HIGH PERFORMANCE PCB SYSTEM

Miniaturisation: HDI & **Thermal Management** & Printed Polymer

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

HIGHLY RELIABLE PRINTED CIRCUIT BOARDS AND DEVICES IN AUTOMOTIVE ELECTRONICS

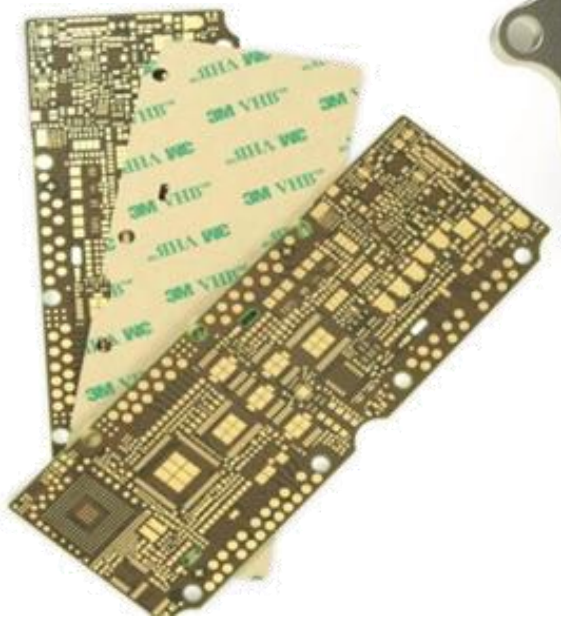
Based on an Example of a High Performance PCB System

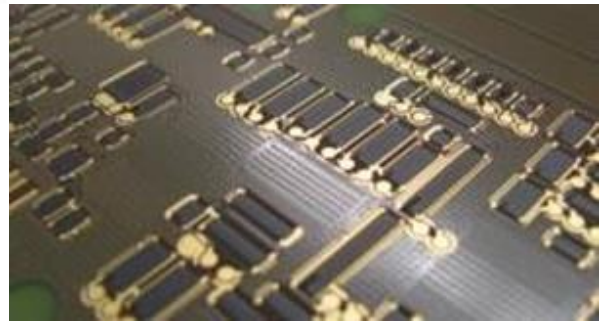
1. Miniaturisation
   - HDI Technology
   - Reliability and Verification by IST

2. EmbR – printed embedded resistors
   - Performance – Tolerances
   - Reliability

3. **Thermal Management**
   - **Thermal vias**
   - **Heat Sink**
   - **Thermal Simulation**

4. Costs
   - PCB replaces Ceramics



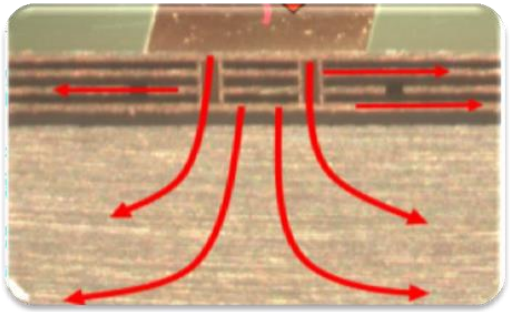


THERMAL MANAGEMENT

General Introduction

Options on PCB basis

- Heat dissipation using vias
- Heat spreading using planes and heatsinks glued onto the PCBs

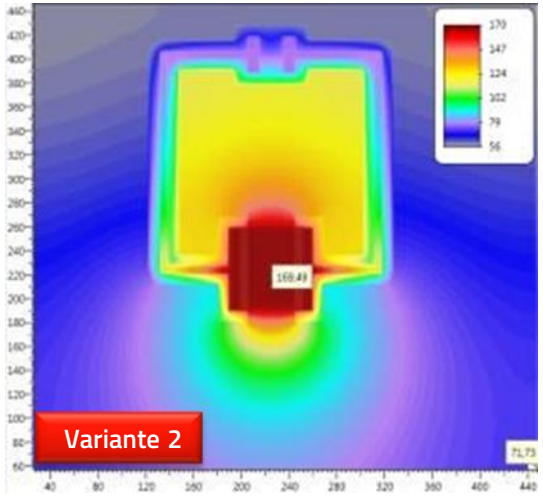


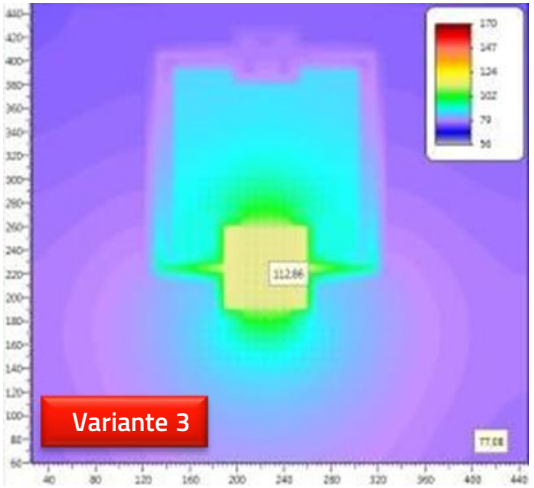
Targets

- Lowering of temperature at the component
- Avoiding critical temperatures inside of the component and unit
- Extention of lifetime and ensure of long term reliability of the unit

- Thermal Simulation

At threshold a thermal simulation in preliminary stages is recommended.



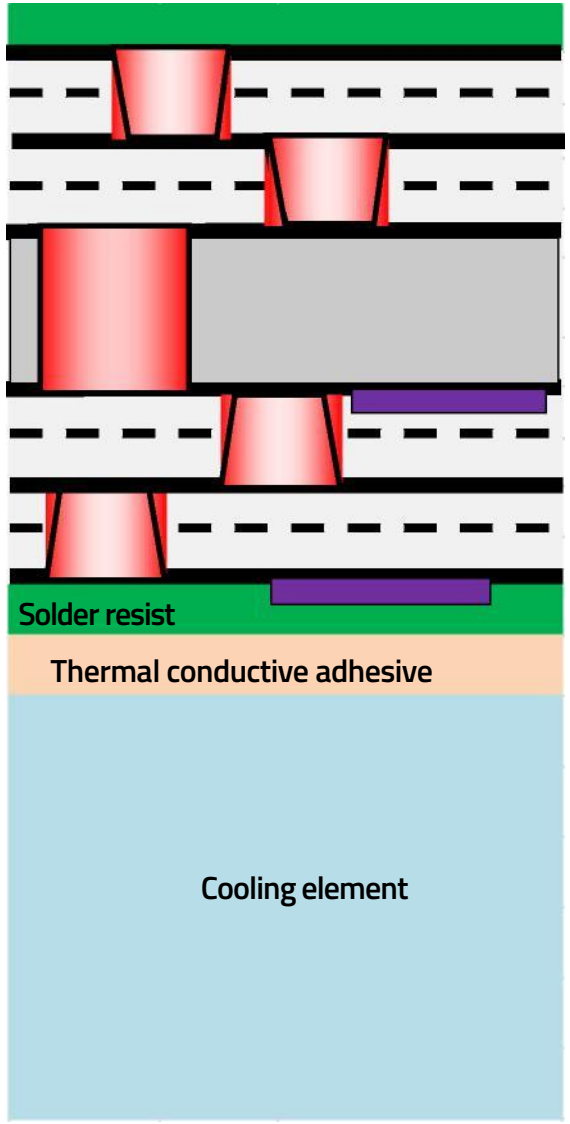


THERMAL MANAGEMENT

PCB System

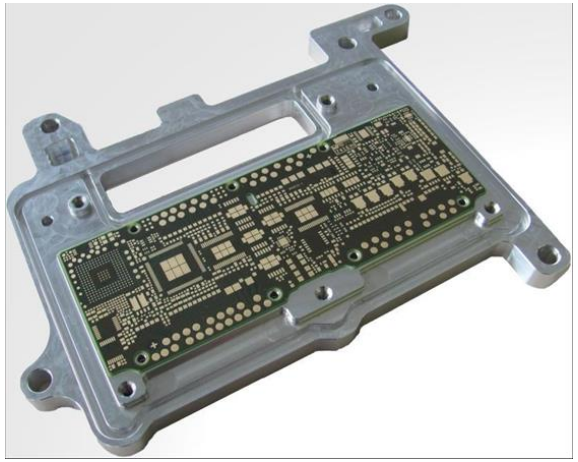
Requirements to the system

- Operating temperature 140 °C, for short time 150 °C
- ALU cooling element with high surface finish quality
  - Thick wire bondable
  - Sufficient adhesive strength in connection with thermal conductive adhesive
  - New logistical challenge for the PCB manufacturer



Optimized Thermal Management

- High number of Microvias (directly in solder pads) and buried vias
  - Large cross section
  - Low thermal resistance
- Thin thermal conductive adhesive 50 µm, EmbR very close to heat sink (cooling element)

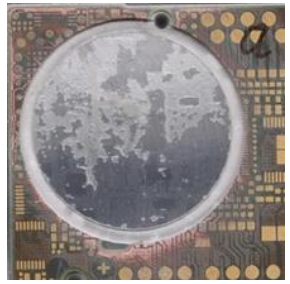


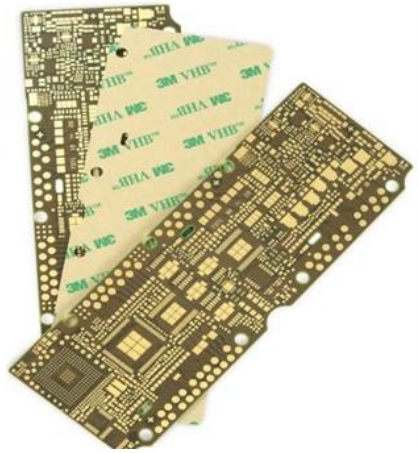
THERMAL MANAGEMENT

Adhesive Bond Strength

Proof of Adhesion of PCB to ALU heat sink

Target: approx. 0.60 N/mm²





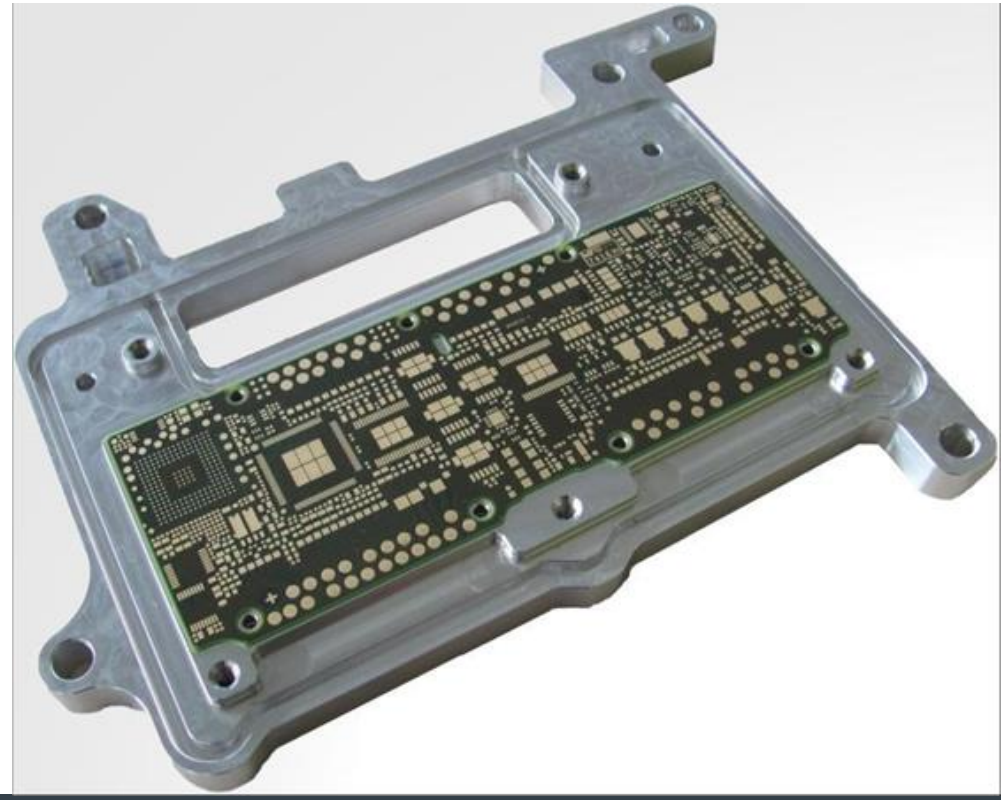
Pretreatment

- TCT (-40 °C/ +155 °C) 1.000 Cykles
- Climate chamber 1000 h (85 °C / 85 % humidity)
- High Temperature Exposure (HTE Test) 1000 h in oven / 155 °C

Result

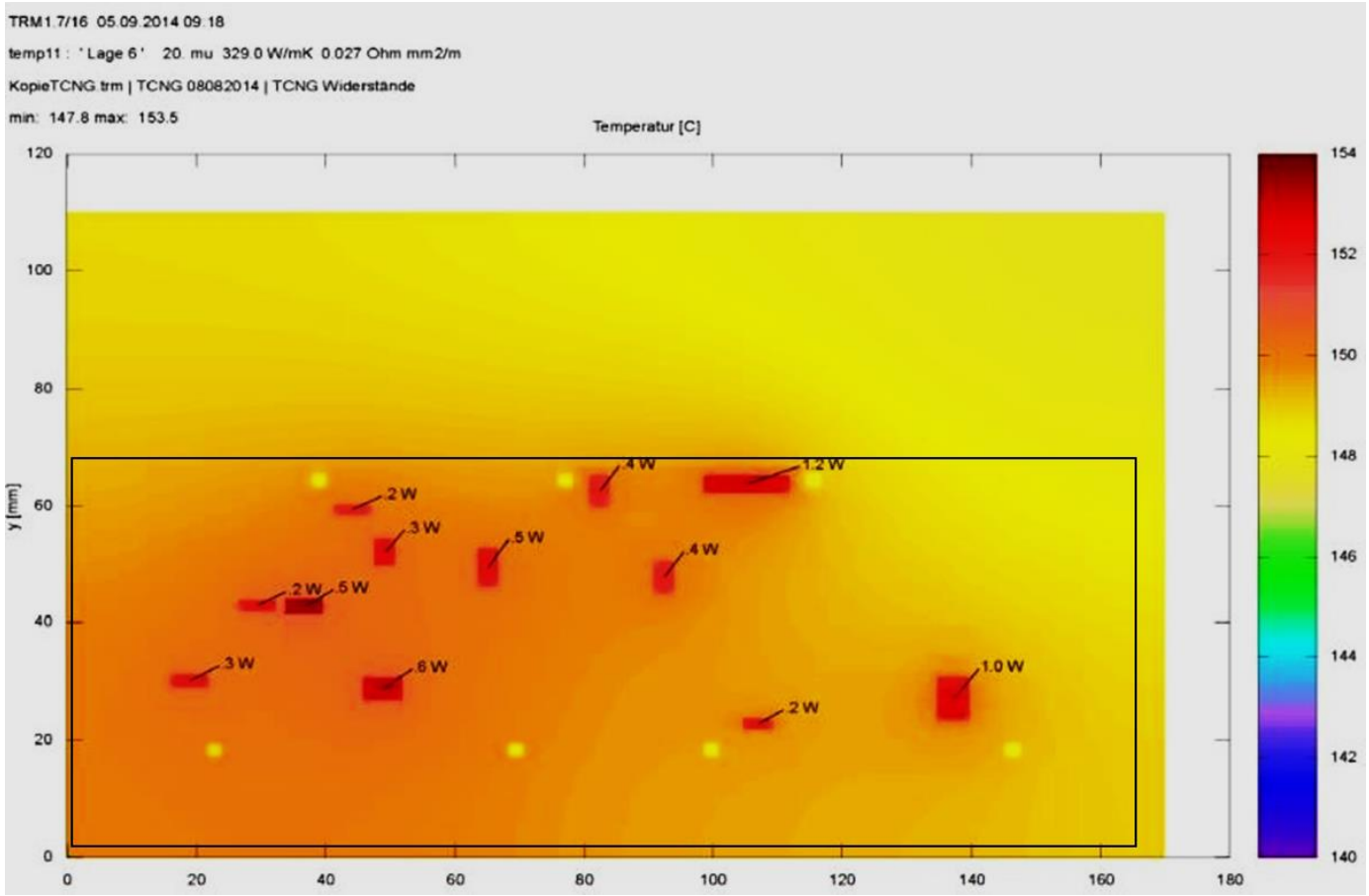
For a good adhesive bond are required:

- Bonding under consideration of defined pressure, temperature and time parameters
- Surface tension ALU min. 38 mN/m



THERMAL MANAGEMENT

Simulation PCB Bottom Side



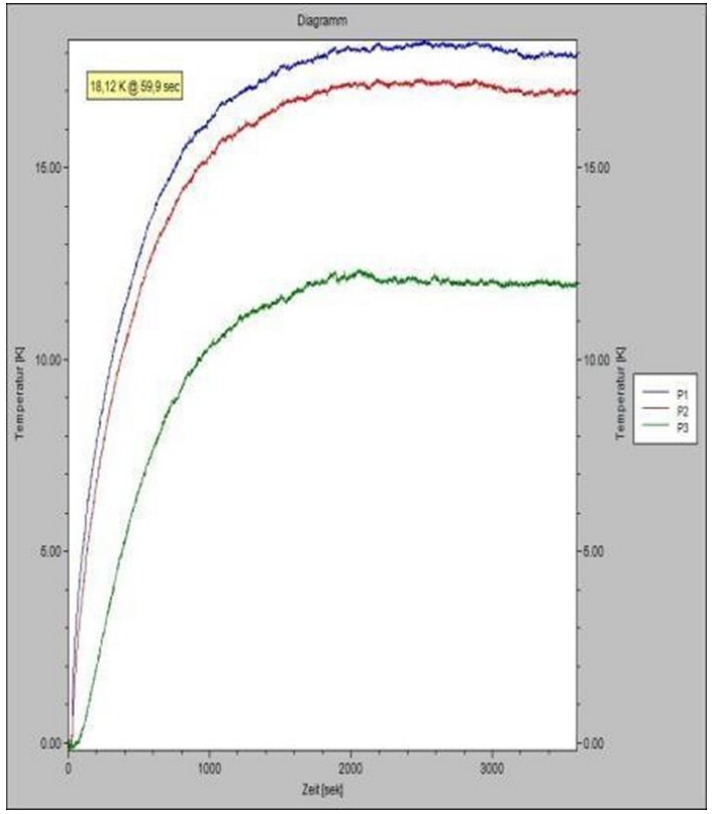
Thermal Simulation - Würth Elektronik CBTProduct Management

- Ambient temperature: 140°C
- Maximum Temperature at resistor: 153,5°C
- Power in accordance with customer specification

THERMAL MANAGEMENT

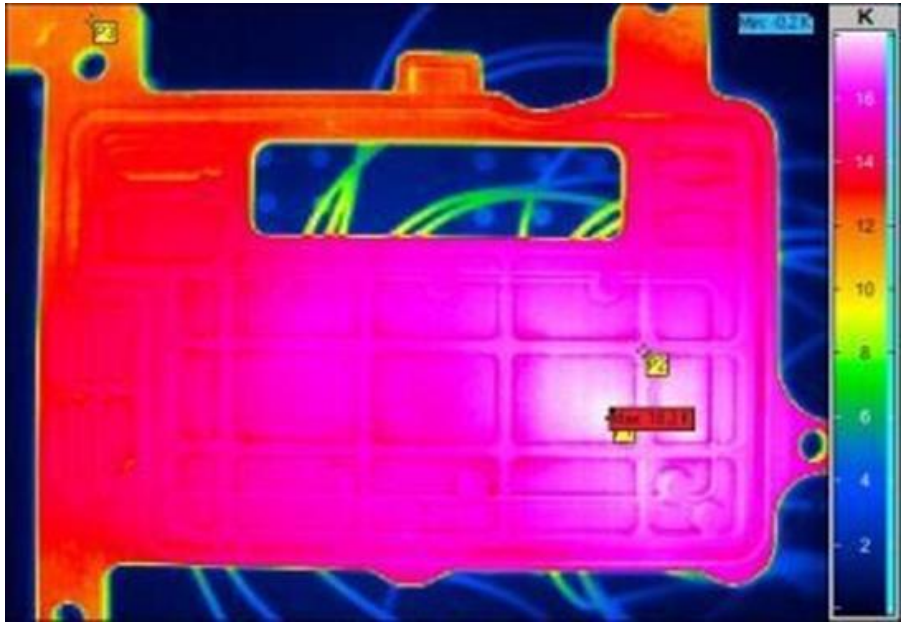
Thermography Measurement Bottom Side

- Ambient temperature 140 °C
- Resistors powered with 5-30 V (HTOL Test)
- Measurement after 60 minutes



- The thermography measurements essentially confirm the results of the simulation.

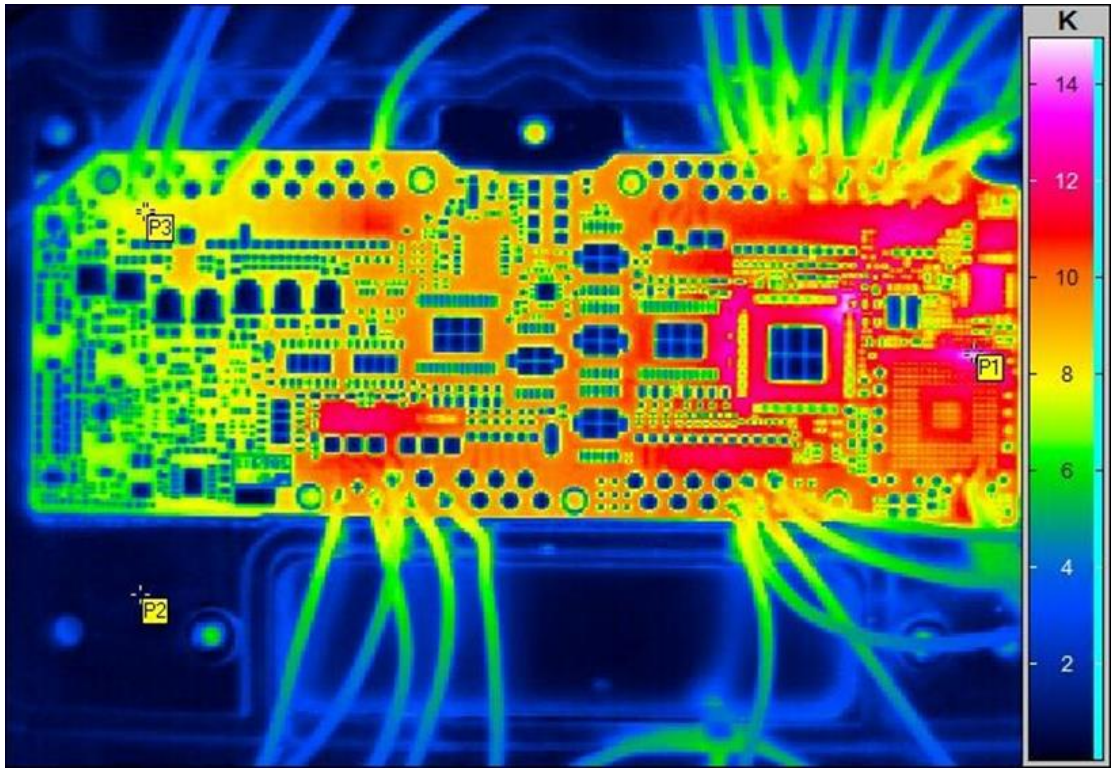
- As these measurements are very complex, only a limited number of resistors could be investigated.



THERMAL MANAGEMENT

Thermography Measurement Top Side

- Ambient temperature 140 °C
- Resistors powered with 5-30 V (HTOL Test)
- Measurement after 60 minutes



- The thermography measurements show that critical hot spots, caused by powered resistors, are avoided, also on the PCB Top side

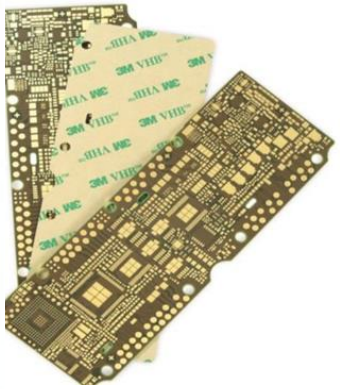
COST COMPARISON

Highly Reliable Printed Circuit Boards and Devices in Automotive Electronics

Ceramics

- High temperature resistance

FR4



- High functionality
- Highest packaging density
- Cost-efficient

COSTS - CIRCUIT BOARD GENERAL

Highly Reliable Printed Circuit Boards and Devices in Automotive Electronics

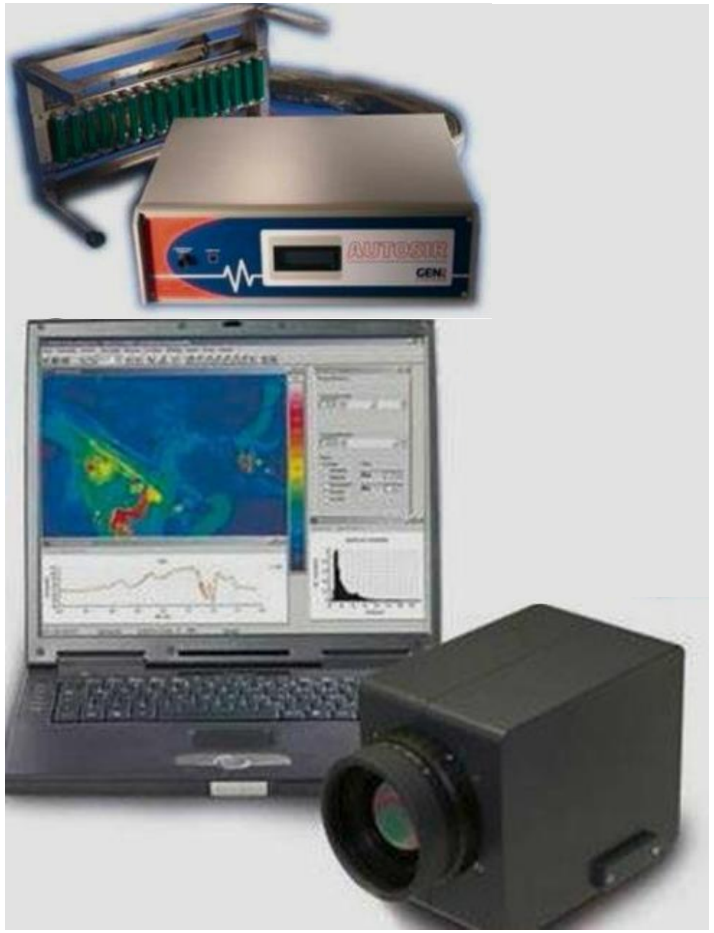
- Main advantage FR4 PCB: Production in the "large" production panel

PCB Cost drivers		FR4 System
PCB size	+	Relatively small size
Unfavourable delivery panel / X-Out	++	Single PCB
Complex build-up	≈	Two lamination processes
Material costs	++	Only one core, four prepregs Tg 170°C
Mechanical drilled Vias	++	Only buried vias in a thin core
Number of plating steps	≈	Only three „simple“ plating processes
Complex contour machining	+	Simple milling contour

REQUIREMENTS TO PCB MANUFACTURER

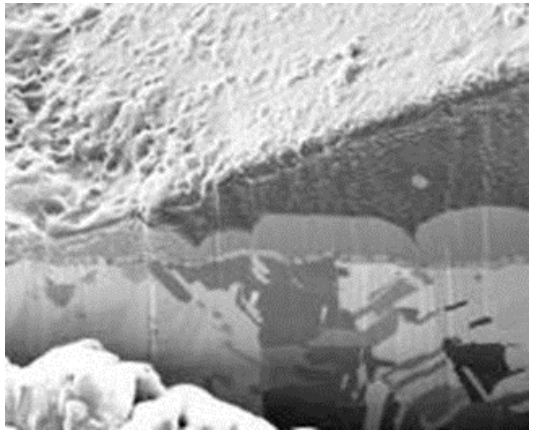
Highly Reliable Printed Circuit Boards and Devices in Automotive Electronics

- Metallurgic analysis
- Inspection acc. to IPC-6012 Class 3
- Stereo/optical microscopy (VIS/UV)
- IR camera
- Ionograph
- CAF Measurement equipment
- Climate test chamber
- Thermal Cycle Test
- IST
- High Current Impulse Test
- Pressure Cooker Test
- **X-Ray fluorescense spectroscopy**
- **Thermal simulation**
- **Testequipment for**
  - **HTOL**
  - **Power Derating**



Collaboration with instituts

- REM/EDX
  (Uni Basel, EMPA Zürich)
- XPS (IGB Stuttgart)
- Wetting tests (ISIT Itzehoe)
- Ultrasonic microscopy
  (ISIT Itzehoe)
- FIB (Uni Basel, EMPA Zürich)



SUMMARY

Highly Reliable Printed Circuit Boards and Devices in Automotive Electronics

- Miniaturisation through
  - HDI Technology
  - Printed resistors (Printed Polymer)
- Highest reliability using a thin HDI build-up without PTH vias
- A technology combination of
  - HDI,
  - Printed resistors and
  - Optimized Thermal Management

  can enable a cost effective substitution of a ceramic solution by a FR4 - PCB.
- A competent and broadly based PCB manufacturer can realize such a task.
- System solutions will be an essential part of collaboration / range of services in the future.

THANKS FOR YOUR ATTENTION

High Performance PCB System
Miniaturisation: HDI & Thermal Management & Printed Polymer