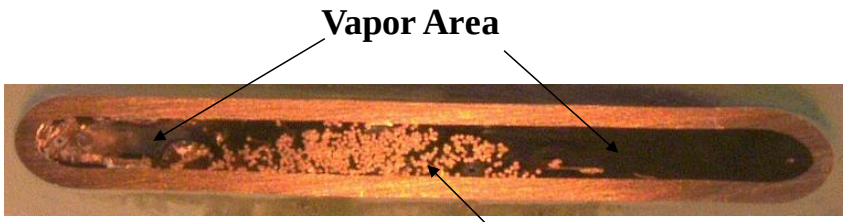
Rhp: 0.3-0.5 K/W

Laptop PC



Cellar Phone

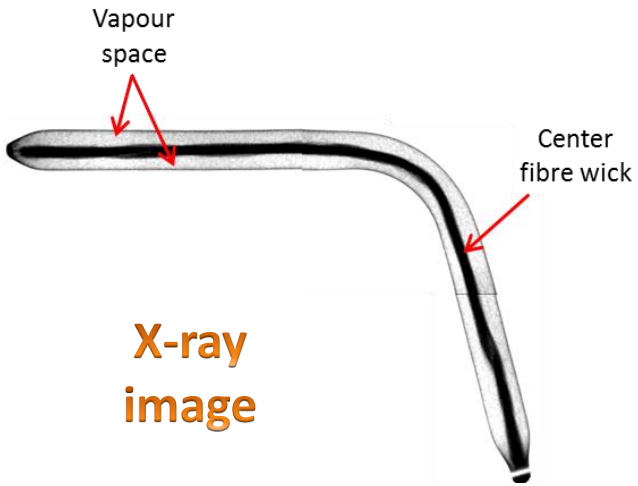
Thin Heat Pipe



Heat pipe cross section

Different Shapes and Sizes of heat pipes

Regardless with the total inner cross-section of the heat pipe, optimized liquid to vapor flow area ratio is with the range of 0.5~0.6



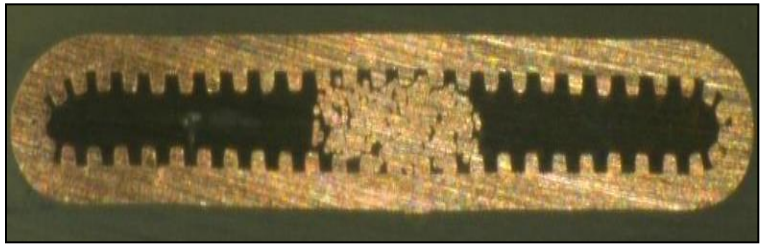
X-ray image

Porosity, ε : 0.7 (Experimental Value)
0.6 for similar shape powder wick

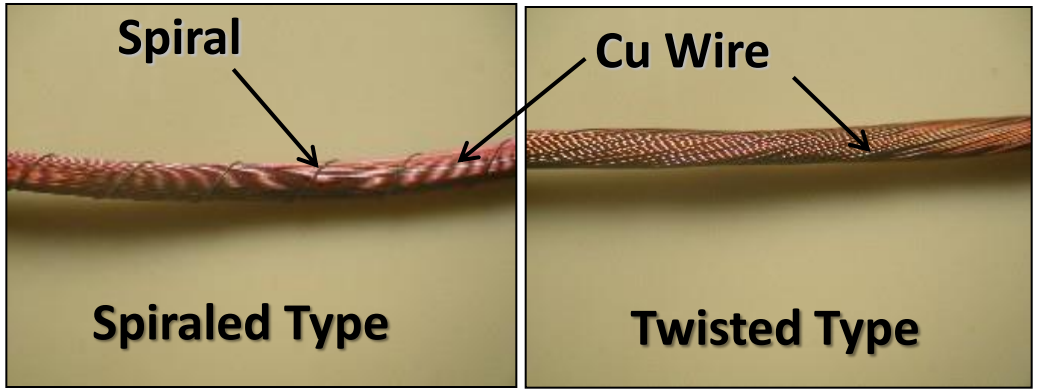
Contact Angle, θ : 18 deg (Experimental Value)

Permeability, K : 8.0×10^{-10} (Calculated Value]
7.5×10^{-11} for similar shape powder wick

Wick Structure of Thin & Flat Heat Pipe

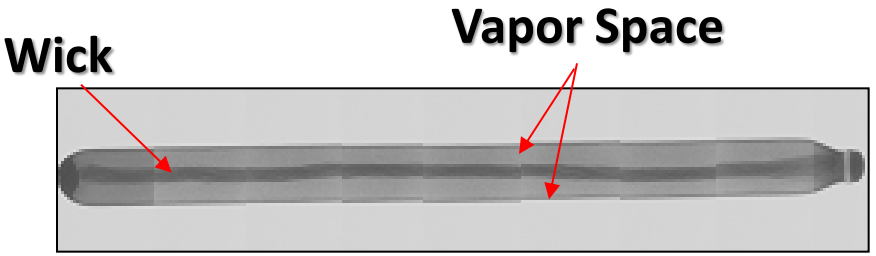


Cross-Section of Center Fiber Wick For 0.8mm to 2mm Thick Heat Pipe



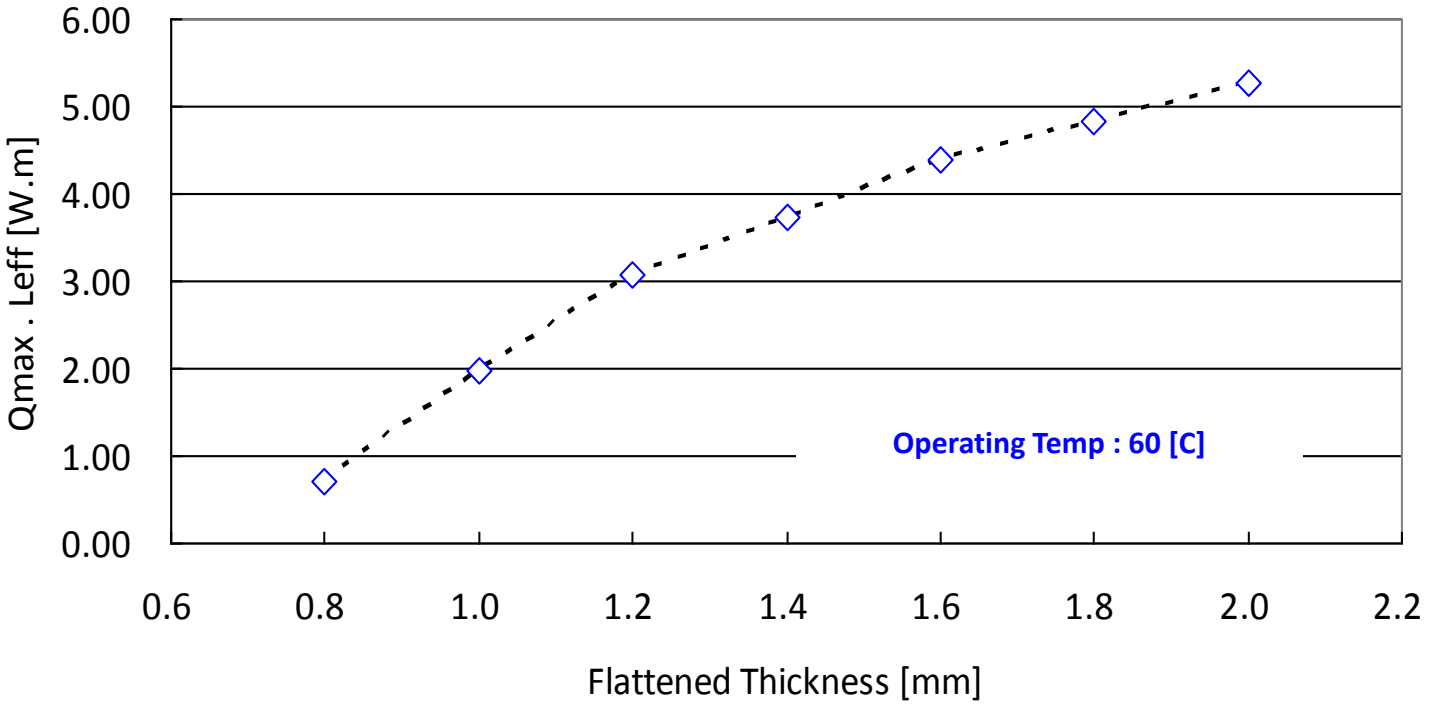
Center Fiber Wick

Features :
- Sufficient Capillary Force
- Sufficient Vapor Space
- Liquid Flow Through Fiber and Groove under Fiber



X-Ray Picture of Straight Thin Heat Pipe

Thin Heat Pipe Performance



Flattened Thickness [mm]	Qmax.Leff [W.m]
0.8	0.70
1.0	1.98
1.2	3.08
1.4	3.74
1.6	4.40
1.8	4.84
2.0	5.28

For a 2.0mm flattened thickness with the effective length 110mm Qmax can be go up to 48W.

17

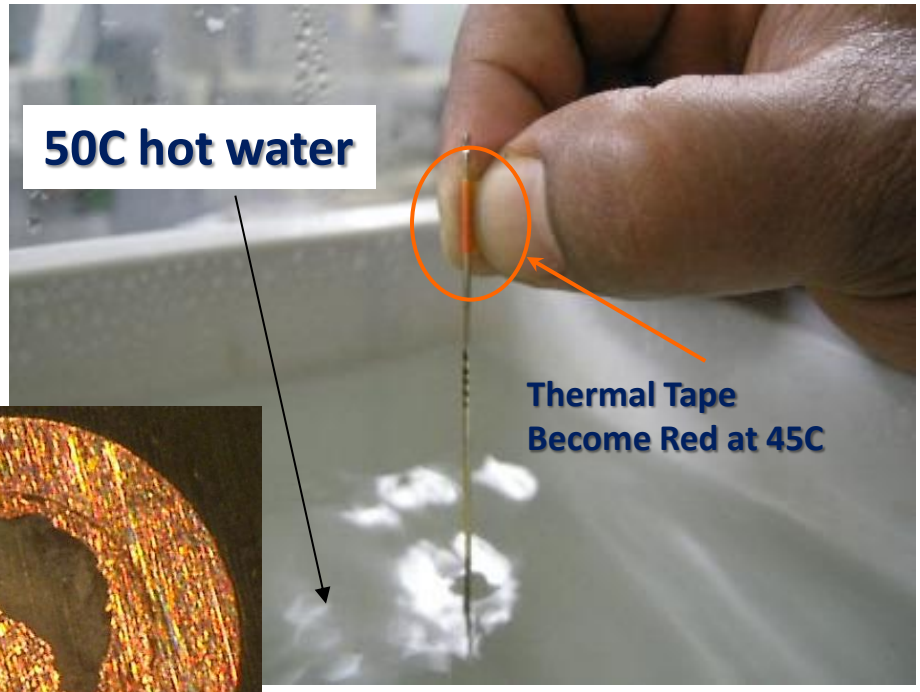
Ultra-Thin Heat Pipe Performance

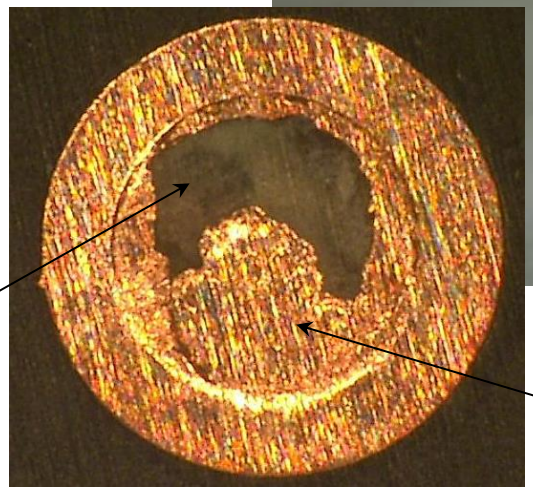
1) D1.0mm Heat Pipe Thermal Performance

Heat Pipe Specification

Length = 75mm

Wick : Center Fiber Wick





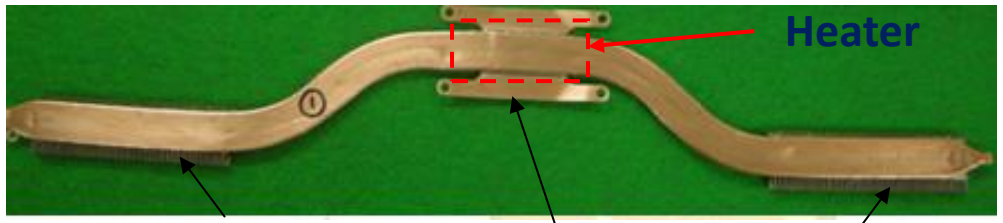
Vapor Flow Area

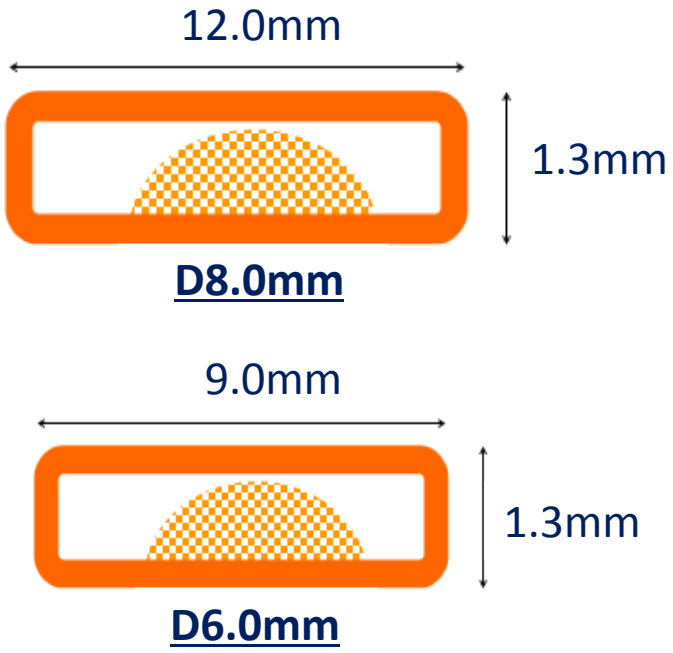
Wick
Liquid Flow Area

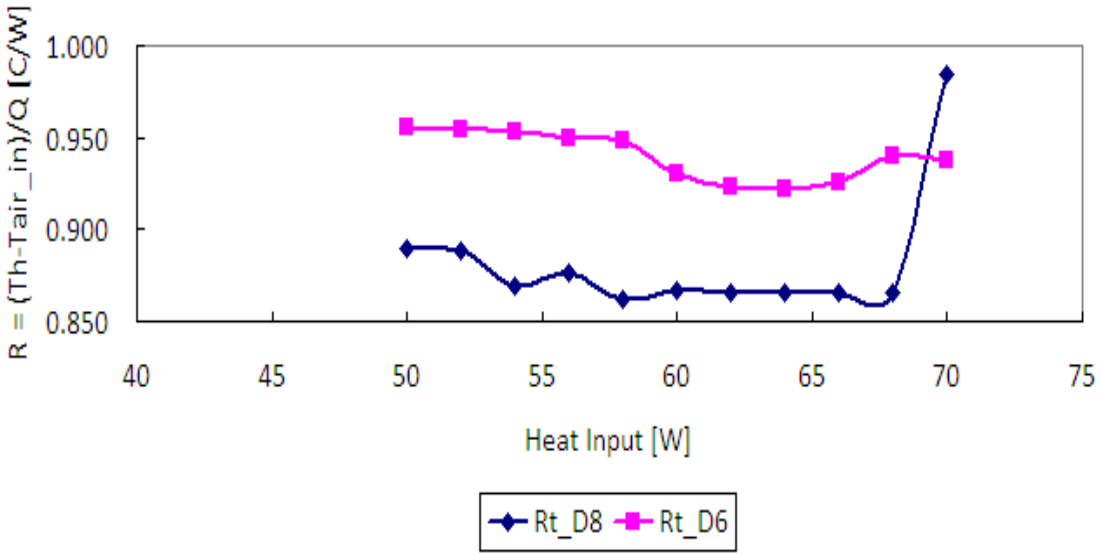
EXPERIMENTAL STUDY : Fabricated Module # 1

Specification

Heat Pipe : L 300.0mm T 1.3mm
Module Weight : 27gm and 20gm
Maximum Height : 5.0mm
Heat Source : In Center





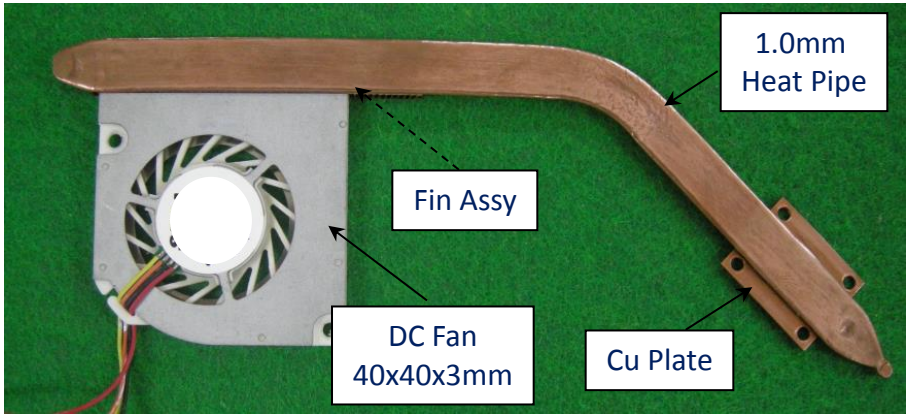


Using D8.0mm Qmax : 68W
Using D6.0mm Qmax : 64W

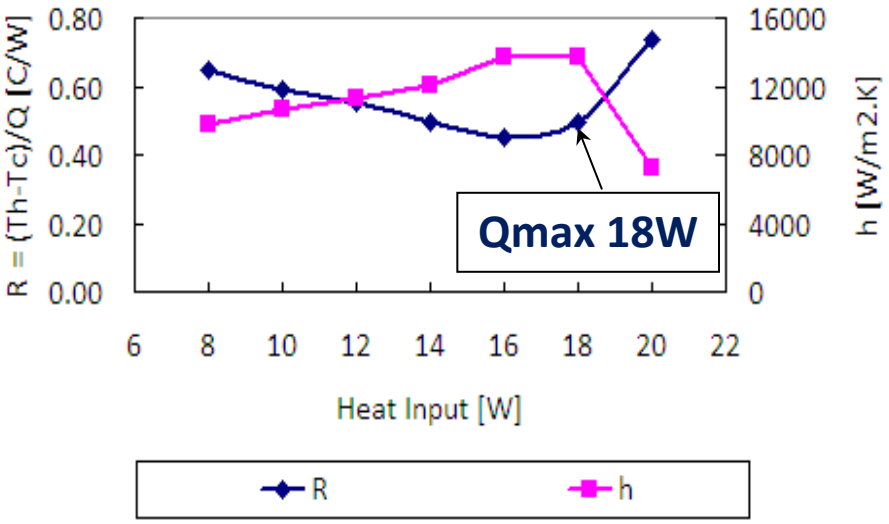
EXPERIMENTAL STUDY : Fabricated Module # 2

Specification

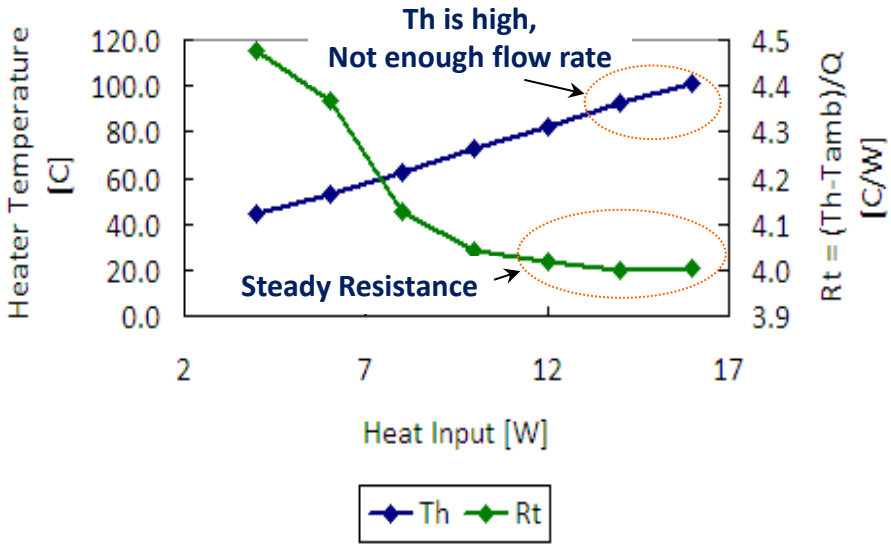
Heat Pipe : L 140.0mm W 9.0mm T 1.0mm
Module Weight : 19gm (Including Fan)
Maximum Height : 4.0mm



Heat Pipe Only



Heat Pipe Module

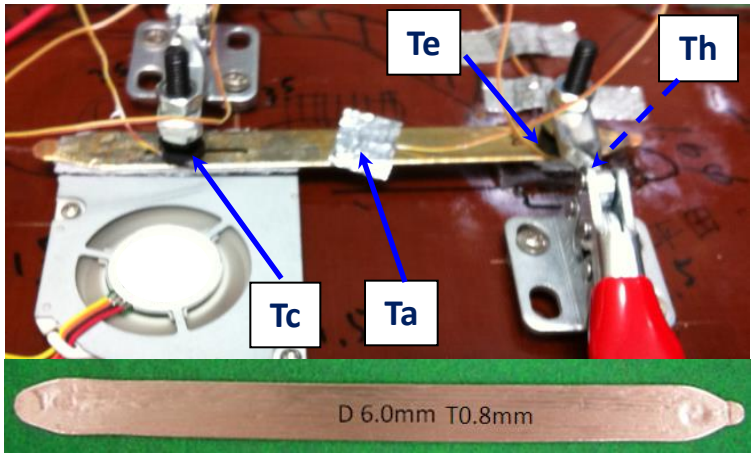


Current module Qmax About 20W if Air Flow Available

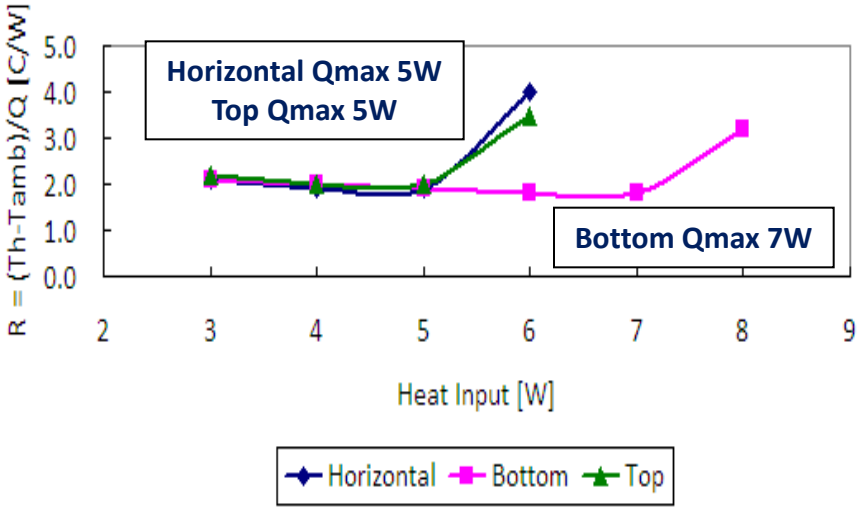
EXPERIMENTAL STUDY : Fabricated Module # 3

Specification

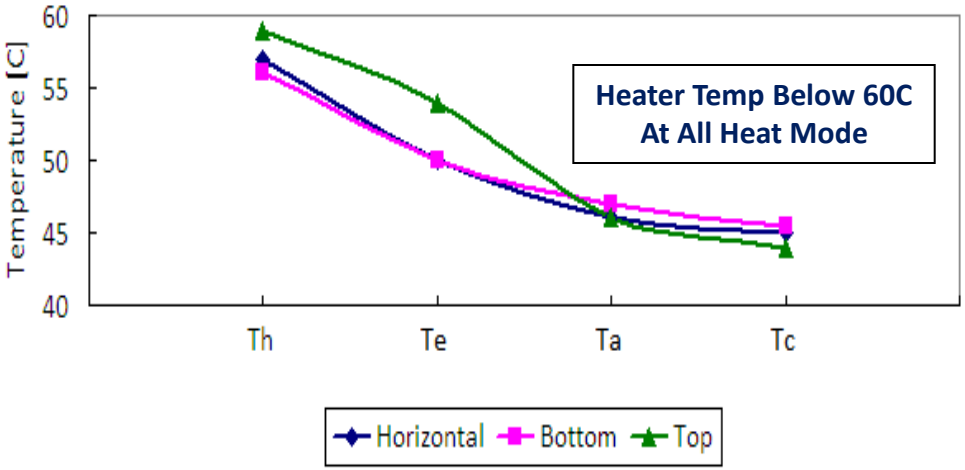
Heat Pipe : L 100.0mm W 9.4mm T 0.8mm
Module Weight : 14gm (Including Fan)
Maximum Height : 3.8mm



Total Resistance



Temperature Profile

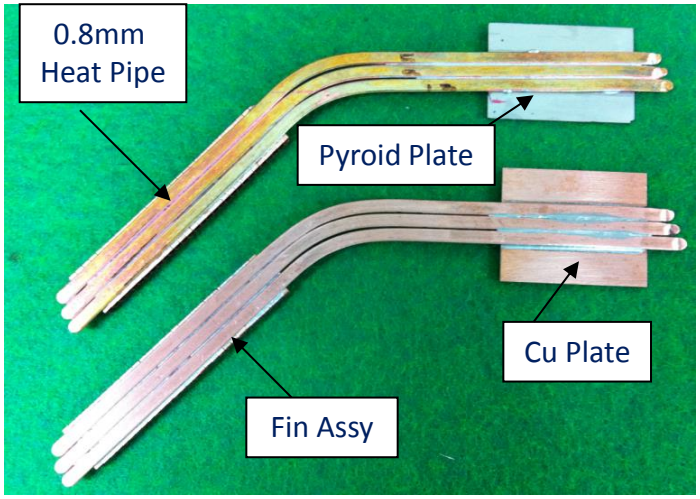


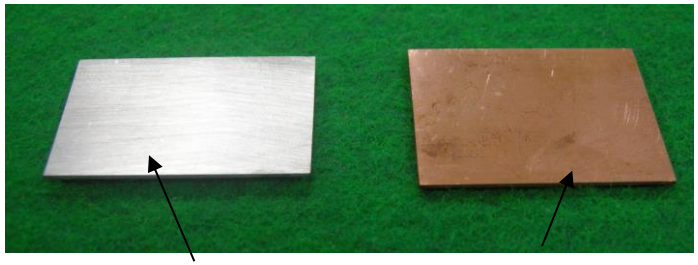
Current module Qmax is 5~7W

EXPERIMENTAL STUDY : Fabricated Module # 4

Specification

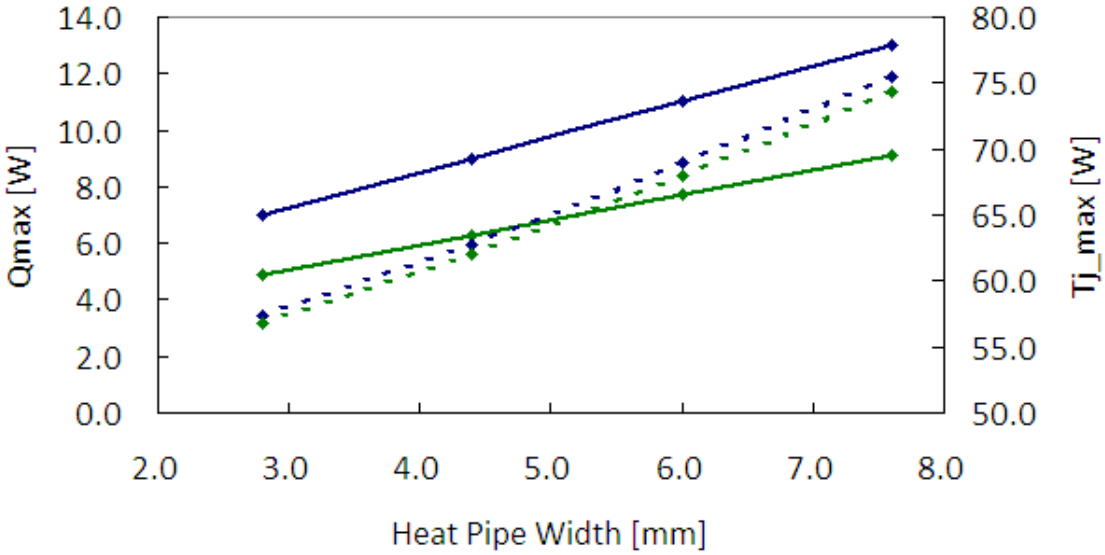
Heat Pipe : L 140.0mm T 0.8mm
Module Weight : 12gm
Maximum Height : 3.8mm
Fin Assy : W 40mm L 10mm H 3.0mm





PYROID
T0.8mm
With Ni Plating

Cu Plate

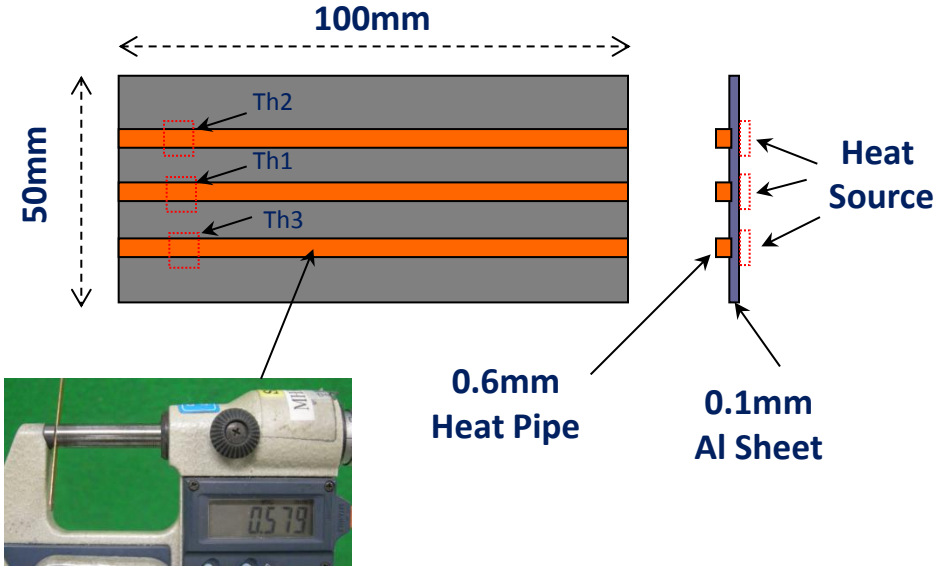


Estimated highest Qmax is 12.0W.

EXPERIMENTAL STUDY : Fabricated Module # 5

Specification

Heat Pipe : L 100.0mm W 4.5mm T 0.6mm
Module Weight : 8gm
Heat Source : Three Heat Sources
H1 : 3W ; H2 : 1.5W H3: 1.5W
Maximum Height : 0.7mm

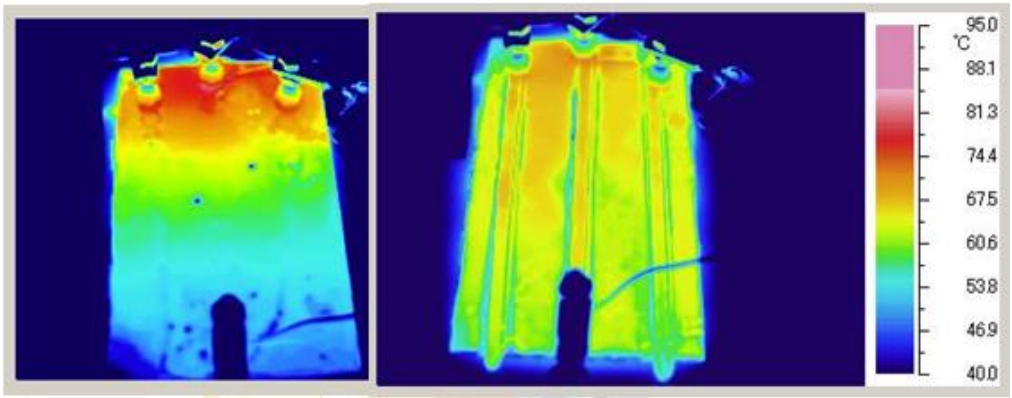


Comparison

Current Module vs 0.7mm Thick Graphite Sheet

	Th1[C]	Th2[C]	Th3[C]
Current Module	75.0	67.5	69.0
0.7mm Graphite Sheet	85.0	77.8	81.2

0.7mm Graphite **Current Module**

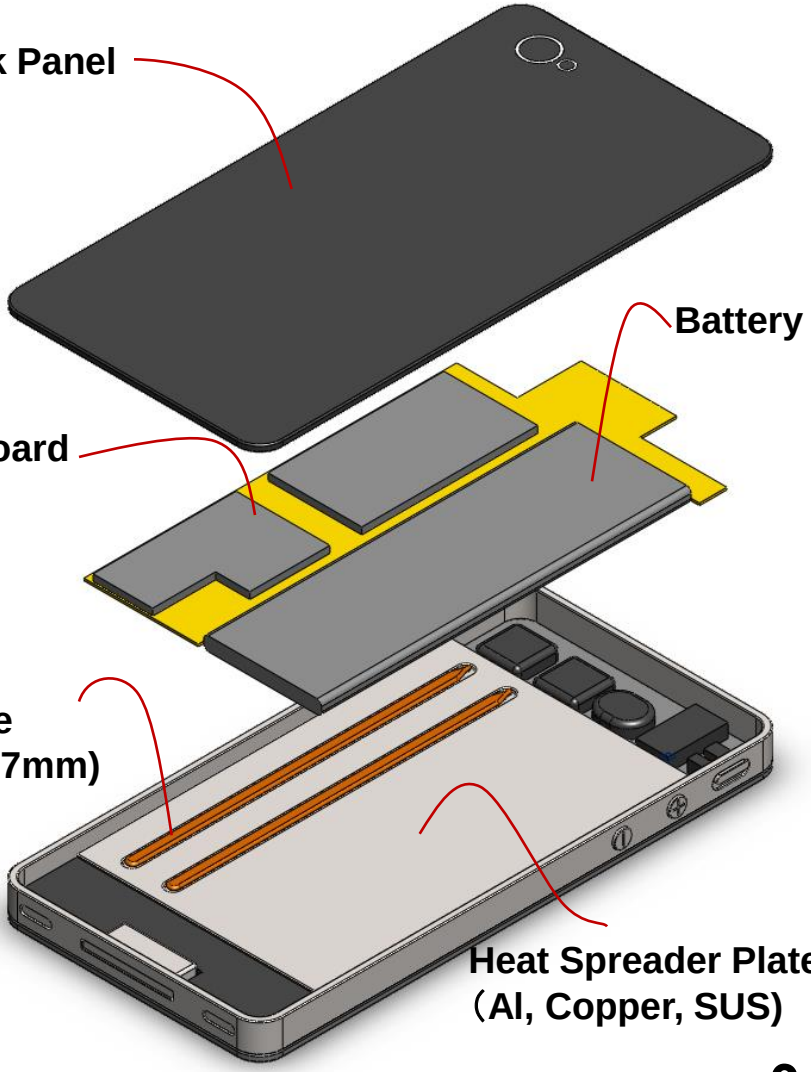


For current module Th is 5~10C lower than graphite sheet.

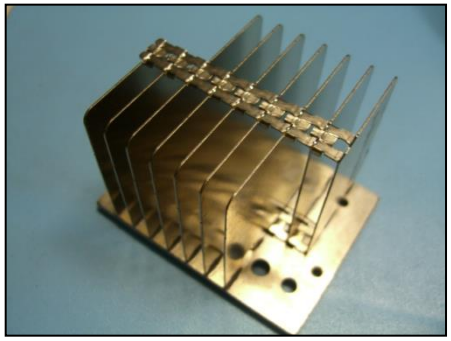
Concept – Heat pipe + Spreader plate

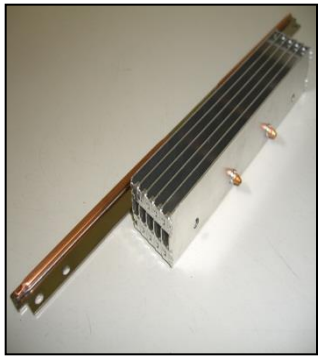
Heat pipes and spreader plate

- Heat pipes 0.7- 1mm thick.
- Metal (Al or Cu) spreader plate 0.2 mm thick.
- Heat pipe is a super heat conducting device, better than any known metal due to its 2-phase internal heat transfer . Therefore, heat pipe is used to spread the heat more efficient on the heat spreader plate for better cooling.



Heat Pipe Applications for Vehicles

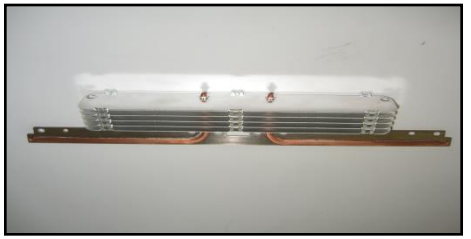


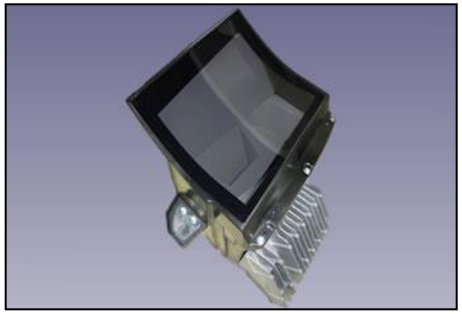


Head Lamp Cooling

Display LED Back-Light Cooling, Car Navigation CPU Cooling

Rear Lamp Cooling





Preheated Intake Air (Fuel System, Energy Conservation)

Power Drive unit (PDU) Cooling

Battery Cooling (Hybrid)