

# 3D printed micro cooler for power electronics

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Treffen bei der Firma Richter Elektronik

# IQ evolution GmbH

The coolers are produced by **SLM** procedure, the **Selective Laser Melting**.

The procedure is also known as LPBF (Laser Powder Bed Fusion).

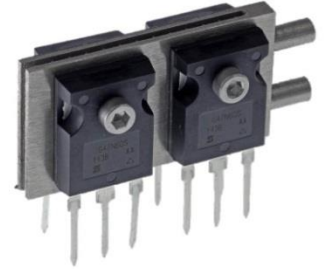
IQ evolution refined this 3D-metal-printing process over more than 10 years, specially to the requirements of building micro structures.

Rapid Prototyping and complex mass production are both efficiently producible with this technology.

For more informations about the 3D-printing process please use our download-center:

[http://iq-evolution.com/downloads\\_de/](http://iq-evolution.com/downloads_de/)

All our products are covered by registered patents.



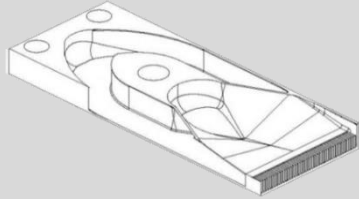
„IQ-Four“, for TO 247 housings



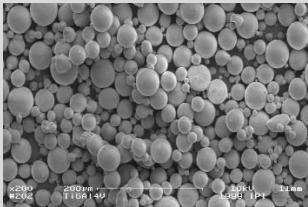
„PCC“, printed circuit cooler

Registered patents: US 9083138; US 12438336; EP 1672690; EP 2061078  
Patent pending : EP 18156325

# SLM, Selective Laser Melting

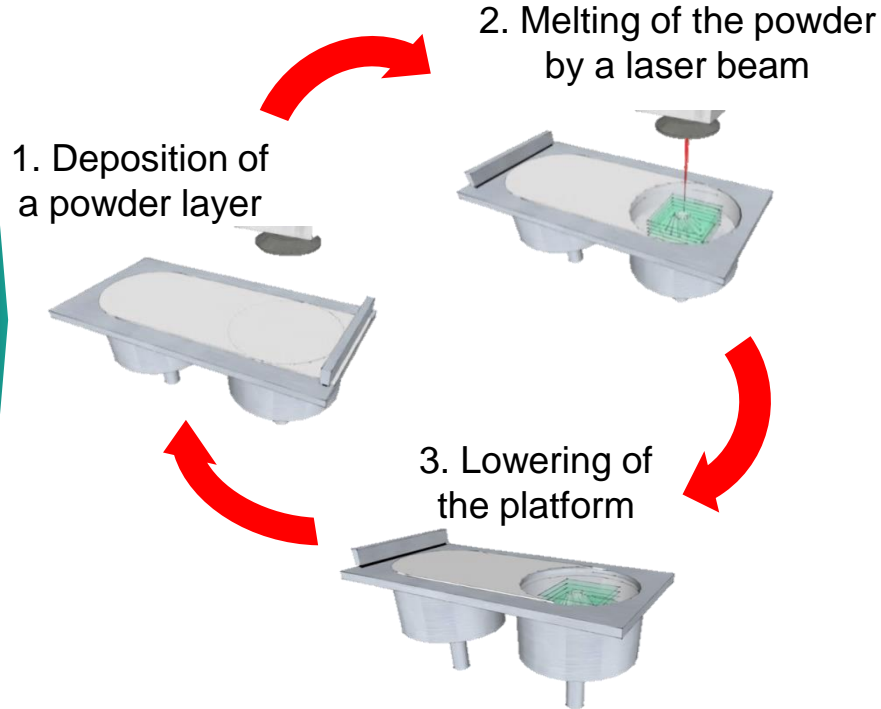


3D-CAD model  
in layers



Metal powder

## Overview SLM



Complex parts  
produced with final  
dimensions



# Customized Microcooler

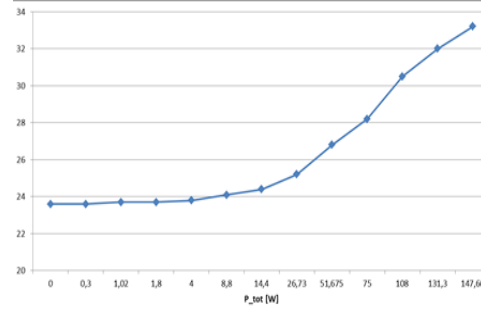
## Prototypes

- + Customers Design
- + Creating 3D Model
- + Pre-Processing
- + Select material
- + Finding parameters
- + Building the first parts



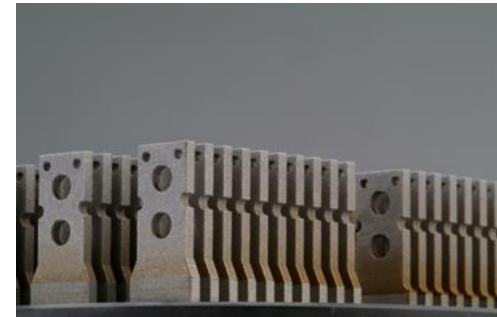
## Testing / controlling

- + Geometrie
- + Wall thickness
- + Flow rate
- + Cooling performance
- + Lifetime



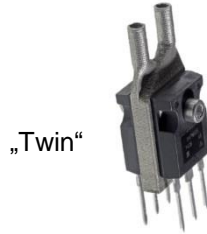
## Series

- + Production capacity
- + Availability
- + Reproducibility
- + Reliability

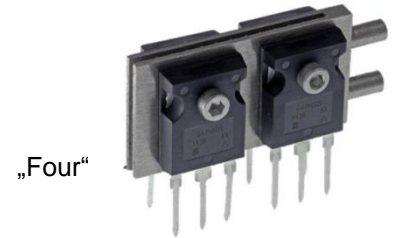


# Standard cooler for TO-247 housing

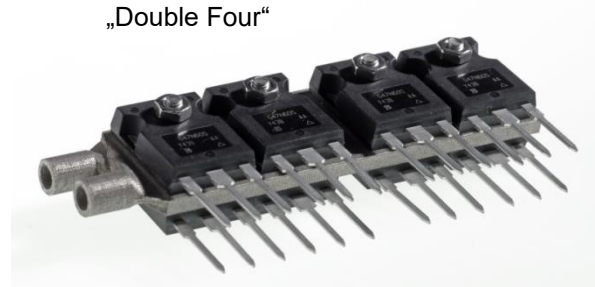
The first standard coolers were made for cooling high power components in TO-247 housings.



The coolers are available for the cooling of two, four and eight housings at the same time.



Beside the design for TO-247 housings, all other housing types are available. Customized designs in other shapes and thicknesses are also possible.



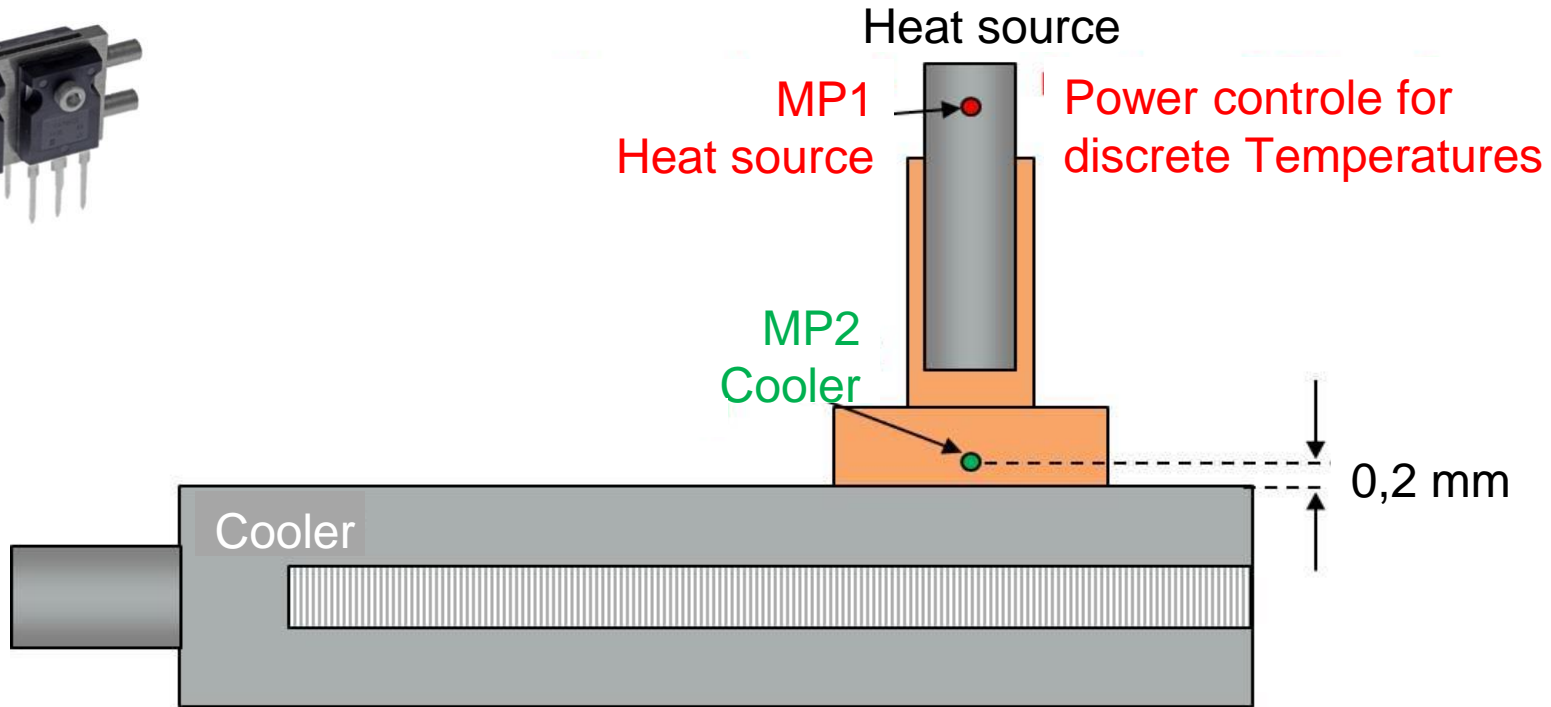
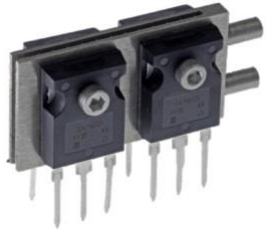
# „IQ-Thincooler“, alternative designs

Due to the manufacturing procedure of 3D metal printing a lot of alternative designs are possible.

No special tools are necessary, the complexity of the parts causes no extra expences, only the size defines the costs.



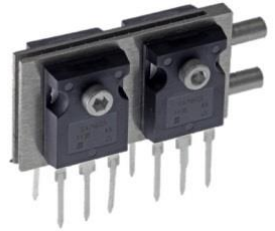
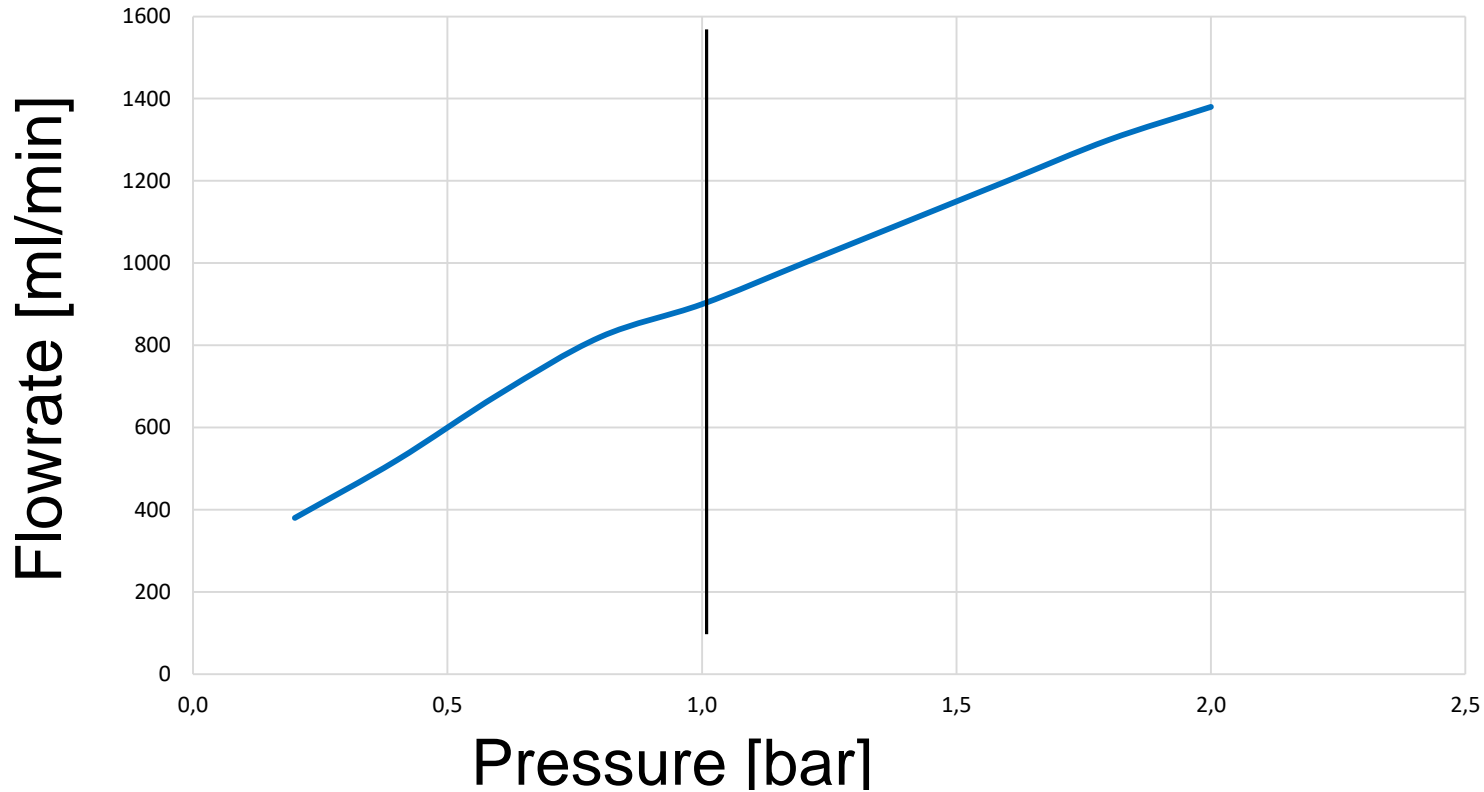
# Measurement of „IQ-Four“ Transistor cooler, setup



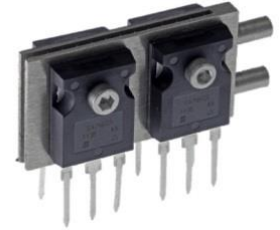
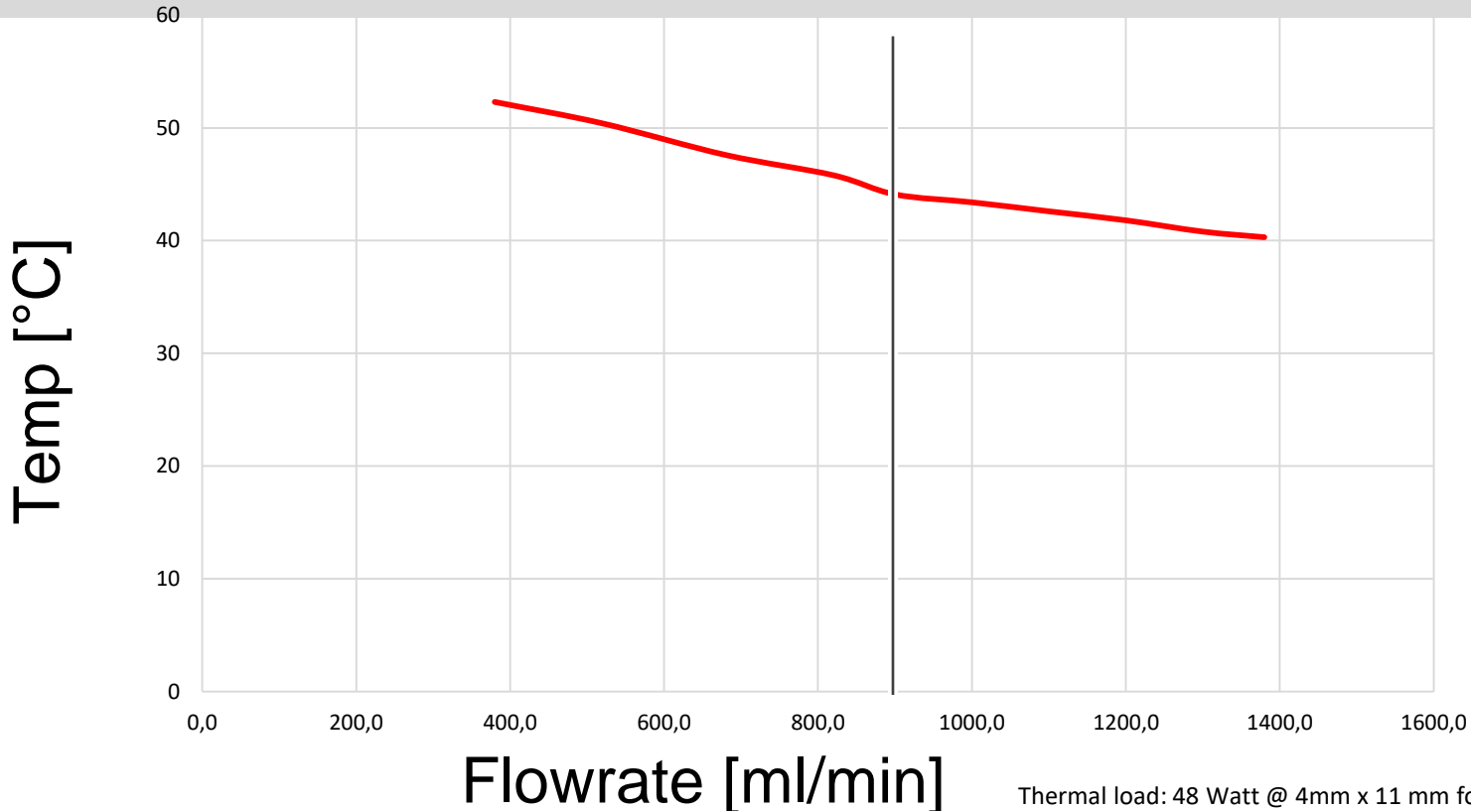
75 Watt @ 4mm x 11mm footprint → 170 W/cm<sup>2</sup>, water inlet temperature 20°C



# Measurement of „IQ-Four“ Transistor cooler, flowrate



# Measurement of „IQ-Four“ Transistor cooler, temperature

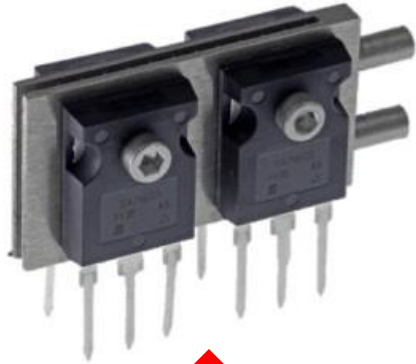


Thermal load: 48 Watt @ 4mm x 11 mm footprint → 110 W/cm<sup>2</sup>

Water inlet temperature: 23°C

# Measurement of „IQ-Four“\* Transistor cooler, 4 Mosfets @ 50A\*\*

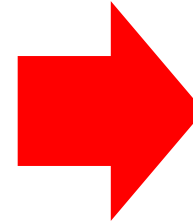
\*Design by Diabatix  
Material 1.4404



Water outlet temp.: 41,57°C



Water inlet temp.: 32,16°C



**670,61 Watt**

**Over all thermal load: 757,00 W**

**Thermal load Mosfet: 723,15 W**

- Mosfet 1: 181,35 W
- Mosfet 2: 182,15 W
- Mosfet 3: 180,50 W
- Mosfet 4: 179,15 W

**Final cooling performance  
via water cooling:**

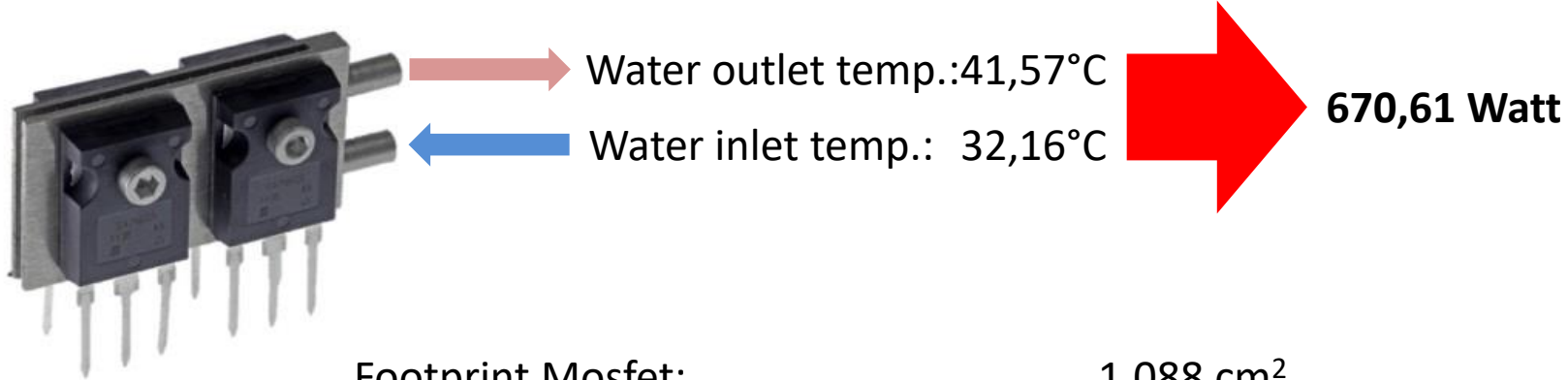
**670,61 W**



**757,00 Watt**

# Measurement of „IQ-Four“\* Transistor cooler, 4 Mosfets @ 50A\*\*

\*Design by Diabatix  
Material 1.4404



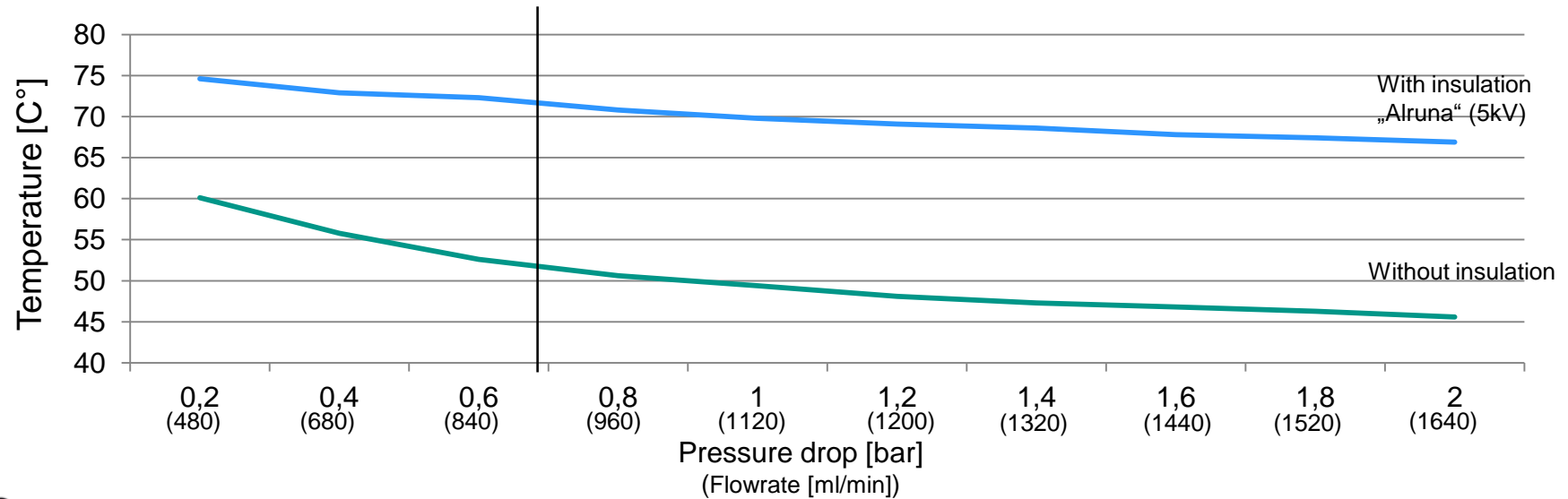
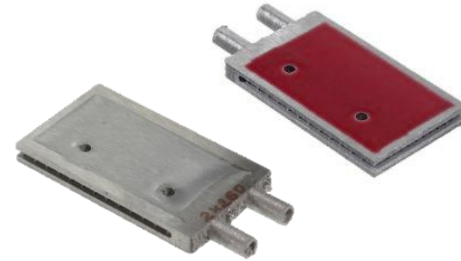
Footprint Mosfet:	1,088 cm <sup>2</sup>
Cooling performance (average):	167,65 W/Mosfet
Heat density / Mosfet:	154,09 W/cm <sup>2</sup>

\*\*C3M0016120K Silicon Carbide Power MOSFET mounted with Hi-Flow® 300P insulating foil, 1,025 ml/min@1,2bar

# „IQ-Four“ with insulated surface

All IQ evolution cooler are available with electrical insulation of the cooler surface.

The kind of insulation depends of the customers demand, e.g. needed disruptive strenght, and has an influence of the cooling performance.



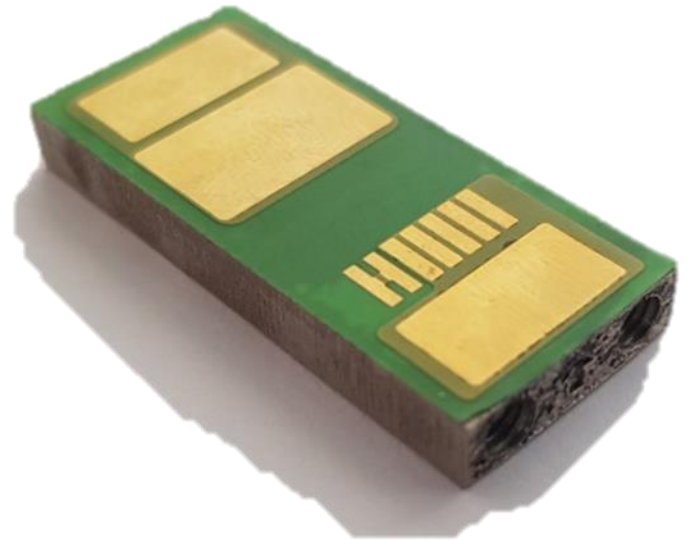
75 Watt @ 4mm x 11mm footprint → 170 W/cm<sup>2</sup>, water inlet temperature 20°C

# „IQ-PCC“, printed circuit cooler

Insulating the coolers surface is just the first step.  
Step two:

→ Creating a complete circuit on the coolers surface!

- Manufactured by Selective Laser Melting (SLM) and standard PCB process
- Material: 1.4404
- Thickness: 4 mm
- Cooling performance up to 1.000 W
- Suitable for direct mounting



# Application samples, bi-directional DC/DC converter

In cooperation with the „Institut for power electronics and electrical drives“ of the RWTH-Aachen University, a DC / DC converter was developed as an application sample of the „IQ-Thincooler“. By using the 3D printed micro coolers and take advantage of the miniaturizing potential, the partners created a impressive sample:

Discrete 1000-V-SiC-MOSFETs with Kelvin-Source:

- Wolfspeed C3M0065100K
- 65 mΩ
- Three times less switching losses

Sensor integration:

- In- and outlet voltage
- Current phase

FPGA and MCU:

- Loop controle
- PC communication
- Without electrical connection to power electronic



$P_{out,max} = 20.6 \text{ kW}$

- 98.1 kW/l

-  $V_{in} = 400 \text{ V}$

-  $V_{out} = 800 \text{ V}$

-  $f_s = 450 \text{ kHz}$

# Application samples, „In-Board“ cooler

- Active water cooler inside the board
- Material: Nickel\*
- Cooler thickness: 0.8 mm, Board 1.3 mm
- Cooling performance: up to 500 W
- Adapted for integration in
  - conventional boards
  - Multilayer-HF boards
- Developed after IMST\*\*-Specification
- Only a third of weight in comparison to a similar board with copper core

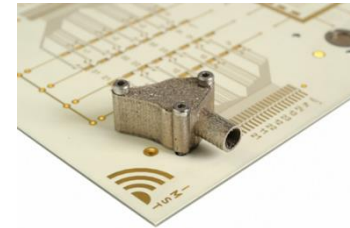
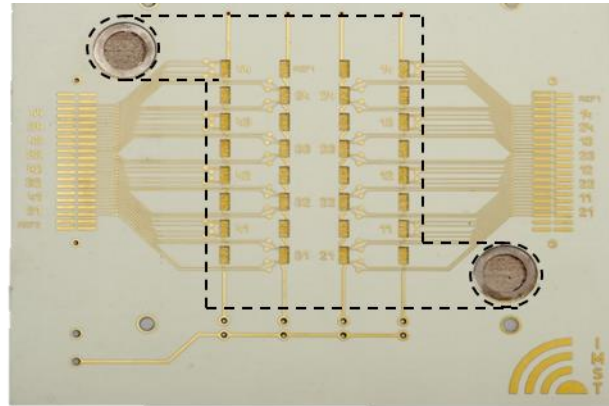
\* Long-time resistant against deionized water



Thin-cooler 0.8mm



Inlet with O-ring seat



Connected water inlet

Dashed line: contour of the integrated cooler



# „In-Board“ cooler, measured data\*

Location: Row 2 of 4

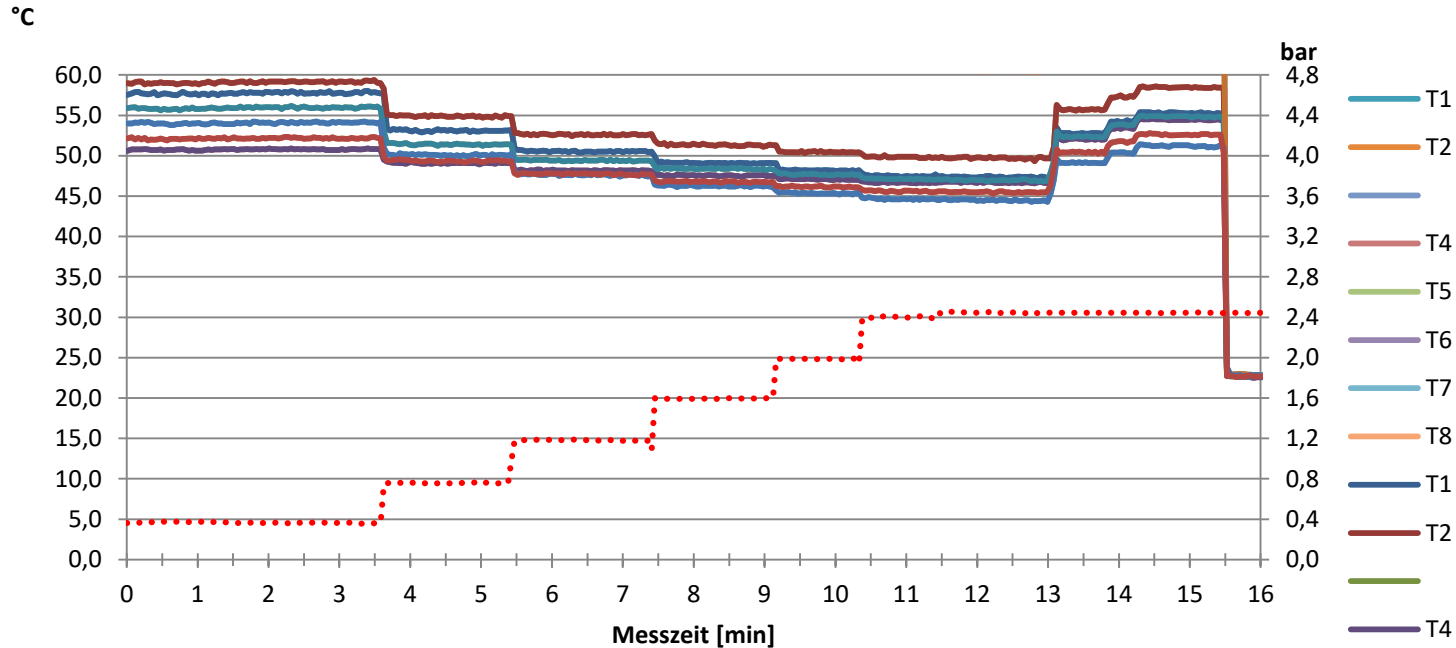
Thermal load: 24 W/row

Click for  
Video clip



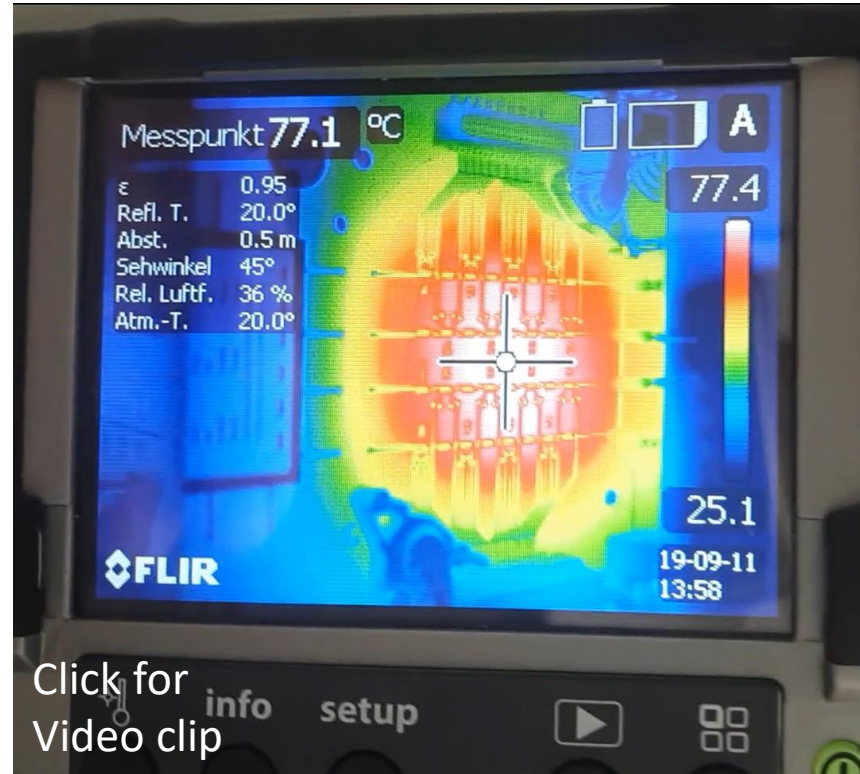
# „In-Board“ cooler, measured data\*

## Temperaturverlauf bei 97 W | 133 W

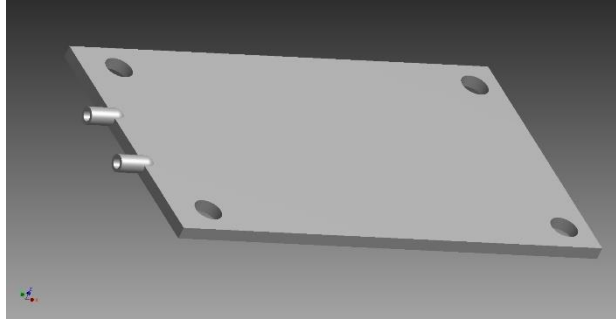


# „In-Board“ cooler, measured data\*

Location: Row 1 to 4  
Thermal load: 24 W/row

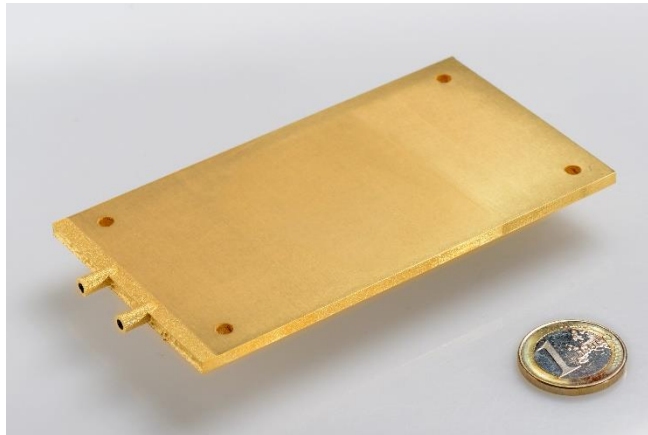


# Project: IGBT Cooler, „IQ-BIG“



IQ und ISEA

Schritt 1: „IQ-BIG“ zur Kühlung herkömmlicher IGBTs



IQ und ISEA

Schritt 2: Direktmontage der IGBT Chips ohne Gehäuse

# Project: IGBT Cooler, „IQ-BIG“

Schritt 1: „IQ-BIG“ zur Kühlung herkömmlicher IGBTs  
Schritt 2: Direktmontage der IGBT Chips ohne Gehäuse



IQ und ISEA

Schritt 3: Direktmontage der IGBT Chips mit modifiziertem Gehäuse  
und / oder  
Schritt 4: Direktmontage von modifizierten IGBT Chips  
im modifiziertem Gehäuse



IQ, ISEA und  
Externer  
Partner

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