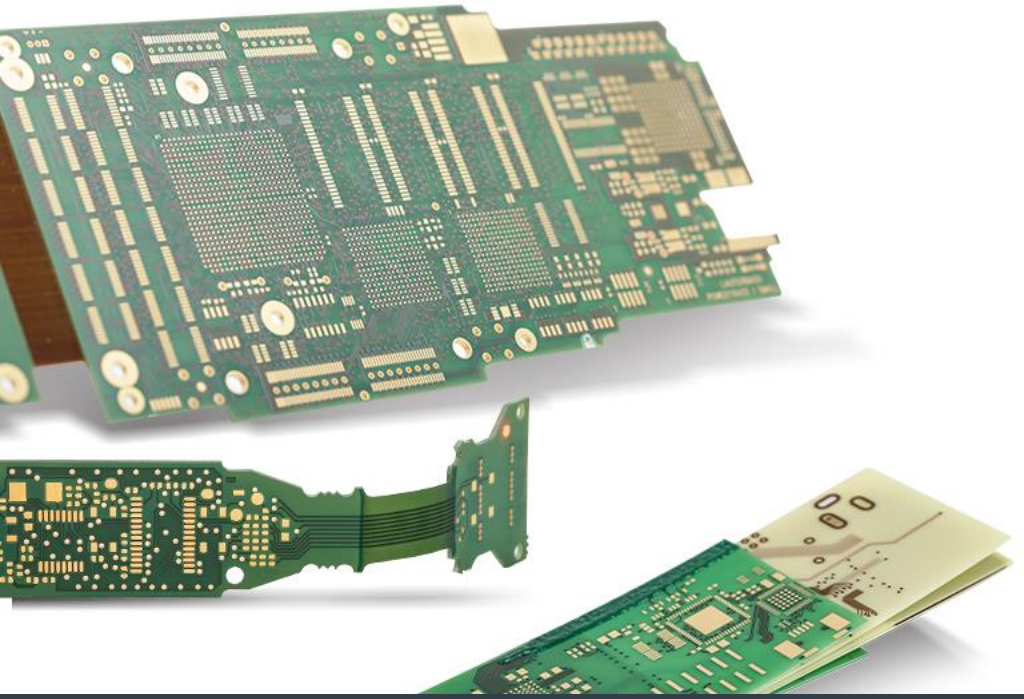
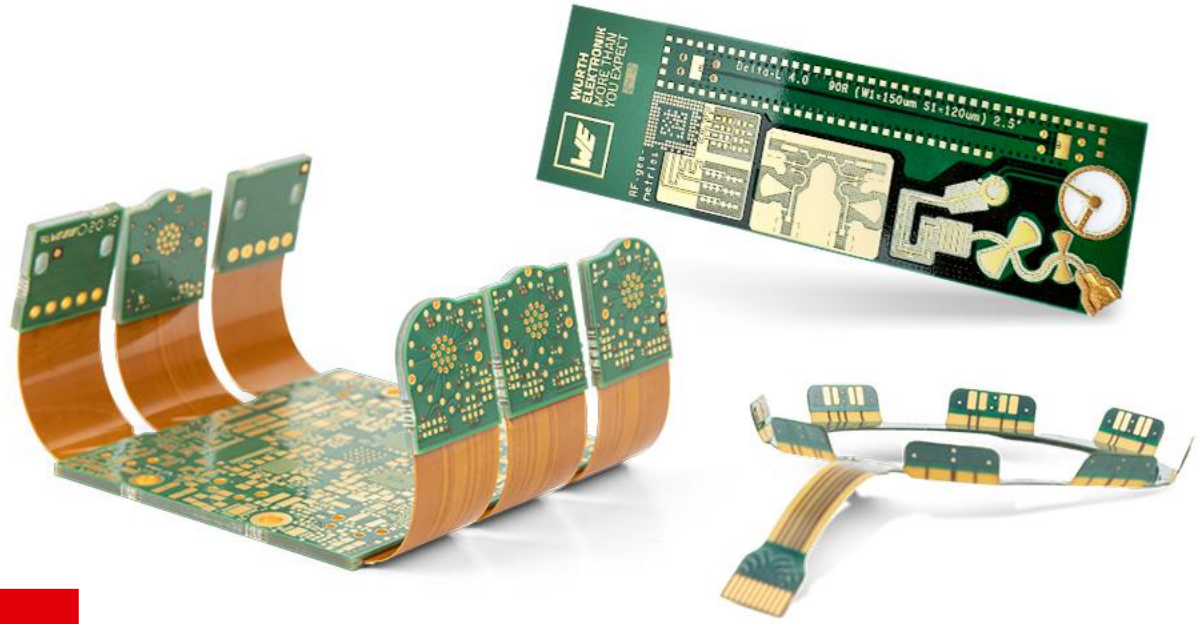




# THE UNDERESTIMATED PCB – AN OVERVIEW OF TEST METHODS, QUALITY AND RELIABILITY

**WÜRTH ELEKTRONIK** MORE THAN YOU EXPECT

# AGENDA

- **Process-Accompanying Tests**
- Chemical Analyses
- Optical Inspections
  - AOI
  - X-ray
  - Final Inspection
- Electrical Tests
  - Flying Probe Test
  - Impedance Control (TDR)
- Cross-Section Analysis
  - First Article Inspection Test

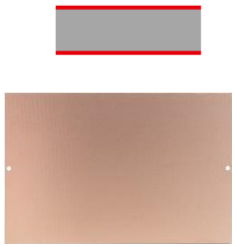
- **Long-Term Stability and Reliability**
  - Material Tests
  - Climate Storage
  - Temperature Cycle Test

**Andreas Dreher**
Field Application Engineer
Technical Project Management

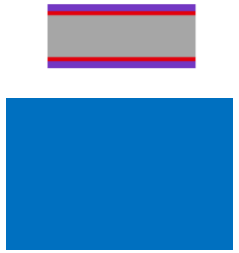
# PRODUCTION OF THE PRINTED CIRCUIT BOARD

## Typicall Process Flow of a Multlayer PCB

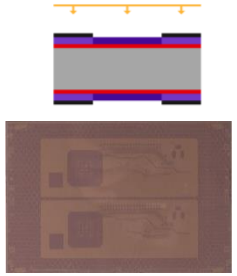
Base Material



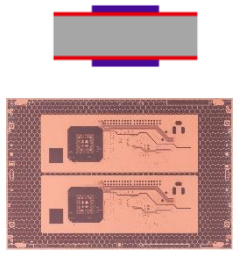
Etch Resist



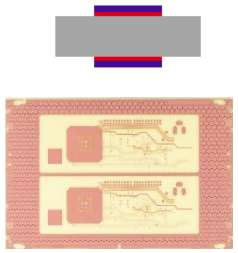
Exposure



Development

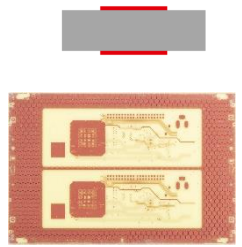


Etching, Stripping

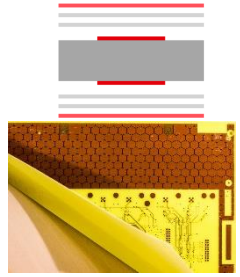


QUALITY GATE

AOI and Adhesion Promoter

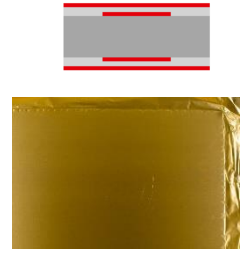


Lay up

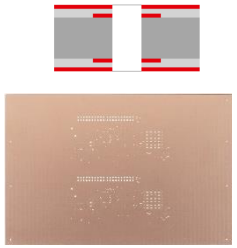


QUALITY GATE

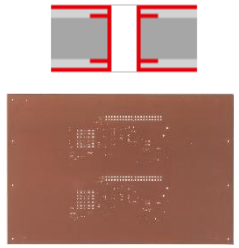
Pressing & Xray



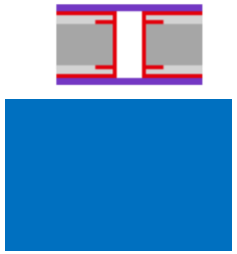
Drilling



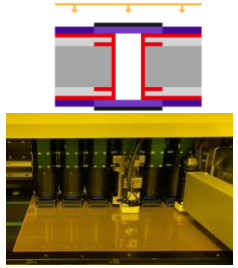
Galv. PLatting



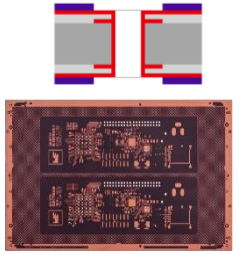
Etch Resist



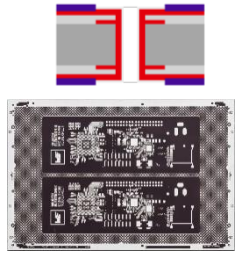
Exposure



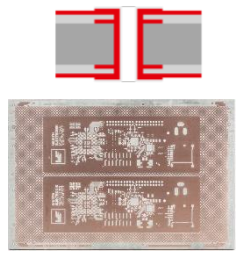
Developtment



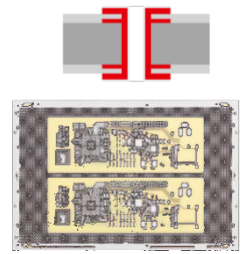
Selective Platting



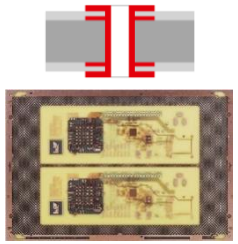
Stripping



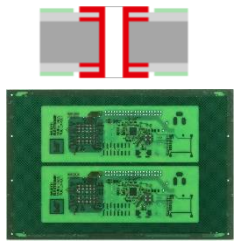
Etching



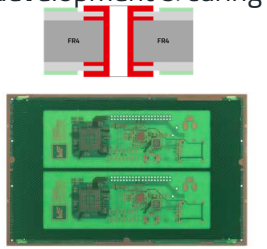
Tin Etching



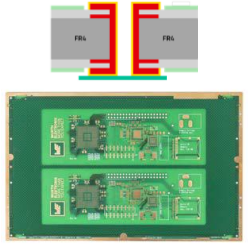
Solder Mask spraying



Solder Mask development & curing

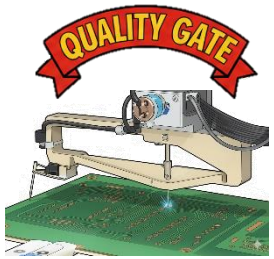


Final Finish

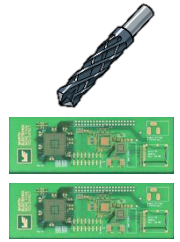


E-Test

QUALITY GATE



Milling



Final Inspecion

QUALITY GATE

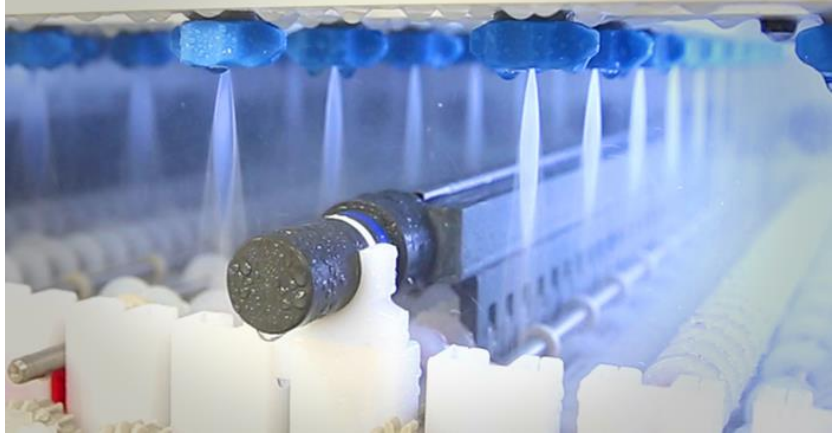
Boxing & Shippment

# IN-PROCESS TEST'S

# VIEW INTO THE PRODUCTION

Inline processing for printed circuit boards

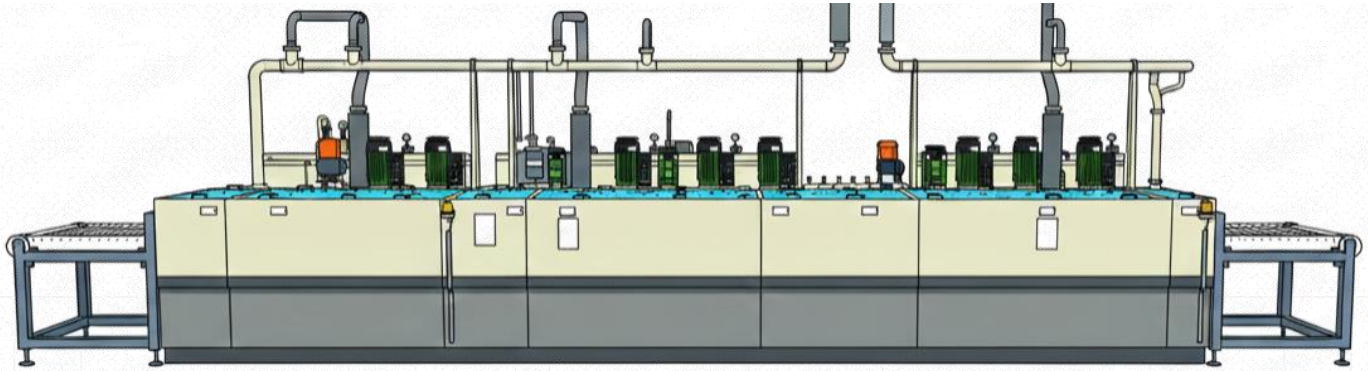

Sprüh-Modul



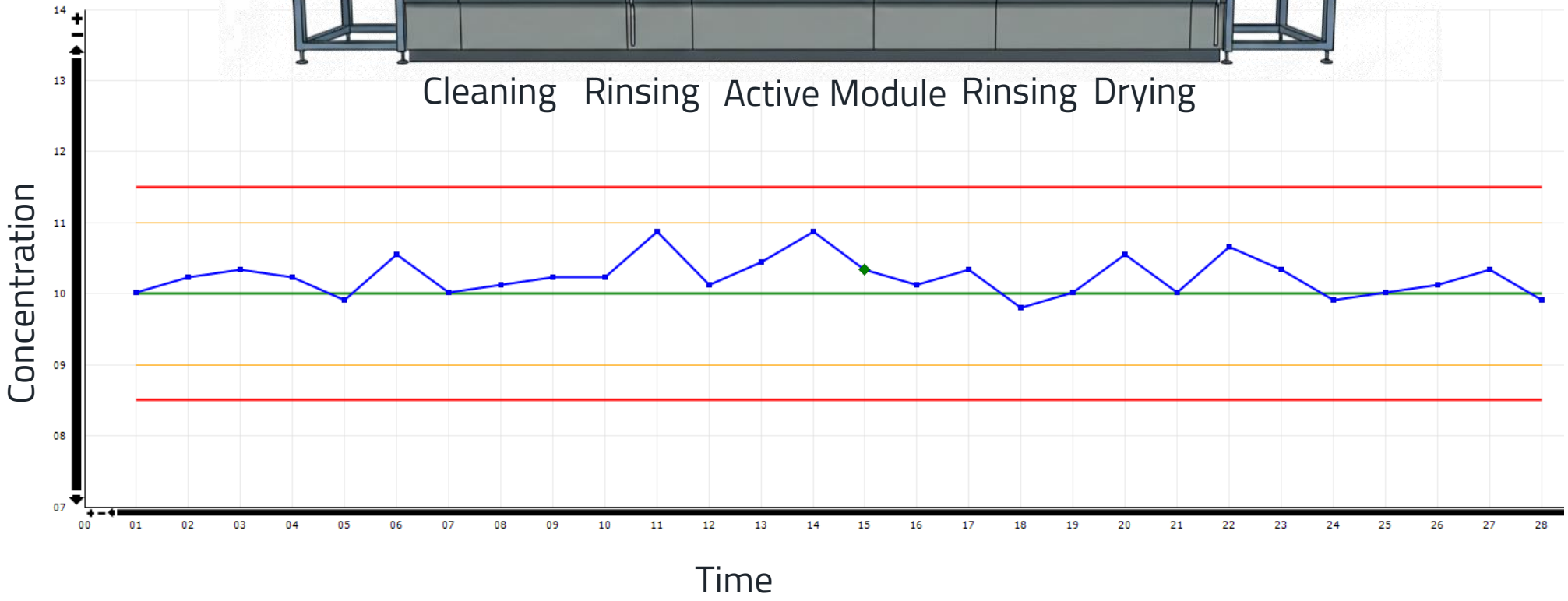
Schwall-Modul

# PROCESS CONTROLL

Control card per module



Cleaning Rinsing Active Module Rinsing Drying



# PROCESS CONTROLL

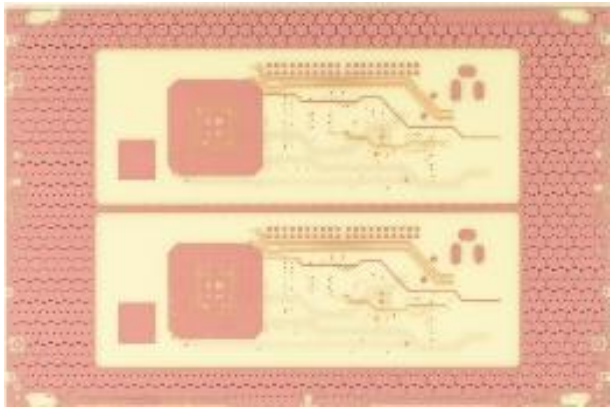
- **Online monitoring**
  - Ph value
  - Circulation
  - Metal content
  - Temperature
  - …

- **Bad analyses**
  - Laboratory testing for advanced analysis
  - Verification of online monitoring

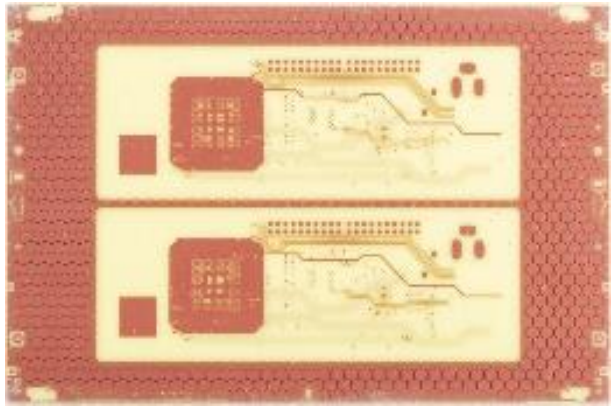
# PRODUCTION OF THE PRINTED CIRCUIT BOARD

Automatical optical Inspection

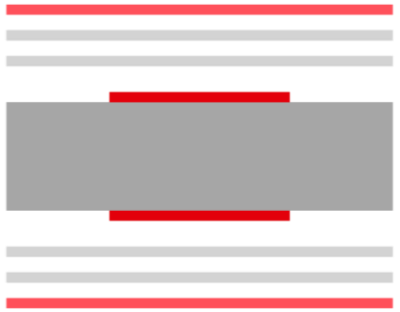
Etching & Stripping

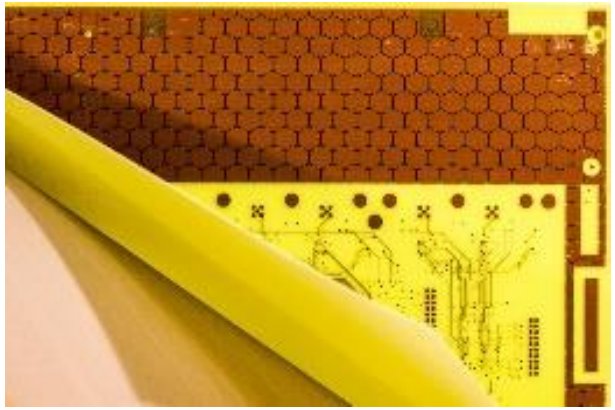


AOI & Adhesion Promoter

Lay up





# VIEW INTO THE PRODUCTION

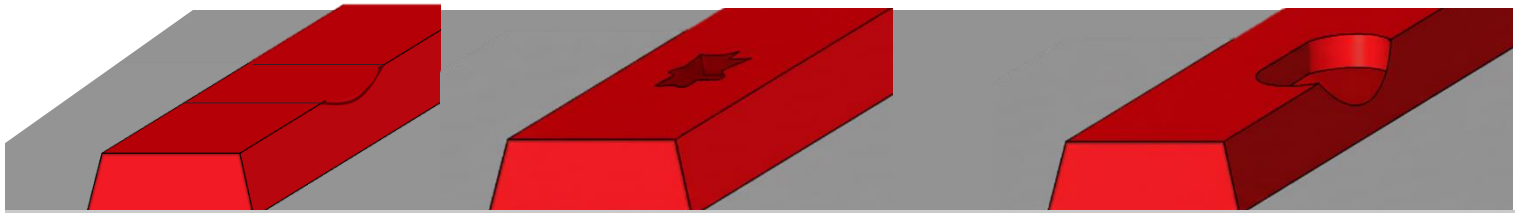
Automatical optical Inspection

# AUTOMATICAL OPTICAL INSPECTION

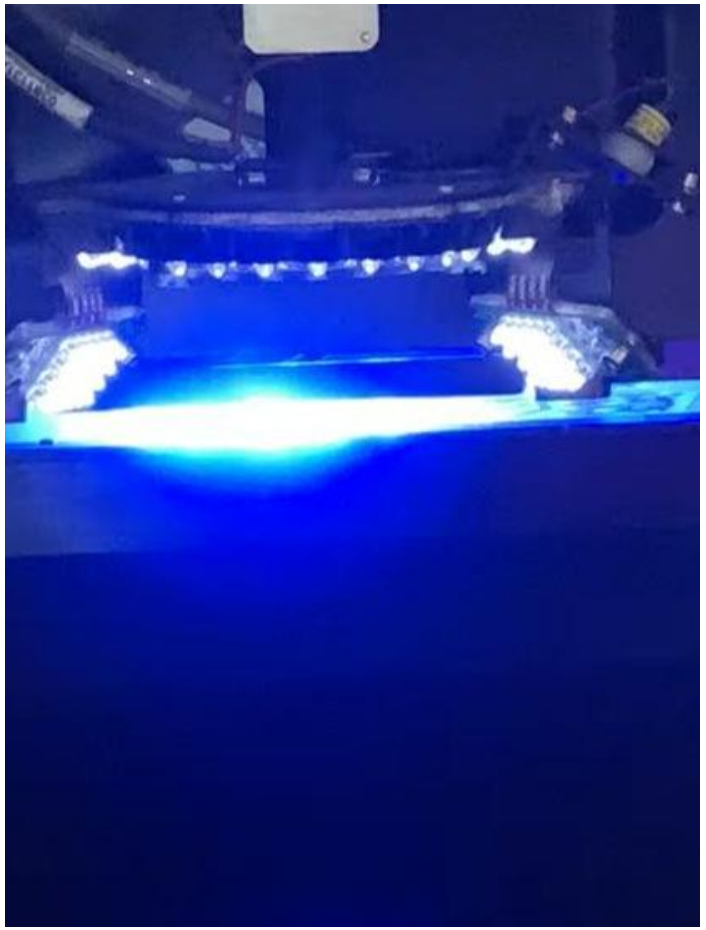
**Typical parameters**

- Resolution 25 µm Line & Space
- Verification against customer data
- Spot check of inner layers

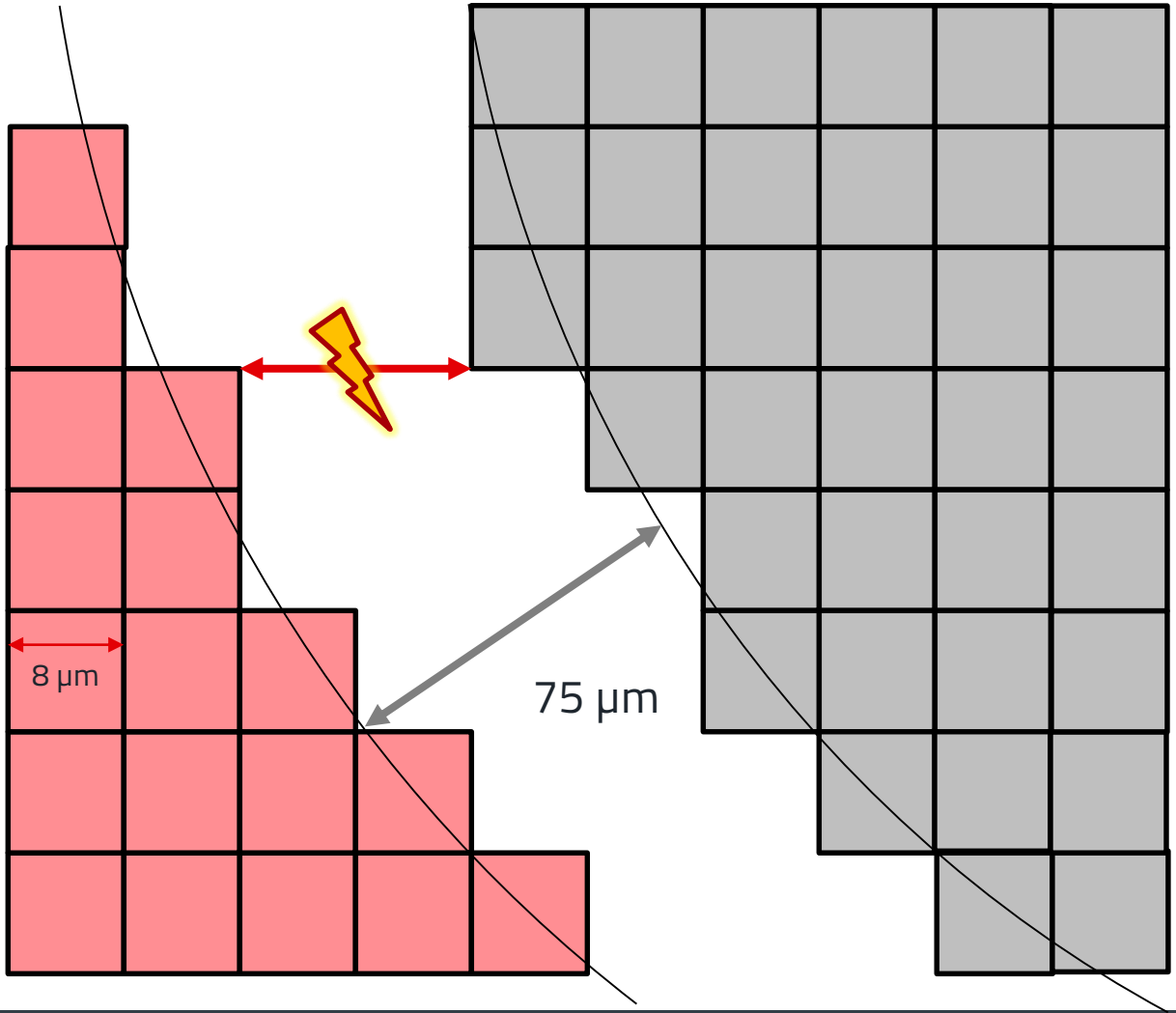
- **Extended testing**
  - 100% testing of inner layers
  - 100% testing of outer layers
  - Customer-specific testing parameters

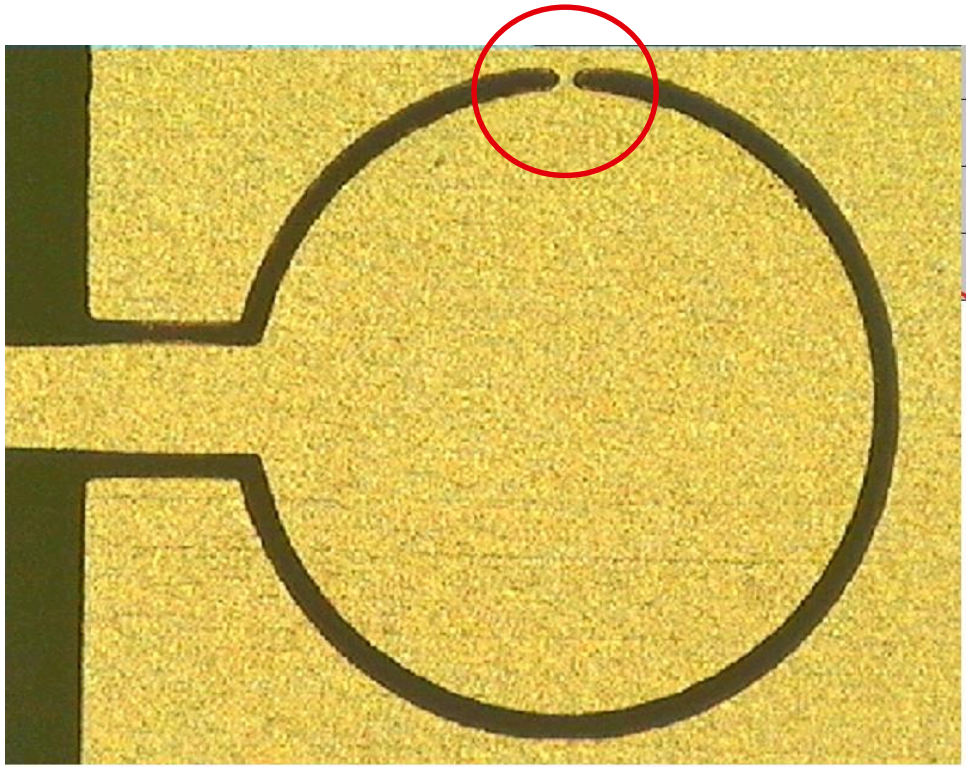


According to IPC 6012, a reduction of up to 20% in the minimum cross-sectional area due to local defects is permissible.



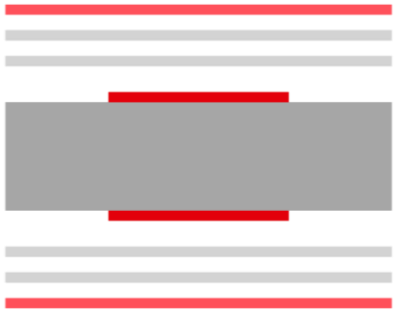
# PRACTICAL EXAMPLE



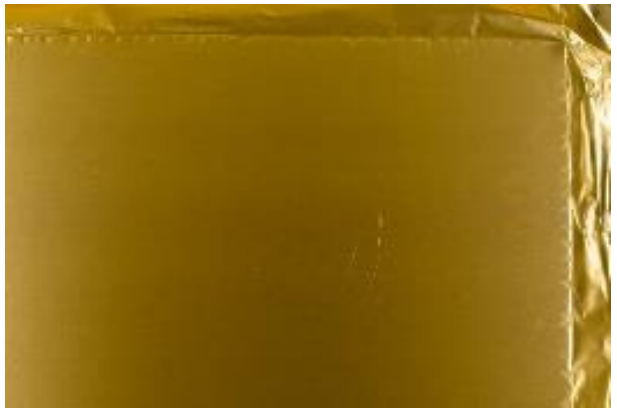



# PRODUCTION OF THE PRINTED CIRCUIT BOARD

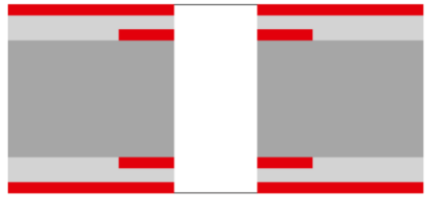
Lay Up

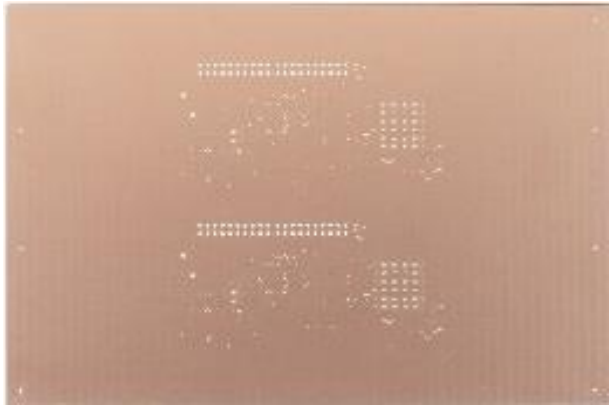


Pressing & Xray

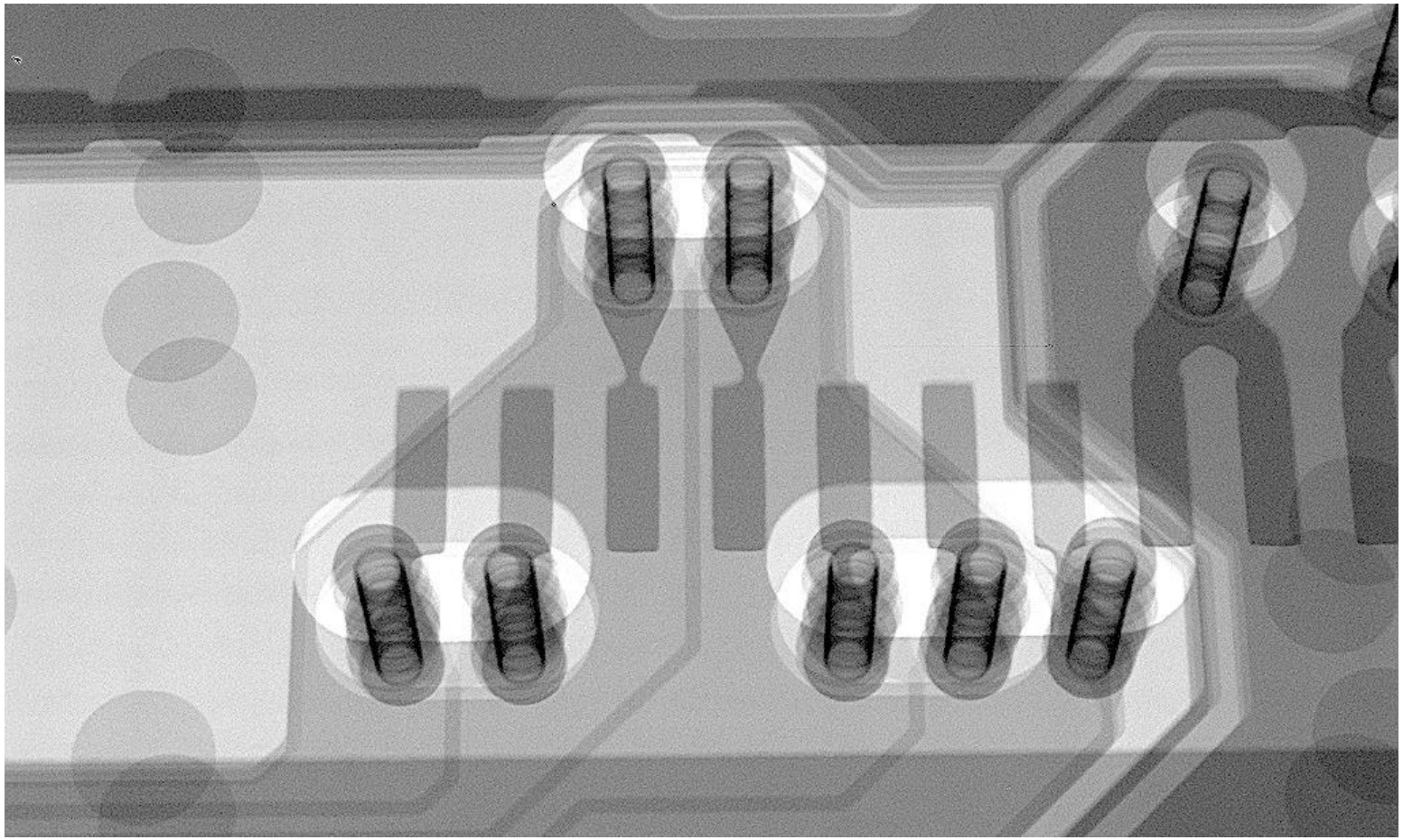



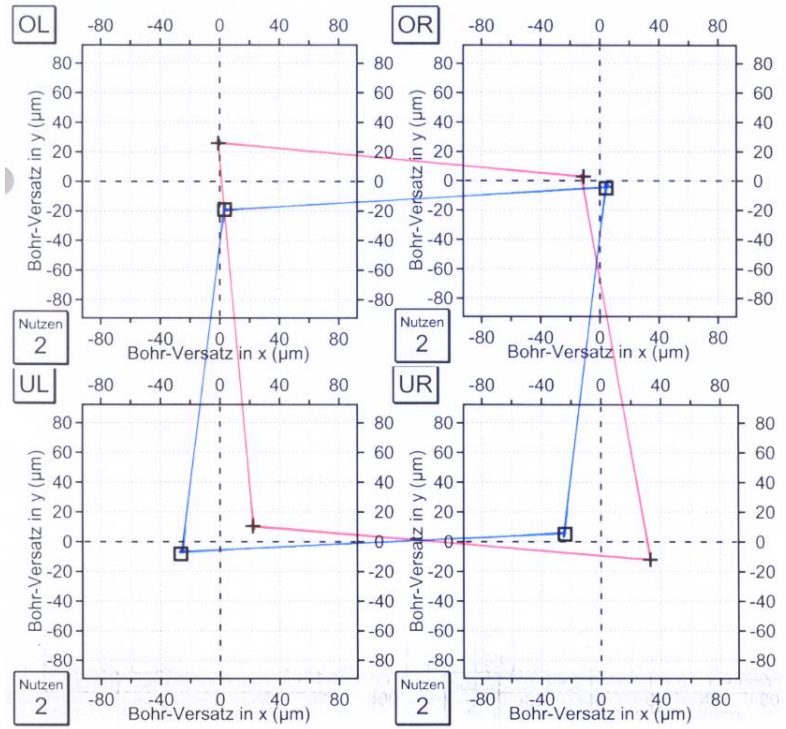
Drilling





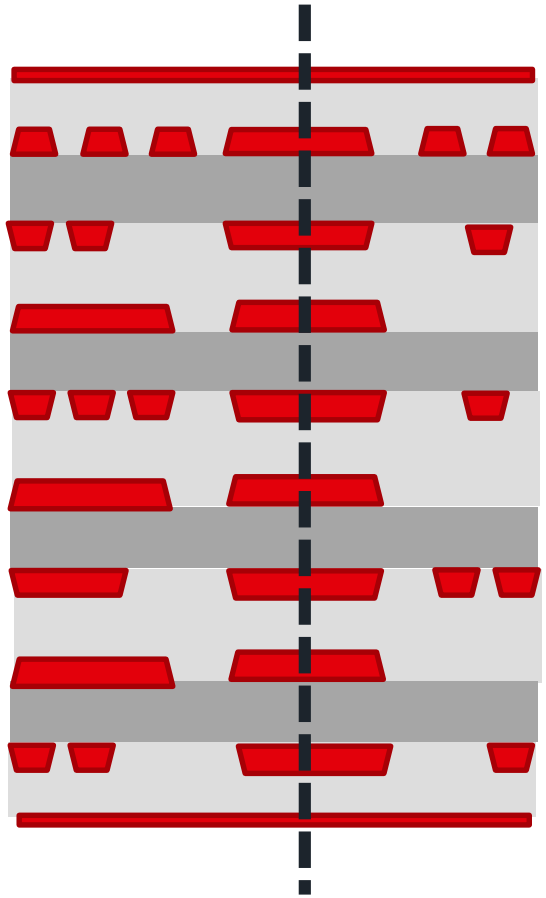
# XRAY INSPECTION



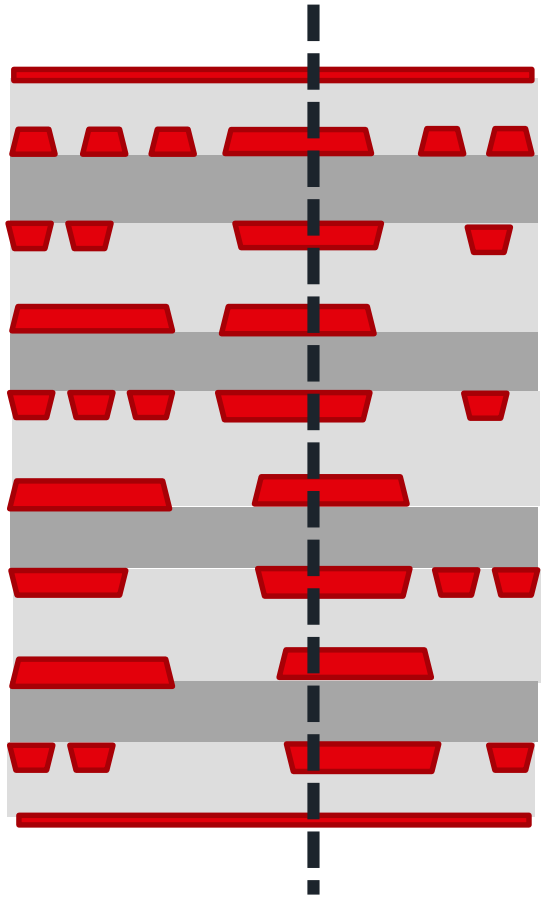


# MISALIGNMENT AND HOW TO HANDLE THIS IN PCB LAYOUT

Ideal



real world



- **Influence to layer shifting:**

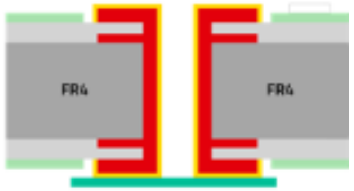
- FR-4 material
- Stackup
- Layout
- Copper balancing
- Material humidity
- Press cycle
- Press loading
- Summer/winter

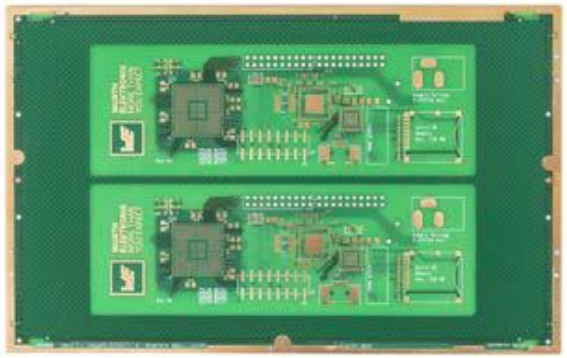
- 100 % X-RAY measurements on multilayers

# PRODUCTION OF THE PRINTED CIRCUIT BOARD

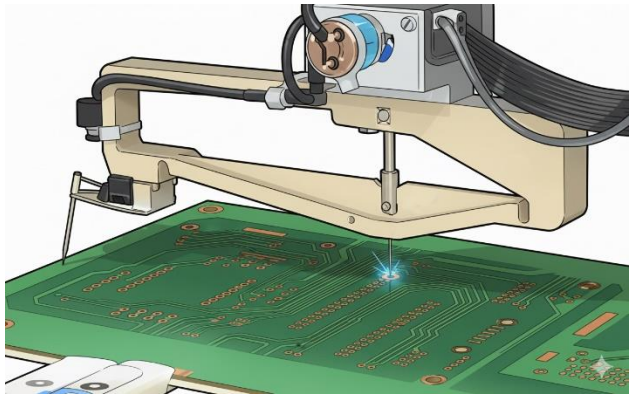
## Electrical Test

### Final Finish

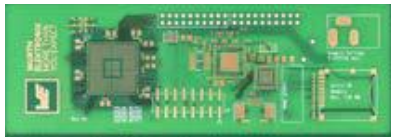


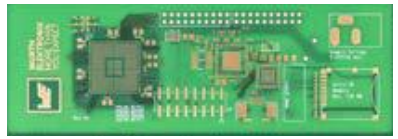



### Electrical Test

### Milling





# ELECTRICAL TEST

**Continuity test**

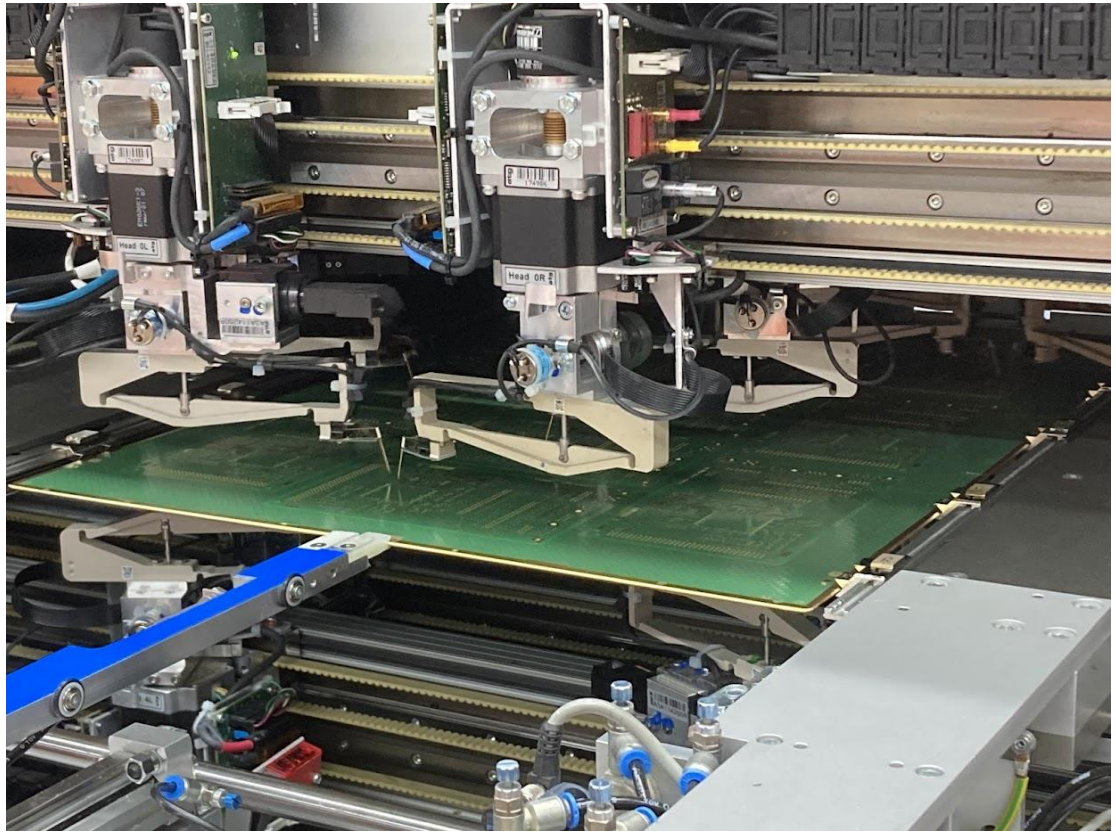
- Typical parameters
- Voltage 10 V
- Current 30 mA
- Resistance 10 Ω

**Short circuit test**

- Typical parameters
- Resistance 20 MΩ

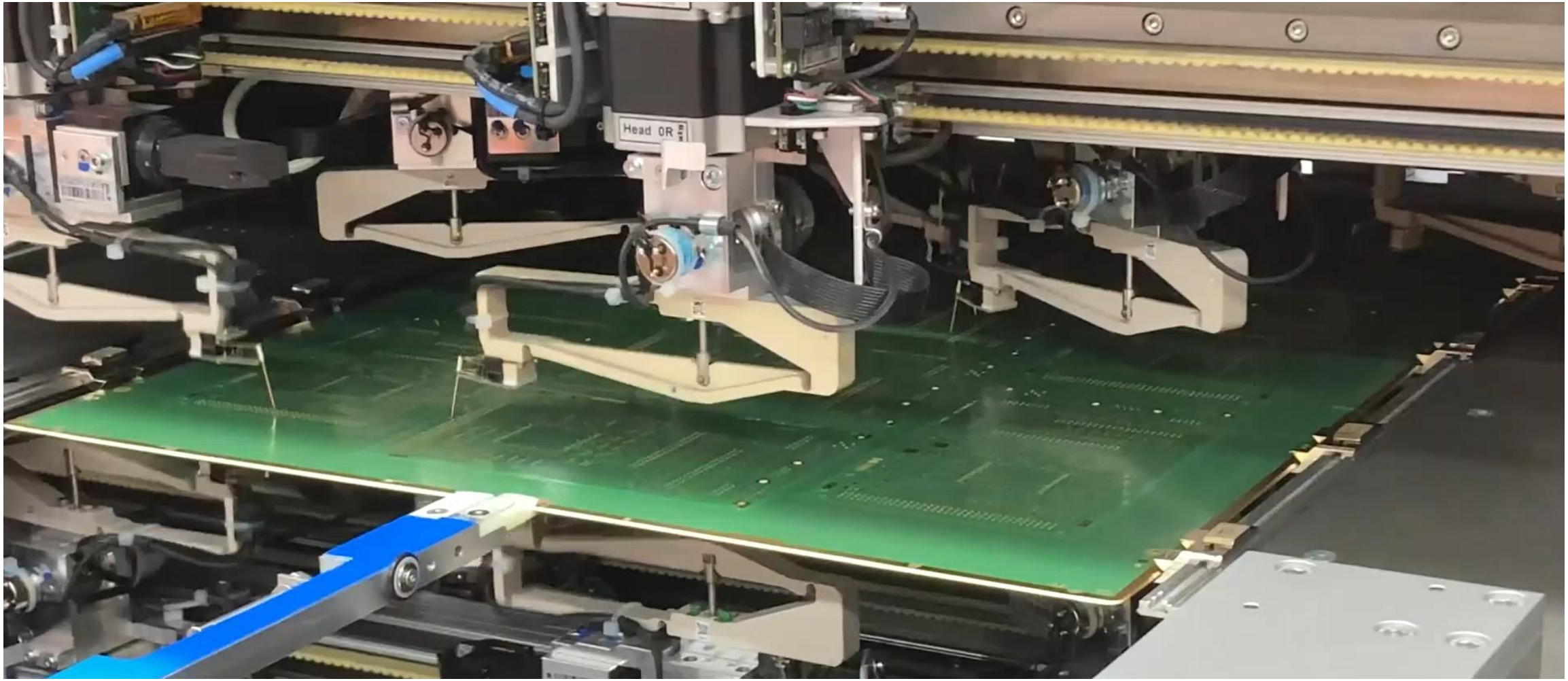
**Extended testing**

- High voltage test up to 1000 V
- Measurement of L-C-R elements



# VIEW INTO THE PRODUCTION

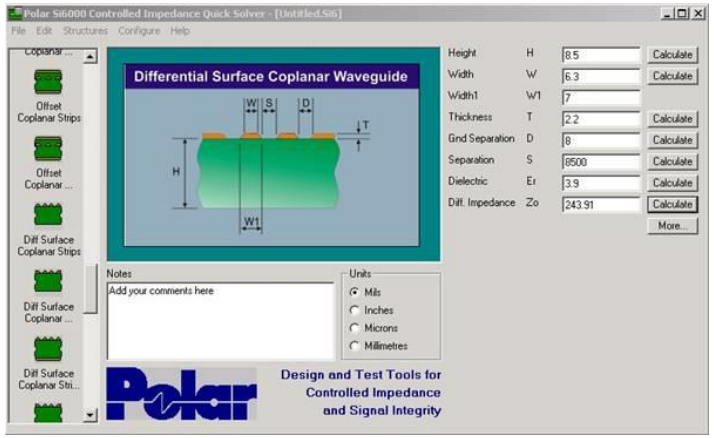
Electrical Test



# IMPEDANCE TESTING

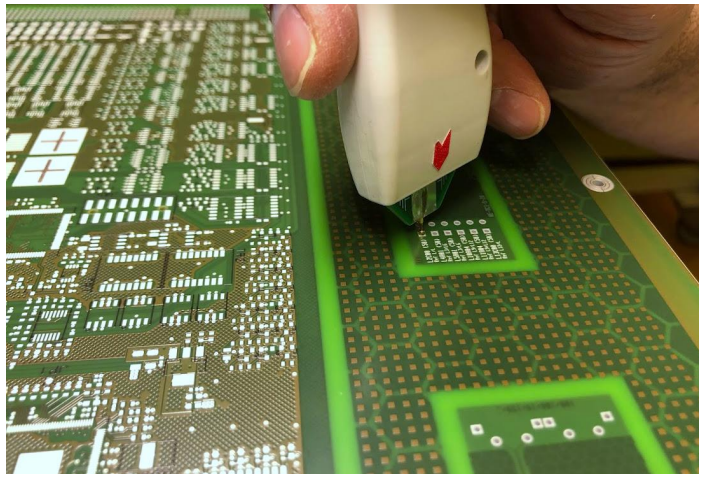
Defined by Component choice

- Impedance Calculation



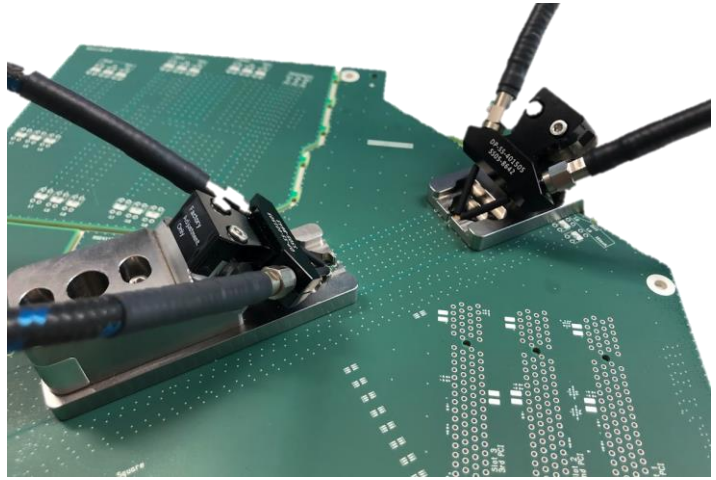

- Material Selection
- Design Rules
- Process Tolerance

- Impedance Measurement



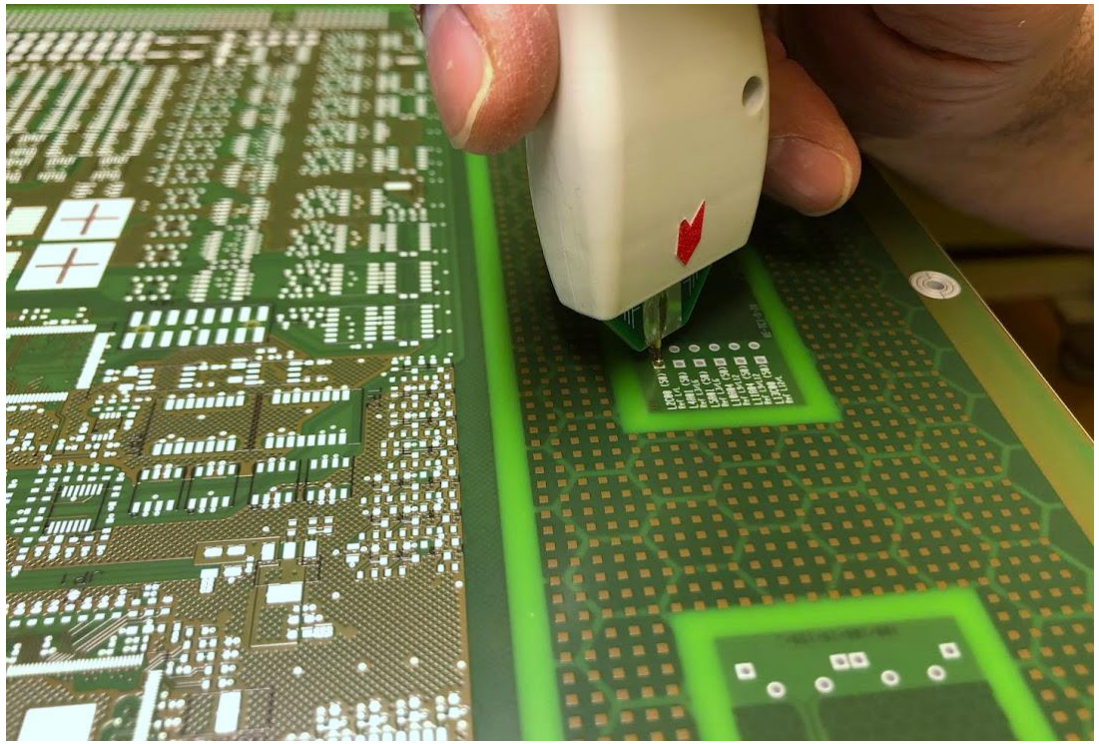
- Process Control

- HIGHSPEED Measurement „Atlas“ up to 40 GHz



- Helping customer with
  - Material Choice
  - Design Rules
- Research & Development

# IMPEDANCE TESTING



Test-Report

für impedanzkontrollierte Leiterplatten

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

| Messungsbeschreibung | Mittlere Imp. | Min./Max. | Nennimpedanz | Bestanden | Kalibriert |
|---|---|---|---|---|---|
| Nr. 1 - L1 90Ohm diff (#1), WE 397287 (LOS 3) | 87,58 | 85,07/90,31 | 90,00 (81,0..99,0) | Ja | Ja |
| Nr. 2 - L1 100Ohm diff (#1), WE 397287 (LOS 3) | 95,28 | 94,67/96,33 | 100,00 (90,0..110,0) | Ja | Ja |
| Nr. 4 - L1 85Ohm diff (#1), WE 397287 (LOS 3) | 82,40 | 79,64/84,82 | 85,00 (76,5..93,5) | Ja | Ja |
| Nr. 5 - L3 90Ohm diff (#1), WE 397287 (LOS 3) | 87,14 | 84,65/88,96 | 90,00 (81,0..99,0) | Ja | Ja |
| Nr. 6 - L3 100Ohm diff (#1), WE 397287 (LOS 3) | 95,13 | 93,34/97,26 | 100,00 (90,0..110,0) | Ja | Ja |
| Nr. 7 - L6 85Ohm diff (#1), WE 397287 (LOS 3) | 84,66 | 83,14/85,63 | 85,00 (76,5..93,5) | Ja | Ja |
| Nr. 8 - L6 100Ohm diff (#1), WE 397287 (LOS 3) | 99,45 | 97,88/101,11 | 100,00 (90,0..110,0) | Ja | Ja |
| Nr. 9 - L6 90Ohm diff (#1), WE 397287 (LOS 3) | 88,31 | 86,84/89,63 | 90,00 (81,0..99,0) | Ja | Ja |
| Nr. 10 - L10 90Ohm diff (#1), WE 397287 (LOS 3) | 89,47 | 86,79/90,56 | 90,00 (81,0..99,0) | Ja | Ja |
| Nr. 11 - L10 100Ohm diff (#1), WE 397287 (LOS 3) | 98,06 | 96,07/99,25 | 100,00 (90,0..110,0) | Ja | Ja |
| Nr. 12 - L12 90Ohm diff (#1), WE 397287 (LOS 3) | 87,26 | 83,38/90,43 | 90,00 (81,0..99,0) | Ja | Ja |
| Nr. 13 - L12 100Ohm diff (#1), WE 397287 (LOS 3) | 95,10 | 94,33/95,93 | 100,00 (90,0..110,0) | Ja | Ja |
| Nr. 14 - L12 85Ohm diff (#1), WE 397287 (LOS 3) | 81,68 | 78,96/86,16 | 85,00 (76,5..93,5) | Ja | Ja |

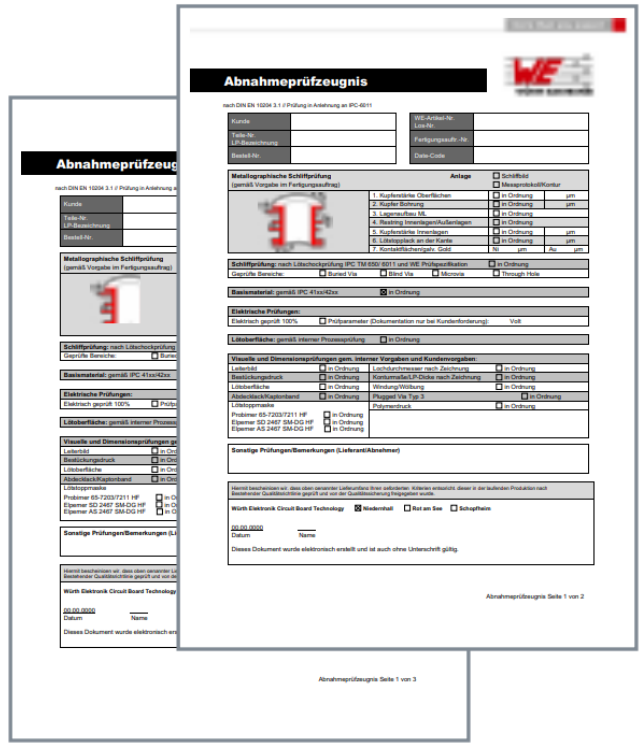
# TEST DOCUMENTATION

According to DIN 10204

- **Certificate of compliance**
  with the order Confirmation of the fulfilment of customer requirements and compliance with certain standards. No documented inspection of certain features.

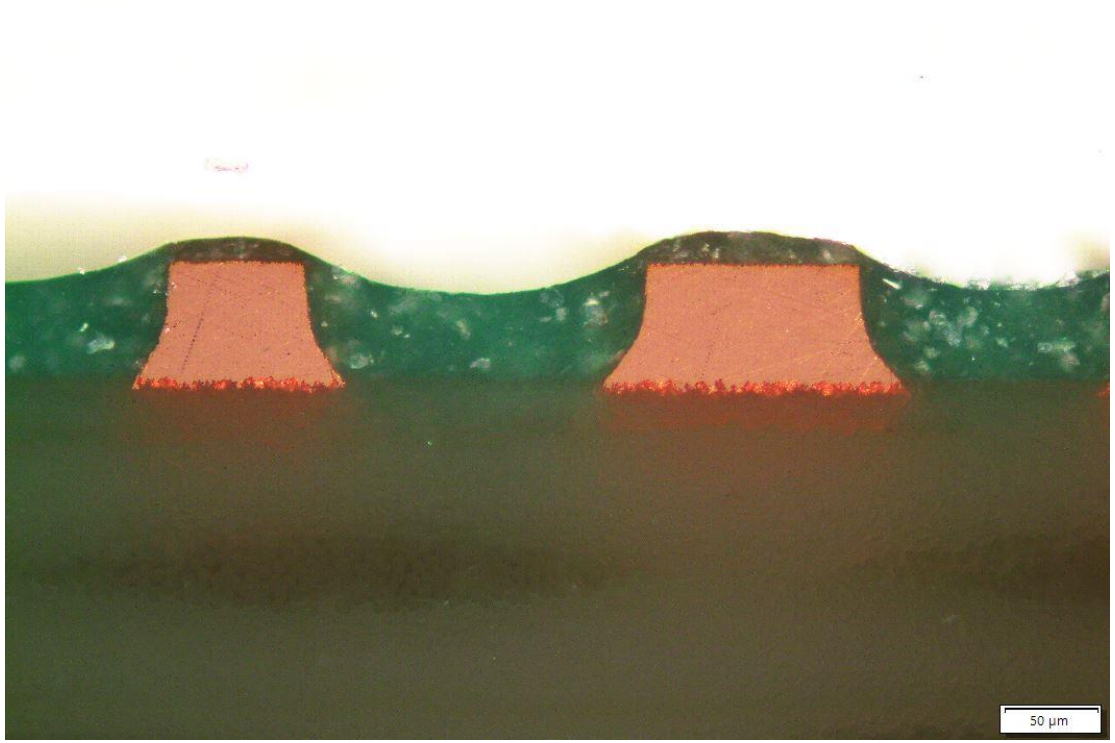
- **Inspection certificate**
  Dimensioned micrographs, detailed notes and measurement results of the most important characteristics regarding product structure, solder resist types and quality.

- **First article inspection report standard**
  Dimensioned micrographs, detailed notes and measurement results of the most important features regarding product structure and quality. Customer confirmation of the documented test results and release.
- **First article inspection report extended**
  Dimensioned micrographs, detailed target/actual comparison of all product features to be tested in accordance with customer order and customer specification. Customer confirmation of the documented test results and release.

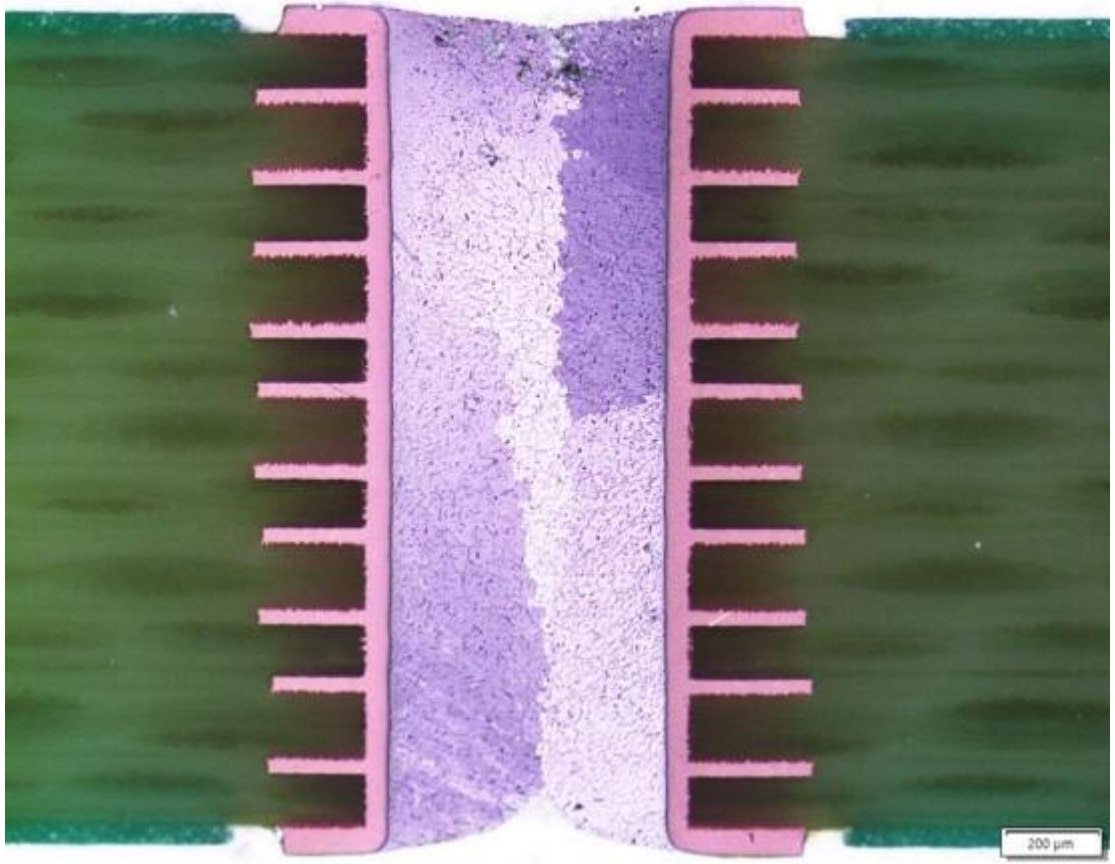


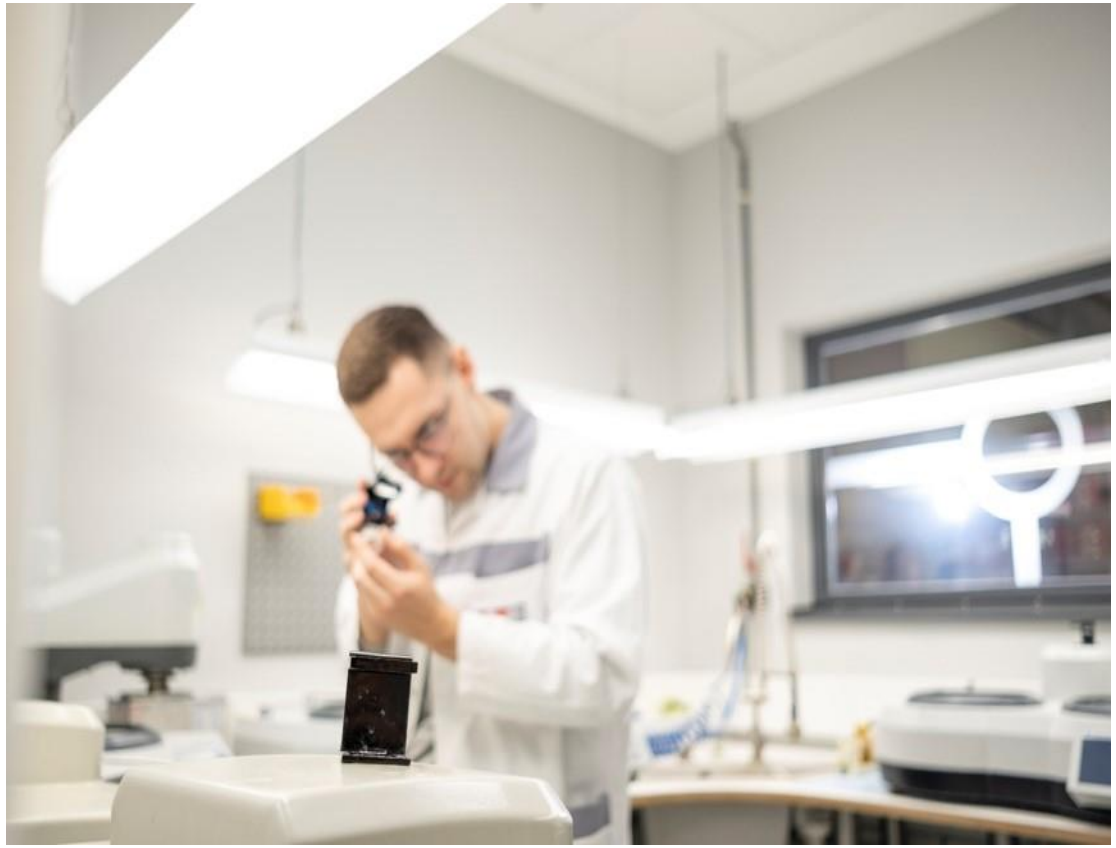

For this inspection documentation, the customer must specify the required inspection characteristics and agree them with Würth Elektronik Circuit Board Technology.

# MICRO SECTIONING

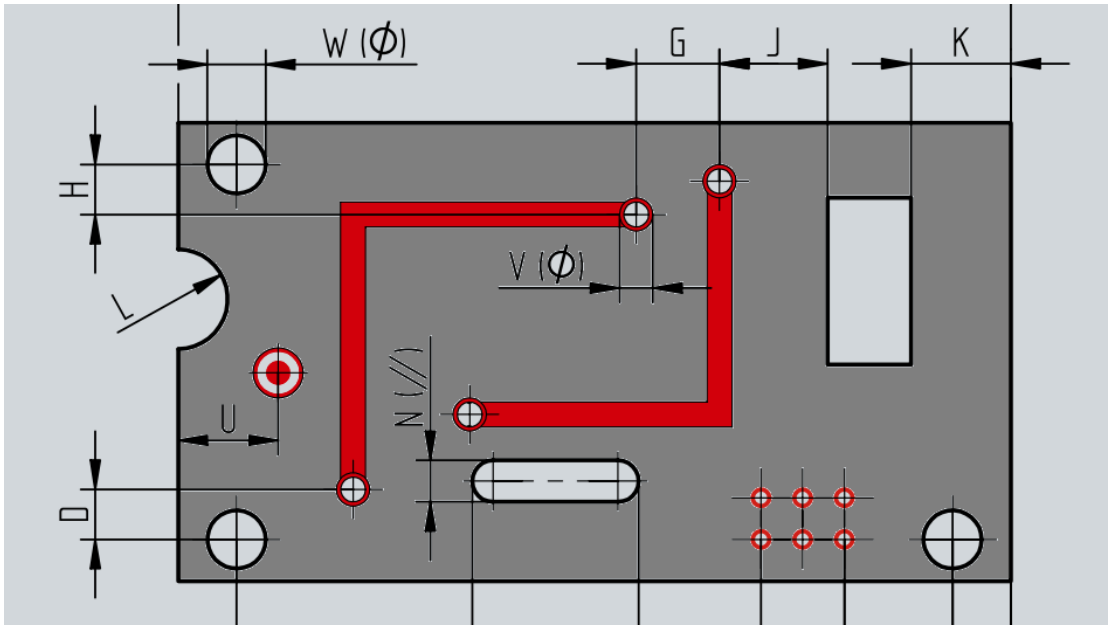



# MICRO SECTIONING



# MECHANICAL TOLERANCES

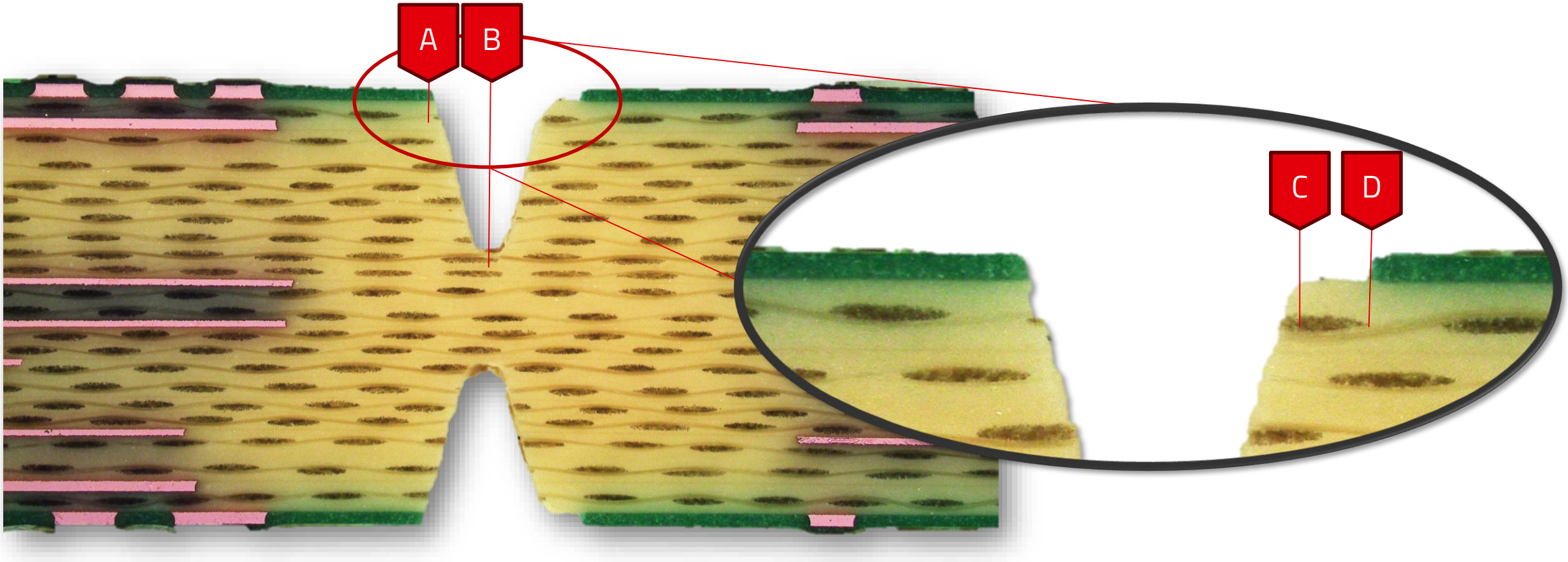



| Variable | Standard | Advanced | Nominal dimension range |
|---|---|---|---|
| Milling | ±0,10 mm | ±0,075 mm* | 0 – ≤ 30 mm |
| | ±0,15 mm | ±0,10 mm* | > 30 – 120 mm |
| | ±0,20 mm | ±0,15 mm* | > 120 – 200 mm |
| | per each further 100 mm ± 0,05 | ±0,20 mm | > 200 mm |
| | | ±0,30 mm | > 400 mm |
| V-grooving | DIN ISO 2768 fine (unbroken as delivered) | — | — |
| Milling + grooving | DIN ISO 2768 fine (unbroken as delivered) | — | — |
| Tool-Ø ≤ 6,00 mm | ±0,05 mm | — | — |
| Tool-Ø > 6,00 mm | ±0,05 mm | — | — |
| | ±0,10 mm | ±0,05 mm | — |

- Specification for Download

# MECHANICAL TOLERANCES

Where is the edge ?



# LONG-TERM STABILITY AND RELIABILITY

# MATERIAL TESTING

## TMA Measuerment

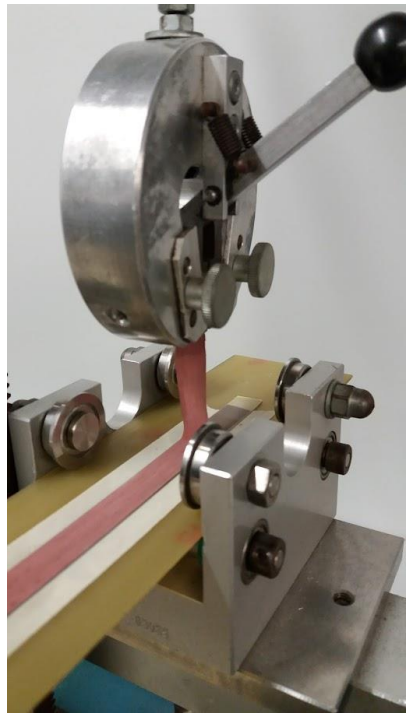
Thermal mechanical Analysis

## FTIR Analysis


Fourier Transform Infrared Spectroscopy

## Thermal Shock

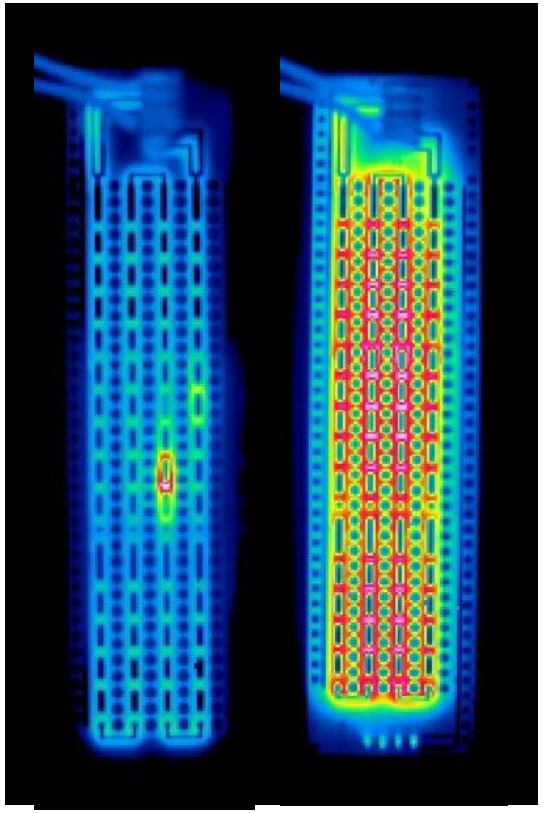
## Copper Peel Strength



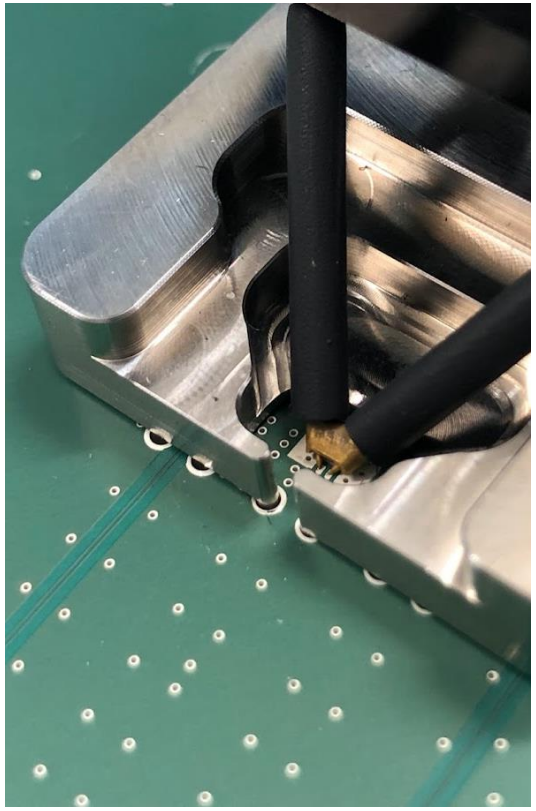
# MATERIAL TESTING

## X-ray fluorescence

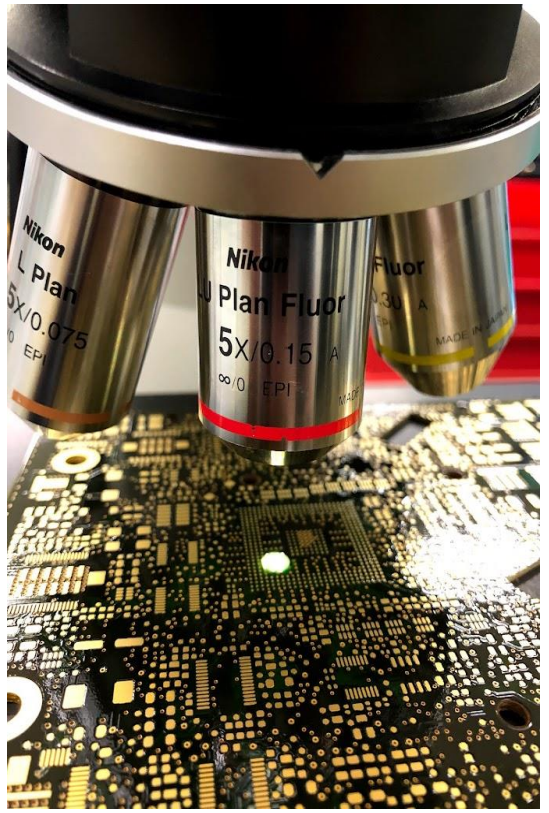
## Thermal Imaging



## High Speed Measurement

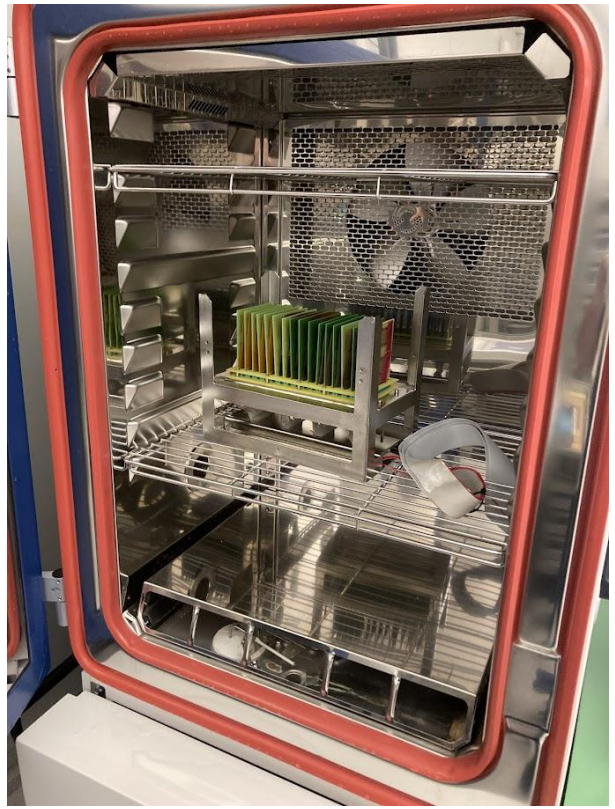


## Microscopes



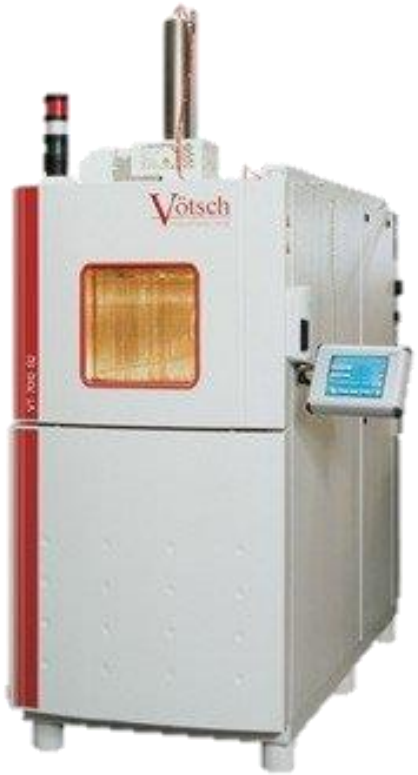
# RELIABILITY TESTING

## Climatic Simulation



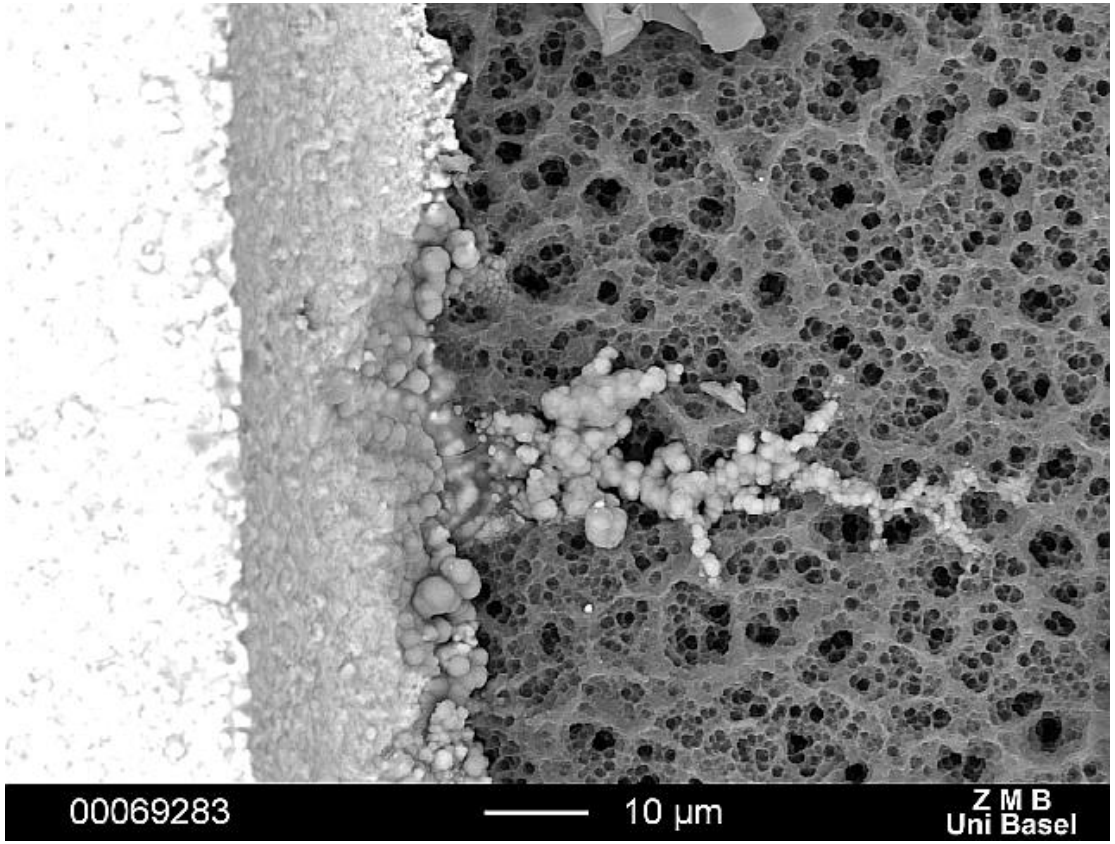
## Thermal Cycling active

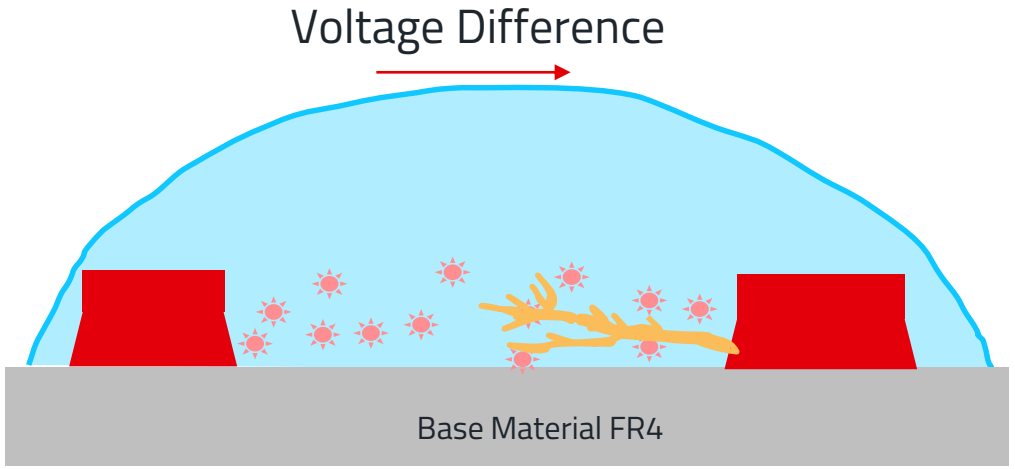
## Thermal Cycling passive



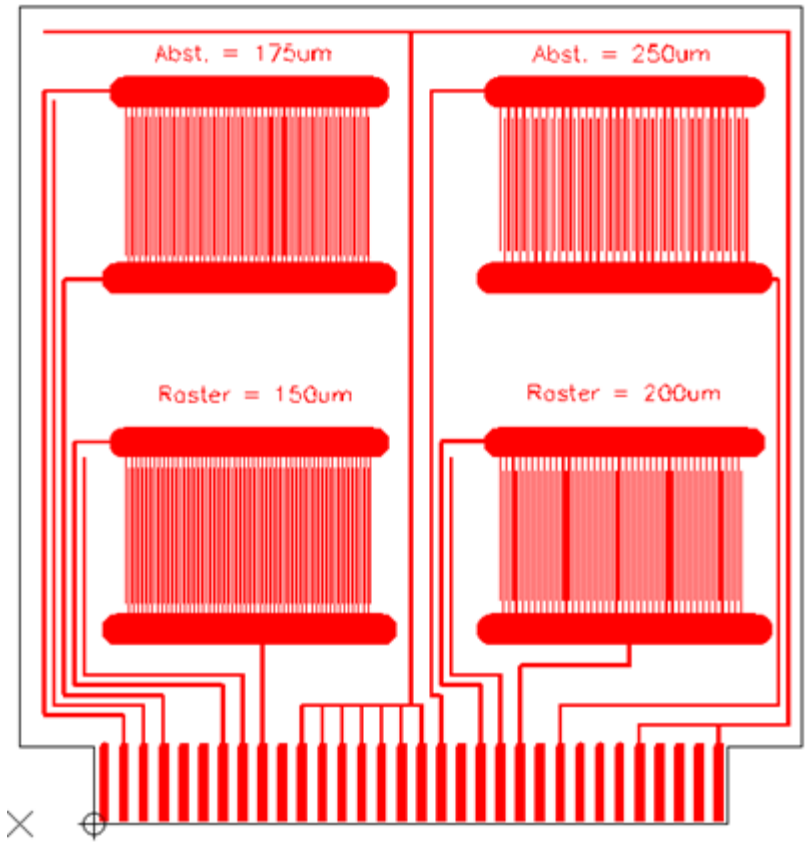
# CLIMATIC SIMULATION

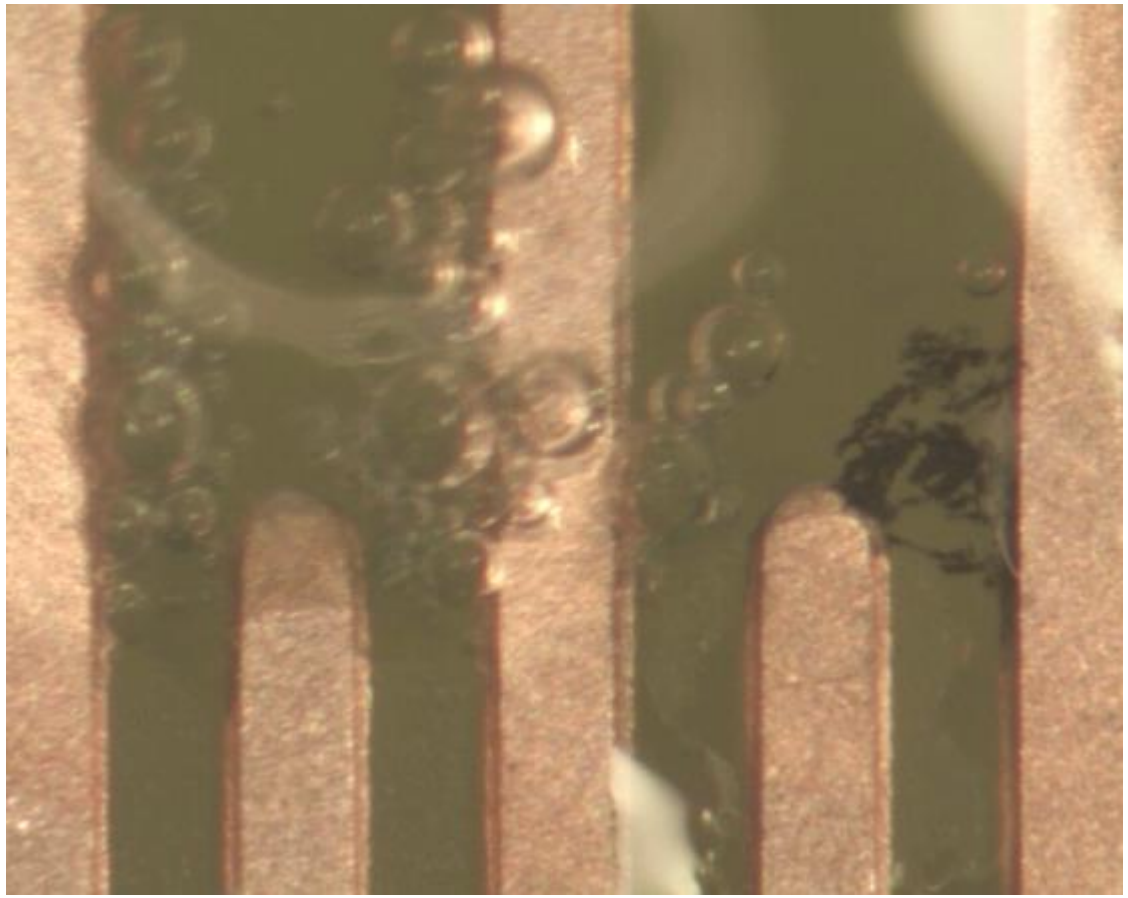
Surface Insulation Resistance (SIR) &  Conductive Anodic Filament (CAF)



# CLIMATIC SIMULATION WITH ONLINE MEASURMENT

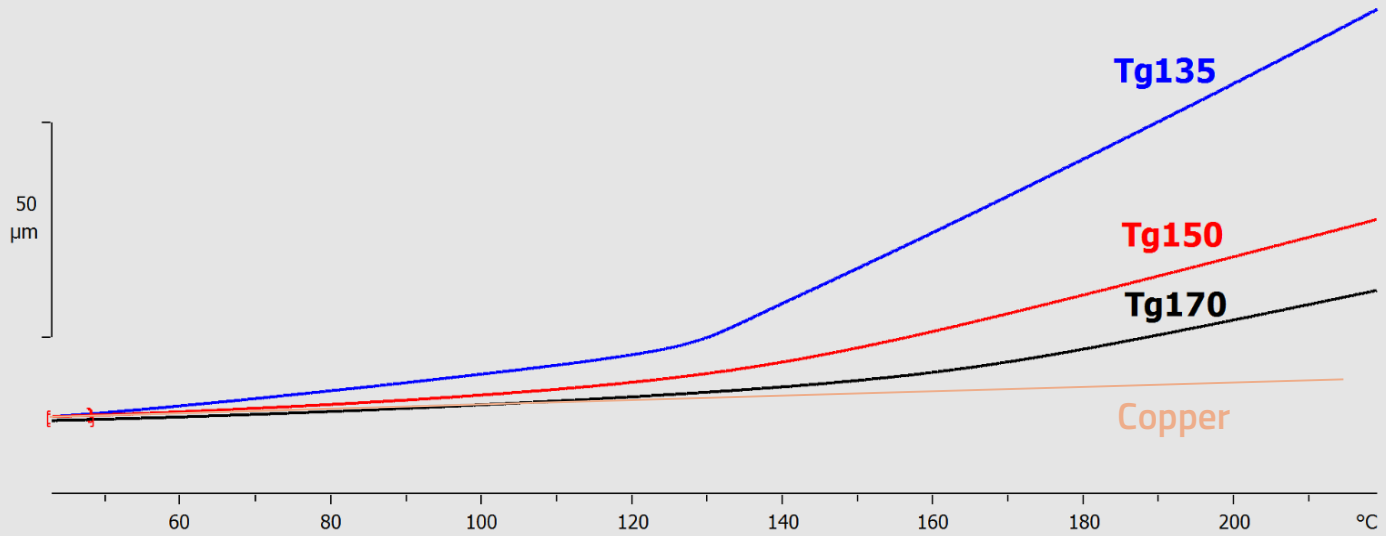


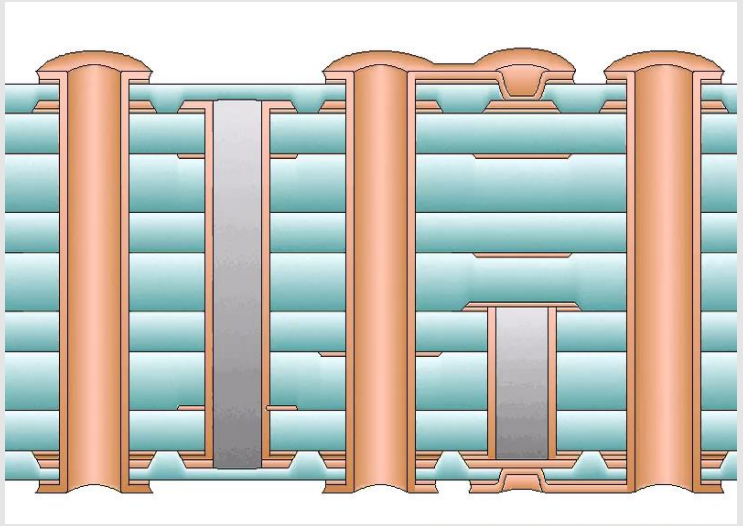
Dendrite formation with drinking water at 10V

# THERMAL CYCLING

Temperature changes cause stress in a circuit board

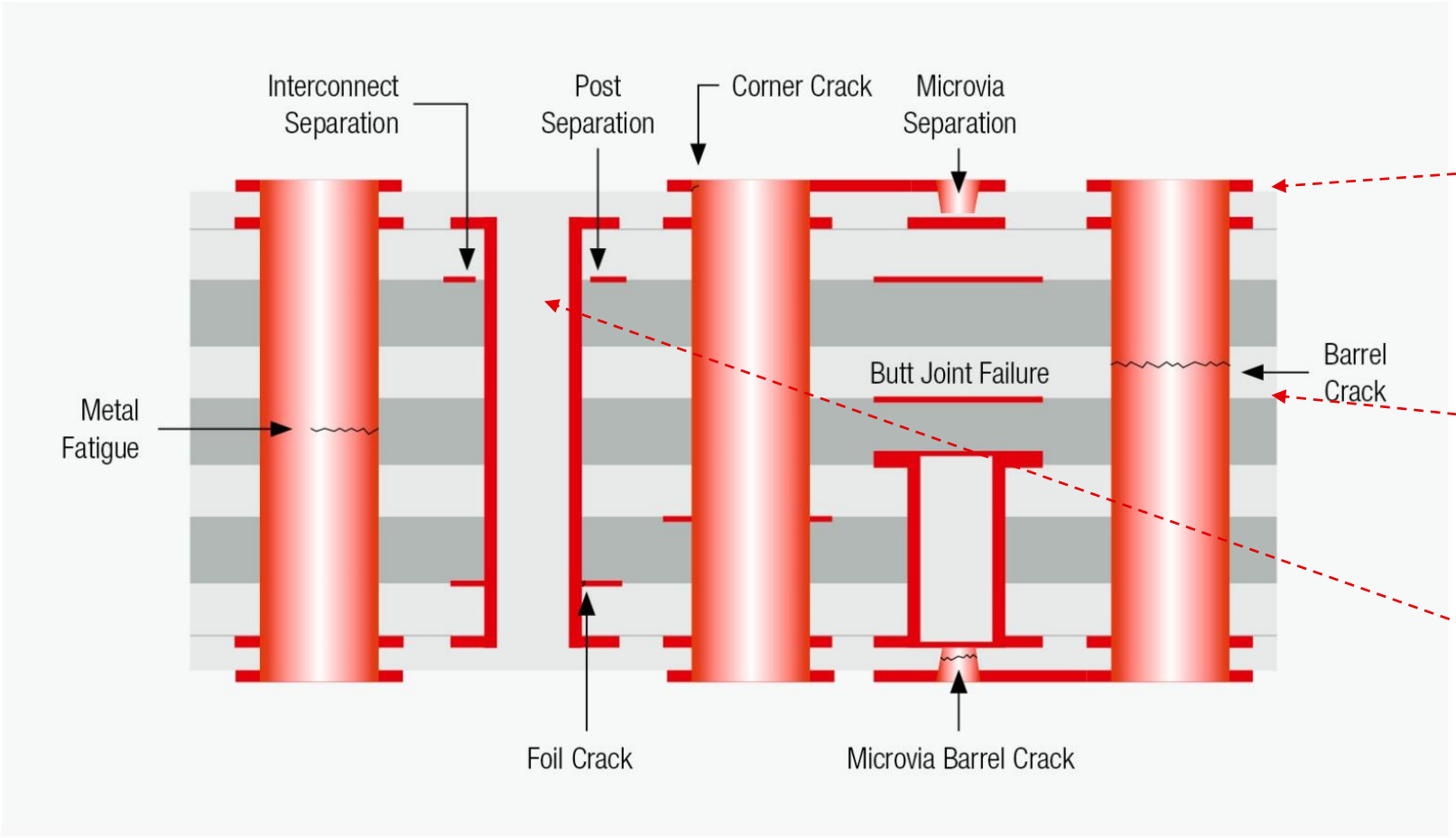


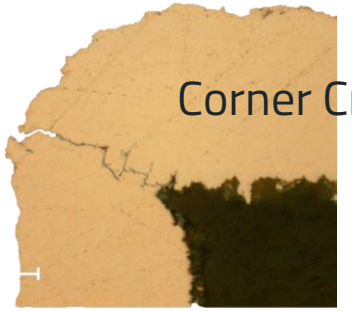

Coefficient of thermal expansion CTE in Z



Source: PWB Interconnect Solutions

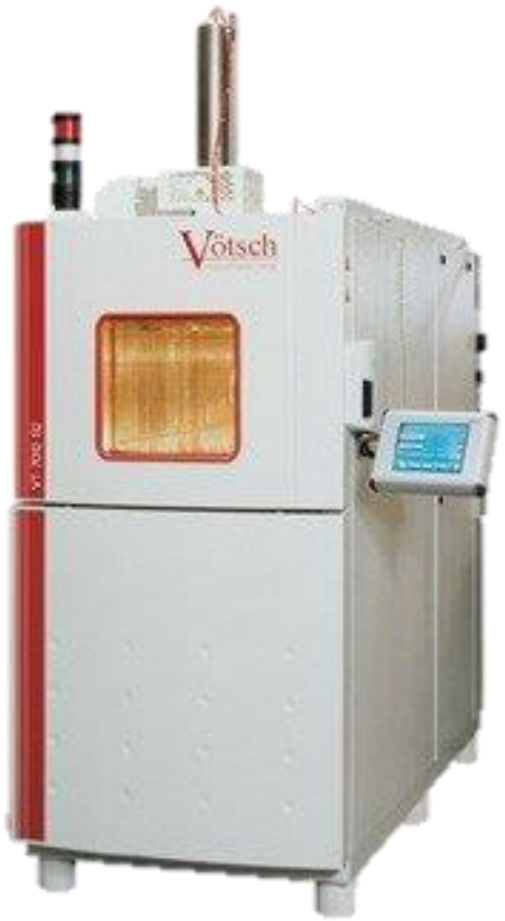
# CYCLE-RELATED FAILURE MODES

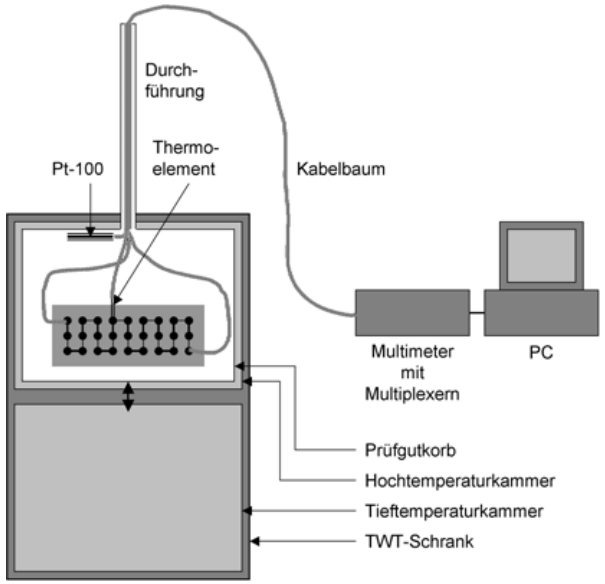


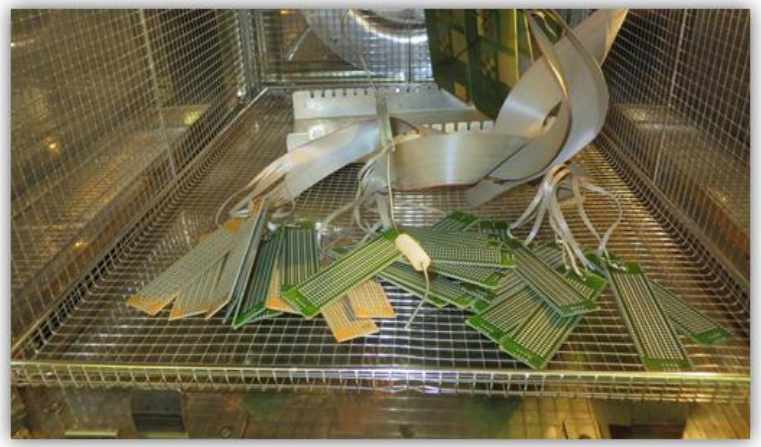


# TEMPERATURE CHANGE TEST 2-CHAMBER SYSTEM

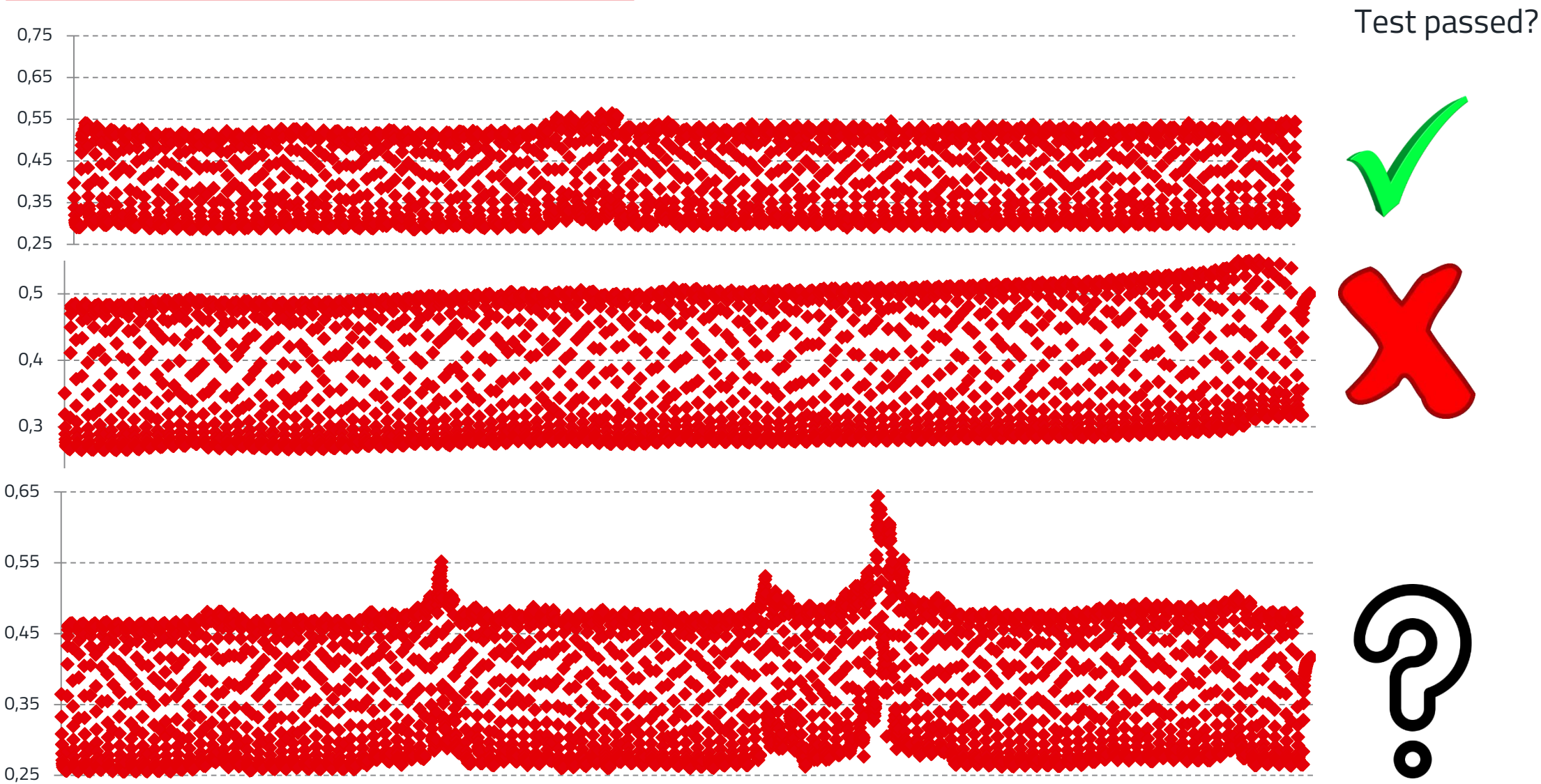



View into the sample chamber



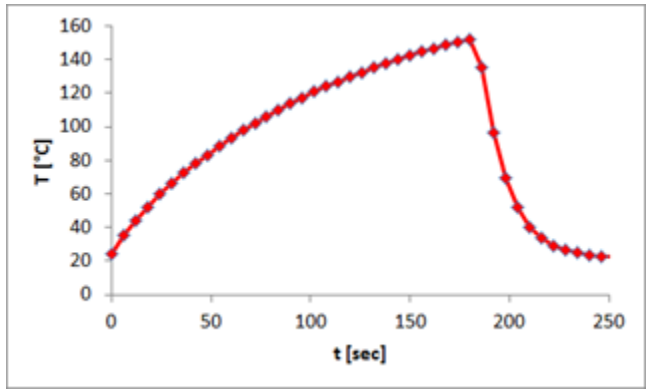
# ONLINE MEASUREMENT 4-WIRE

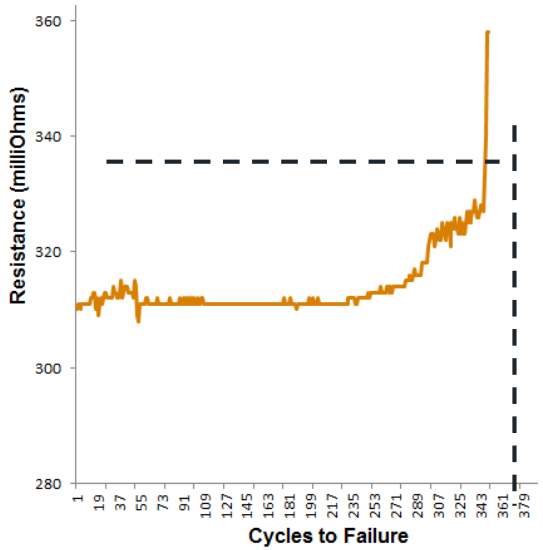


# INTERCONNECT STRESS TEST

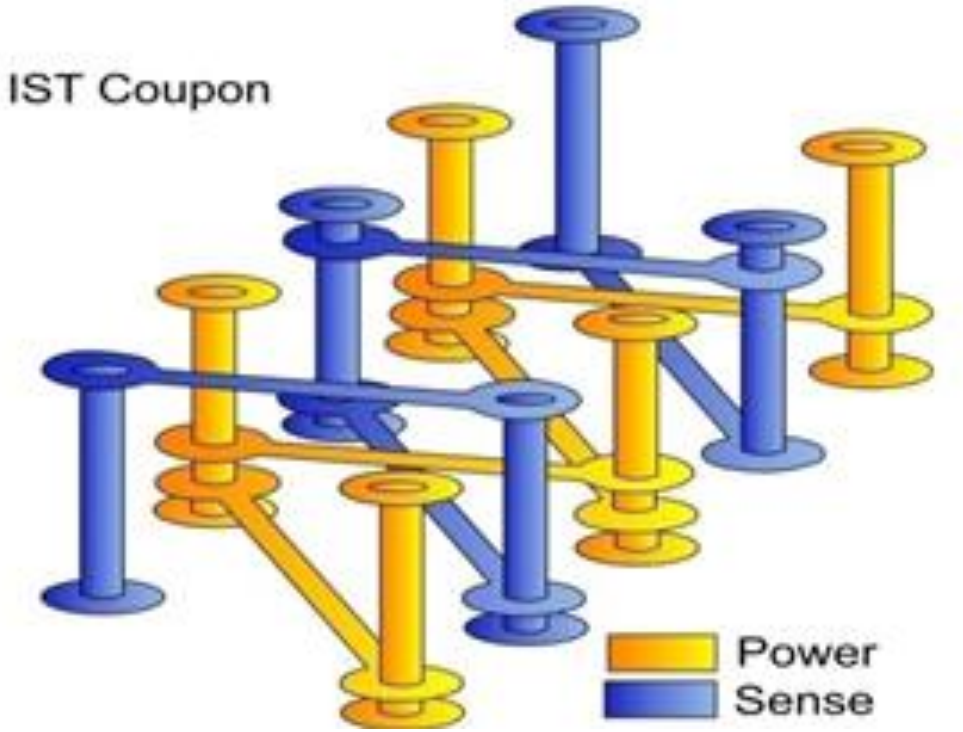
What is Interconnect Stress Test or IST?

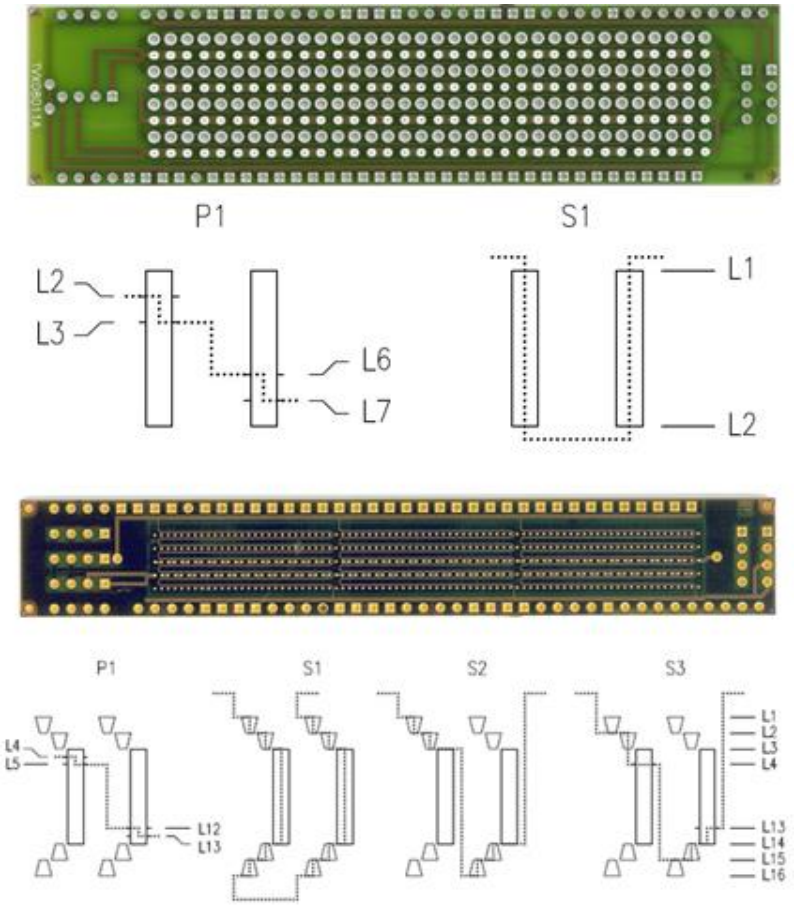
- Special test coupon according to the circuit board design
- Resistance measurement online ΔR/R all circuits (Power & Sense)
- Heating via electrical loss



# STRUCTURE OF TEST COUPON



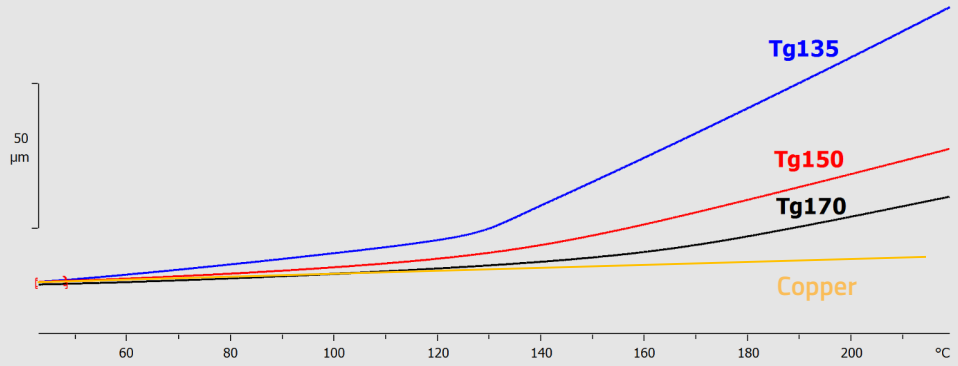




Individual coupon design possible (and necessary)

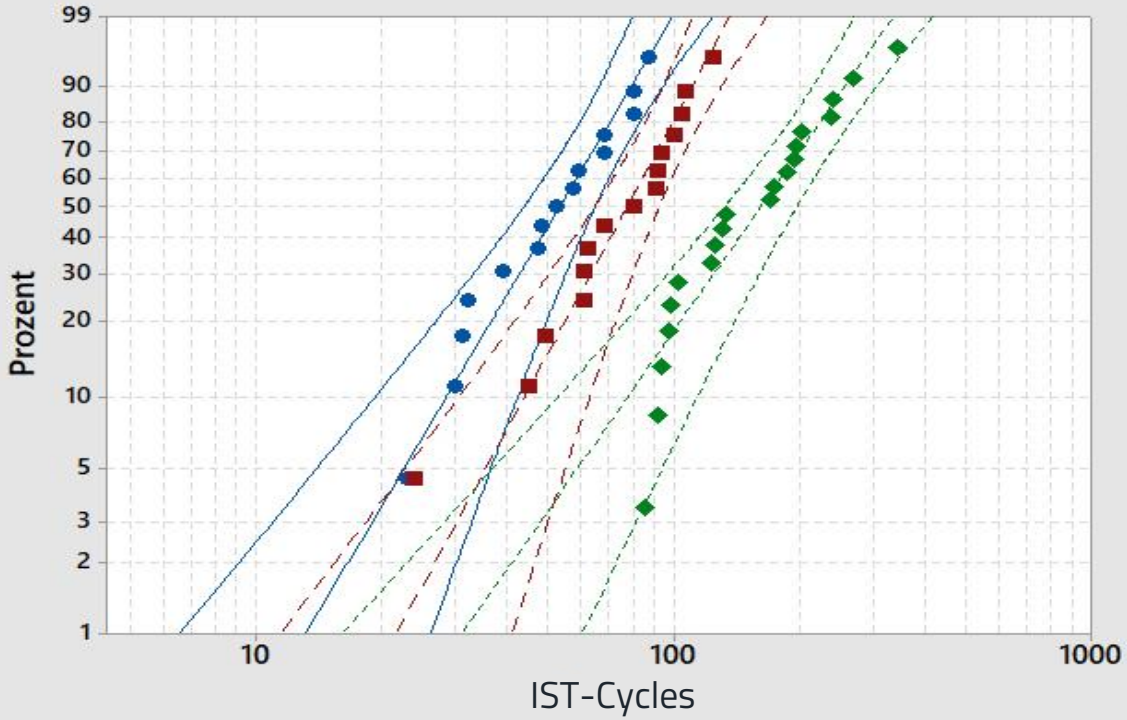
# PCB THICKNESS

The influence of the PCB thickness is enormous:

Approximately 20% change in the PCB thickness can lead to a change in reliability by a factor of 3!



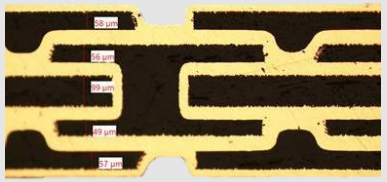

## Weibull –Graph



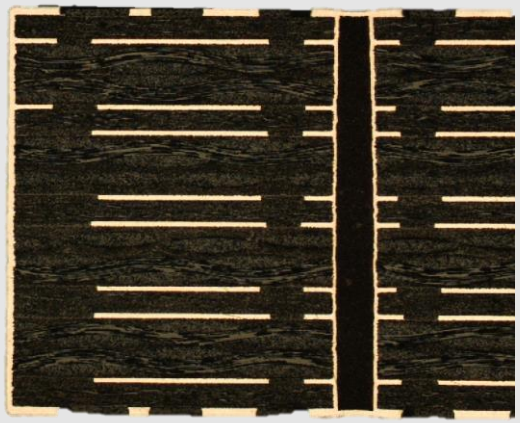

- 2,2 mm Skala 60 Zyklen
- 2,0 mm Skala 86 Zyklen
- 1,8 mm Skala 185 Zyklen

# PCB THICKNESS

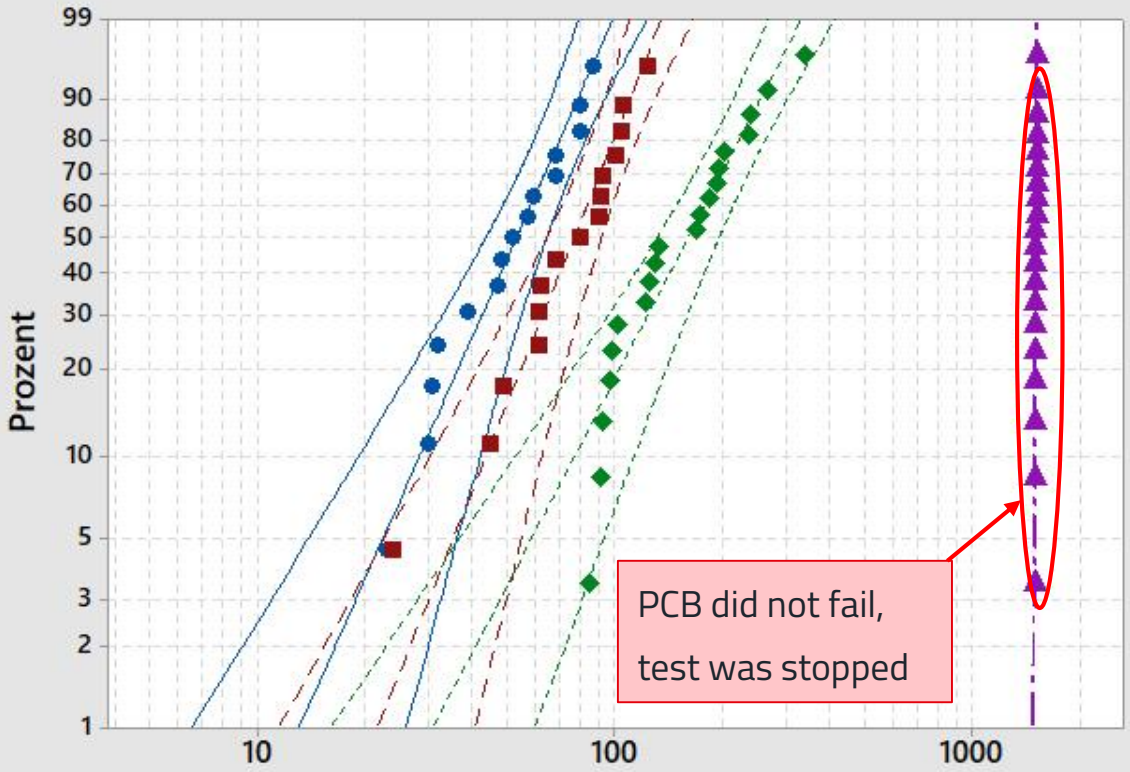
The influence of the PCB thickness is enormous:



0,6 mm



1,8 mm




- 2,2 mm Skala 60 Zyklen
- 2,0 mm Skala 86 Zyklen
- 1,8 mm Skala 185 Zyklen
- 0,6 mm Skala +2000 Zyklen

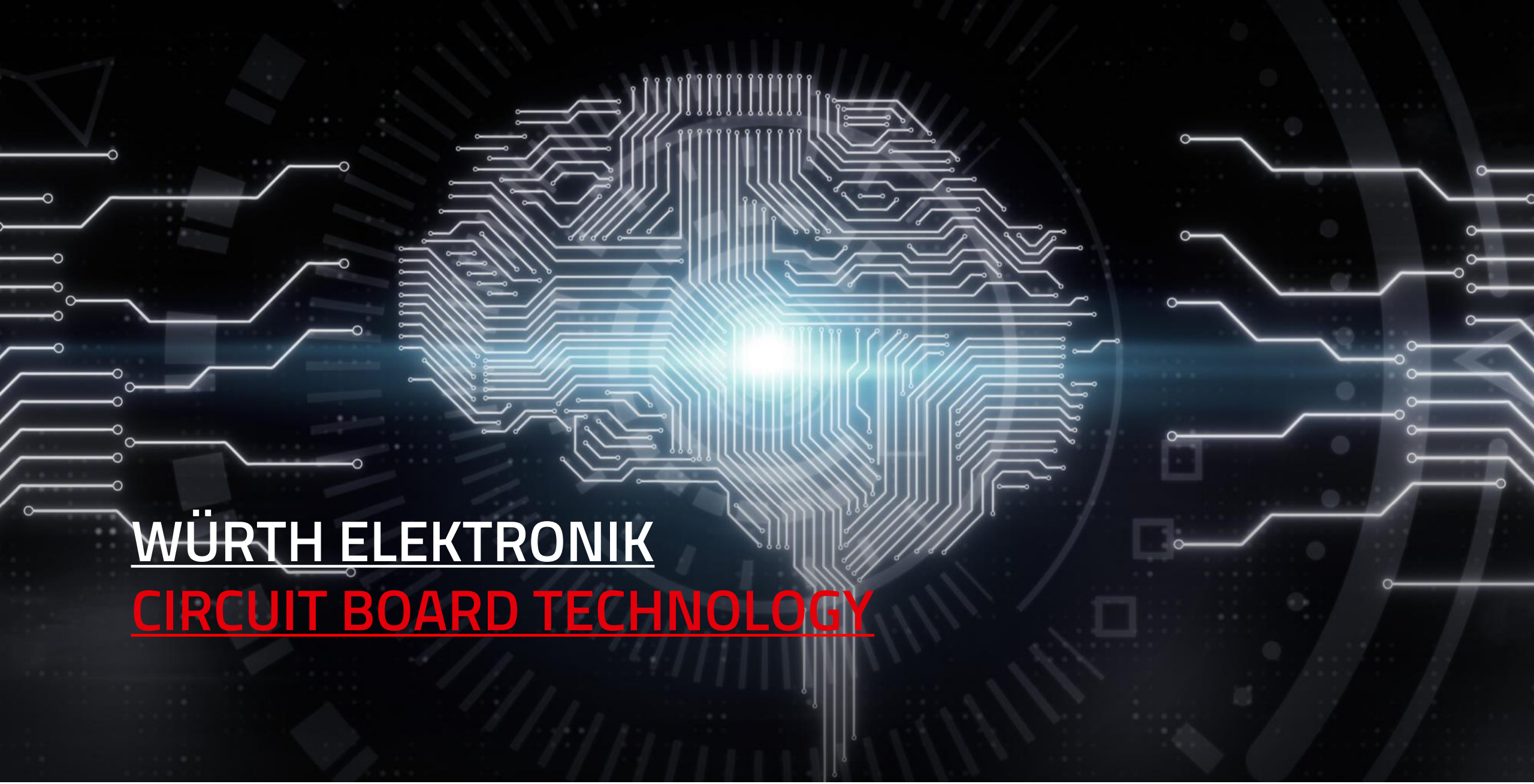
# SUMMARY

## Process Controll

- Complex processes are necessary for printed circuit board (PCB) manufacturing and are monitored by ongoing measurement.
- Expanded laboratory tests are performed routinely, and control charts are maintained.
- Quality gates audit critical steps in manufacturing.
- Various delivery documentations are available.

## Long-Term Stability and Reliability

- Numerous in-house test methods are available at Würth Elektronik for the qualification of processes and materials.
- We can support you with the planning and execution of tests on printed circuit boards. Please contact us if required



# WÜRTH ELEKTRONIK
# CIRCUIT BOARD TECHNOLOGY