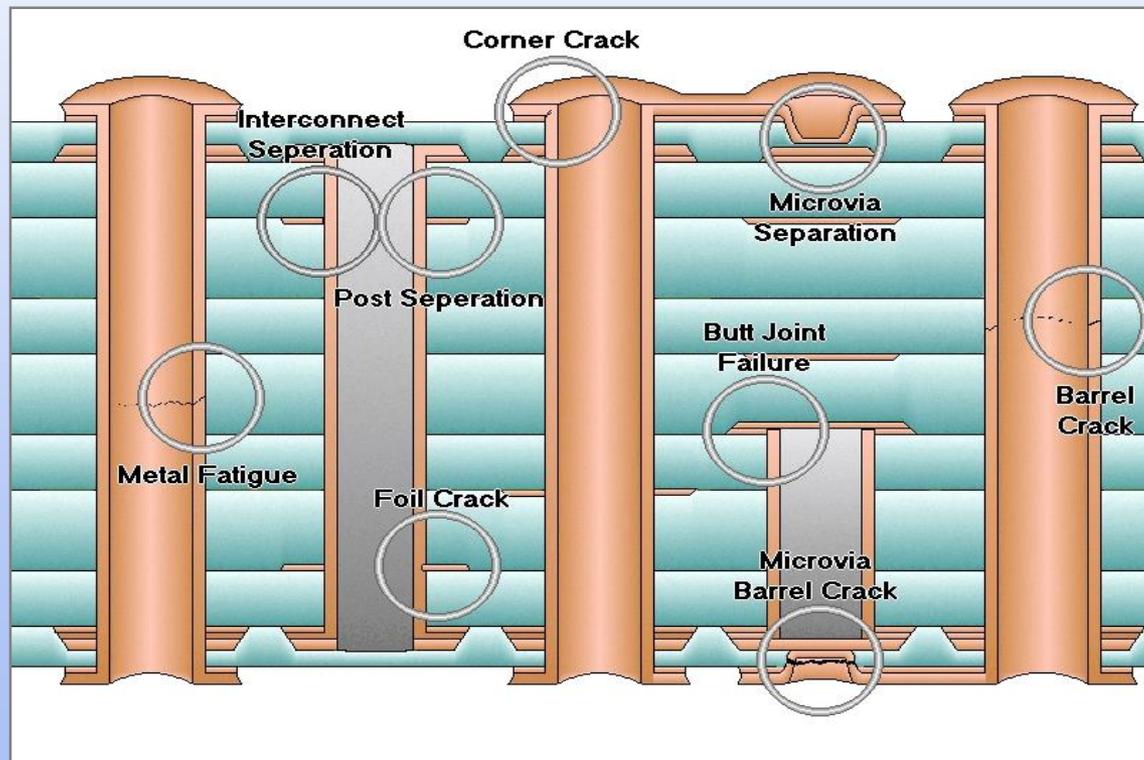
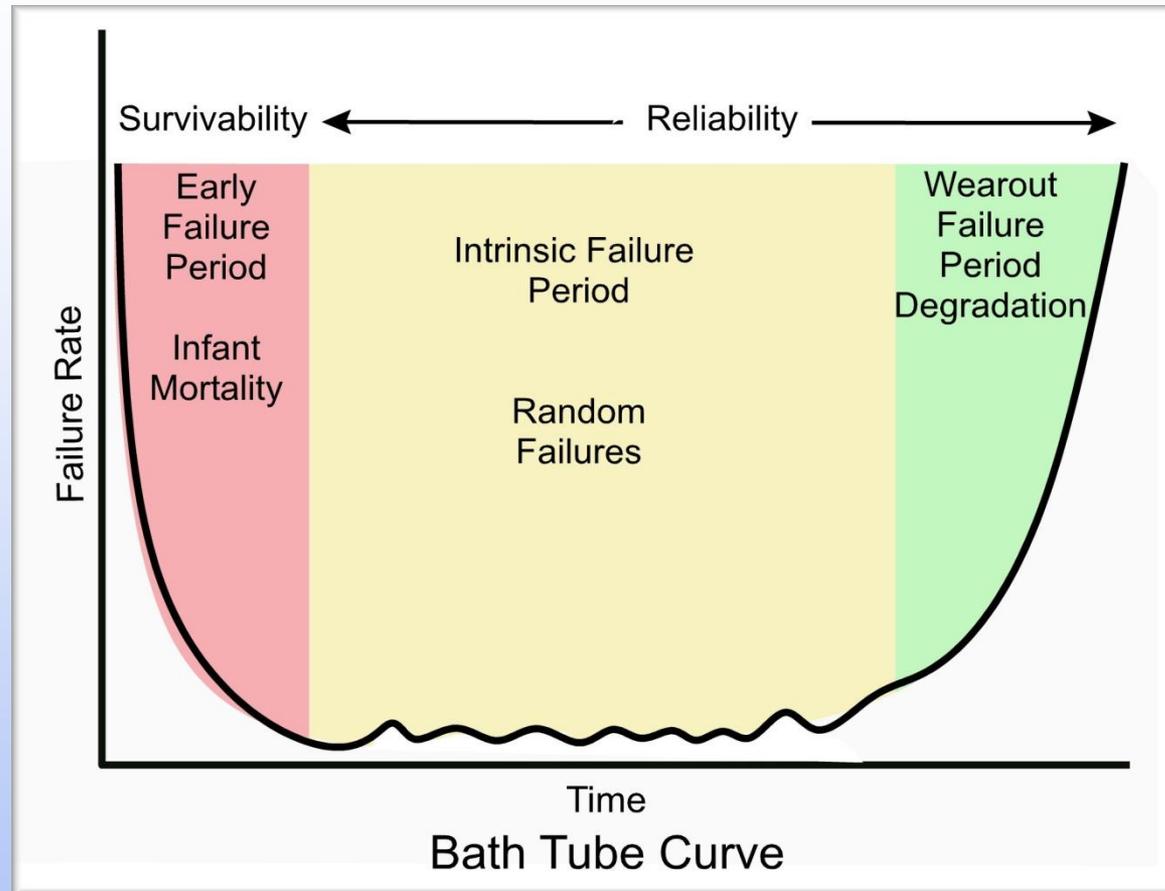


IST Interconnect Stress Test – der neue Standard für die Zuverlässigkeitsprüfung von Leiterplatten

Hermann Reischer/Polar Instruments GmbH



Was ist “Zuverlässigkeit”?



Zuverlässigkeit ist die **Wahrscheinlichkeit**, dass ein Produkt die beabsichtigte Funktion für einen **angegebenen Zeitraum** unter **definierten Bedingungen** erfüllt.

Zukünftige Anforderungen an die Leiterplatte:

Bleifrei-Lötprozesse:

Löttemperaturen > 260°C

Hot Air Levelling

6-fach Rework

Hohe Zuverlässigkeit:

Medizintechnik

Luft/Raumfahrt

Rüstung

Automotive/Bahnbereich

Testmethoden:

Temperaturwechseltest (TWT) – Prüfling wird wechselweise in zwei Klimakammern mit -40°C und $+125^{\circ}\text{C}$ eingefahren, 500 – 1500 Zyklen.

IST Interconnect Stress Test - Spezieller Testcoupon mit Durchkontaktierungen, elektrische Aufheizung des Coupons auf 150°C für 3 Minuten, Abkühlung auf Raumtemperatur in 2 Minuten

IPC-TM650.2.6.26

Association Connecting Electronics Industries



3000 Lakeside Drive, Suite 309S
Bannockburn, IL 60015-1249

IPC-TM-650 TEST METHODS MANUAL

1 Scope These methods determine the physical endurance of representative coupons of printed boards to a series of high temperature excursions from ambient. The temperature excursions cause thermo-mechanical fatigue of the electrical interconnect structures.

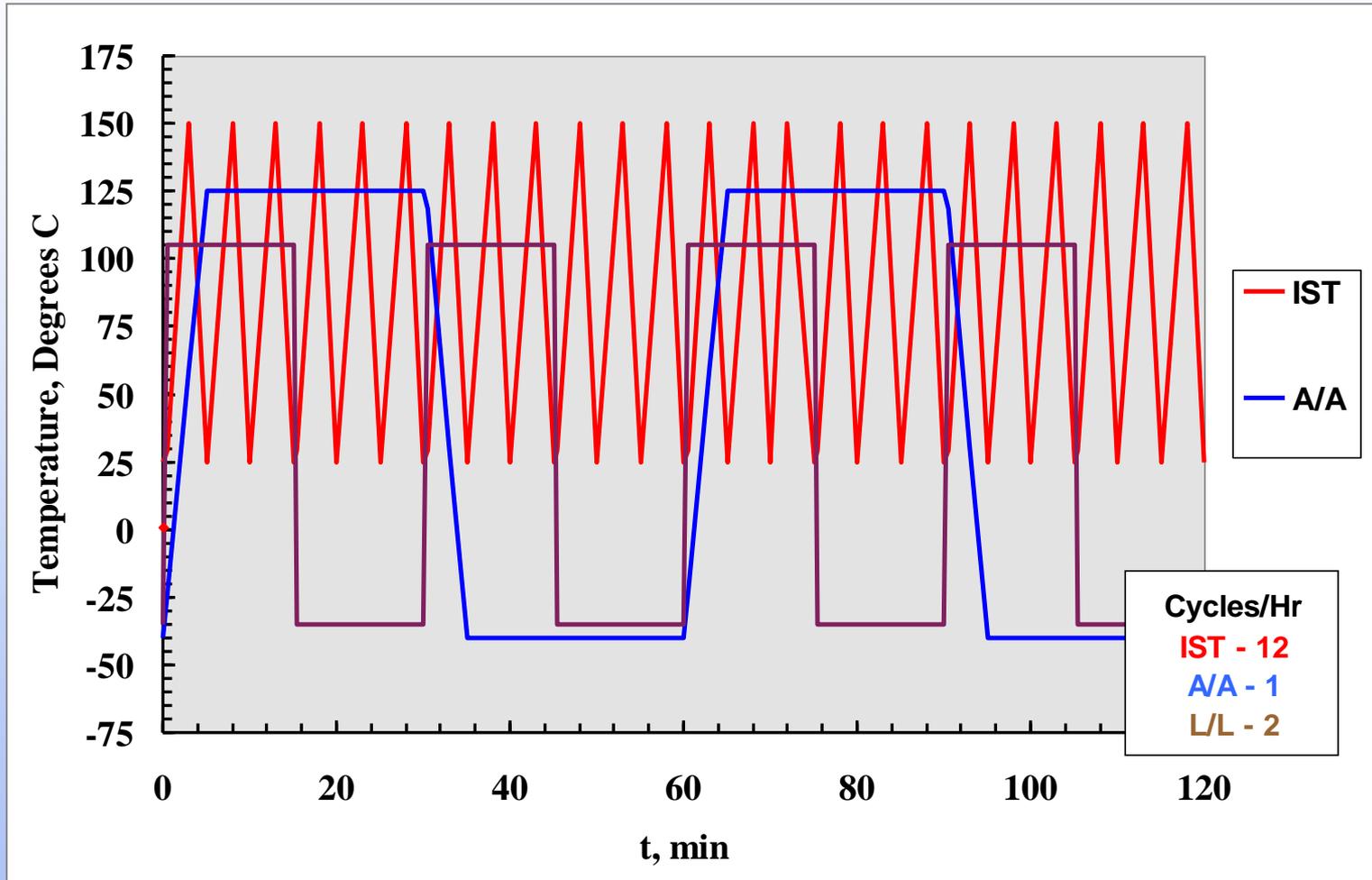
The test coupon is resistance heated by passing DC current through the coupon to bring the temperature of the copper to a designated temperature. Switching the current on and off creates thermal cycles between room temperature and the designated temperature within the sample. The laminate and surrounding materials are heated to different extents depend-

| | |
|---|----------------------|
| Number 2.6.26 | |
| Subject DC Current Induced Thermal Cycling Test | |
| Date 5/14 | Revision A |
| Originating Task Group PTV Reliability Test Methods (6-10c) | |

1.2 Method B Description Method B uses a coupon with one electrical net. The net consists of via structures connected by external and/or internal circuit lines in a daisy chain. DC current is passed through the electrical net to heat the coupon to a designated temperature. When the electrical net is at the designated temperature, the DC current is turned off and a cooling fan is turned on to cool the coupons to ambient temperature. One heating and cooling sequence represents a thermal cycle. Thermal cycling is continued to either a set number of cycles or a failure. Temperature coefficient of resistance (TCR) is measured.

Quelle: https://www.ipc.org/TM/2-6_2-6-26A.pdf

Vergleich IST Interconnect Stress Test vs. Klimakammer



1000 Zyklen: IST ~ 4 Tage, Klimakammer ~ 42 Tage

Increasing Demand for Demonstrated Reliability



Consumer Electronics



Telecom



Aerospace

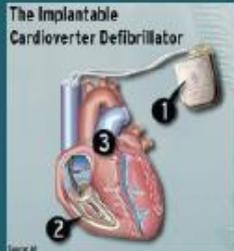


Automotive

50 100 150 200 250 300 350 400 450 500
Customer Spec's for Minimum IST Cycles to Failure After Assembly



High End Computers



The Implantable Cardioverter Defibrillator

Medical Devices

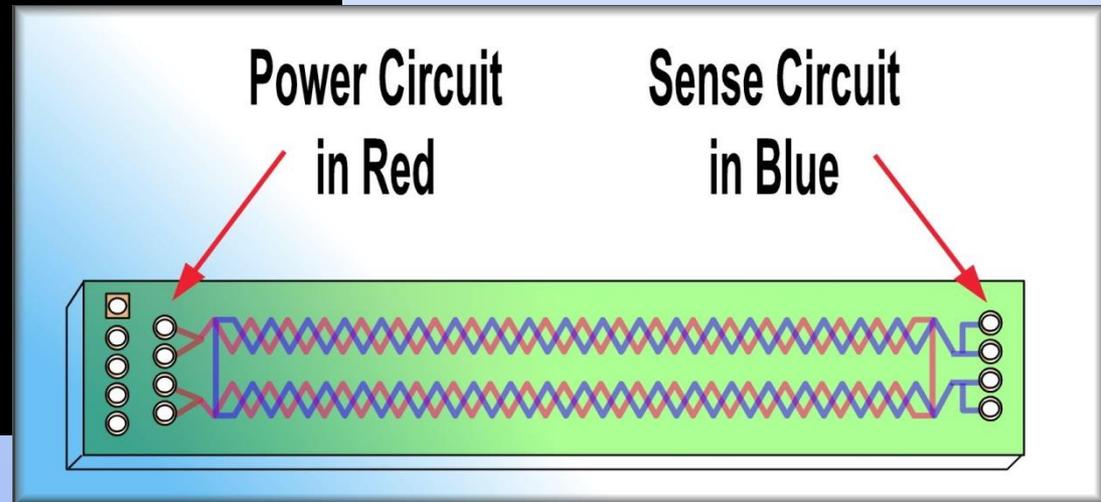
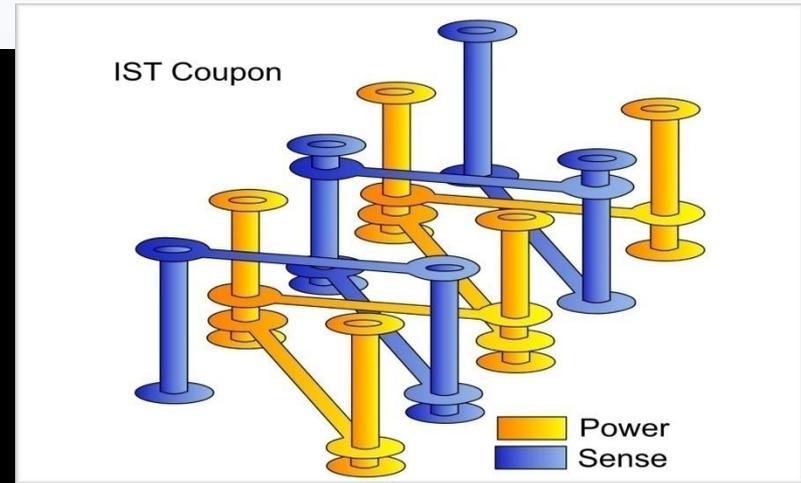
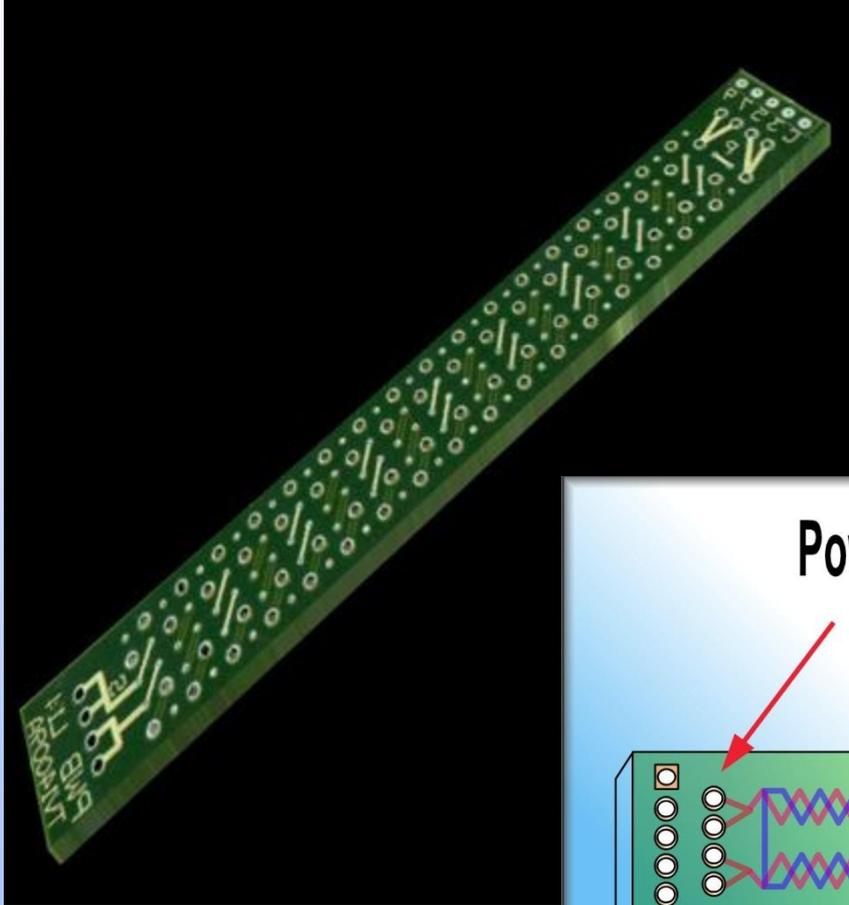


Commercial Aviation

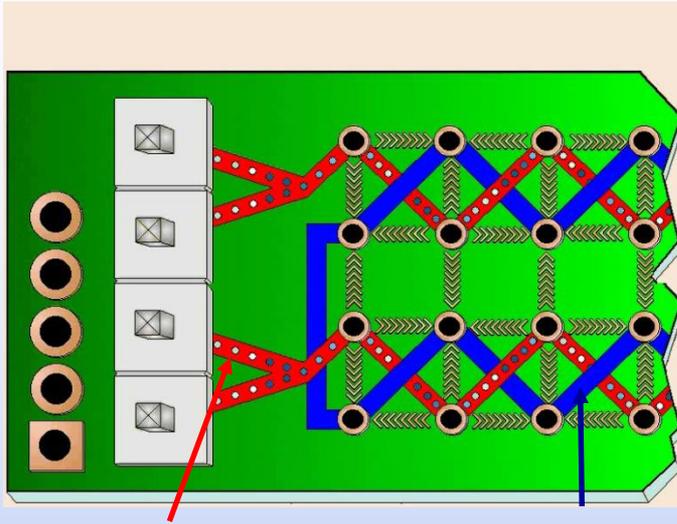


Space

IST Testcoupon:

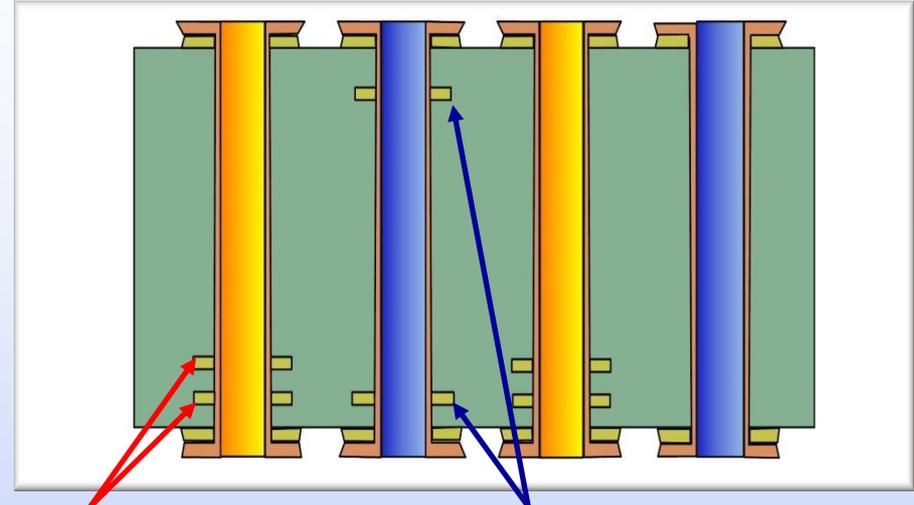


IST Testcoupon:



Heizkreis

Meßkreis

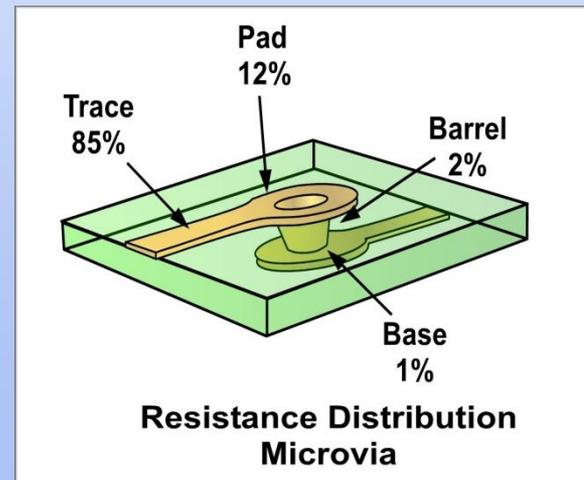
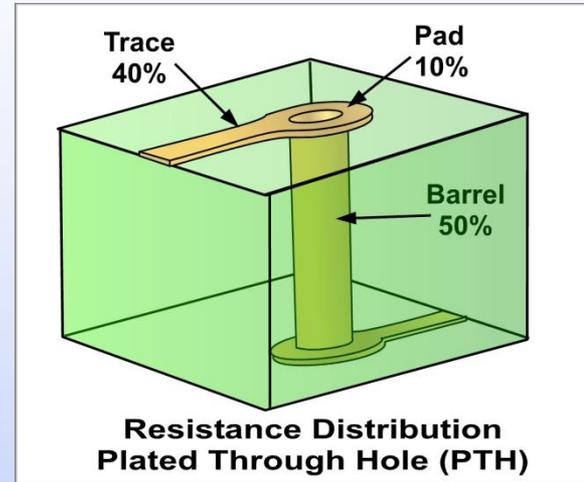
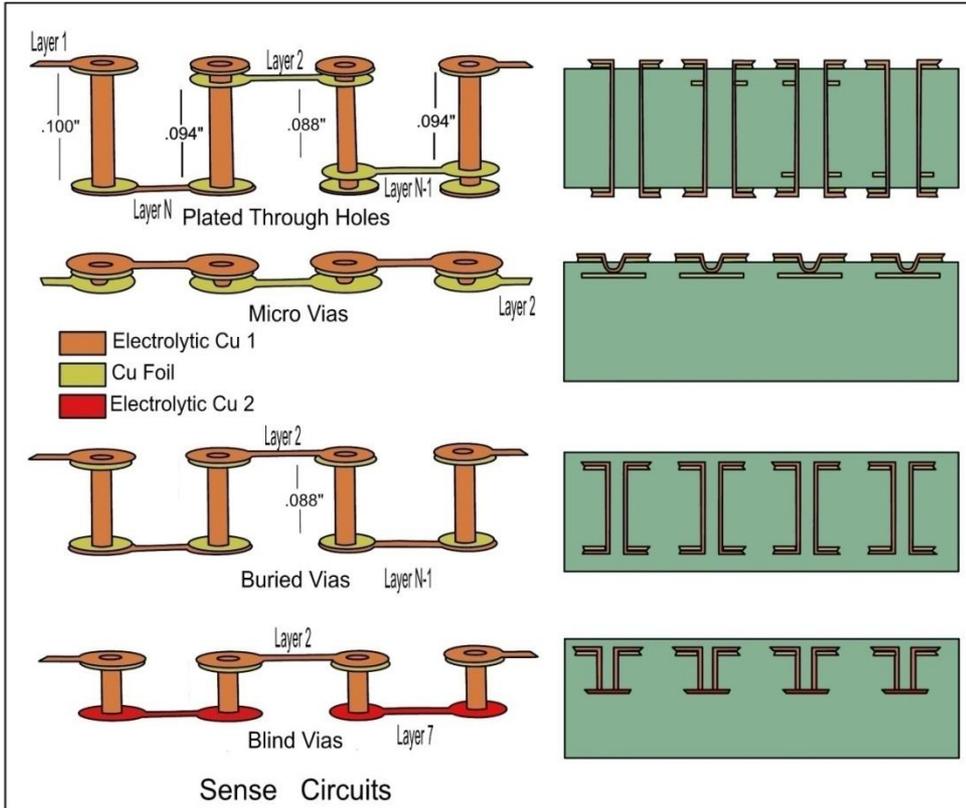
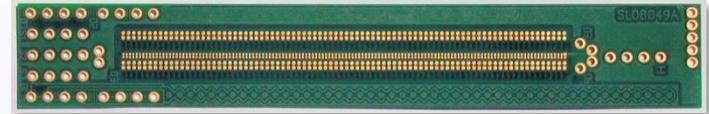


Heizkreis

Meßkreis

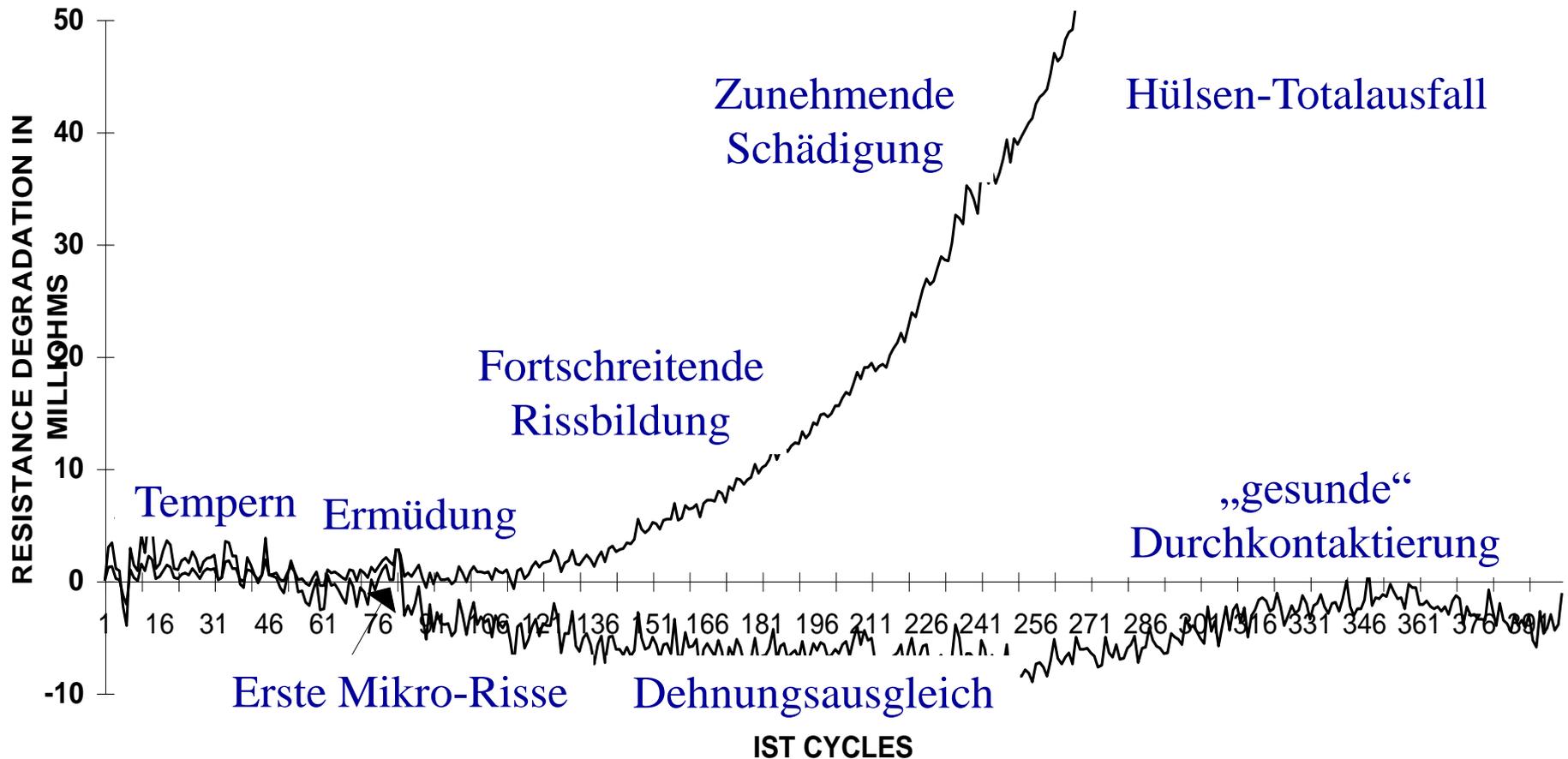
- Die Temperaturverteilung erfolgt vom Heizkreis auf den Meßkreis
- Es fließt nur Meßstrom durch die Durchkontaktierungen des Meßkreises
- Kupferlagen unterstützen eine gleichförmige Temperaturverteilung
- Durchkontaktierungs-Raster bestimmt die Temperaturdifferenz zwischen Heiz- und Meßkreis
- zusätzlicher "Superheat-Kreis" möglich für noch homogenere Temperaturverteilung

IST Testcoupon:



Widerstandserhöhung durch therm. Belastung:

RESISTANCE DEGRADATION OF THE PTH INTERCONNECT



Typisches Abbruchkriterium nach IPC: 10% Widerstandserhöhung

IST-HC System:

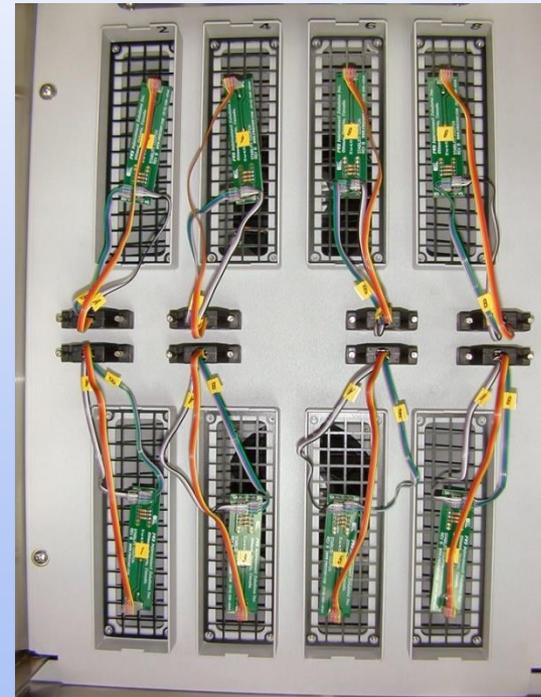


The Institute for Interconnecting and Packaging Electronic Circuits
2215 Sanders Road Northbrook IL 60062-6135

IPC

IPC-TM-650
Test Methods Manual

| | |
|---|----------|
| Number 2.6.26 | |
| Subject | |
| DC Current Induced Thermal Cycling Test | |
| Date | Revision |
| 11/99 | Proposal |
| Originating Committee: Test Methods Subcommittee (7-11) | |



8-Kanal Couponaufnahme

Coupondaten 8-Kanal-Darstellung:

The image displays a 'Tester Control Panel' software interface. The top section shows data for four heads (2, 4, 6, 8) in a tabular format. The bottom section shows graphical representations for eight heads (2, 4, 6, 8, 1, 3, 5, 7) with gauges for Cycle #, Power, Sense A, and Sense B.

Table 1: Head 2 Data (TestCoupon3)

| Parameter | Value 1 | Value 2 | Value 3 |
|-----------|-----------------------|---------|---------|
| Start Res | 715 | 762.8 | 935.6 |
| Fail Res | 1171.1 | 1249.3 | 1532.4 |
| Res | 745.4 | 790 | 937 |
| Temp | 34 | 32.3 | 23.4 |
| Delta Res | 0 | 0 | 0 |
| Current | 2.048 | 1.527 | 3.1 |
| Voltage | 1.527 | 3.1 | 14 |
| Power | 3.1 | 14 | |
| Time | 14 | | |
| Status | Heating Pre-cycle # 0 | | |

Table 2: Head 4 Data (TestCoupon4)

| Parameter | Value 1 | Value 2 | Value 3 |
|-----------|-----------------------|---------|---------|
| Start Res | 765 | 728.5 | 896.9 |
| Fail Res | 1253 | 1193.2 | 1469 |
| Res | 792.2 | 754 | 898 |
| Temp | 32.2 | 32.1 | 23.3 |
| Delta Res | 0 | 0 | 0 |
| Current | 1.98 | 1.569 | 3.1 |
| Voltage | 1.569 | 3.1 | 14 |
| Power | 3.1 | 14 | |
| Time | 14 | | |
| Status | Heating Pre-cycle # 0 | | |

Table 3: Head 6 Data (TestCoupon5)

| Parameter | Value 1 | Value 2 | Value 3 |
|-----------|-----------------------|---------|---------|
| Start Res | 772 | 728.5 | 905.8 |
| Fail Res | 1264.4 | 1193.2 | 1483.6 |
| Res | 801.3 | 755 | 908 |
| Temp | 32.9 | 32.4 | 23.6 |
| Delta Res | 0 | 0 | 0 |
| Current | 1.971 | 1.58 | 3.1 |
| Voltage | 1.58 | 3.1 | 13.9 |
| Power | 3.1 | 13.9 | |
| Time | 13.9 | | |
| Status | Heating Pre-cycle # 0 | | |

Table 4: Head 8 Data (TestCoupon6)

| Parameter | Value 1 | Value 2 | Value 3 |
|-----------|-----------------------|---------|---------|
| Start Res | 771 | 726.8 | 895.5 |
| Fail Res | 1262.8 | 1190.4 | 1466.7 |
| Res | 800.7 | 752 | 897 |
| Temp | 33 | 32 | 23.4 |
| Delta Res | 0 | 0 | 0 |
| Current | 1.973 | 1.579 | 3.1 |
| Voltage | 1.579 | 3.1 | 13.9 |
| Power | 3.1 | 13.9 | |
| Time | 13.9 | | |
| Status | Heating Pre-cycle # 0 | | |

Table 5: Head 1 Data (TestCoupon15)

| Parameter | Value 1 | Value 2 | Value 3 |
|-----------|-----------------------|---------|---------|
| Start Res | 669 | 595.7 | 564.4 |
| Fail Res | 1095.7 | 975.7 | 924.4 |
| Res | 696.1 | 618 | 573 |
| Temp | 33.5 | 32.7 | 27 |
| Delta Res | 0 | 0 | 0 |
| Current | 2.118 | 1.474 | 3.1 |
| Voltage | 1.474 | 3.1 | 14.2 |
| Power | 3.1 | 14.2 | |
| Time | 14.2 | | |
| Status | Heating Pre-cycle # 0 | | |

Table 6: Head 3 Data (TestCoupon16)

| Parameter | Value 1 | Value 2 | Value 3 |
|-----------|-----------------------|---------|---------|
| Start Res | 592 | 665.7 | 558 |
| Fail Res | 969.6 | 1090.3 | 918 |
| Res | 615.6 | 690 | 564 |
| Temp | 33.4 | 32.5 | 27 |
| Delta Res | 0 | 0 | 0 |
| Current | 2.251 | 1.386 | 3.1 |
| Voltage | 1.386 | 3.1 | 14 |
| Power | 3.1 | 14 | |
| Time | 14 | | |
| Status | Heating Pre-cycle # 0 | | |

Table 7: Head 2 Gauge Data (A32_2)

| Parameter | Value |
|-----------|-------|
| Cycle # | 112 |
| Power | 0.1 |
| Sense A | 0.1 |
| Sense B | |

Table 8: Head 4 Gauge Data (A32_4)

| Parameter | Value |
|-----------|-------|
| Cycle # | 112 |
| Power | 0.2 |
| Sense A | 0.1 |
| Sense B | |

Table 9: Head 6 Gauge Data (B34_2)

| Parameter | Value |
|-----------|-------|
| Cycle # | 112 |
| Power | 0.3 |
| Sense A | 0.4 |
| Sense B | |

Table 10: Head 8 Gauge Data (B34_4)

| Parameter | Value |
|-----------|-------|
| Cycle # | 100 |
| Power | 0.6 |
| Sense A | 7.4 |
| Sense B | |

Table 11: Head 1 Gauge Data (A32_1)

| Parameter | Value |
|-----------|-------|
| Cycle # | 92 |
| Power | 0 |
| Sense A | 7.5 |
| Sense B | |

Table 12: Head 3 Gauge Data (A32_3)

| Parameter | Value |
|-----------|-------|
| Cycle # | 112 |
| Power | 0.3 |
| Sense A | 0.4 |
| Sense B | |

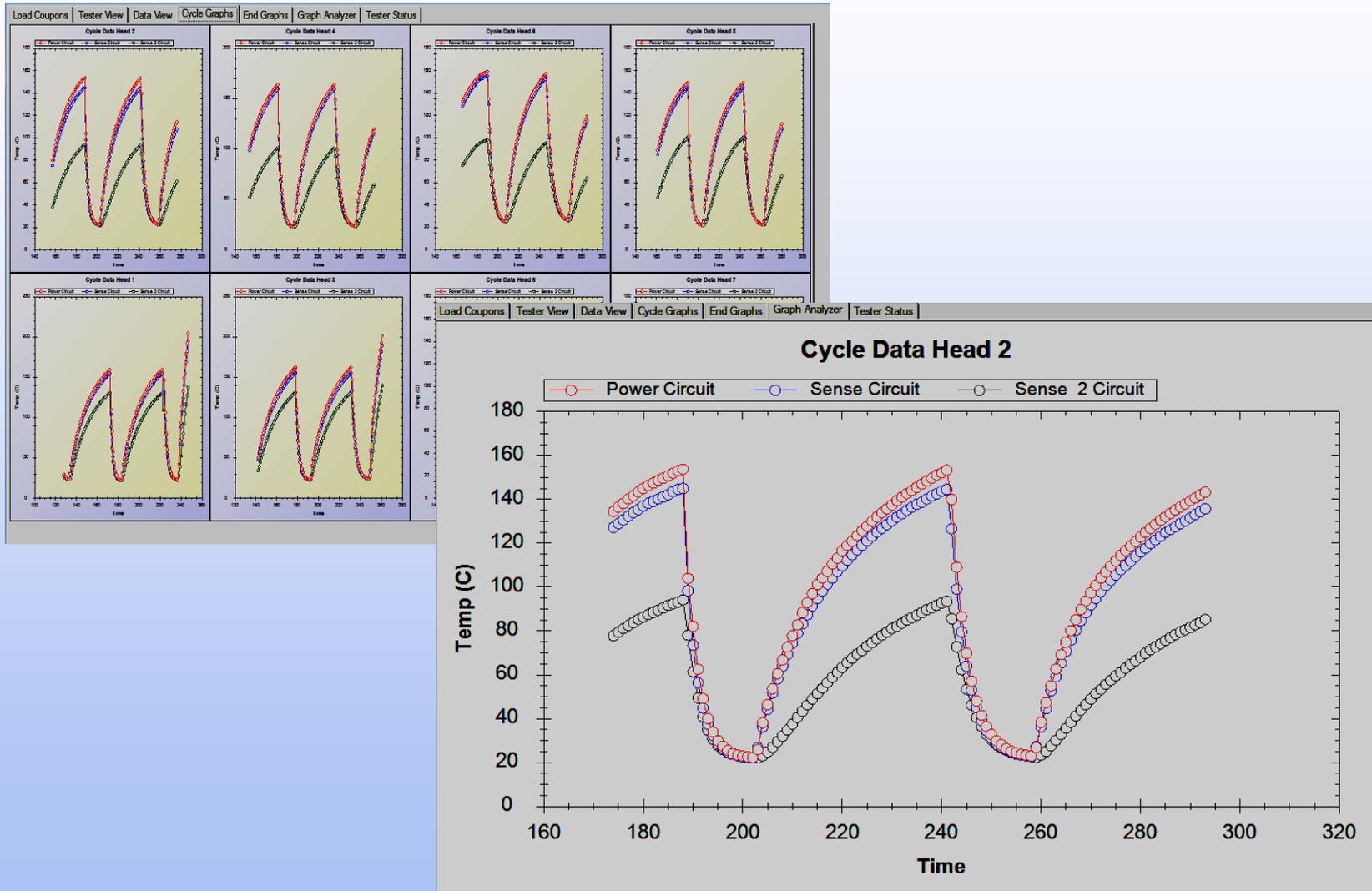
Table 13: Head 5 Gauge Data (B34_1)

| Parameter | Value |
|-----------|-------|
| Cycle # | 111 |
| Power | 0.6 |
| Sense A | 7.5 |
| Sense B | |

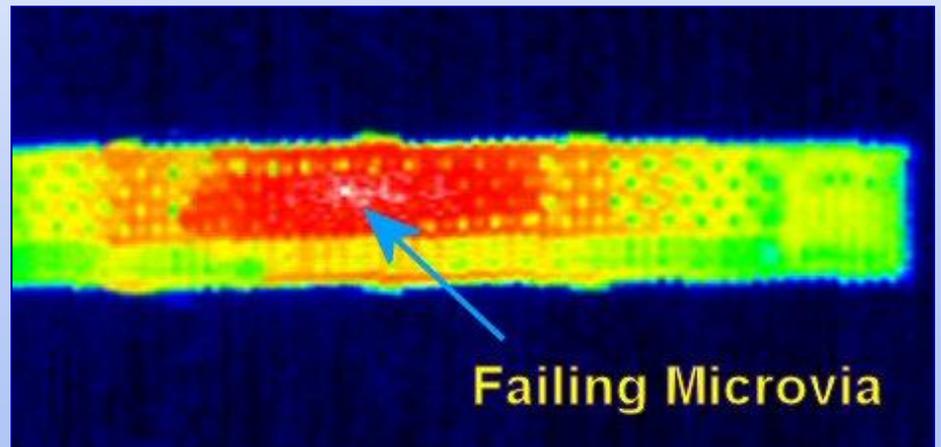
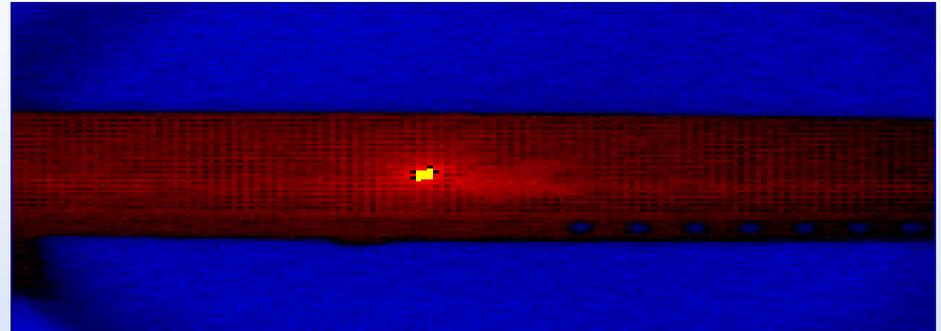
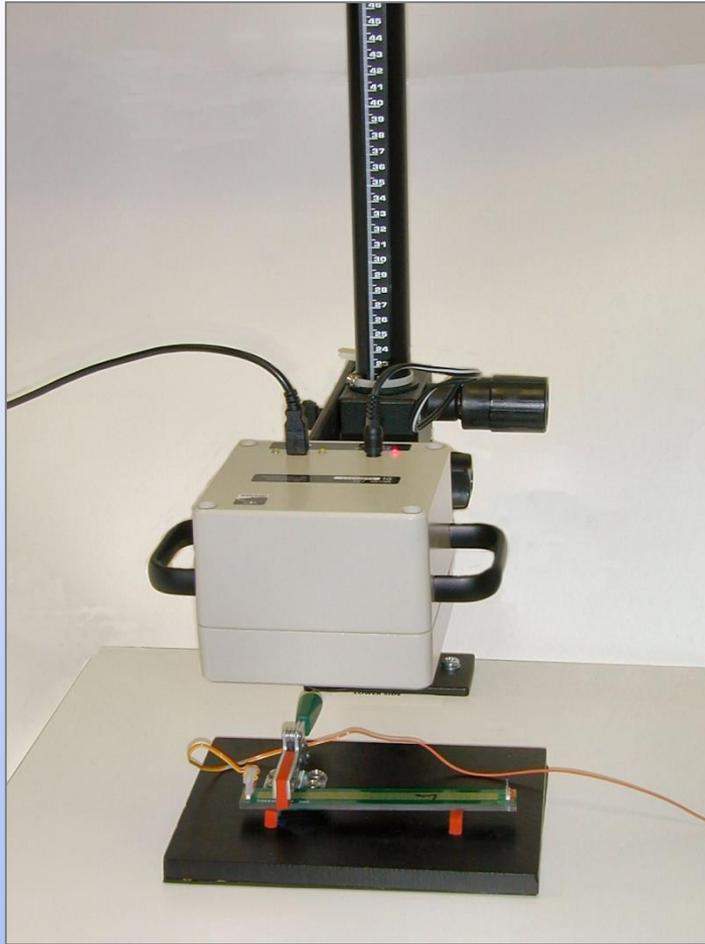
Table 14: Head 7 Gauge Data (B34_3)

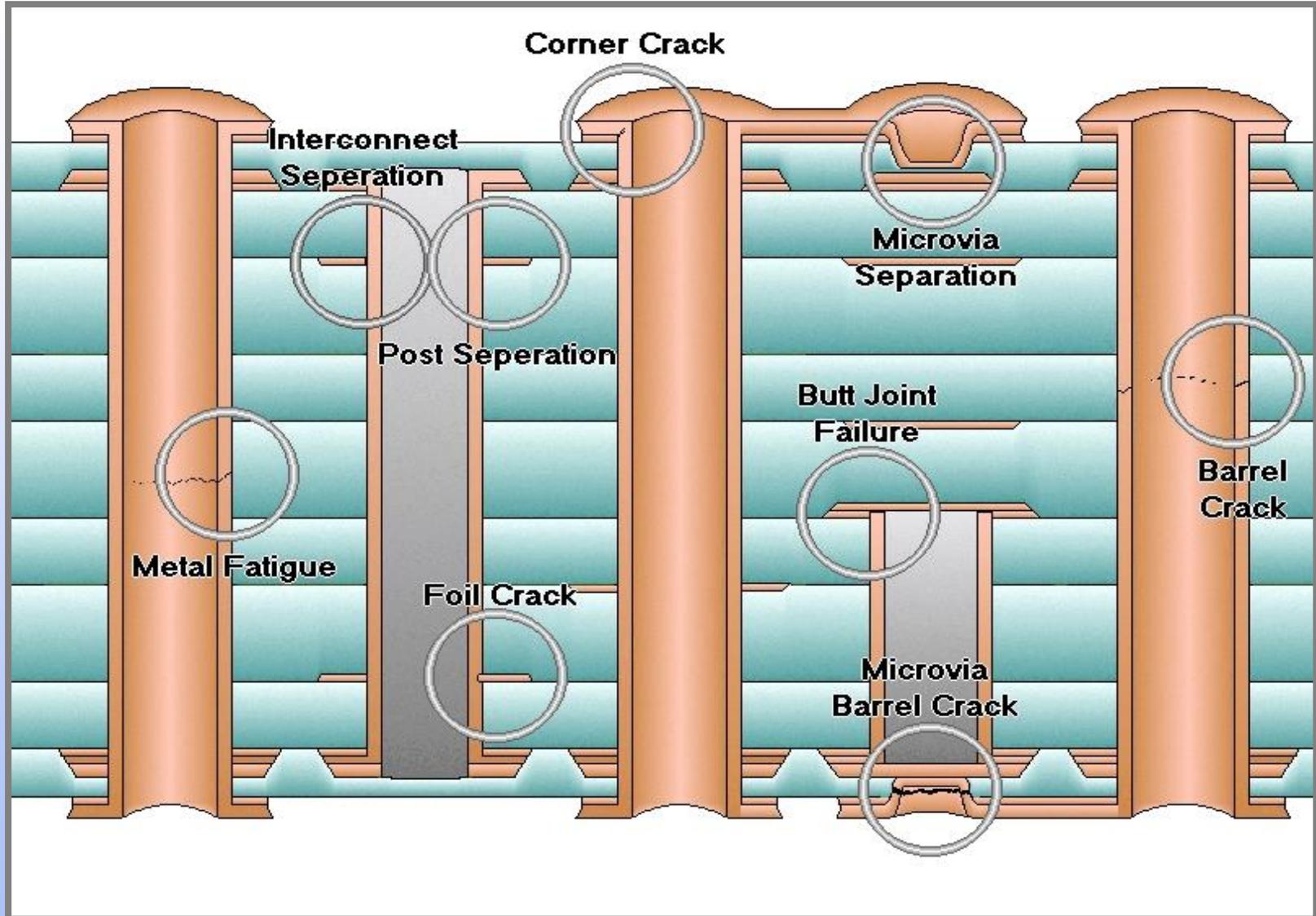
| Parameter | Value |
|-----------|-------|
| Cycle # | 112 |
| Power | -0.7 |
| Sense A | -0.4 |
| Sense B | |

Temperaturverläufe an 8 Coupons:

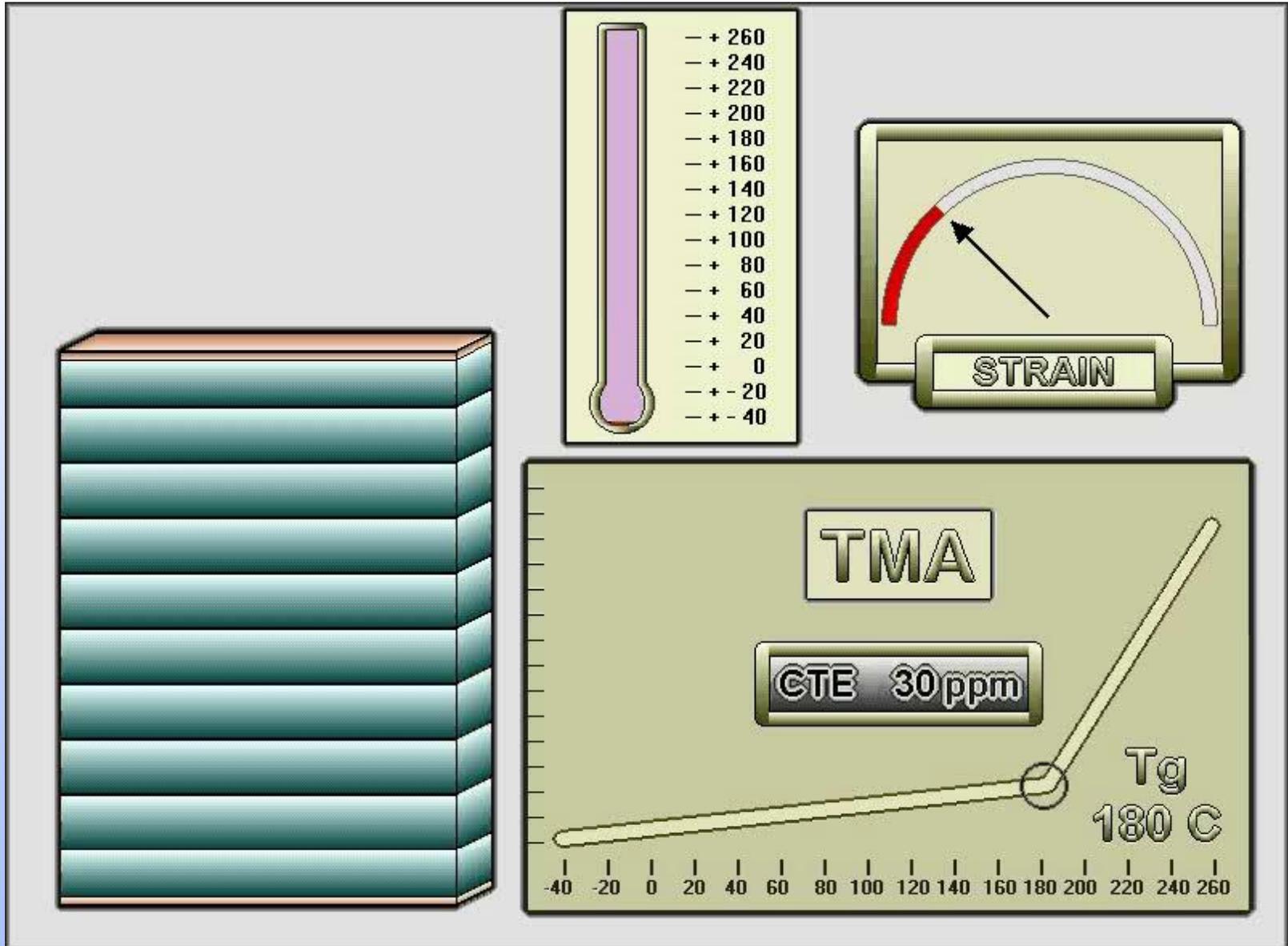


Fehlerlokalisierung mit Infrarotkamera:

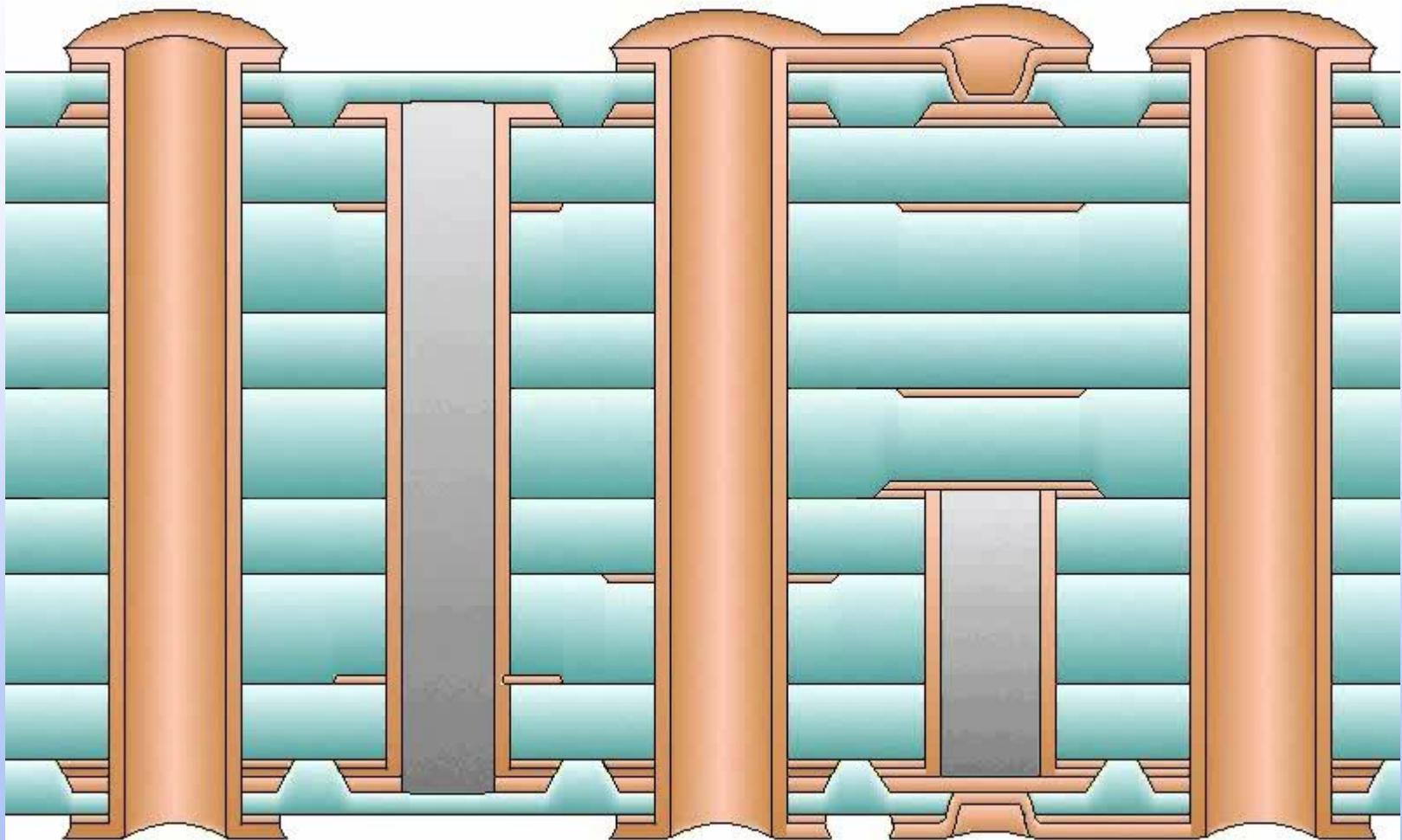




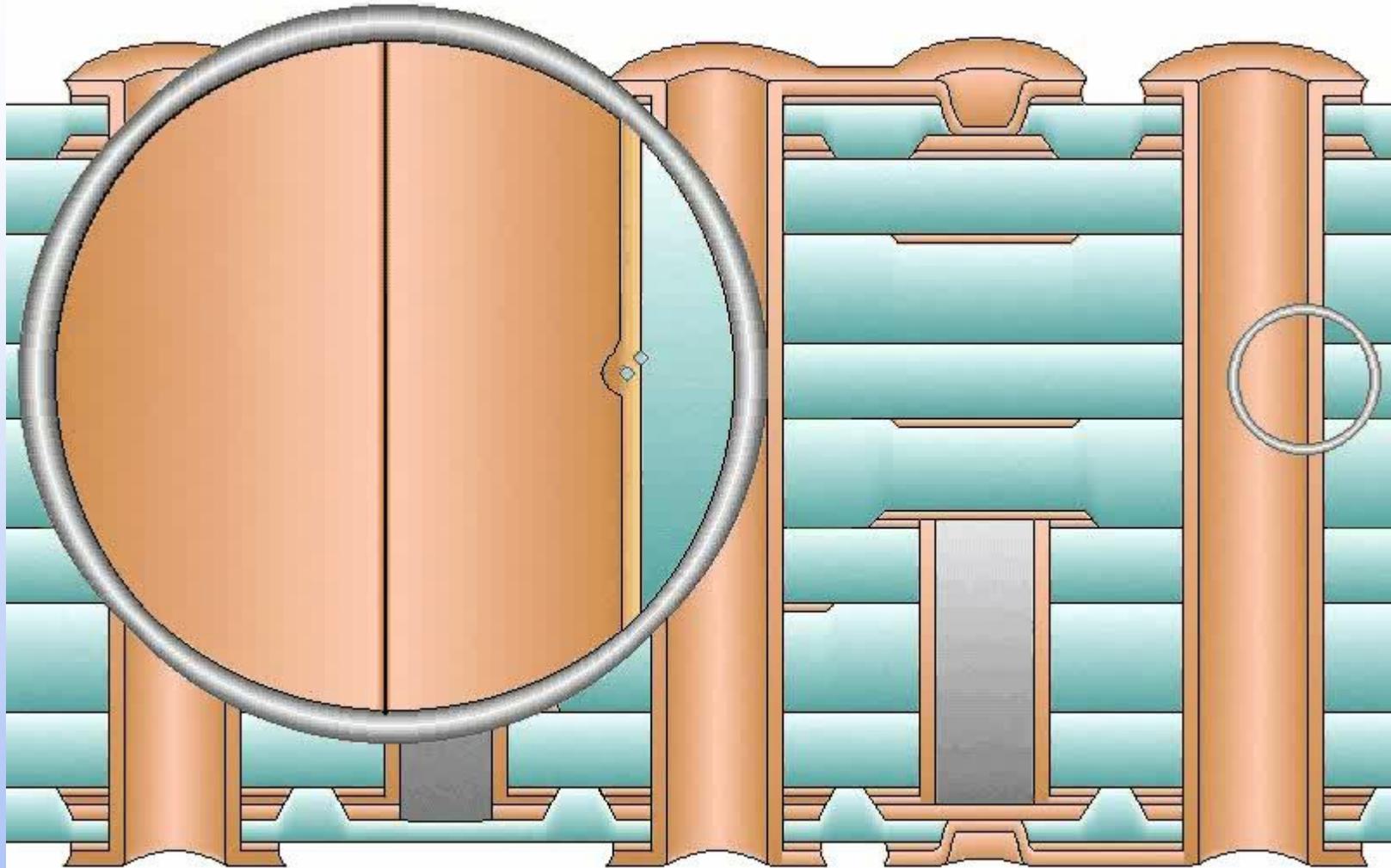
Temperatur-Ausdehnungsverhalten:



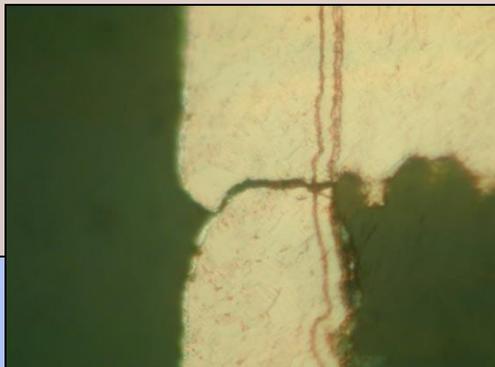
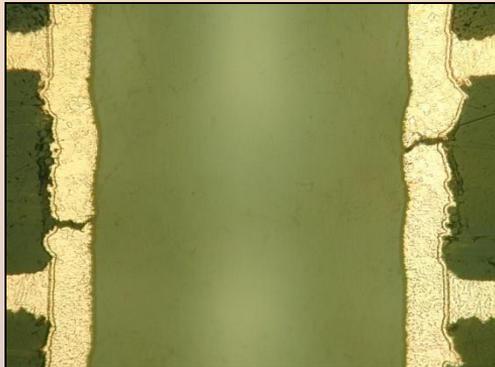
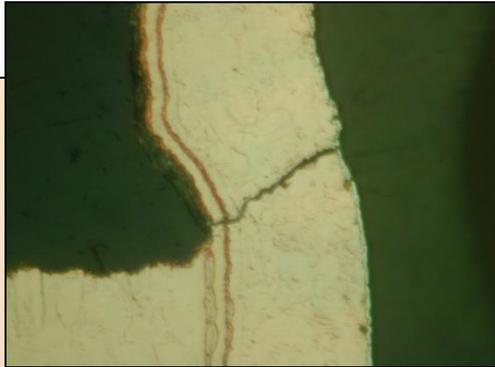
Heiz- und Abkühlzyklus in Leiterplatte:



Hülse

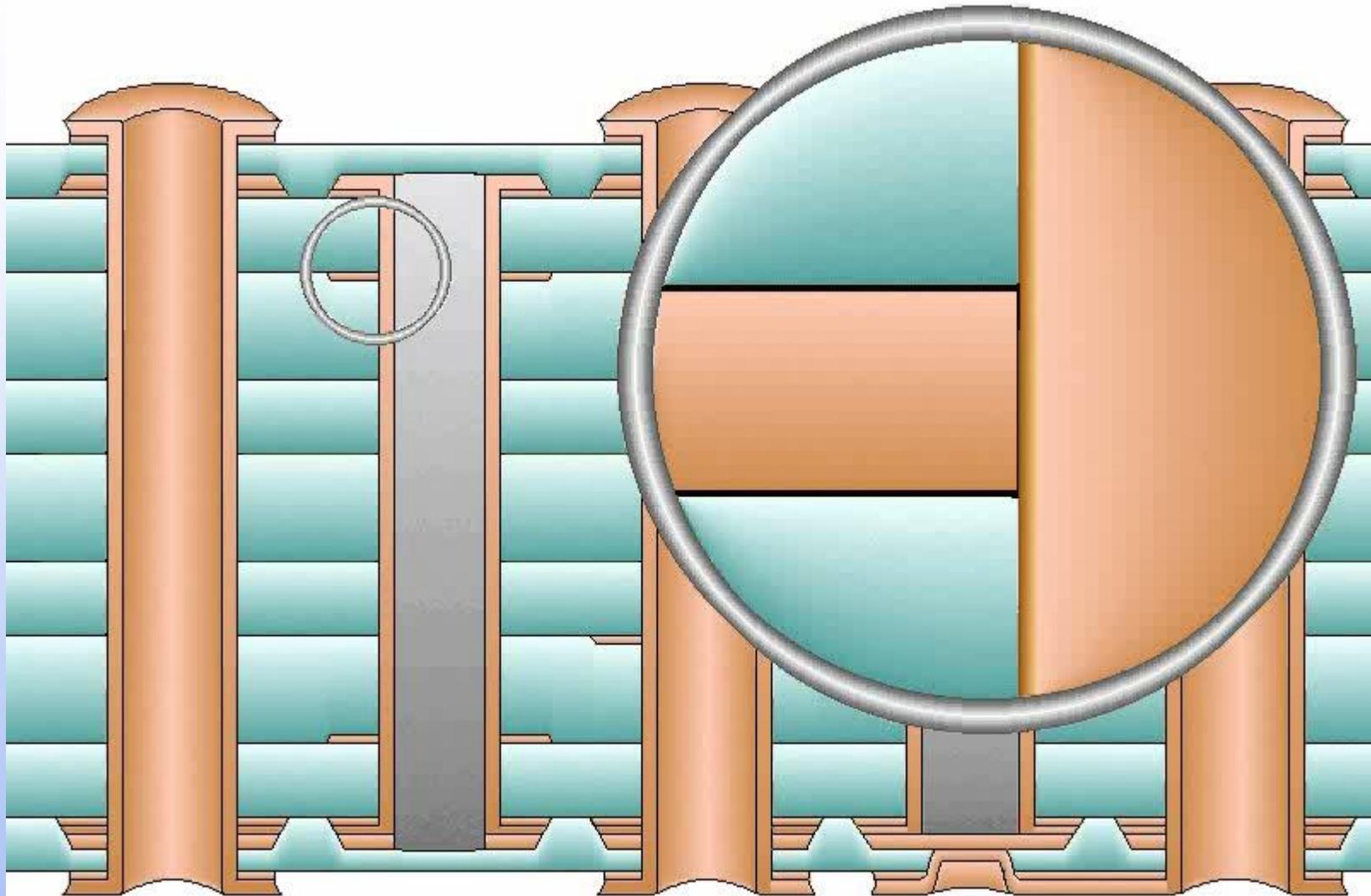


Typische Fehlerbilder - Hülsenrisse:

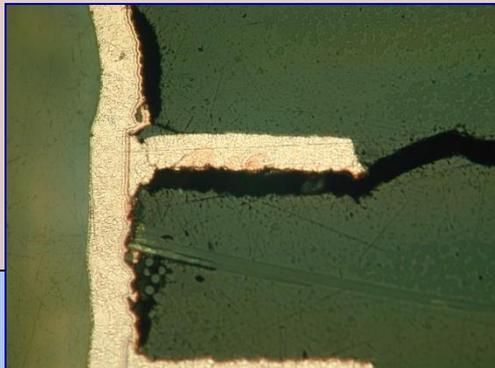
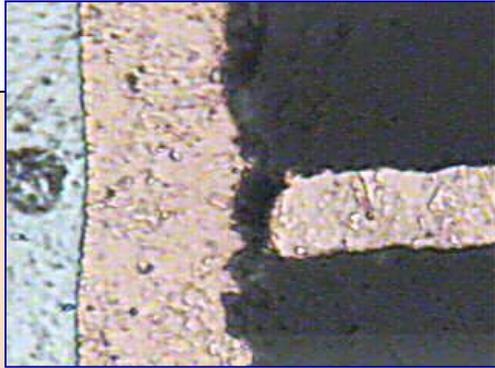


- **Kupferhülse wird in Längsrichtung gedehnt**
- **Riss in der Wand der Durchkontaktierung**
- **Rascher Schädigungsfortschritt**
- **meist große Rissbreite**
- **Unterbrochen bei Raumtemperatur**

Innenlagenabriss:

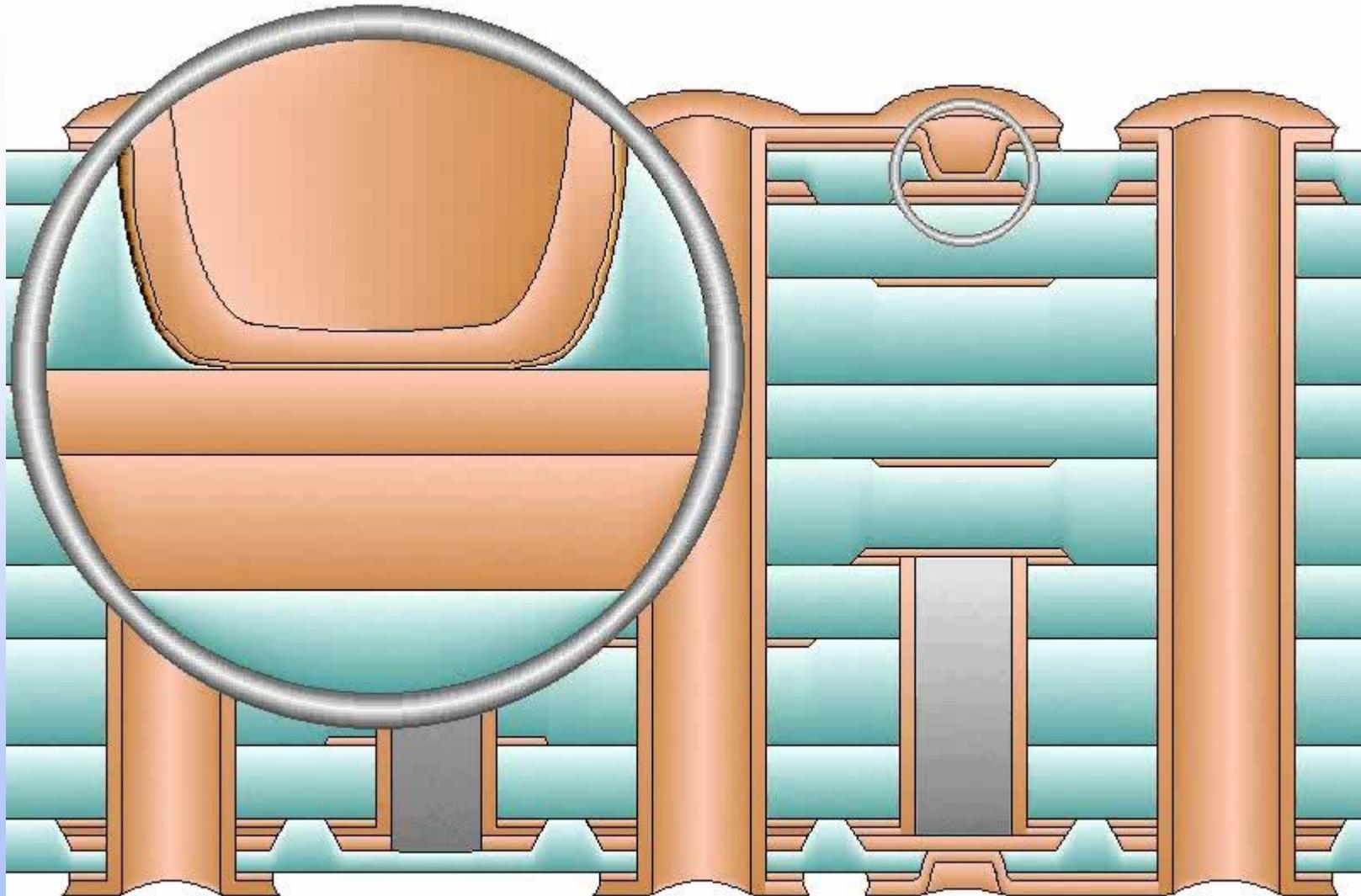


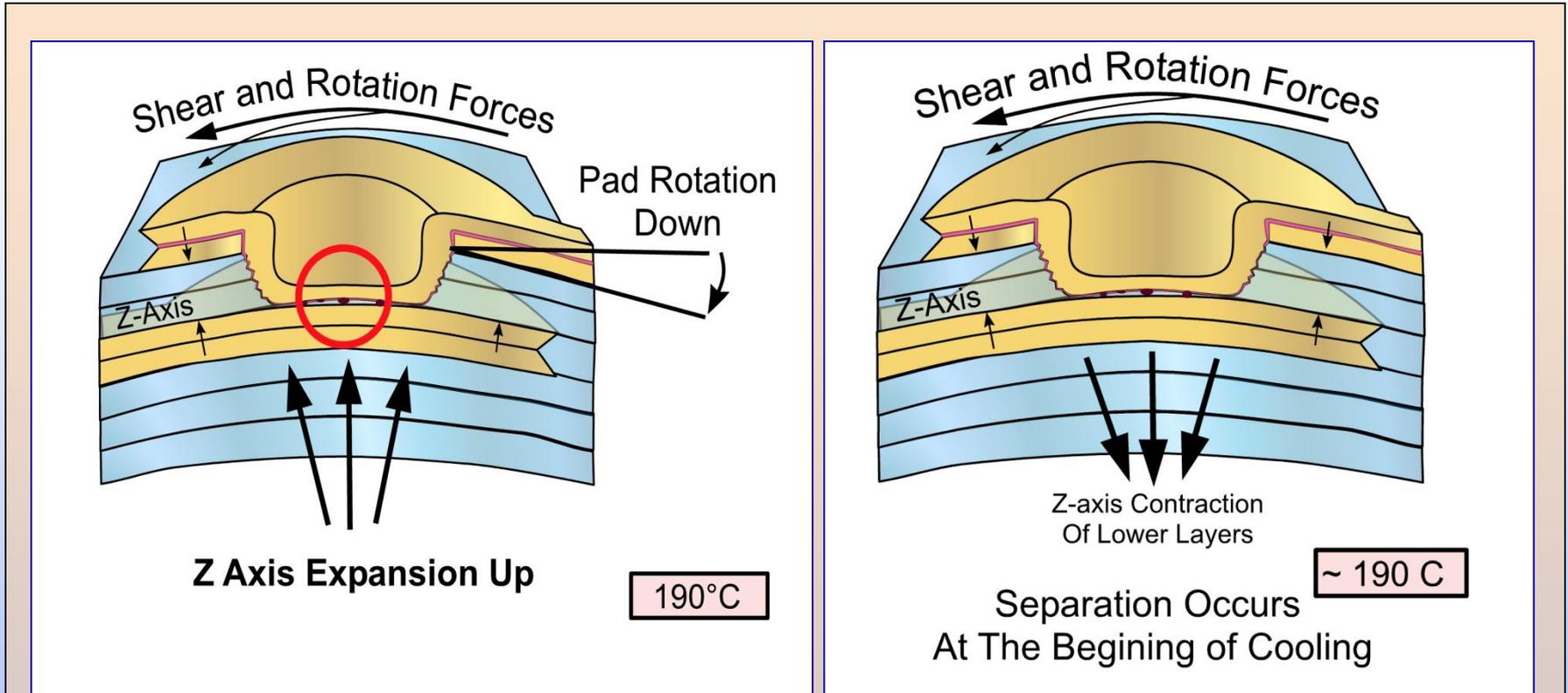
Typische Fehlerbilder - Innenlagenabriss:



- **Rascher Schädigungsfortschritt**
- **meist große Rissbreite**
- **Unterbrochen bei Raumtemperatur**

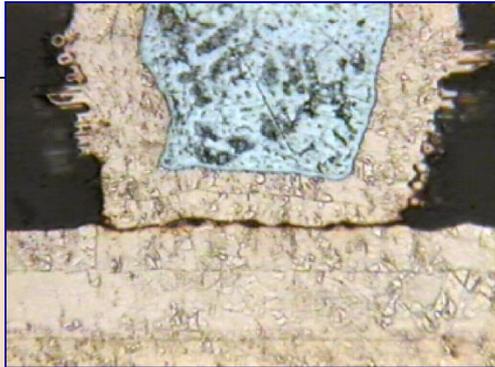
Mikrovia-Targetpad-Abrisse:



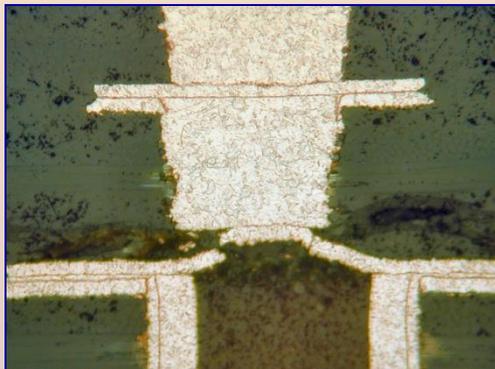


- **Schädigung meist erst ab 190°C**
- **Abriss vom Capture Pad bei Kontraktion (Abkühlung)**

Typische Mikrovia-Schädigungsbilder:



- Target-Pad Abriss

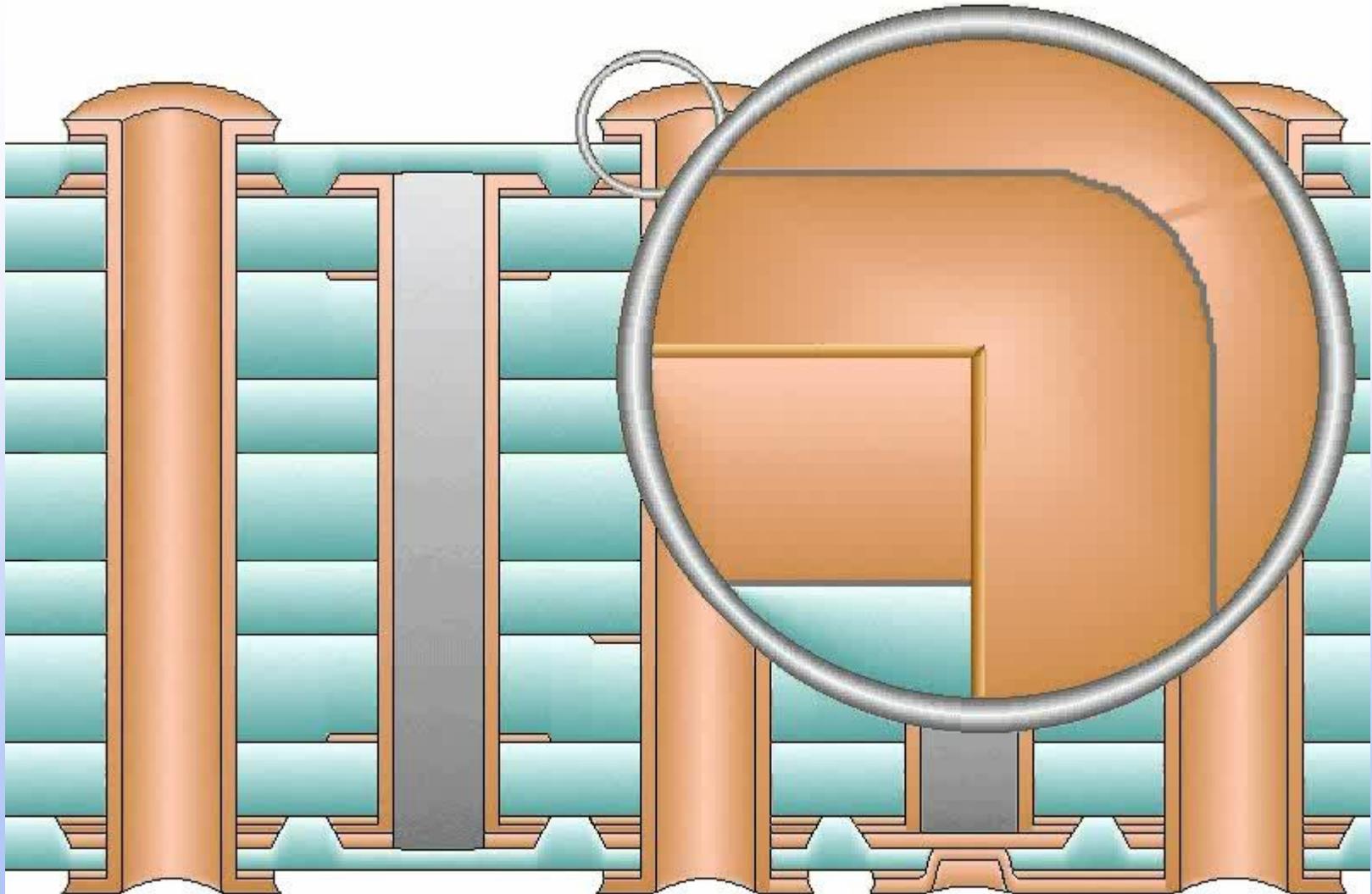


- Abriss Capture Pad

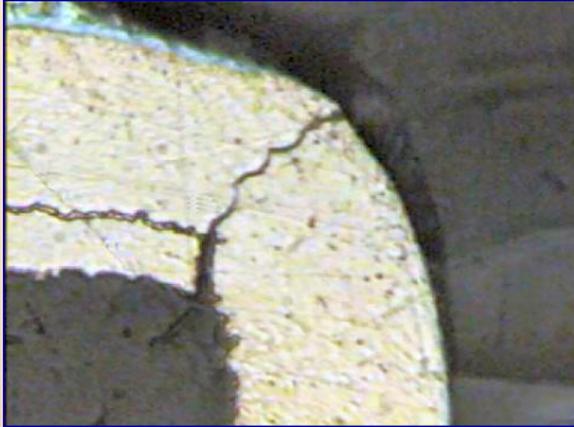


- Microvia Corner Cracks

“Corner Cracks”:

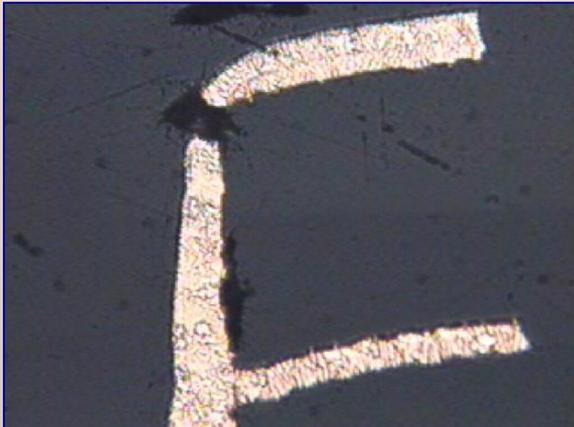


Typische Corner-Crack-Schädigungsbilder:



- Riss im 90° Knie

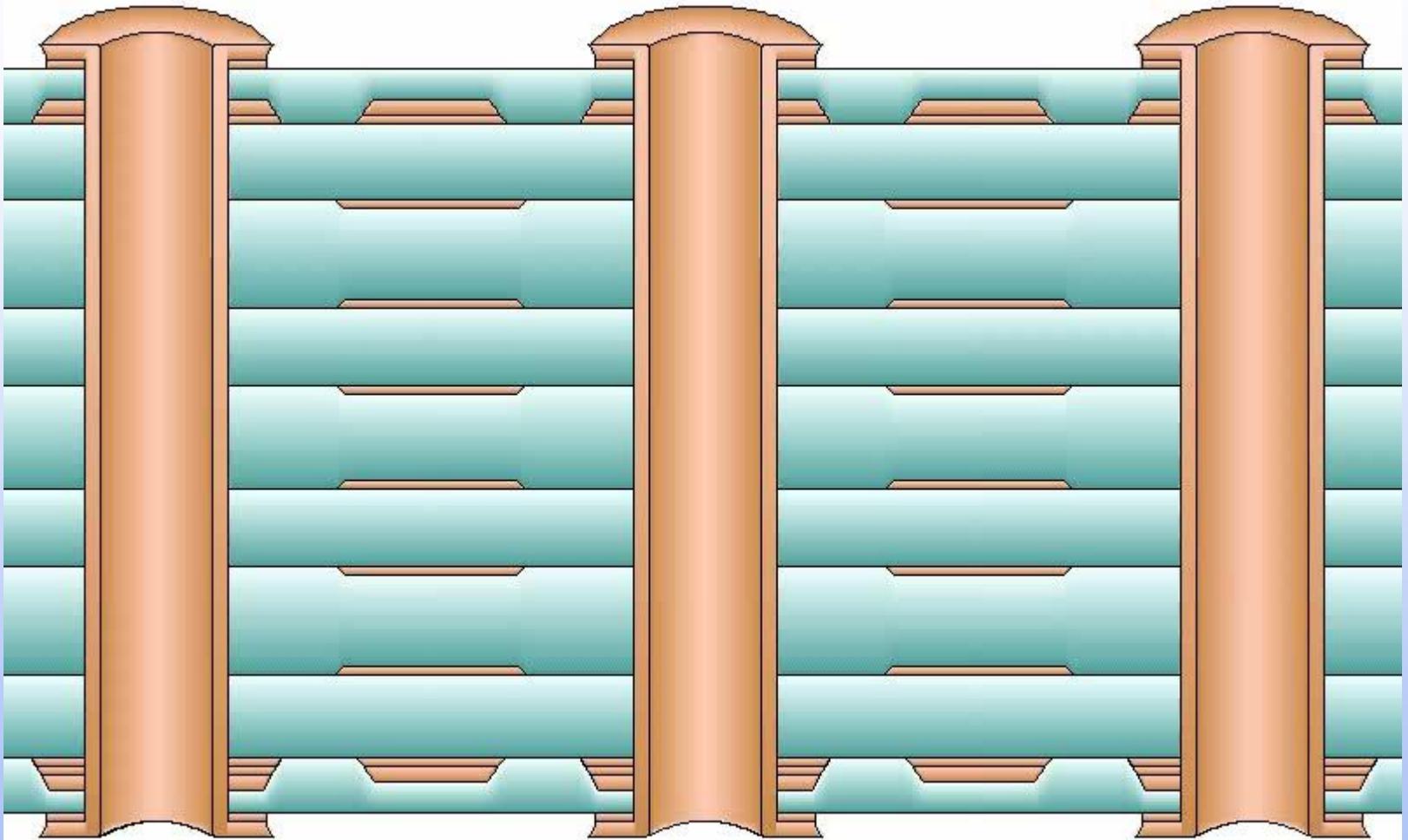
- häufiger bei Bleifrei-Technologie



- mech. Belastung wird an Oberfläche gedrängt

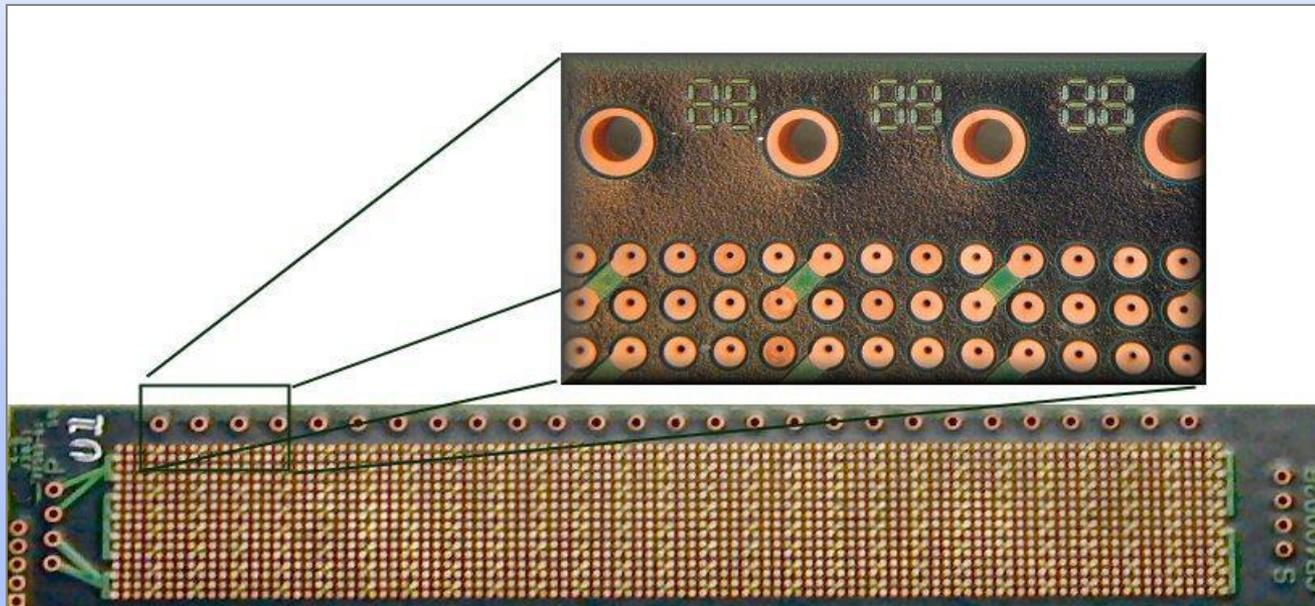
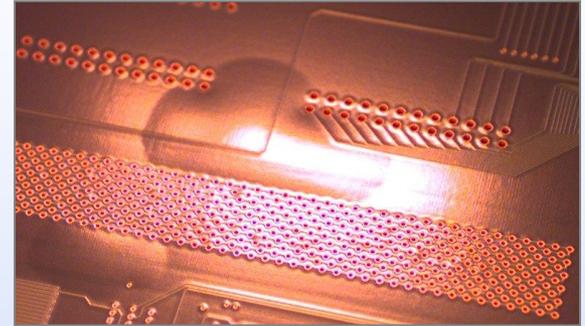
- typisch kleine Risse

Delamination

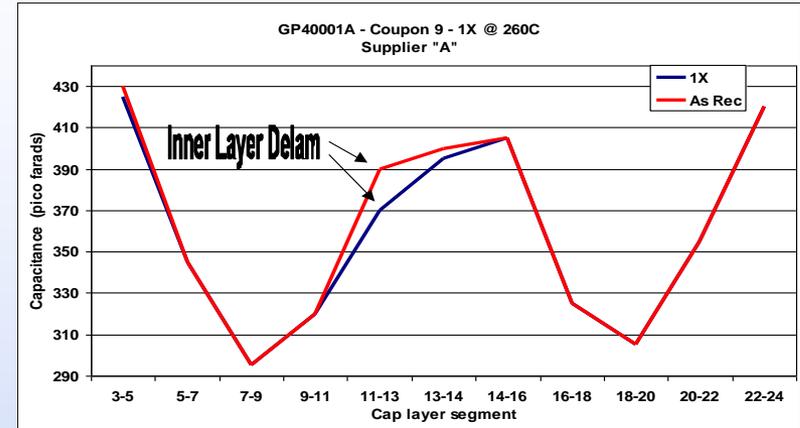
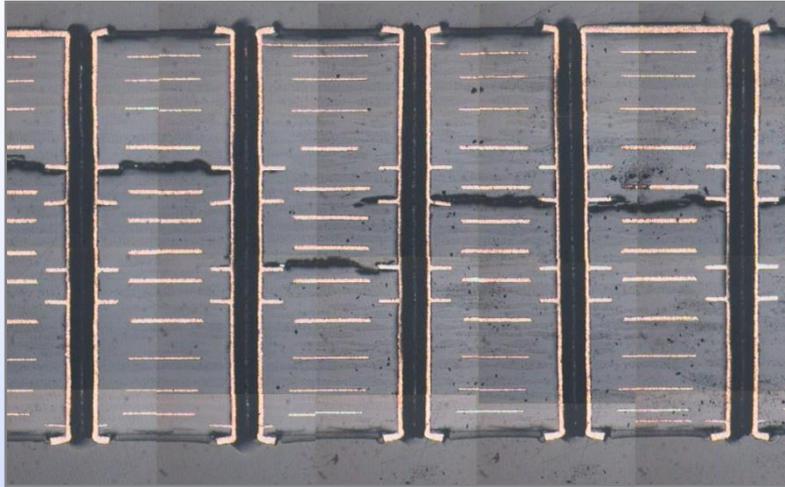


Delaminationstest:

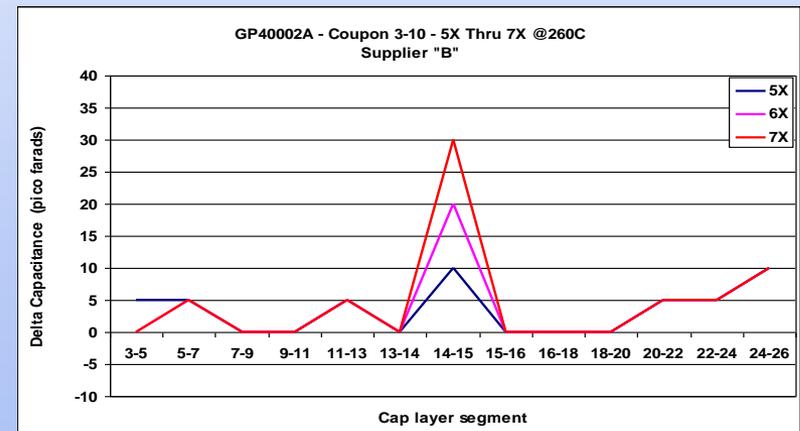
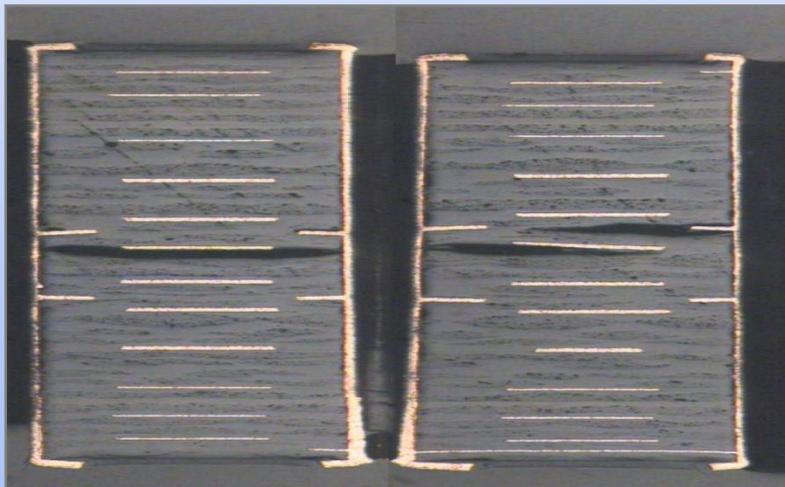
- Prüfung auf Delamination über Kapazitätsmessung
- Testpunkte in IST Coupon integriert
- Vergleich Kapazität vor und nach IST Test



Delaminationstest:

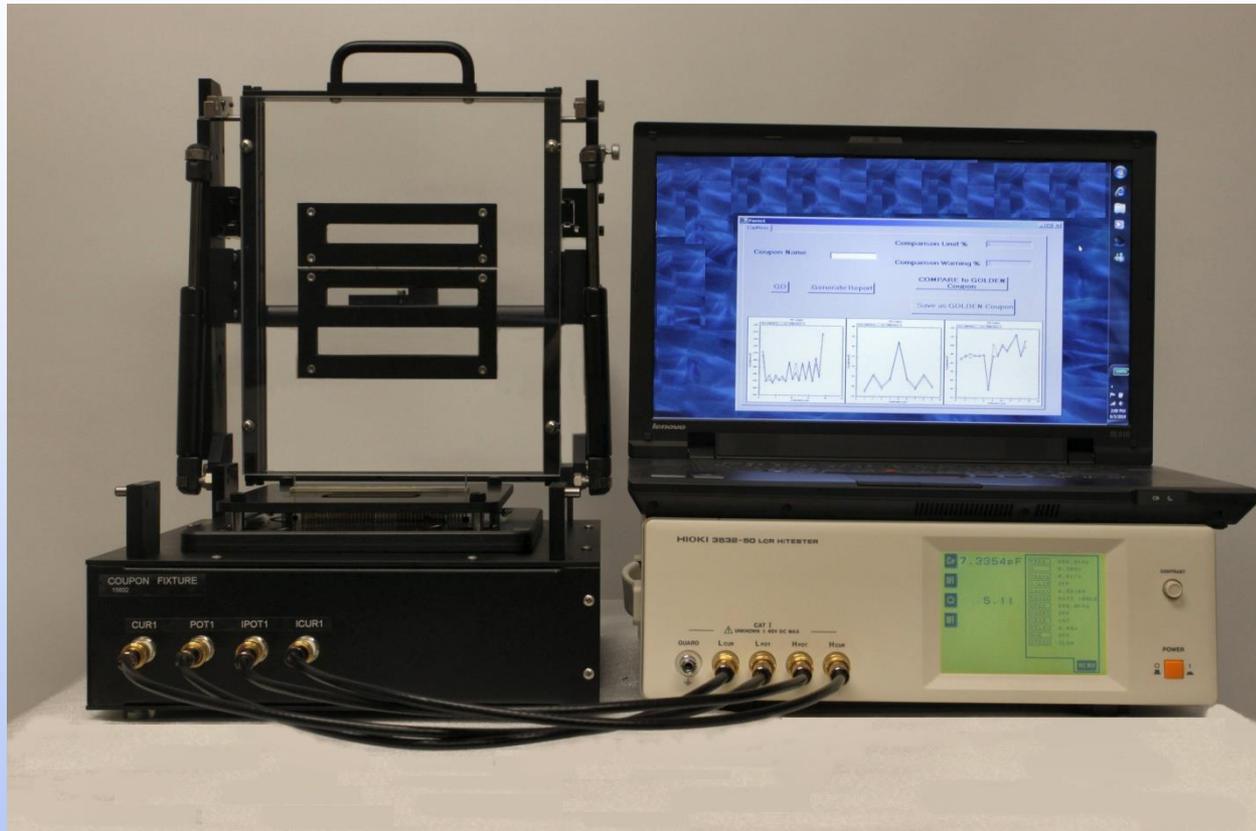


Absolute Kapazitätswerte vor und nach IST Test

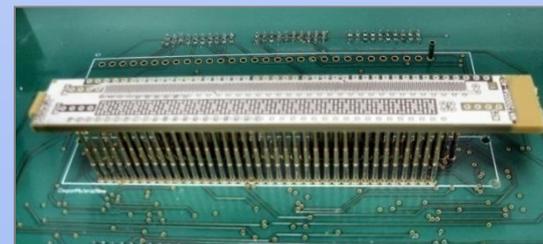


Relative Kapazitätsänderung durch IST Test

DELAM-Tester:

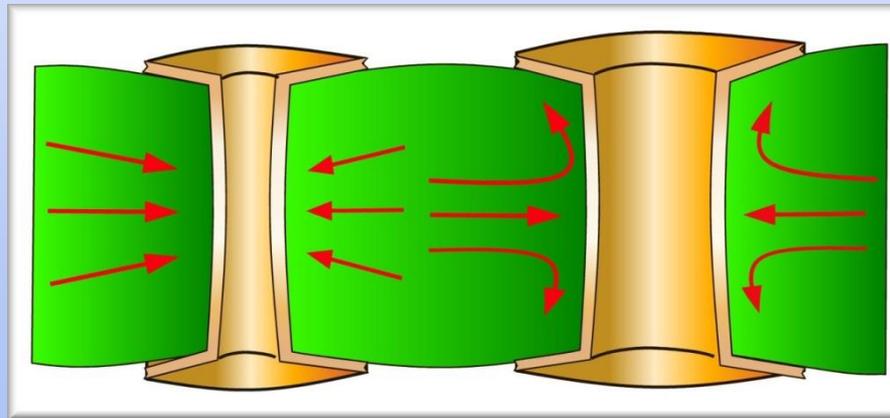


- PC-gesteuerte Auswertung der Kapazitätsänderung
- Testpunkte in IST Coupon integriert



Einflussgrößen auf Zyklenfestigkeit:

- Temperatur
- Bohrlochdurchmesser
- Leiterplattendicke
- Ausdehnungskoeffizient des Basismaterials (CTE)
- Kupferdicke in der Hülse
- Abstand der Bohrungen (Raster)



Verteilung der Druckkräfte abhängig vom Bohrlochdurchmesser

IST Referenzen Europa:

- Astrium UK
- Atotech
- Dyconex (3 Systeme)
- ESA
- Graphic PLC
- GS Swiss PCB
- Invotec UK
- Optiprint AG
- Schweizer
- Tesat
- Würth (3 Systeme)

Vielen Dank!

Polar Instruments GmbH

A-4865 Nussdorf am Attersee

Aichereben 16

hermann.reischer@polarinstruments.eu

www.polarinstruments.com/de

Tel. +43 7666 20041-0

Fax +43 7666 20041-20

