Top down approach and trends in Thermal Management

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Messe Stuttgart

THAL TECHNOLOGIES

THERMAL MANAGEMENT EXPO EUROPE

Thal Technologies company profile

PERFORMANCE MATERIALS

Protect electronics with Thal Thermal Interface and insulation materials

LED solutions

High-End Industrial LED modules design and manufacturing

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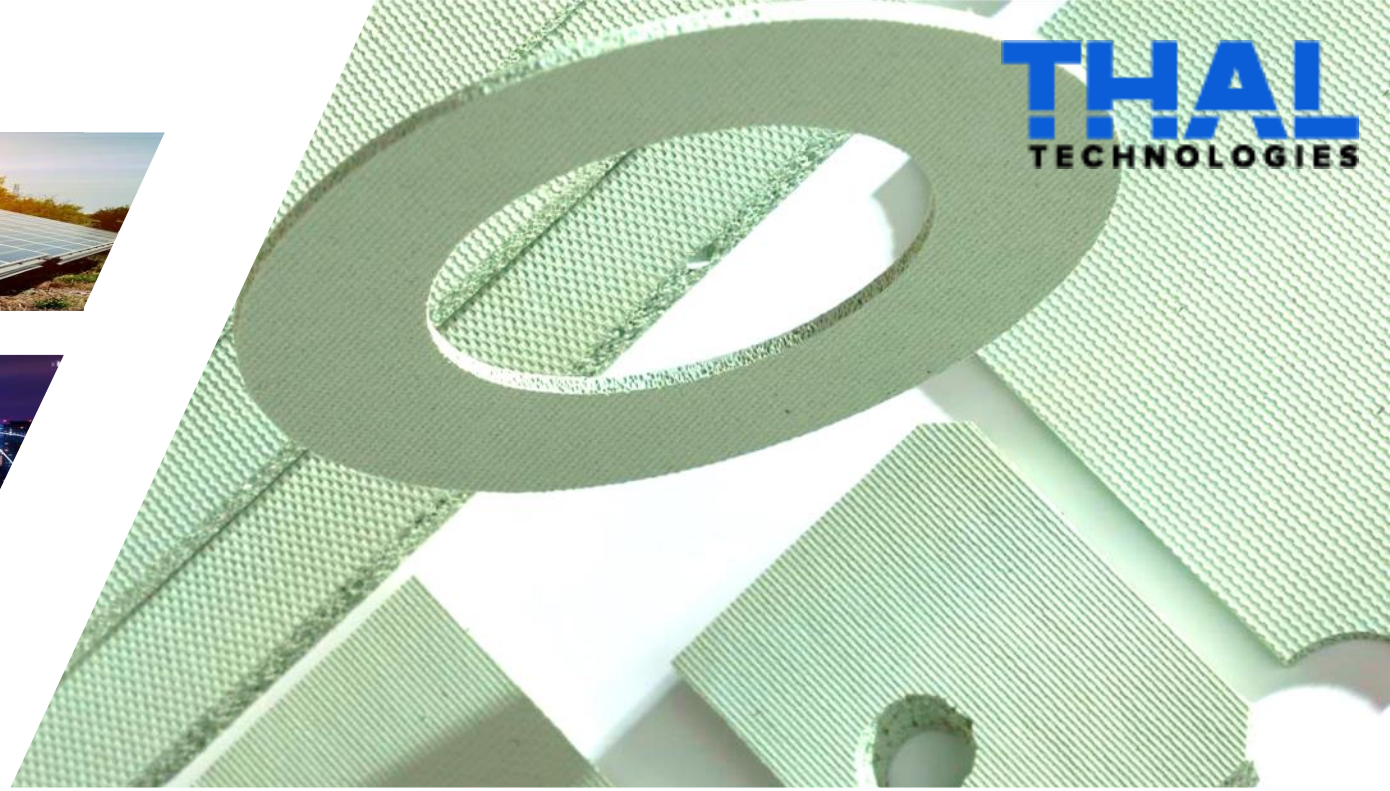
THERMAL INTERFACE MATERIALS



THAI TECHNOLOGIES

INNOVATION

ENGINEERING

RESEARCH & DEVELOPMENT

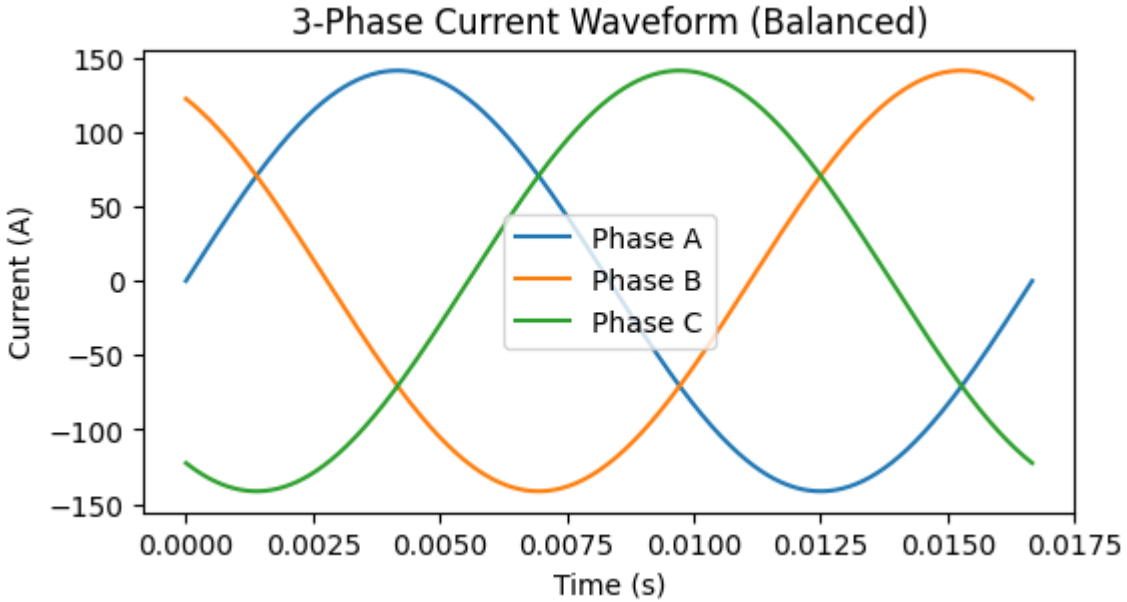
MANUFACTURING

SUPPLY CHAIN

TESTING

QUALITY ASSURANCE

Good things come in threes



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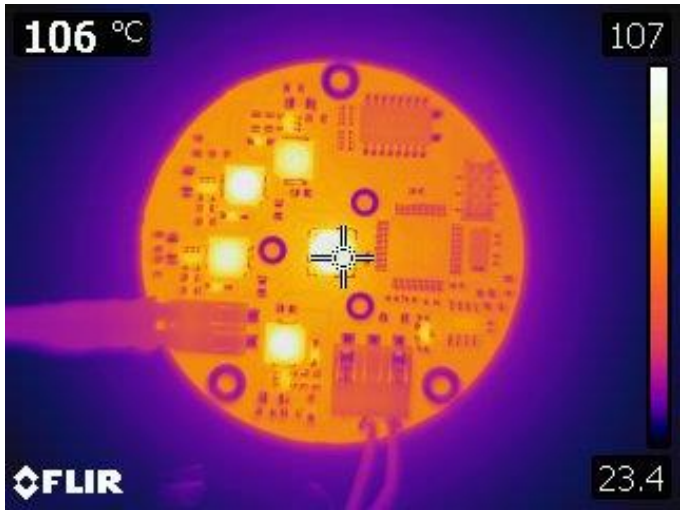
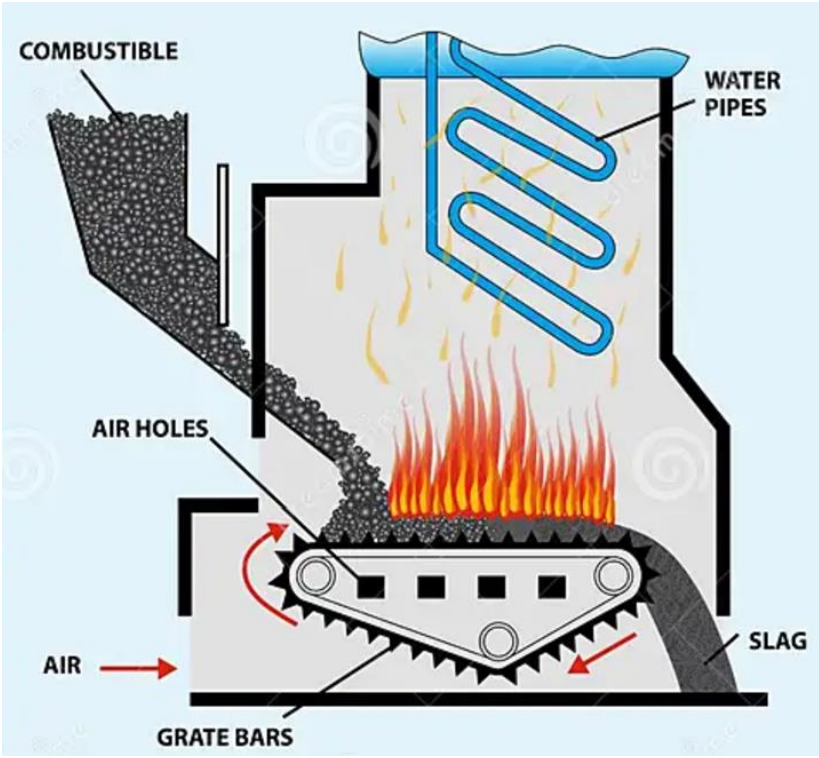
3 types of thermal management

- Biology
- Chemistry
- Electronics





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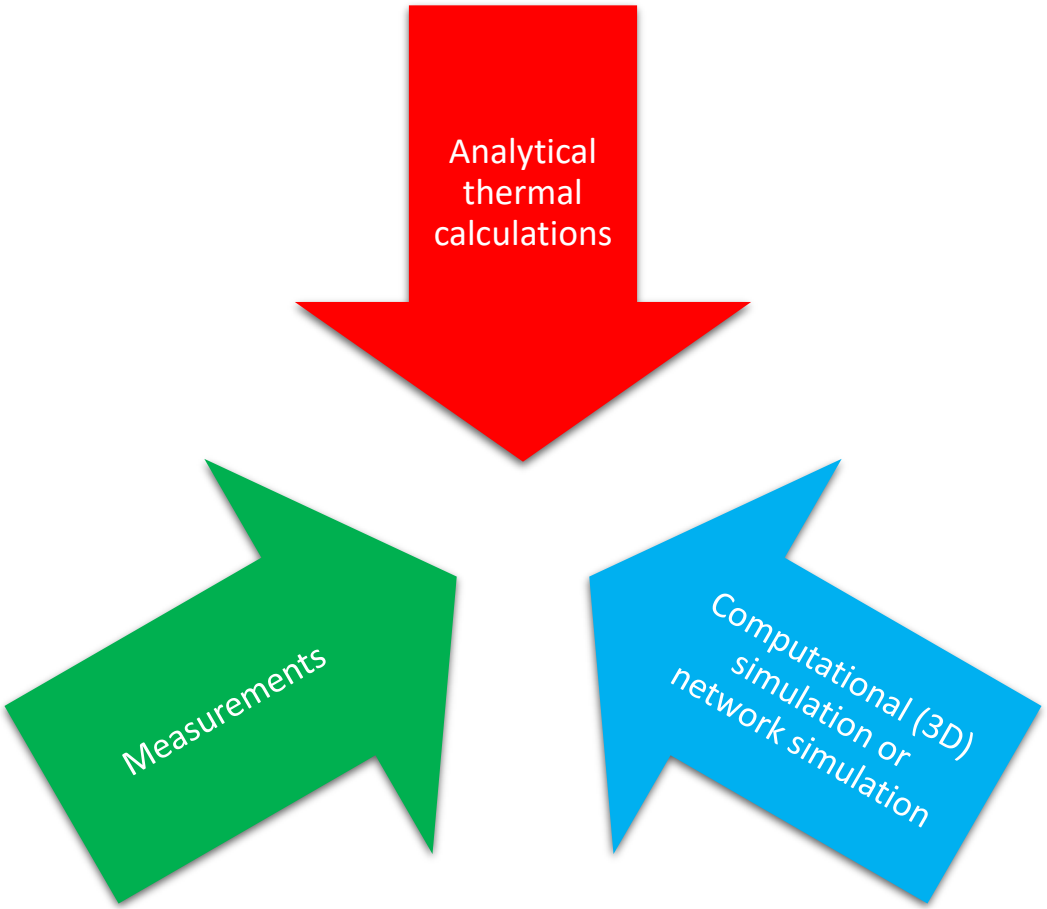
3 types of thermal investigation



- Never trust only on one type of investigation.
- Always validate your work by executing one or two other investigations.

3 Criteria for thermal limitation

- Minimum and Maximum material properties
- Lifetime requirement
- Safety

3 modes of heat transfer

Temperature rise ΔT from junction to air:

$$Q = h_{tot} \times A \times \Delta T$$

$$h_{tot} = h_{cond} + h_{conv} + h_{rad}$$

Q = power dissipation

h = heat transfer coefficient

A = surface area

1. **Conduction**
2. **Convection**
3. **Radiation**

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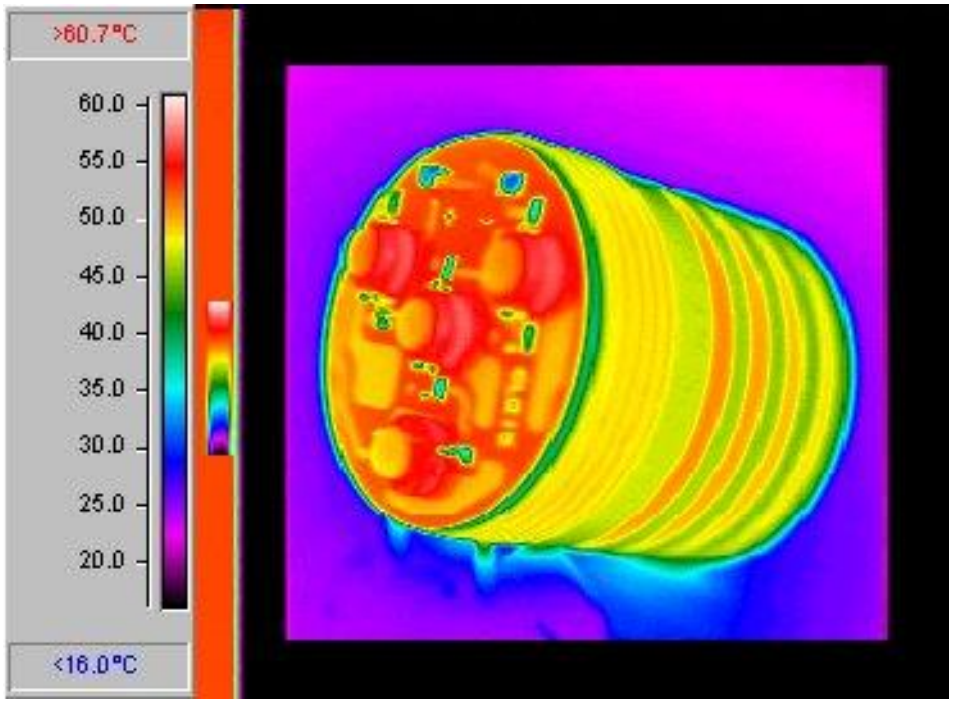
Thermal conductivity

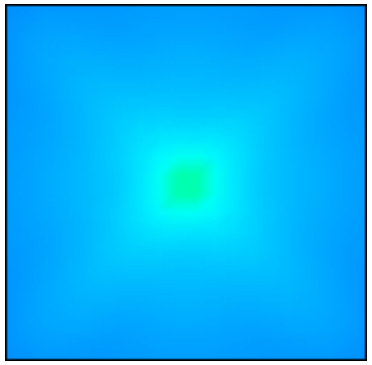
- Ideally the whole system should have the same temperature. This can be reached with the use of highly thermal conductive (k) materials and minimizing the interfacial resistance.



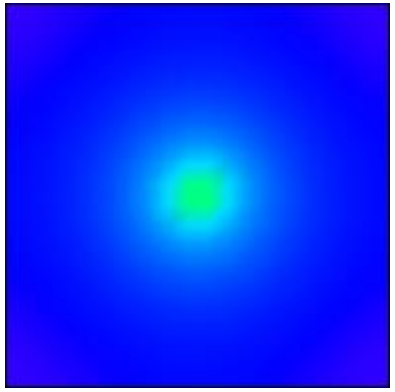
Materials thermal conductivity

Copper	**90..400 W/mK**
Gold	**290 W/mK**
Aluminium	**50 .. 235 W/mK**
Steel (low carbon)	**66 W/mK**
Boron Nitride	**39 W/mK**
Solder	**20..50 W/mK**
Stainless Steel	**20 W/mK**
Alumina	**27 W/mK**
Mica	**0.7 W/mK**
Water	**0.5 W/mK**
Heat sink compound	**0.5 .. 4 W/mK**
FR4	**0.3 W/mK**
Epoxy	**0.2 .. 0.3 W/mK**
Mylar	**0.2 W/mK**
Air	**0.027 W/mK**

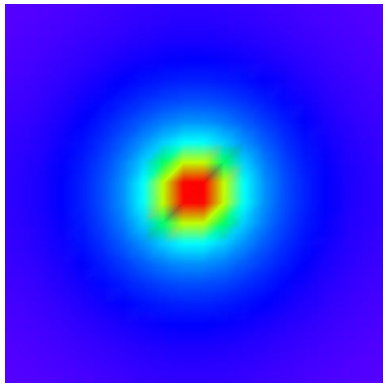
Simulation example spreading resistance



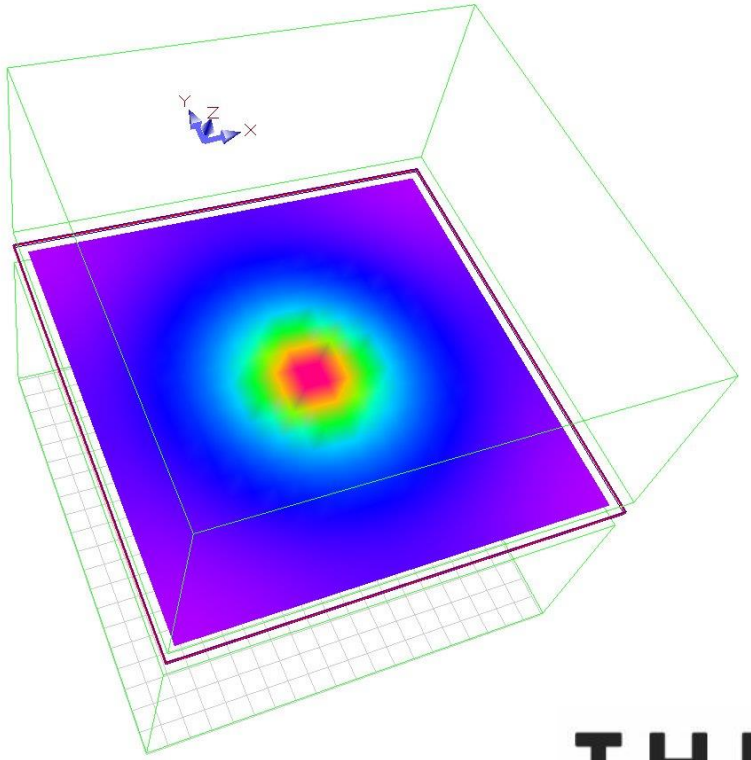
k = 400 W/mK



k = 50 W/mK



k = 5 W/mK



Convective heat transfer

Assembly is in Still Air

- Use the following equation for rule of thumb

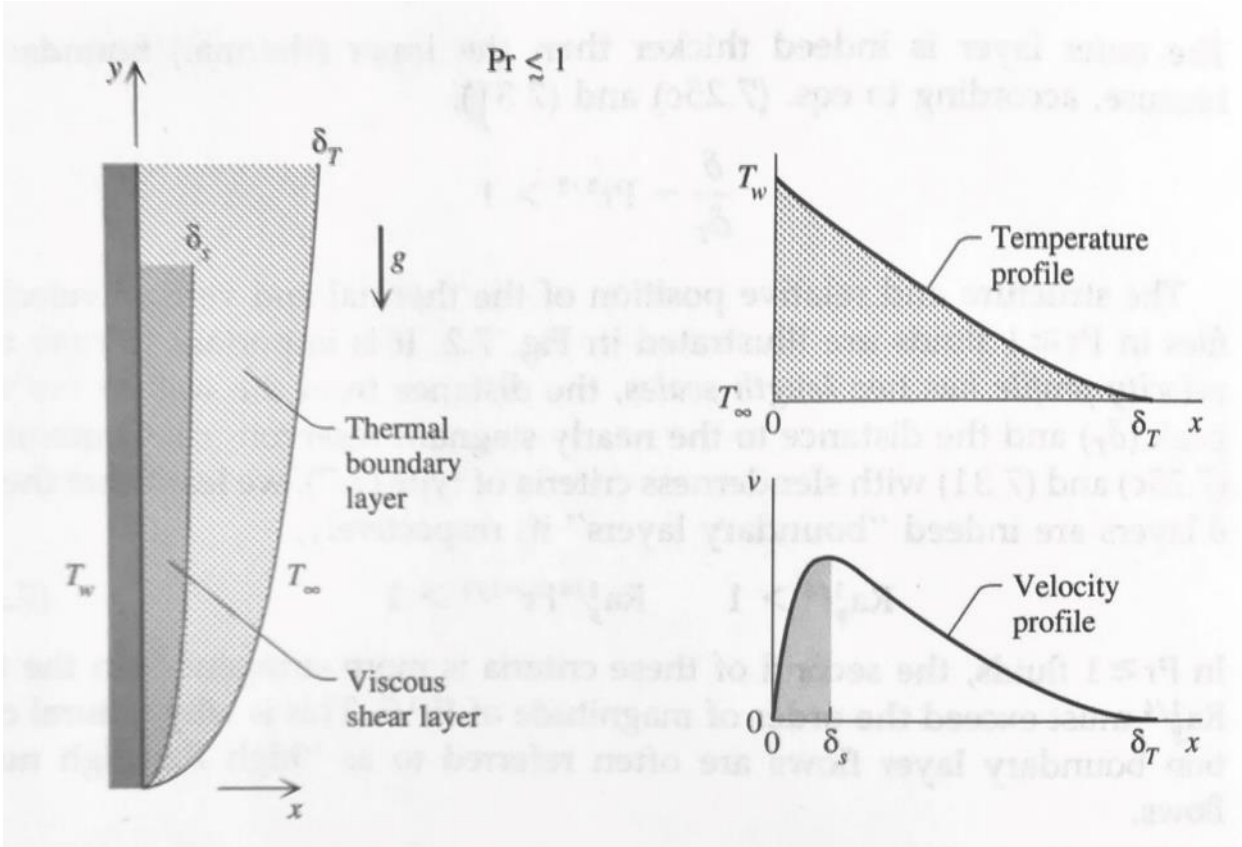
$$q = h\,A\,\Delta T$$

$$h = a\left(\frac{\Delta T}{L}\right)^{1/4}$$

q = dissipated power (W)
A = Area (m^2)
T = (Temperature plate – Temperature ambient) (K)
L = plate length (m)
h = convective heat transfer coefficient (W/m^2K)
a = coefficient 1.32 for top of plate, 0.59 for bottom, dependent on shape and orientation

Still air (or natural convection) still requires air flow (e.g. holes in cover), otherwise air is just a good insulator

Buoyancy heat transfer with air on vertical wall



Source: Heat Transfer, Adrian Bejan

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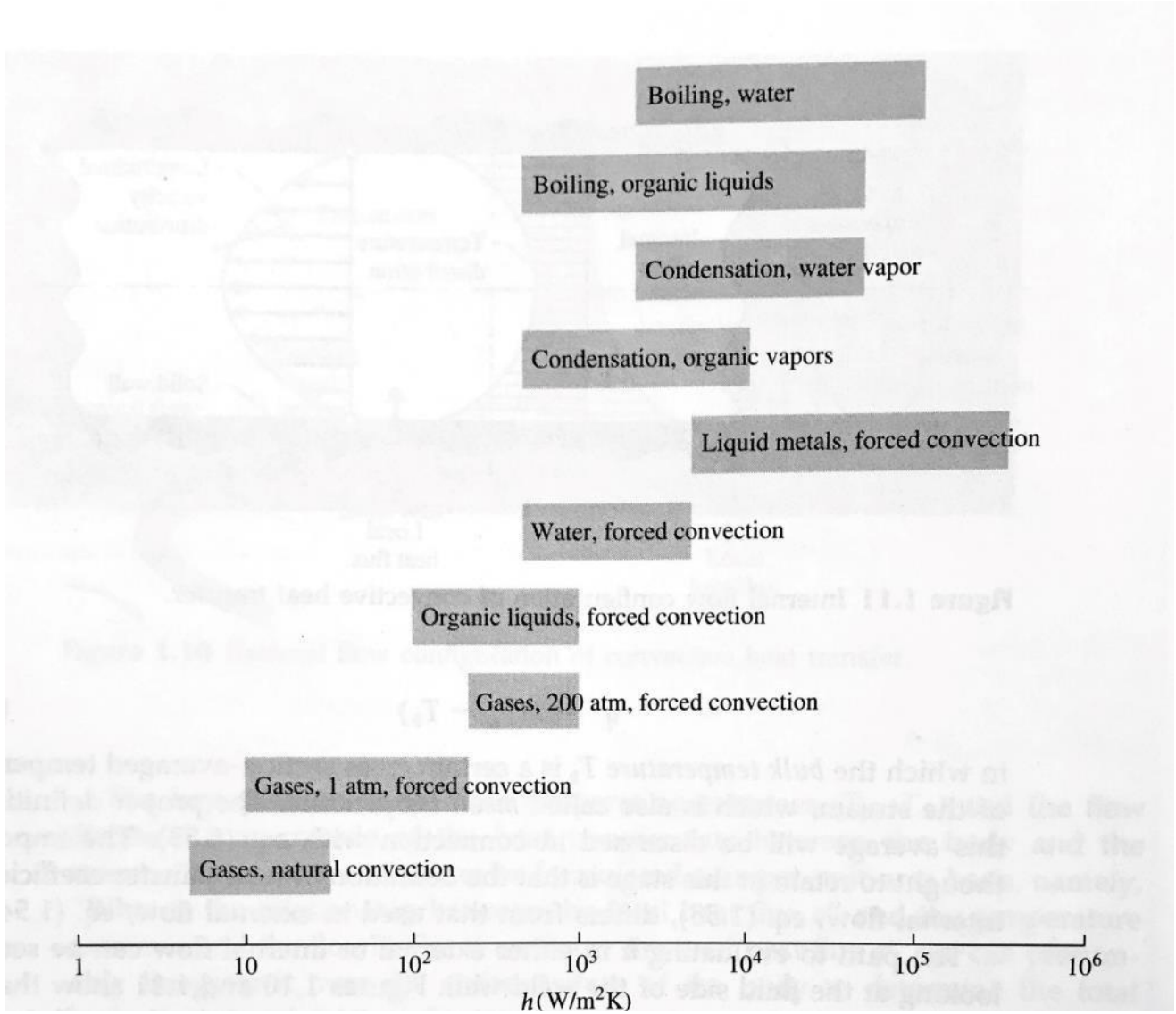
Heat transfer



Source: Heat Transfer, Adrian Bejan

Heat radiation

$$Q_{12} = h_{rad} \times A \times \Delta T$$

$$Q_{12} = \varepsilon F_{12} A \sigma (T_1^4 - T_2^4)$$

Q Power dissipation
ε absorption coefficient [-]
F_{12} View factor [-]
A projected surface area [m^2]
σ Stefan-Boltzmann constant [W/m^2K^4]
T_1 Surface temperature [K]
T_2 Ambient temperature [K]

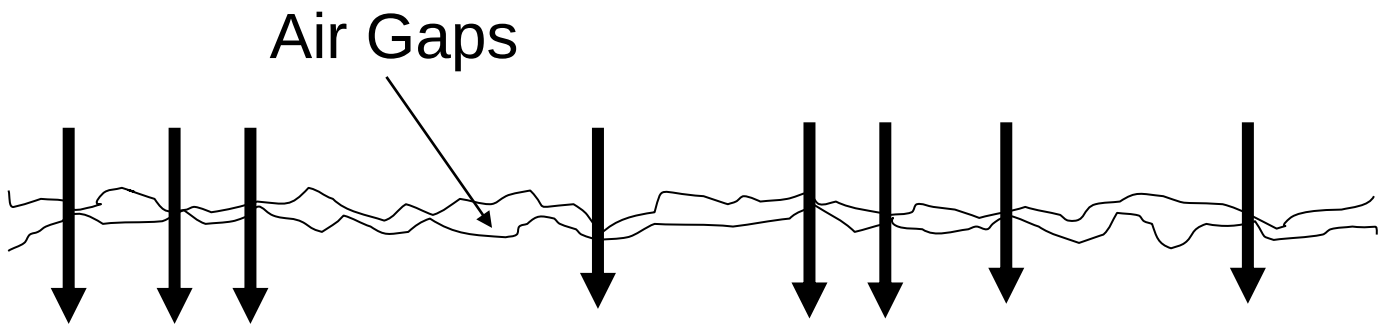
Note: Radiation is not gravity dependant

Surface emissivity coefficient ε

Aluminium polished	0.04 ~ 0.05
Aluminium oxidized	0.11 ~ 0.19
Aluminium anodized	0.6 ~ 0.8
Aluminium black anodized	0.7 ~ 0.9
Copper polished	0.04
Copper rolled	0.64
Lead oxidized	0.28
Lead unoxidized	0.05
Nickel electrolytic	0.04
Chromium polished	0.07
Lacquer	0.85 ~ 0.97

Interfacial Thermal Resistance

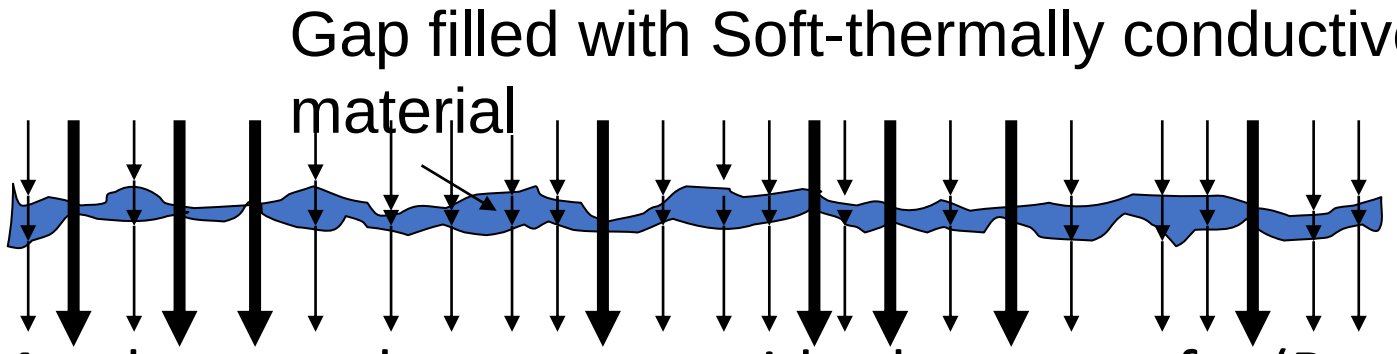
- Every surface to surface interface produces a resistance to heat transfer



- Point to point contact provides the majority of heat transfer (Air is a poor conductor of heat)

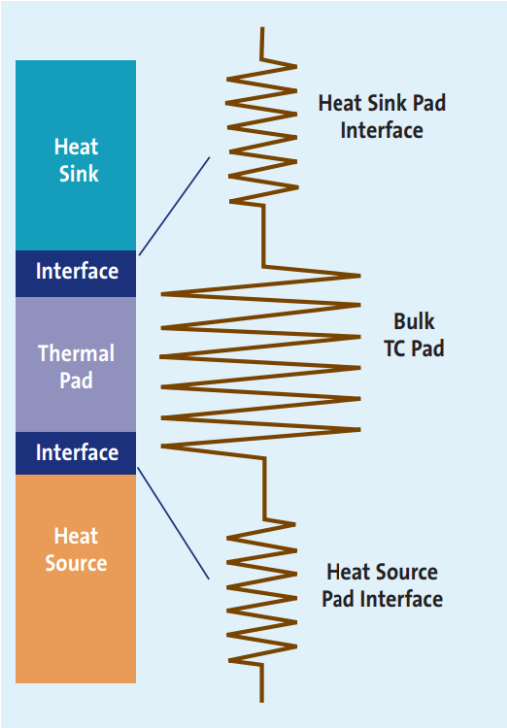
Interfacial Thermal Resistance

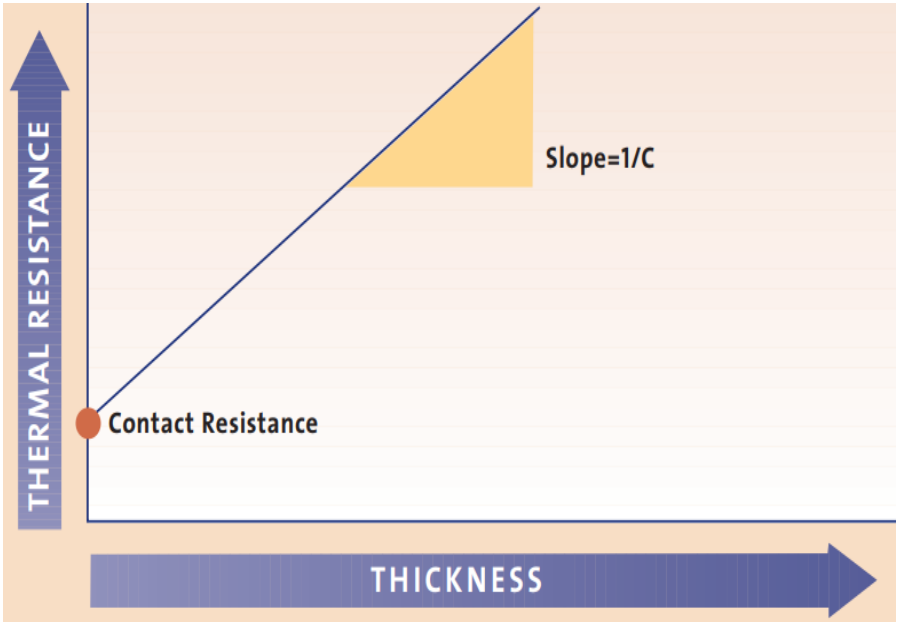
- Every surface to surface interface produces a resistance to heat transfer

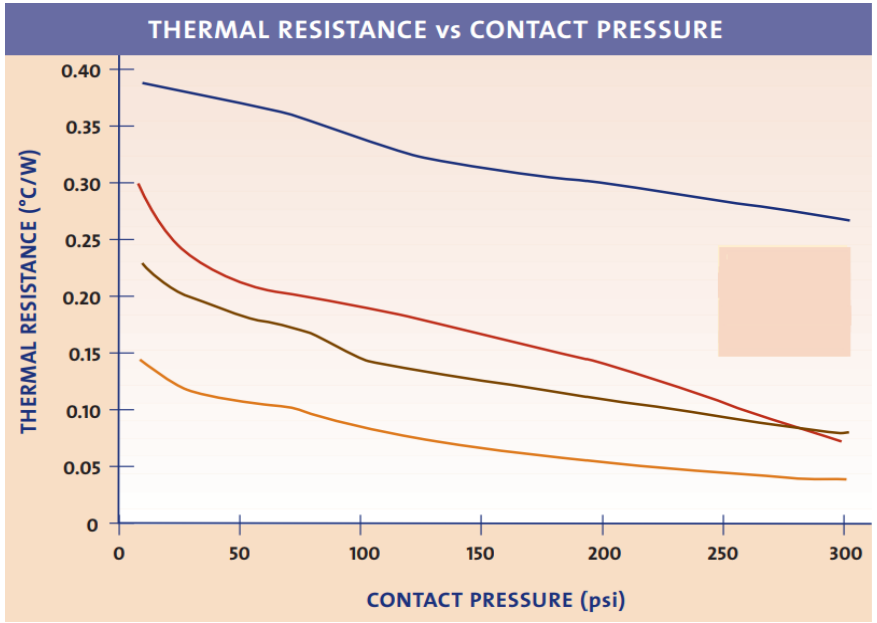


- Metal to metal contact provides heat transfer (Replace Air with a soft -thermally conductive material)

Material and Interfacial thermal resistance







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Trend in Thermal Interface Materials

Acrylic tapes and gap pads

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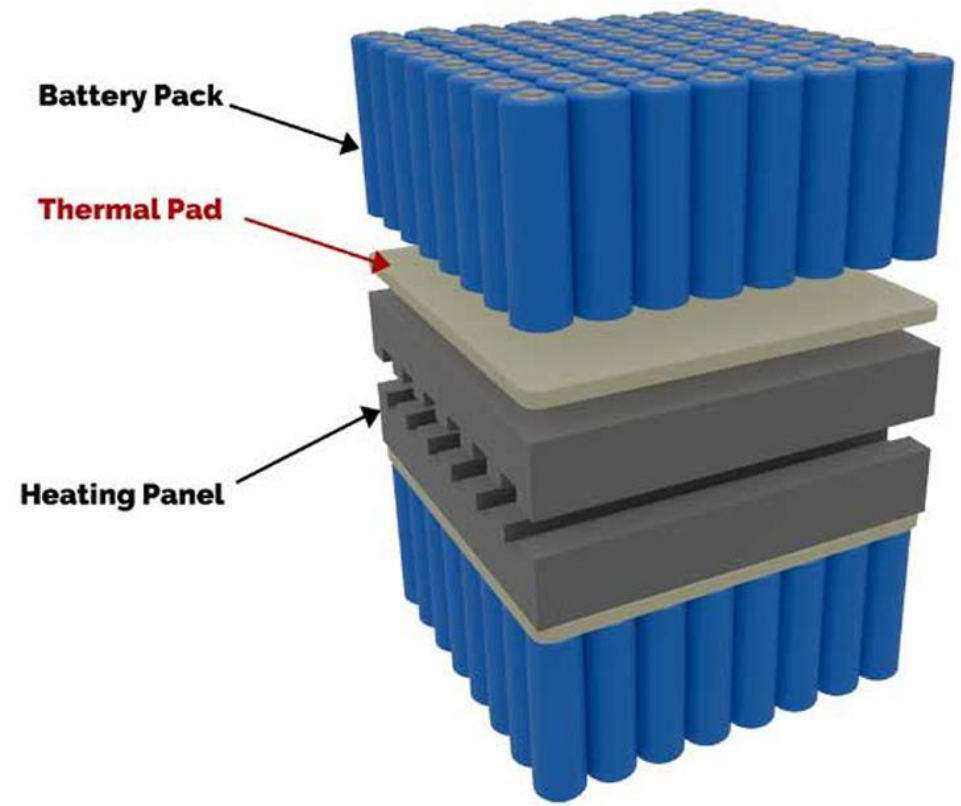
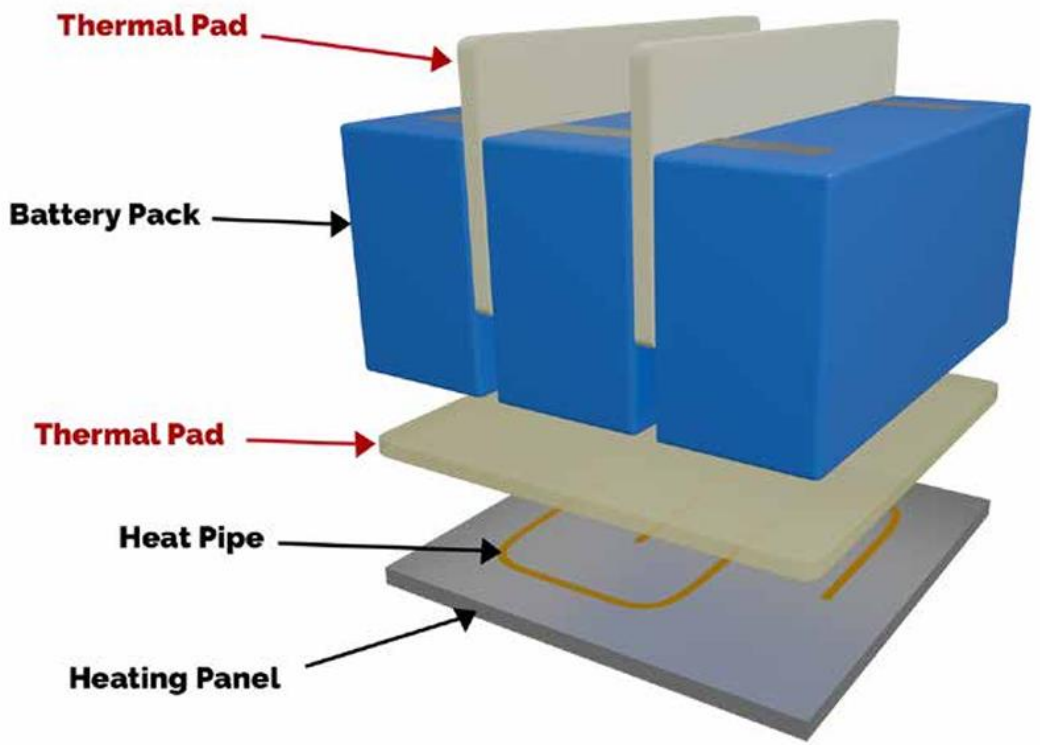
How it’s made

Typical application of conduction cooling





How can we help you?

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