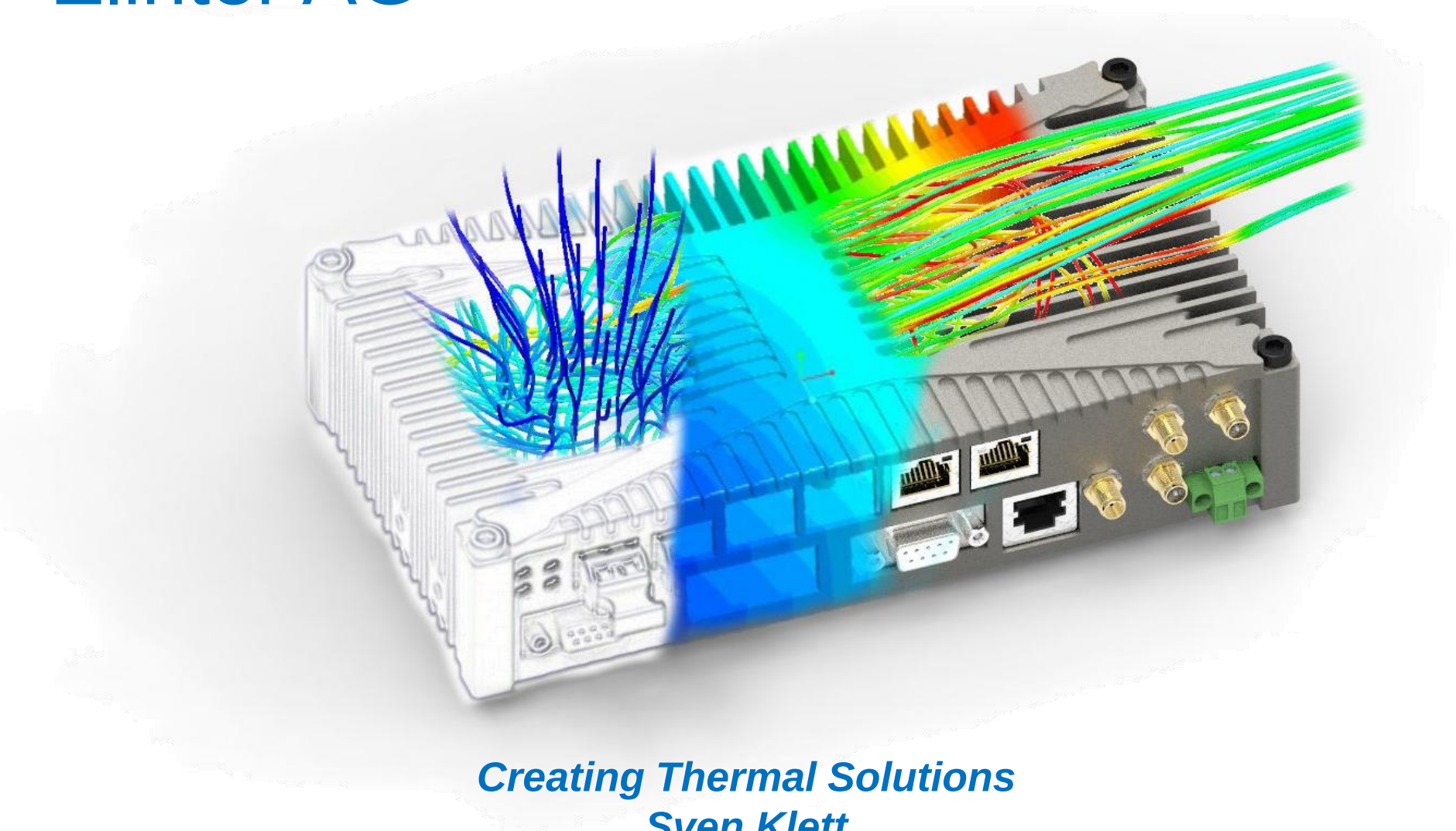
Elinter AG



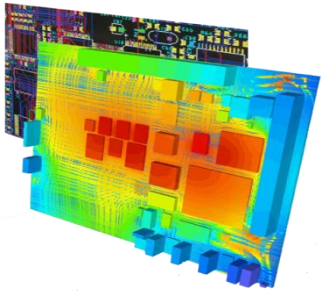
Creating Thermal Solutions

Sven Klett

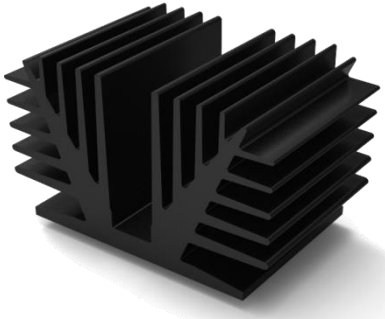
CTO Elinter AG

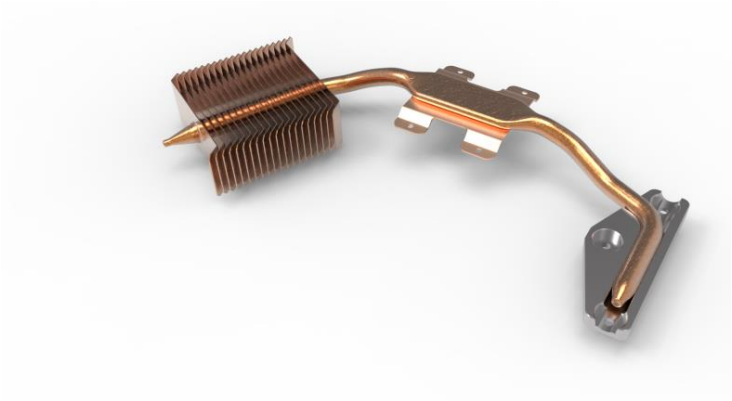
Core Knowhow

Thermal Simulation & Thermographie



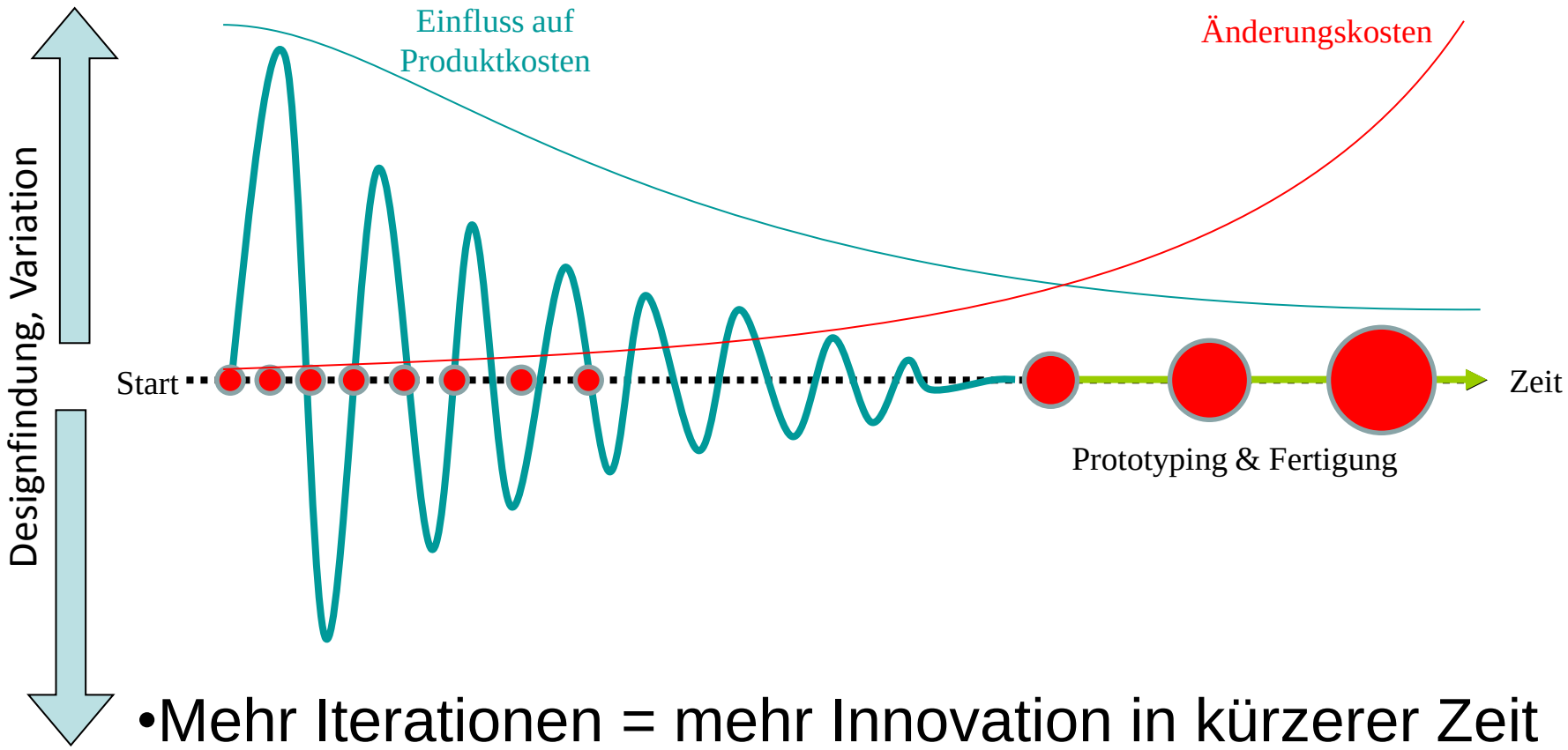
Cooling & Heating





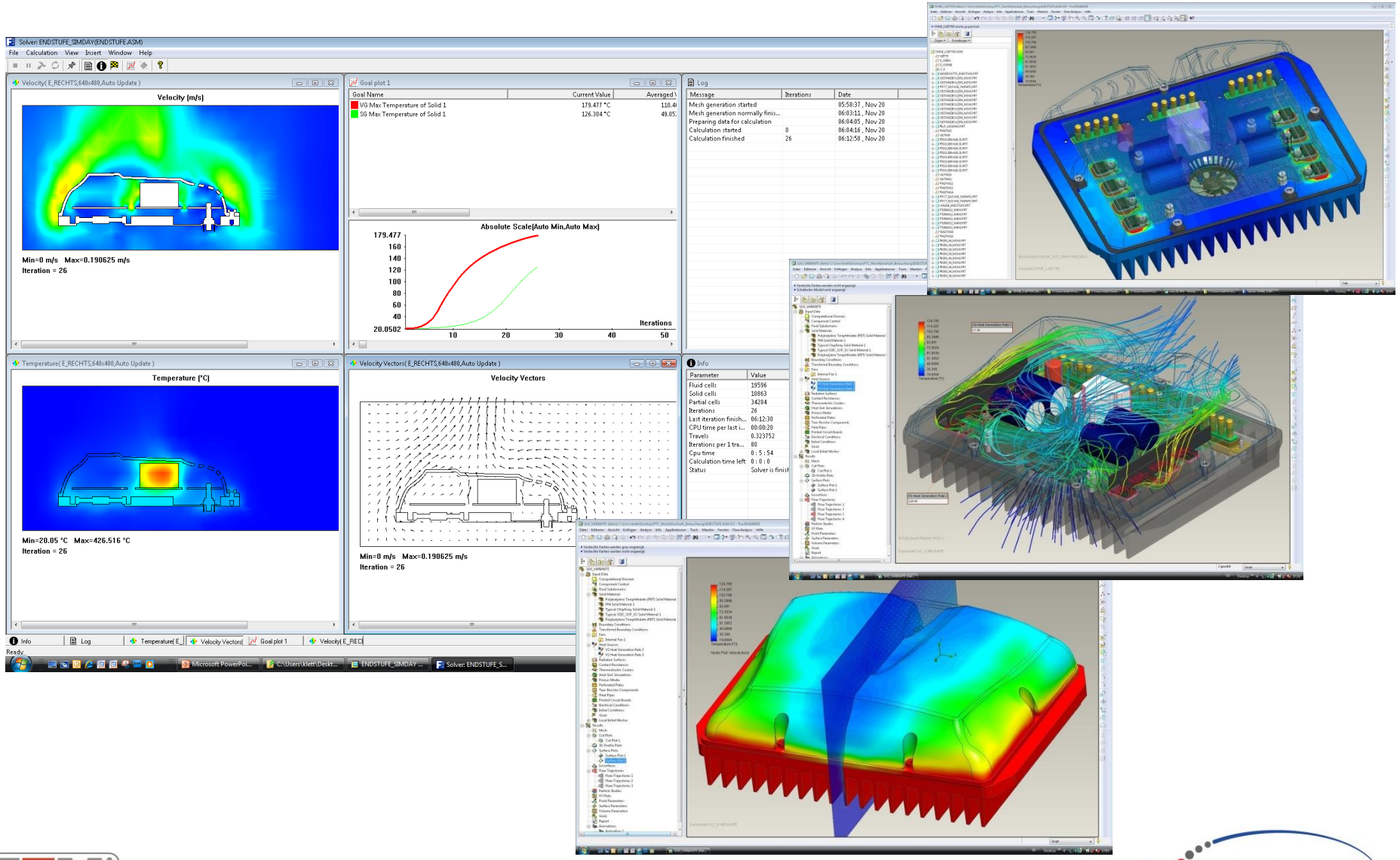
Housings, Systems & Production

Simulation in der Produktentwicklung



- Mehr Iterationen = mehr Innovation in kürzerer Zeit
- Weniger Prototypen = Niedrigere Kosten
- Mehr Produktknowhow = Nachhaltiger Vorsprung

Thermische Simulation heute

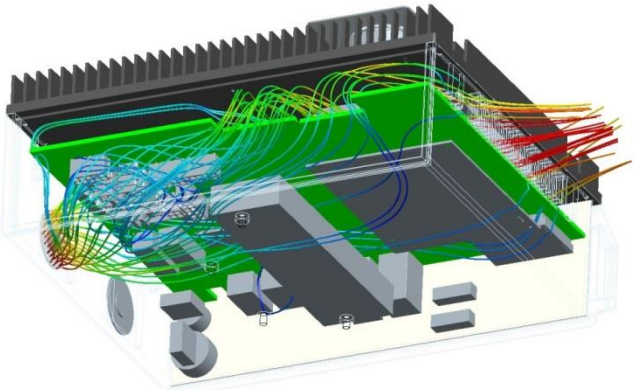


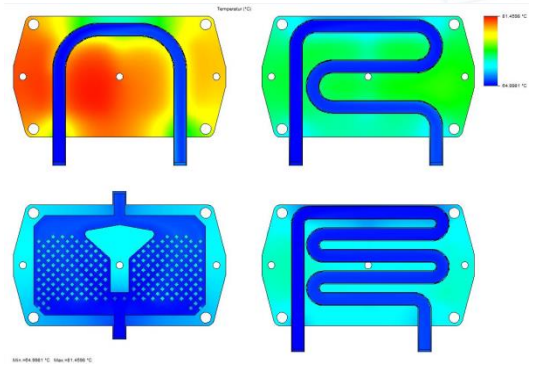
Mechatronikkühlung (passiv)

- Materialauswahl (Kunststoff, Metall, Keramik…)
- Passive Kühlung (stehende Luft)
- Einbaulage (Gravitation, Zuluft, Umgebungswärme)
- Strahlungskühlung (Oberflächen und Emissivität)
- Schlitze und Öffnungen (IP Schutzgrad, EMV…)
- Thermal Interfaces (Wärmeleitfolien, Pasten etc)
- Heatspreaders

Mechatronikkühlung (aktiv)

- Lüfter (Bauform und Leistung)
- Push oder Pull Anordnung
- Luftfilter
- Wasserkühlung
- Gehäusekennlinie
- Heatspreaders

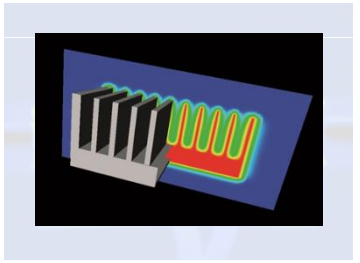




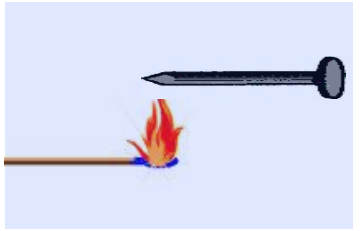
Grundsätzliche Kühlmöglichkeiten

- **Konvektion**
  → mittels Luft (Wasser)

- **Stahlung**
  → durch Luft (Vakuum) hindurch



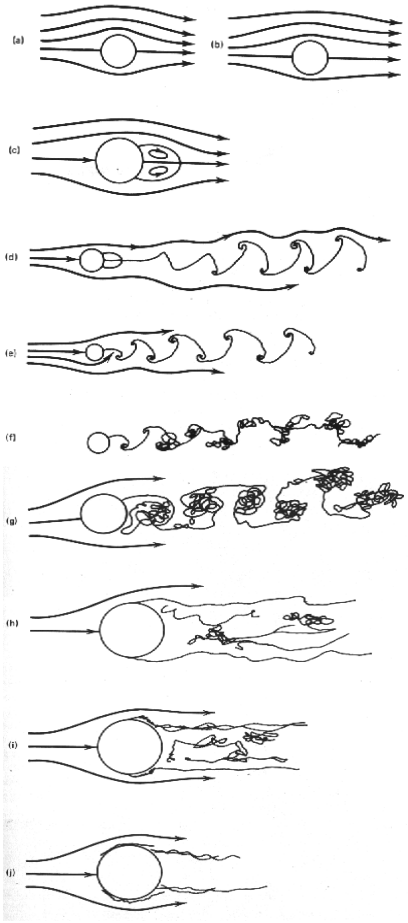
- **Konduktion**
  → **Wärmeleitung** in Festkörpern

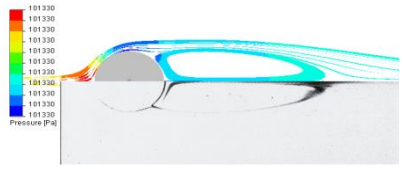


Wärmeübergangkoeffizienten

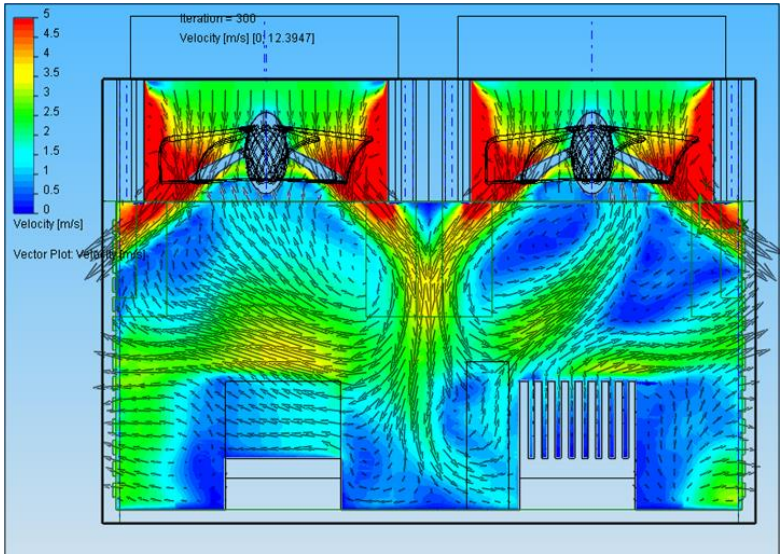
- Natürliche Konvektion:
  - Meist laminar
  - α abhängig vom Temperaturunterschied
    - Luft 2 – 8 (typ. 5) W/m^{2}K
    - Wasser 100 - 1000 W/m^{2}K

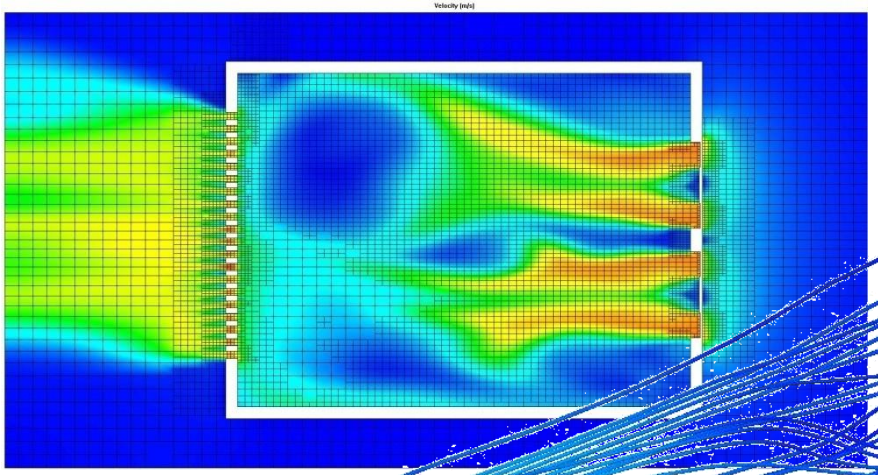
- Erzwungene Konvektion:
  - Meist turbulent
  - α abhängig von der Luftgeschwindigkeit
    - Luft 20 - 80 W/m^{2}K
    - Wasser 100 - 20000 W/m^{2}K



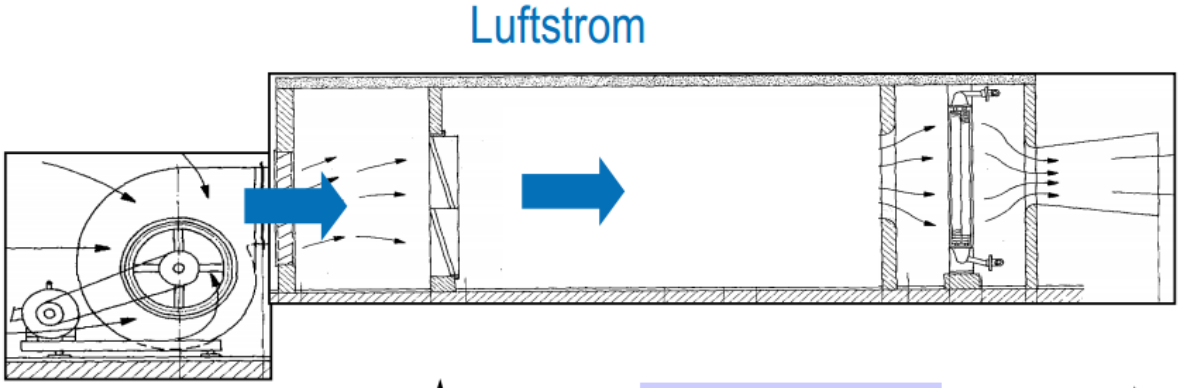


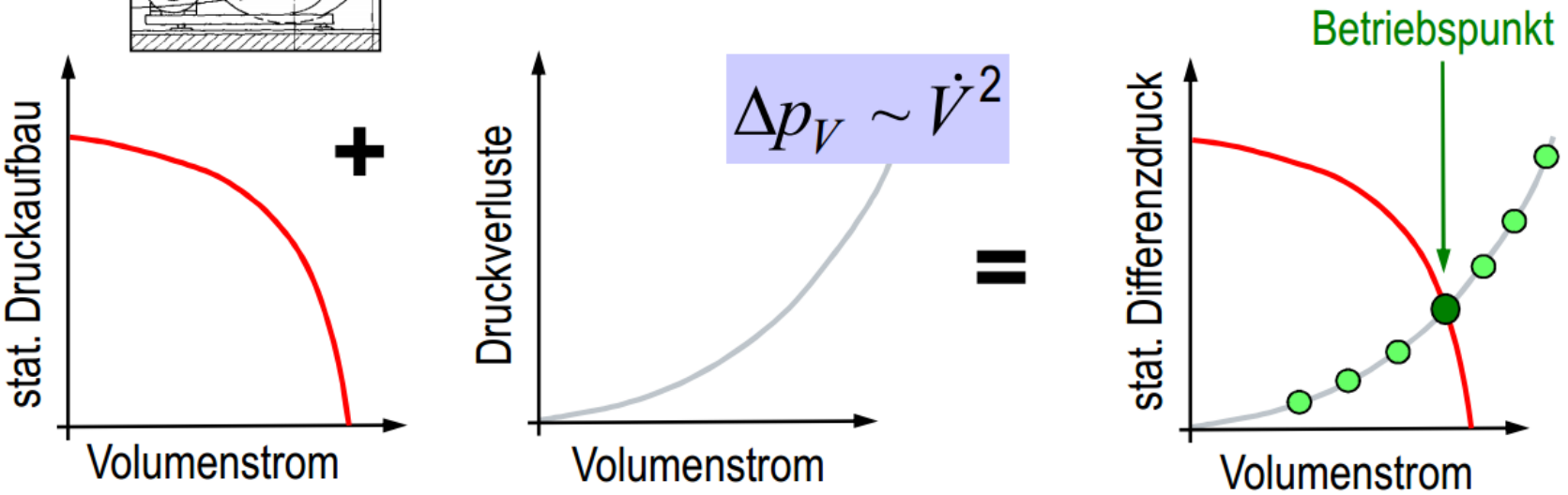
Aktive Kühlung mit Lüftern





Gehäusekennlinie

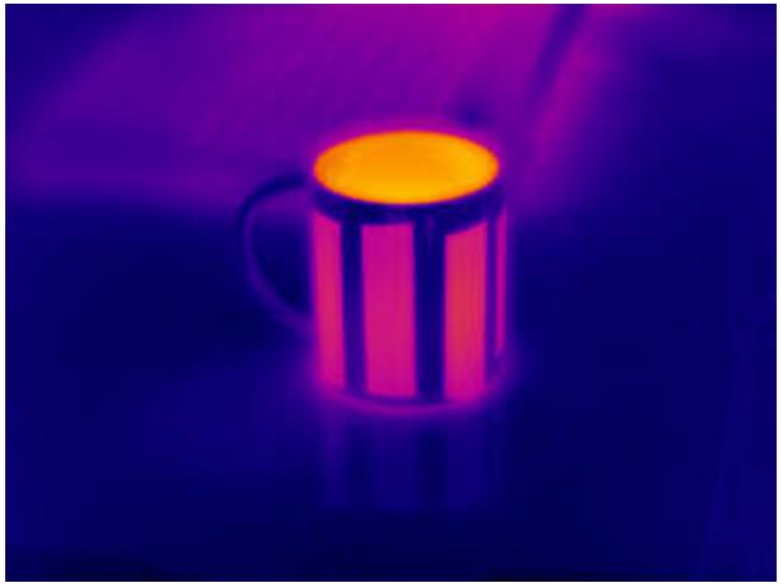




ebmpapst

Abgabe über Wärmestrahlung

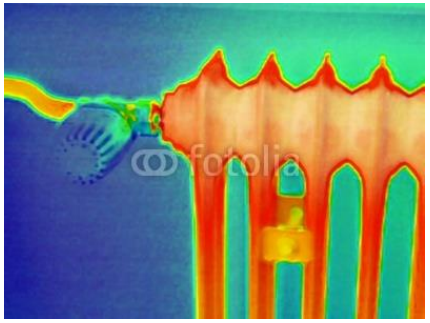
- **Strahlung -** Emissionskoeffizient ε_r



ε_r → 0% bei allen blanken Metallen (Al, Cu, SnPb, Ni/Au)

ε_r → 100% bei allen anderen Stoffen (Dicke > 10µm, Farbe egal)

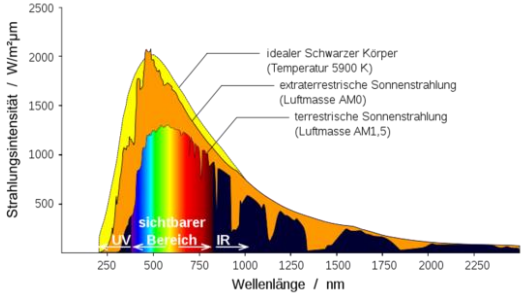
IR-Emissivität



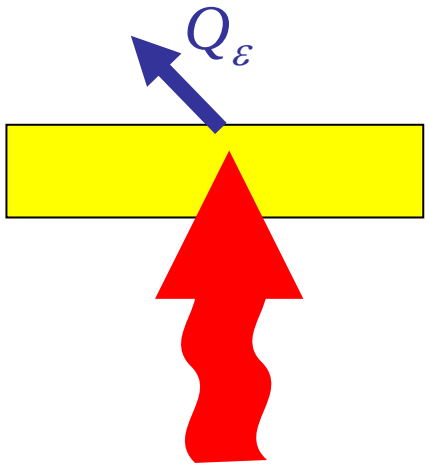
- **Unabhängig von der Farbe**
- **Oberflächenbeschaffenheit ist entscheidend**

Polierte Oberflächen = kleines ε

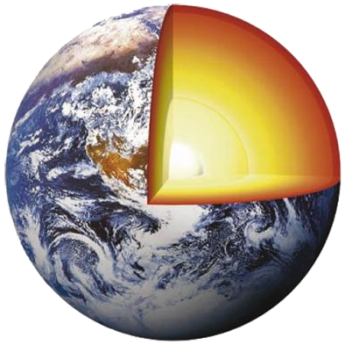
Beschichtete Oberflächen = großes ε

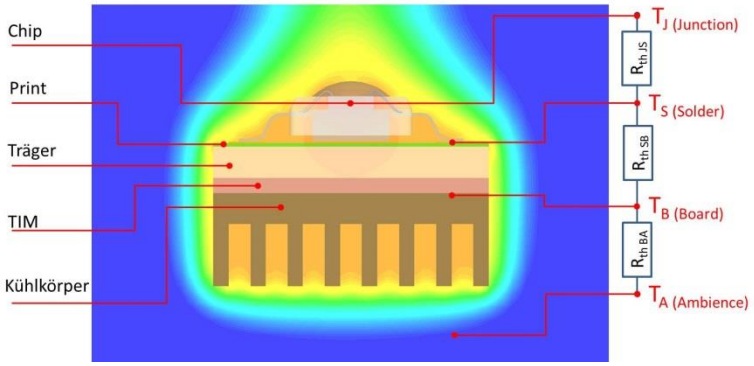


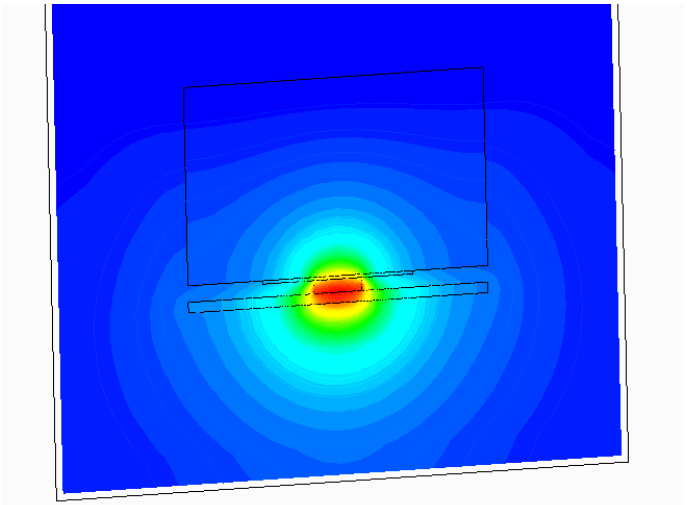
Material	Emissivität
Polierte Metalle	0.01-0.07
Oxidierte Metalle	0.25-0.7
Keramiken	0.4-0.8
Graphit	0.75-0.95
Organische Materialien	0.80-0.96
Farben	0.80-0.98



Wärmeleitfähigkeit



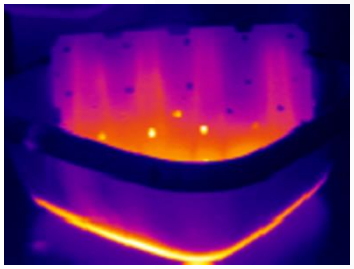


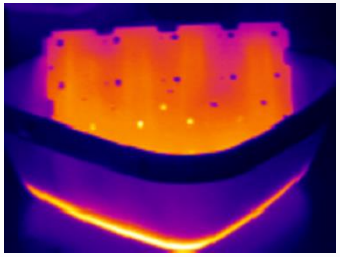


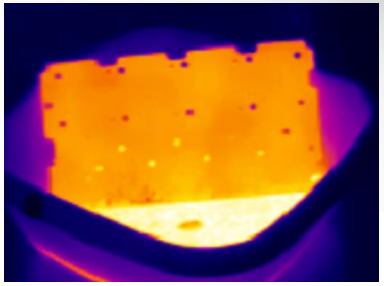
Material	Leitfähigkeit (W/mK)
Wasser bewegt	100-10'000
Heatpipe	typ 5'000
Kupfer techn.	300
Aluminium rein	220
Aluminum techn.	150
Silizium	120-150
Alu-Druckguss	90-110
Wasser	100-1'000
Luft - bewegt	20-80
Edelstahl	15
Kunststoffe	1-10
Wärmeleitpaste	0.5
FR4	0.3
Lacke	0.2
Luft	0.02-0.10

Heatspreaders

- Einfacher Aufbau
- Troubleshooter wenn kein Platz für Kühlung

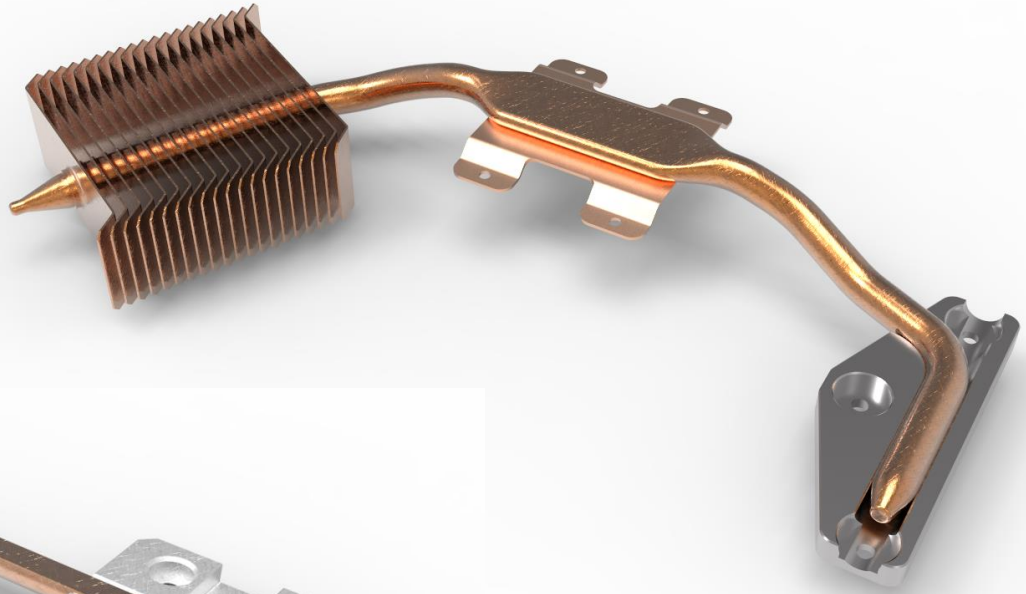


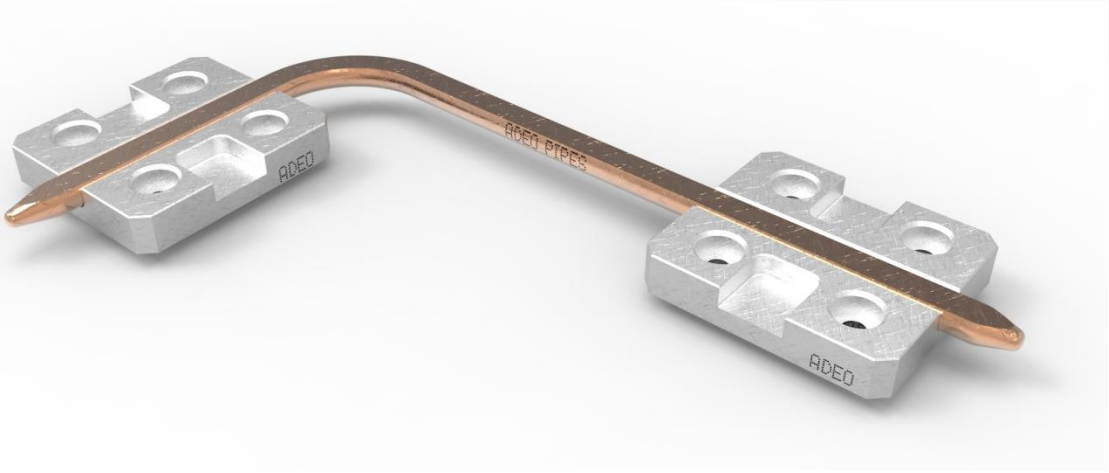




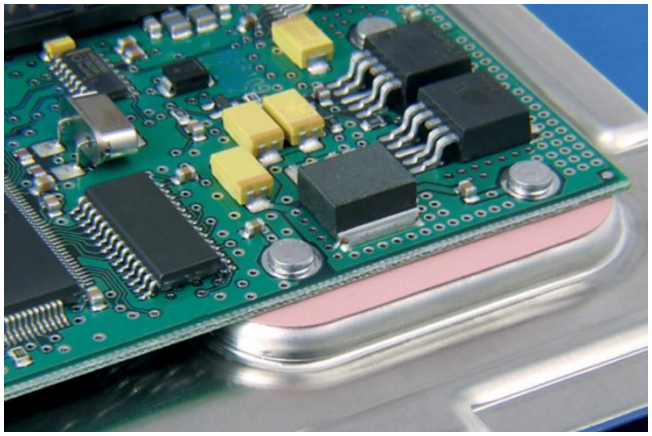
Heatpipes

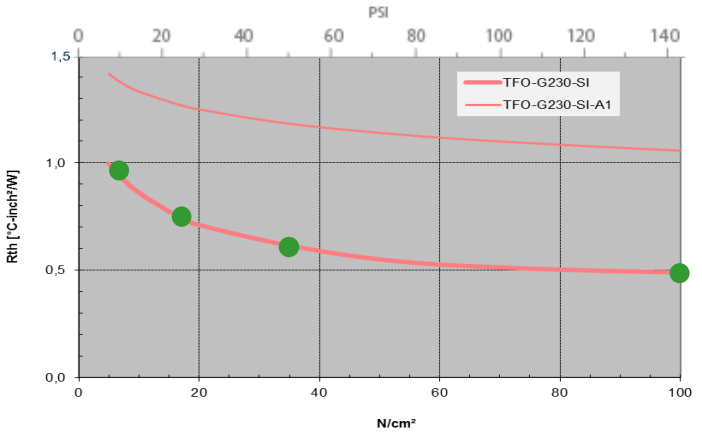
- Ultra kompakte Kühlsysteme
- Wärmeabfuhr da wo es Platz hat
- Passives System
- Wartungsfrei





Thermal Interface Material (TIM)



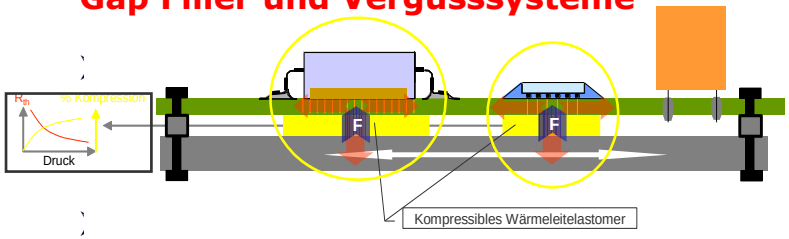


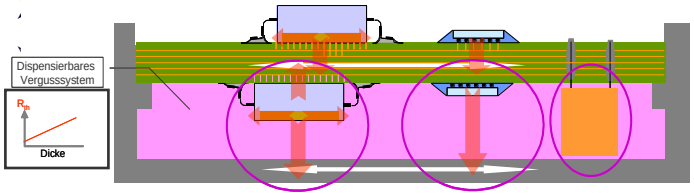
TYPICAL PROPERTIES OF SIL-PAD 900S					
PROPERTY	IMPERIAL VALUE	METRIC VALUE			TEST METHOD
Color	Pink	Pink			Visual
Reinforcement Carrier	Fiberglass	Fiberglass			—
Thickness (inch) / (mm)	0.009	0.229			ASTM D374
Hardness (Shore A)	92	92			ASTM D2240
Elongation (%45° to Warp and Fill)	20	20			
Tensile Strength (psi) / (MPa)	1300	9			20 MPa
Continuous Use Temp (°F) / (°C)	-76 to 356	-60 to 180			—
ELECTRICAL					
Dielectric Breakdown Voltage (Vac)	5500	5500			ASTM D149
Type 3 Electrodes	8300	8300			ASTM D149
Dielectric Constant (1000 Hz)	6.0	6.0			ASTM D150
Volume Resistivity (Ohm-meter)	10^{10}	10^{10}			ASTM D257
Flame Rating	V-O	V-O			U.L. 94
THERMAL					
Thermal Conductivity (W/m-K)	1.6	1.6			ASTM D5470
THERMAL PERFORMANCE vs PRESSURE					
Pressure (psi)	10	25	50	100	200
TO-220 Thermal Performance (°C/W)	3.96	3.41	2.90	2.53	2.32
Thermal Impedance (°C-in²/W) (1)	0.95	0.75	0.61	0.47	0.41

- **Highly dielectric > 5.5 kV AC**
- **High tensile strength 20 MPA through stronger glass fibre mesh**

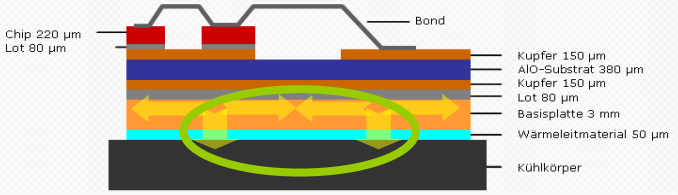
TIM- Typische Aufbautechniken

Gap Filler und Vergusssysteme

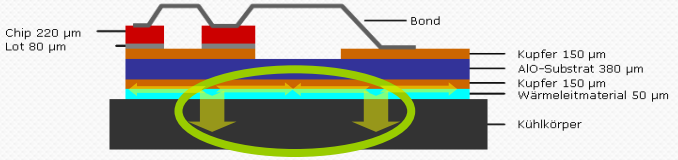




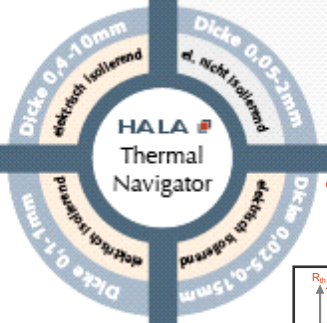
Therm. leitfähige Interfacematerialien



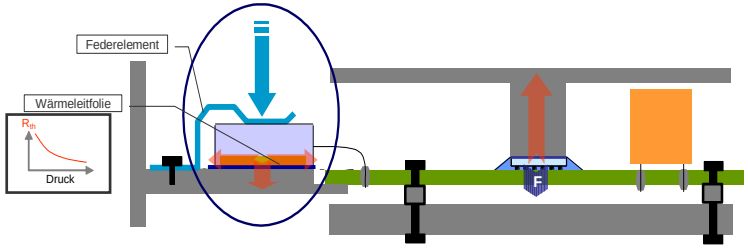
a) Typischer Modulaufbau mit Basisplatte (Kupfer)



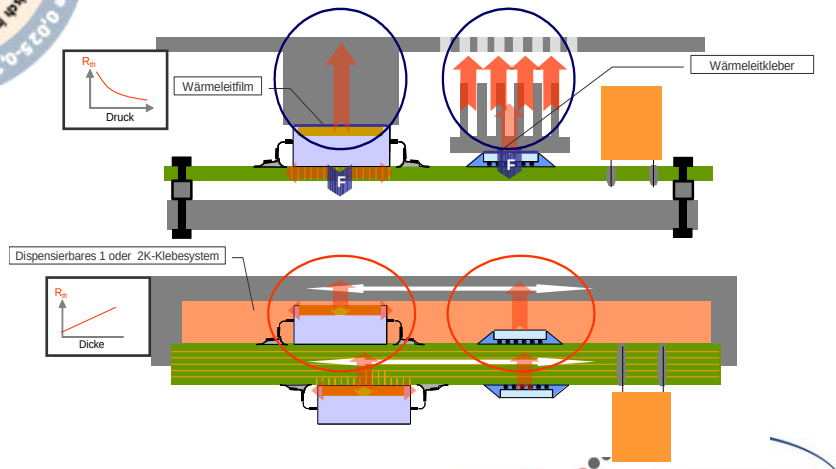
b) Typischer Modulaufbau ohne Basisplatte (Kupfer)



Therm. leitfähige Silikonmaterialien

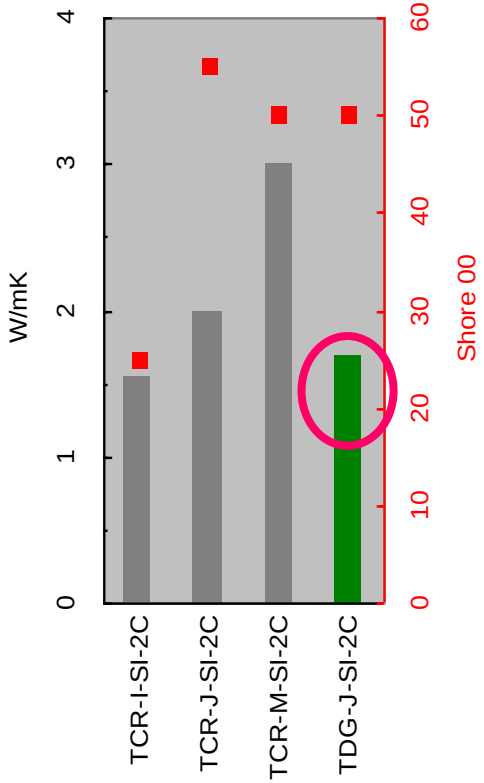


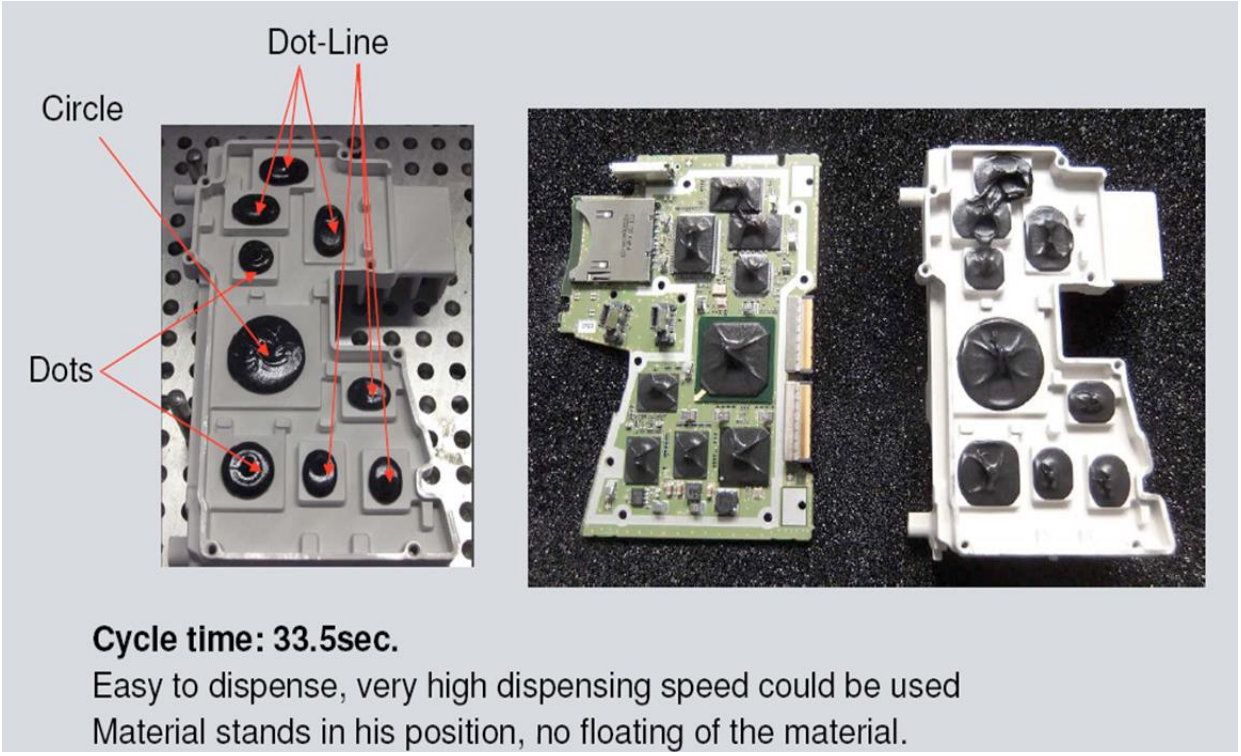
Therm. leitfähige Isolierfilme u. Kleber



Design In von Gap Fillern

Dispensable 2 Part Gap Filler





Cycle time: 33.5sec.

Easy to dispense, very high dispensing speed could be used

Material stands in his position, no floating of the material.