Engineering Support – Partnership in Design

Primary objective:

- Maximize cooling surface area
- Smallest volume
- Lowest manufacturing costs

Thermshield can:

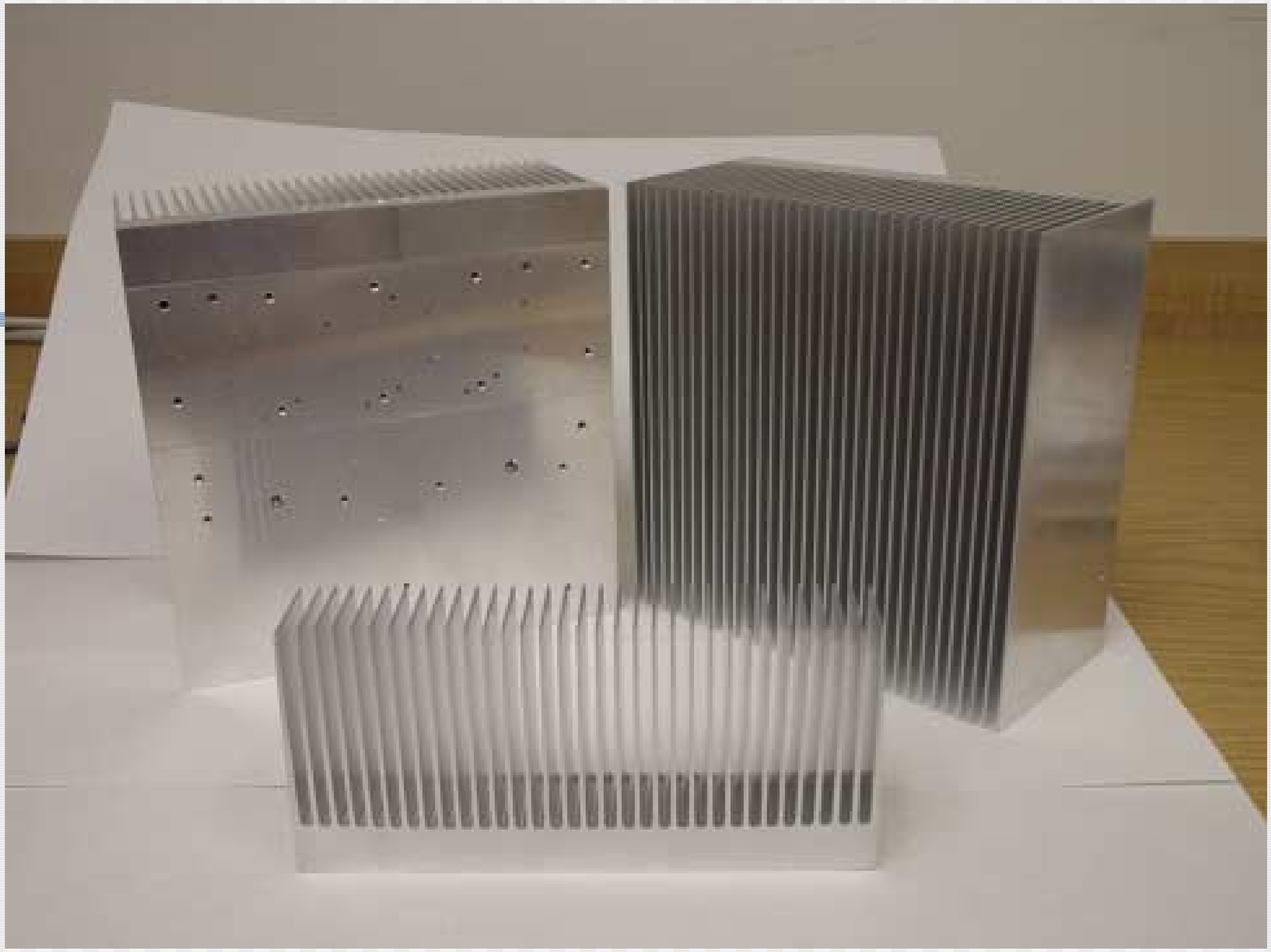
- Act as consultant in design team
- Work with system architect(s) at project initiation
- Produce or confirm numerical thermal analysis
- Provide manufacturing expertise for cooling technologies

Engineering Support – Partnership in Production

Manufacturing costs & reaction time are critical.

Thermshield can:

- Manufacture prototype / test parts
- Re-spin prototype design to refine thermal performance
- Production tooling for preproduction volumes
- Support manufacturing on a world wide basis.
- Logistics, Local stock and Supply Chain management



Ultrahigh Ratio Extrusion:

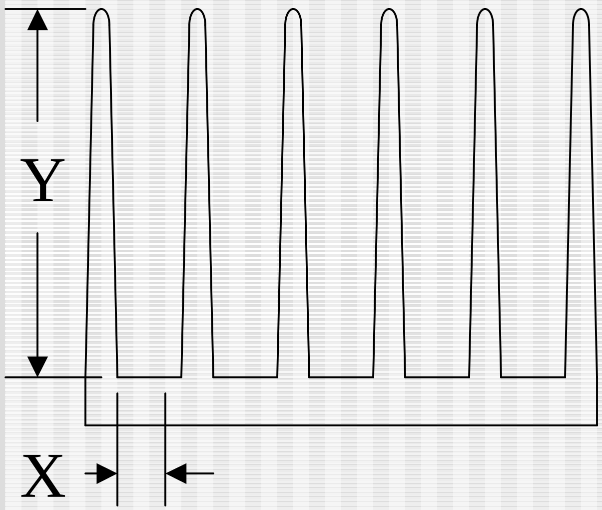
- up to 23:1 In 5.0 dia tool
- up to 20:1 in 8.0 dia tool
- Replaces bonded fin at lower cost
- Fin thicknesses down to 0.040”

Ultrahigh Ratio Extrusion:

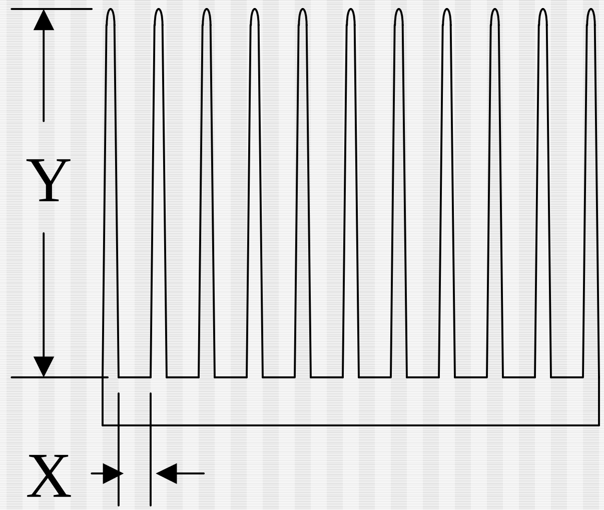
- up to 23:1 in 5.0 dia tool
- up to 20:1 in 8.0 dia tool
- up to 18:1 in 12.0 dia tool
- Replaces bonded fin at lower cost
- Fin thicknesses down to 0.040” at 1.0 height

Advantages:

- More cooling surface area in equal volume
- Lighter weight – lower cost to buy and ship
- Increased thermal performance in forced air



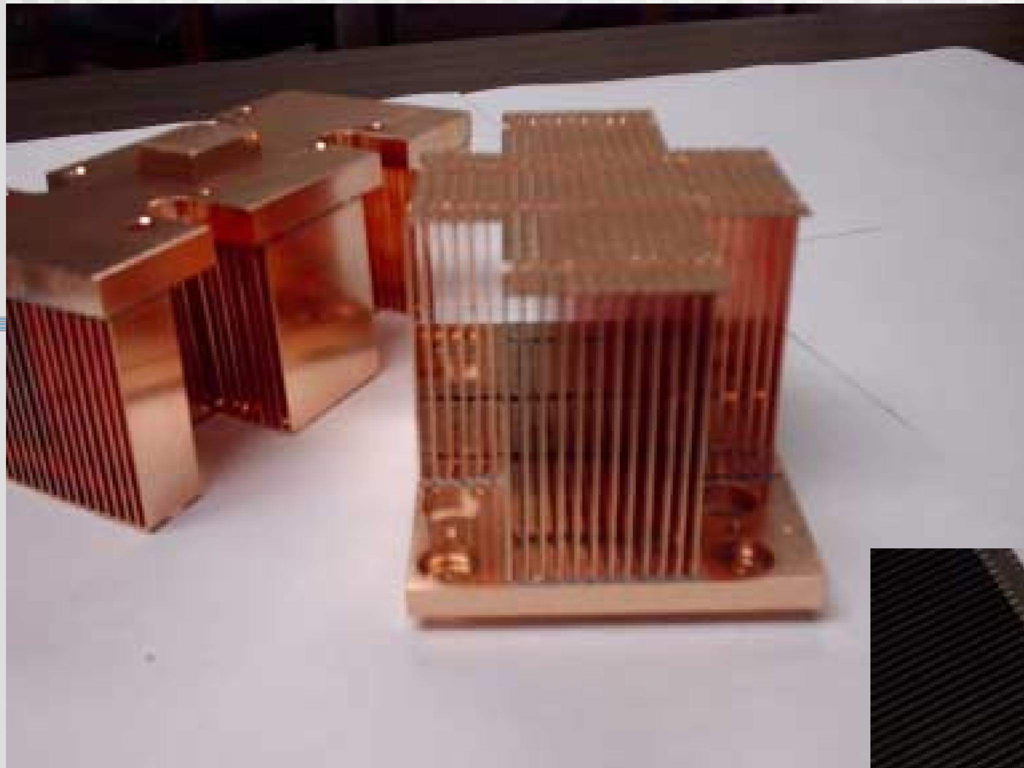
Conventional Extrusion ratio = Y/X = 8:1



Ultrahigh Extrusion ratio = Y/X = 20:1

Ultra High Ratio Extrusions

Thermshield



Stacked Fin Coolers

- Very thin fins – down to 0.006”
- Competes with folded fin w/ lower cost
- Alum. / copper or both

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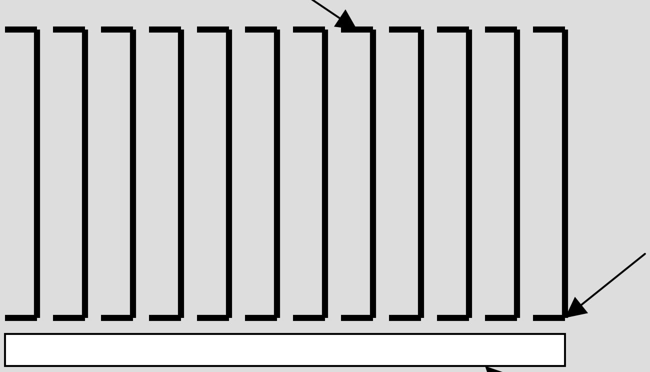

NOTES:

Fins and base can be either aluminum or copper or both.

Fin material down to 0.15 mm (0.006”)

Interlock at tip and base allows easy assembly.

Stacked Fin Details

Thermshield

Stacked Fin Heat Sinks – Pros and Cons

PRO:

- Fin thicknesses to 0.006" reduce weight / cost
- Min fin pitch 12 FPI
- Mixed materials - copper and aluminum
- Interlocked fin design – low handling cost

CON:

- Requires braze, solder or epoxy joint – base to fins
- Protos require tooling
- More costly than skived / extrusion.

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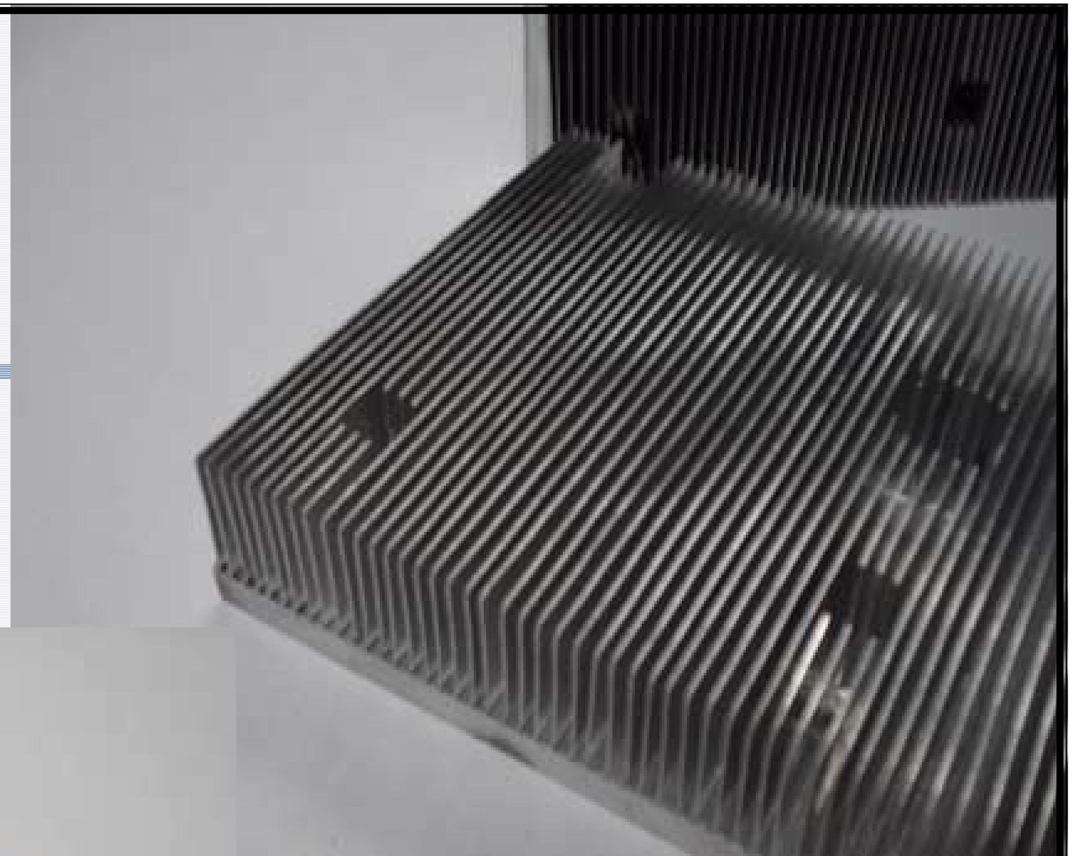
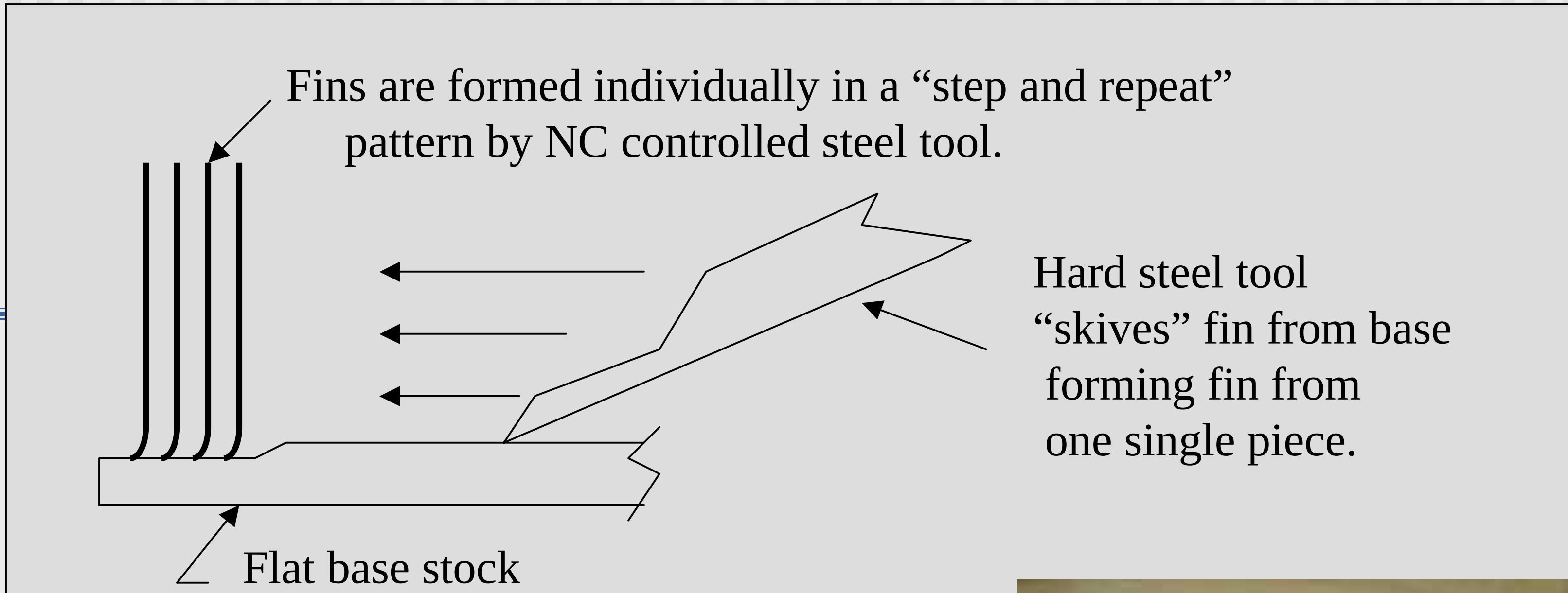
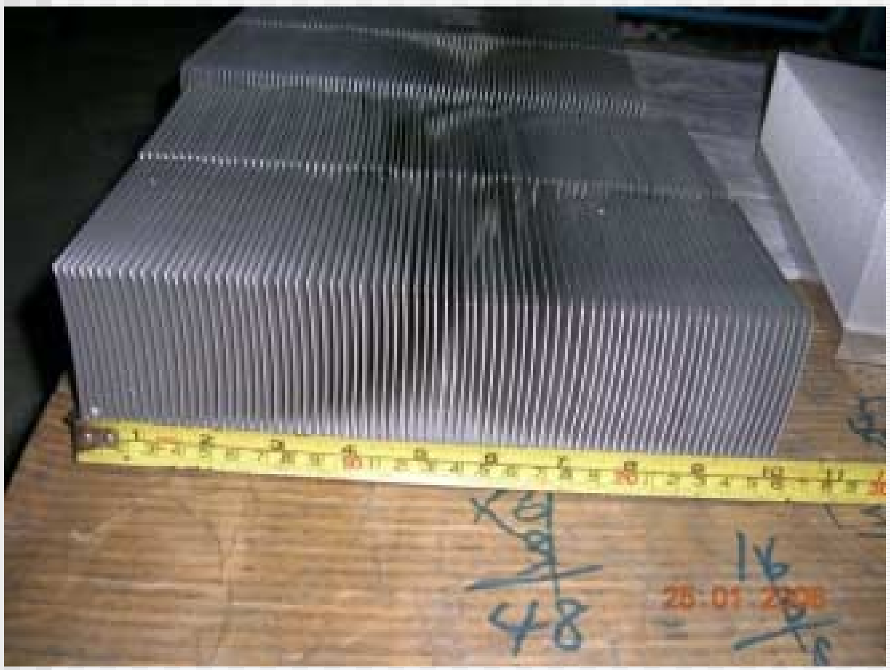
Skived Fin Heat Sinks

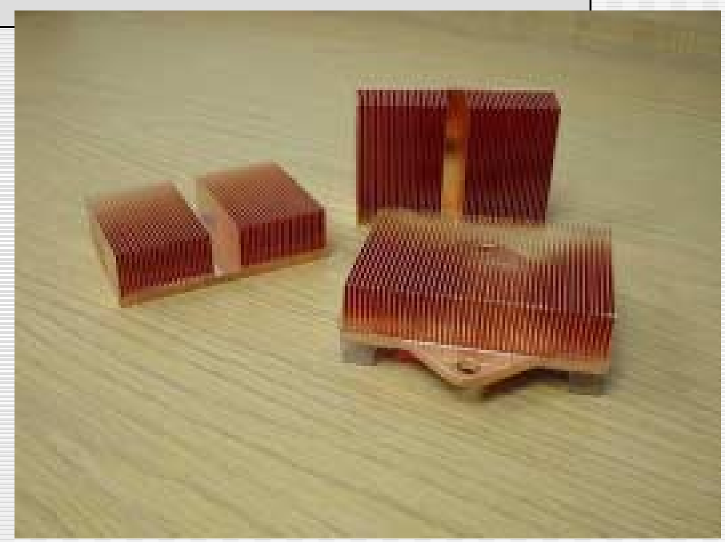
- Single piece construction
- Copper or aluminum
- Very high aspect ratios
- Max. cooling area / volume



Thermshield







Skived Fin Details

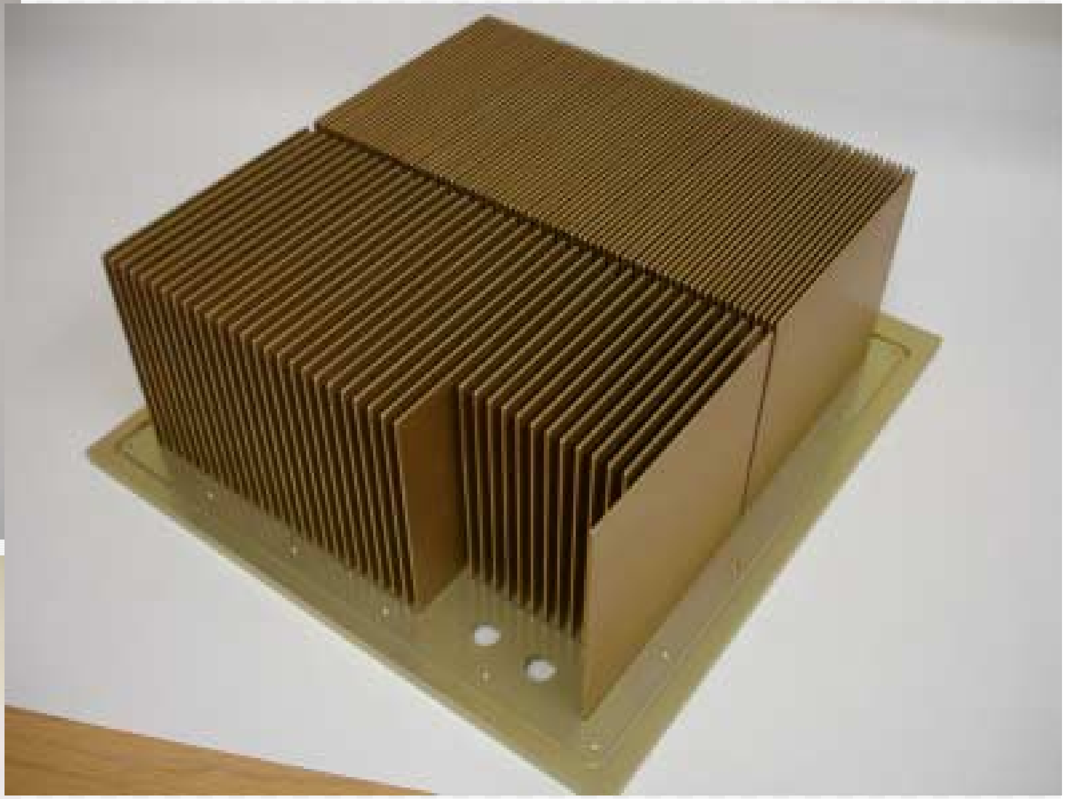
Skived Fin Heat Sinks – Pros and Cons

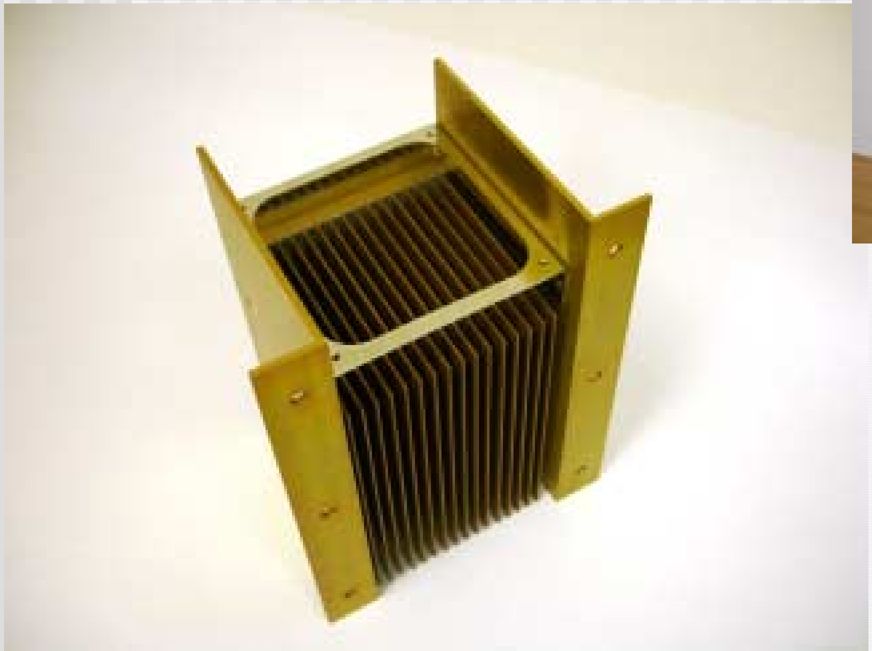
PRO:

- Fin thicknesses to 0.020” in alum reduce weight / cost
- Min. fin pitch 12 FPI
- Can be made from copper OR aluminum
- Single piece design reduces thermal resist / cost
- Can be prototyped without tooling expense.

CON:

- Fin height limited to ~30 mm in copper and ~ 60 in aluminum
- Copper is difficult to manufacture, limited height / pitch
- More costly than extrusion.





Bonded fin heat sinks

both standard and custom sizes.

Bonded Fin Heat Sinks – Pros and Cons

PRO:

Unlimited extrusion aspect ratios and fin heights
Increased cooling surface area over extrusion - > 2X
Flexible fin density (FPI) and fin thickness
Mixed materials – copper and/or aluminum

CON:

Increased cost over extrusion of same volume - > 40%
Tall, thin fins easily damaged in shipping and handling
Cannot be black anodized

Heat Pipes – Wide Variety of Applications

-Small Diameter for low power, flexibility of use.

- -Embedded processor applications
- -High power graphics chips
- -Notebook Computers

-Large Diameter for high power (<100W)

- -Power amplifiers
- -Air to air heat exchangers

-Z-Axis for Multiple KW cooling

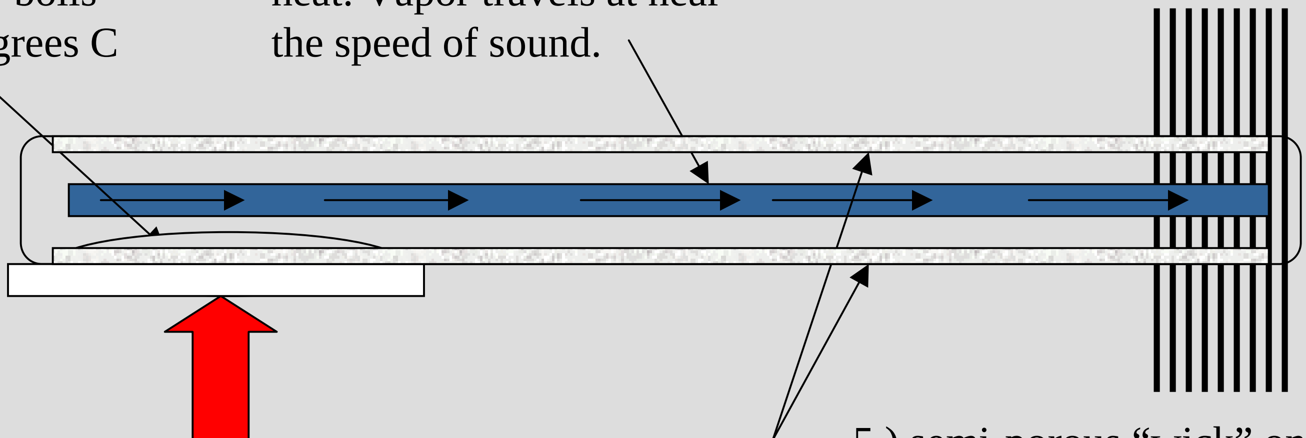
- -Motor drives
- -Large scale UPS
- -TV / radio broadcast

Heat Pipes – How they work.

2.)
Water at reduced
Pressure inside
Heat pipe “boils”
At ~50 degrees C

3.)
Heated vapor travels to
cool end of pipe to release
heat. Vapor travels at near
the speed of sound.

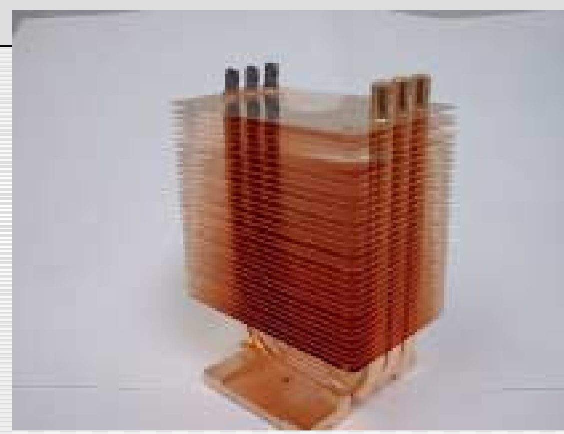
4.) Cooling air passed across
cooling fins removes heat to atmosphere
changing vapor back to liquid.

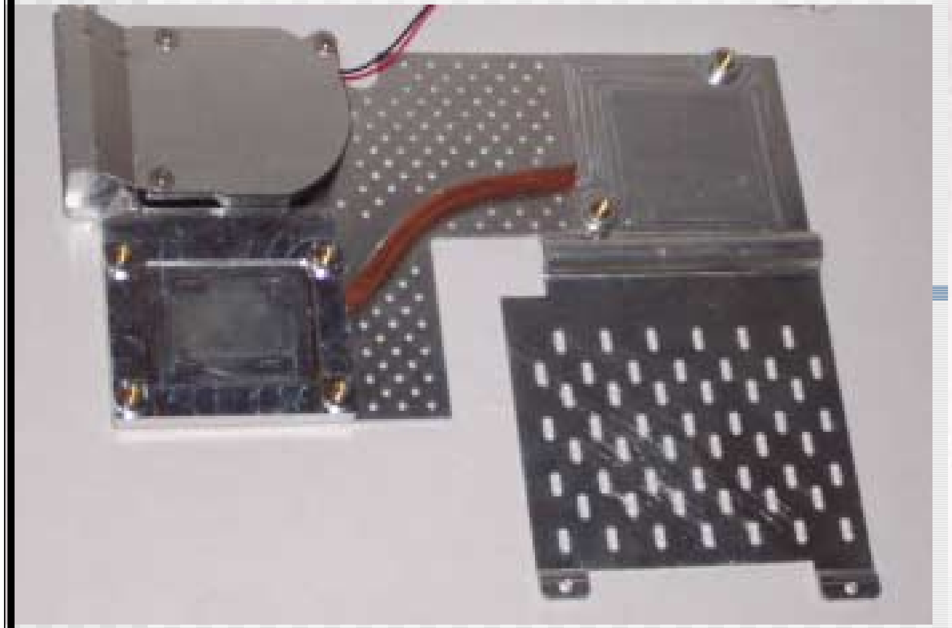


1.) Evaporator -
Heat Input from
Microprocessor or
Other hot component

5.) semi-porous “wick” on
inside diameter of the tube
uses capillary force to return cooled
liquid back to Evaporator.
Process is continuous.

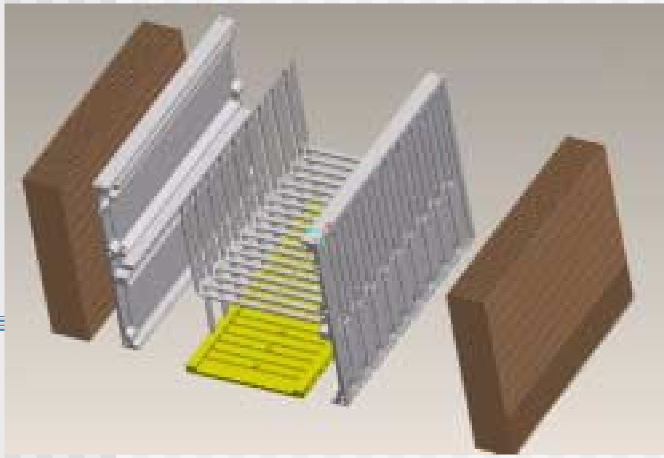
NOTES:
Heat Pipes typically operate with
a temperature rise of less than 4 degrees C
from end to end.

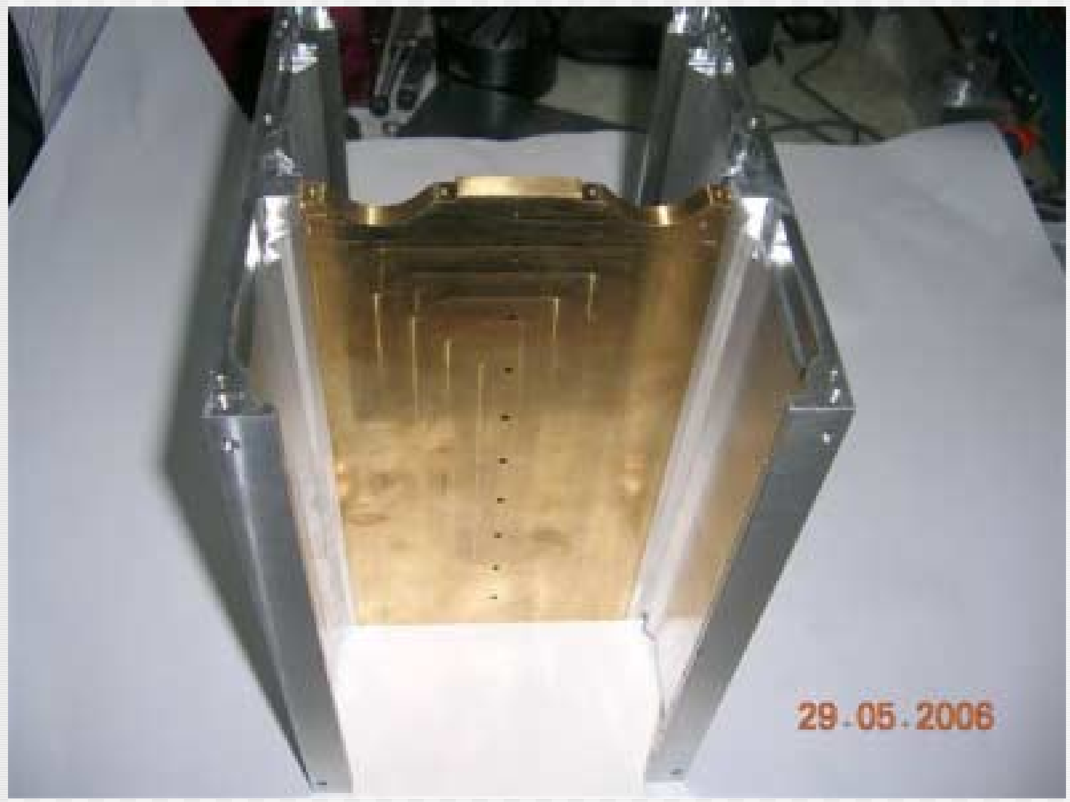




Small Dia. Heat Pipes:

- Very economical
- Versatile in design
- Next generation microprocessors up to 65 Watts





High power RF amplifier
54 heat pipes.

Small diameter Heat Pipe Assemblies – Pros and Cons

PRO:

- Heat pipes are cheap and dependable
- 5 mm to 15 mm dia / many stock lengths
- Move heat to a remote location with little heat loss.
- Fins can be made from copper OR aluminum
- Thermals better than copper with lower cost aluminum
- Reduce package size

CON:

- Sensitive to gravity / orientation
- Market acceptance

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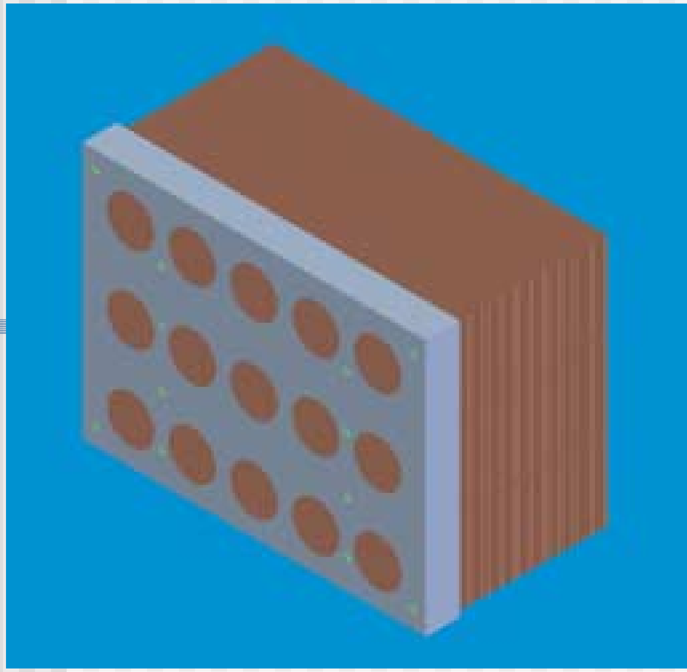
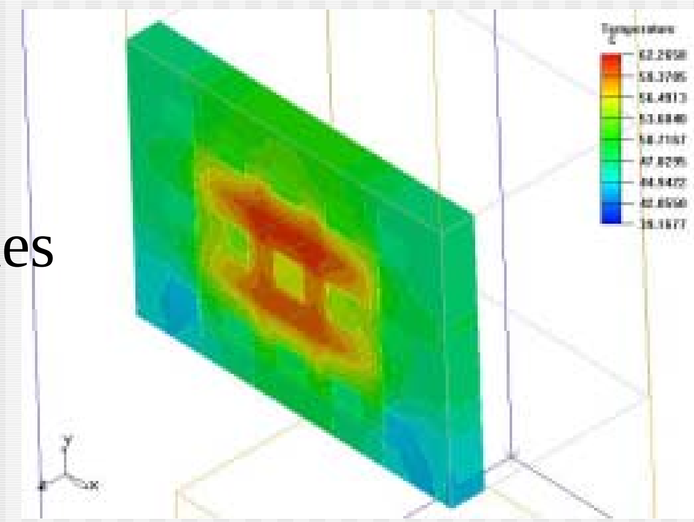
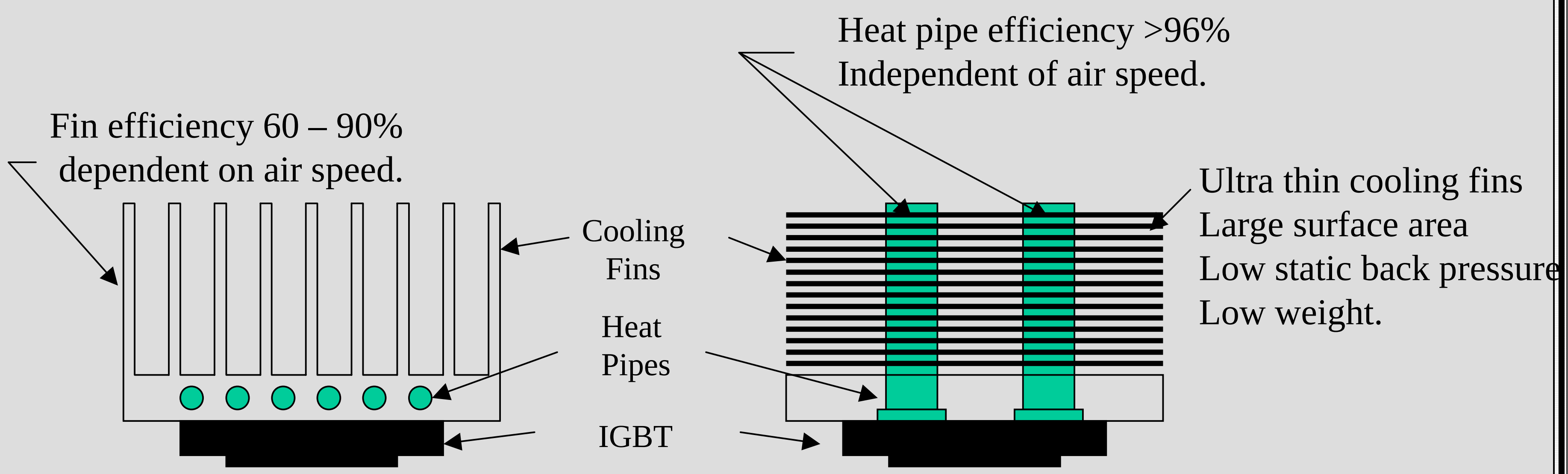


High Power
Heat Pipe
Assemblies

- New designs for up to 2KW power modules
- >100% increased cooling over bonded fin
- Cost competitive with liquid cooling
  but without the support equipment.





Extrusion with optional heat pipes

Large diameter heat pipes w/flat fins

NOTES:
Z-axis coolers use offer direct contact of
High conductivity tower heat pipes make direct contact
to power module of microprocessor base.

Z-axis coolers

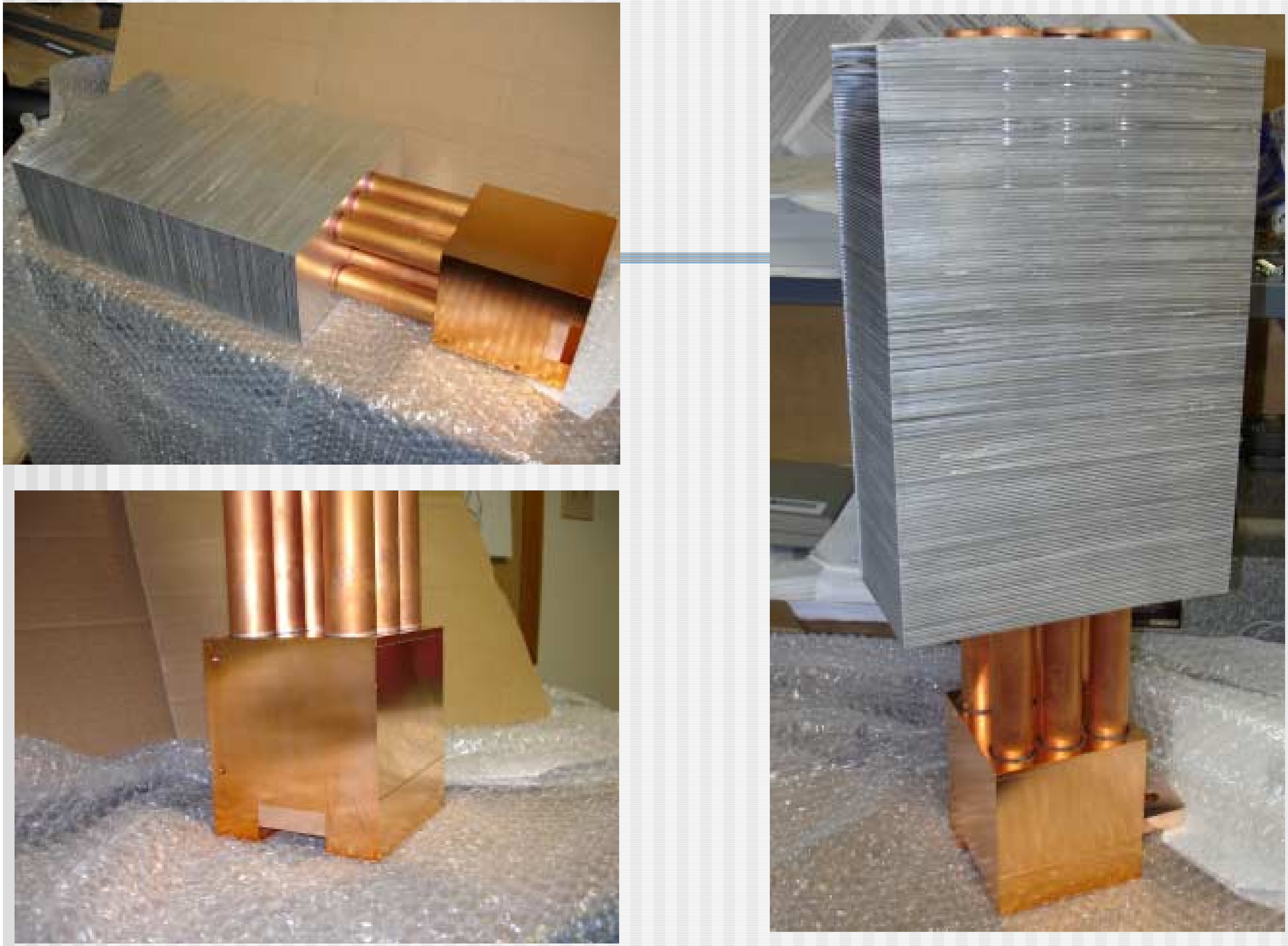
Z-axis Heat Sinks – Pros and Cons

PRO:

- Heat pipes directly contact hot spots
- Fins can be made from copper OR aluminum
- Thermals can be very low / water cooled level
- Small package design

CON:

- Sensitive to gravity / orientation
- Height of pipe must be >3 inches
- Cost is high / less than water cooled



Press pack thyristor cooler using 25.4 mm dia heat pipes.

NOTES:
Cooler developed to remove 3KW of heat from electronics rack without cooling water entering the enclosure.

Liquid to Air HX using Large diameter heat pipes

Thermshield

THANKS!