AppliedPrecision
Enabling the world's core technologies

Infineon

The „probe card signature“ – syndrome or who has the “old maid”

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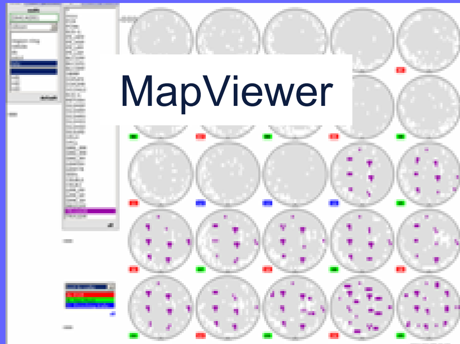
James Andersen (APLLC)

Dresden,
June 2005

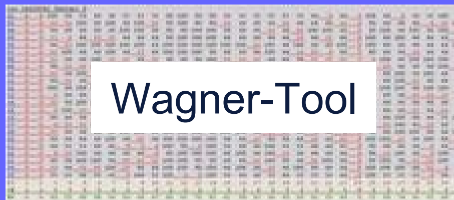
Never stop thinking.

The „probe card signature" – syndrome or who has the "old maid"

Yield Monitoring Software …



Cres online Monitoring



… detect WT yield drops < 1%

Data Interface
Yield Report
etc.

How to find the root cause fast?

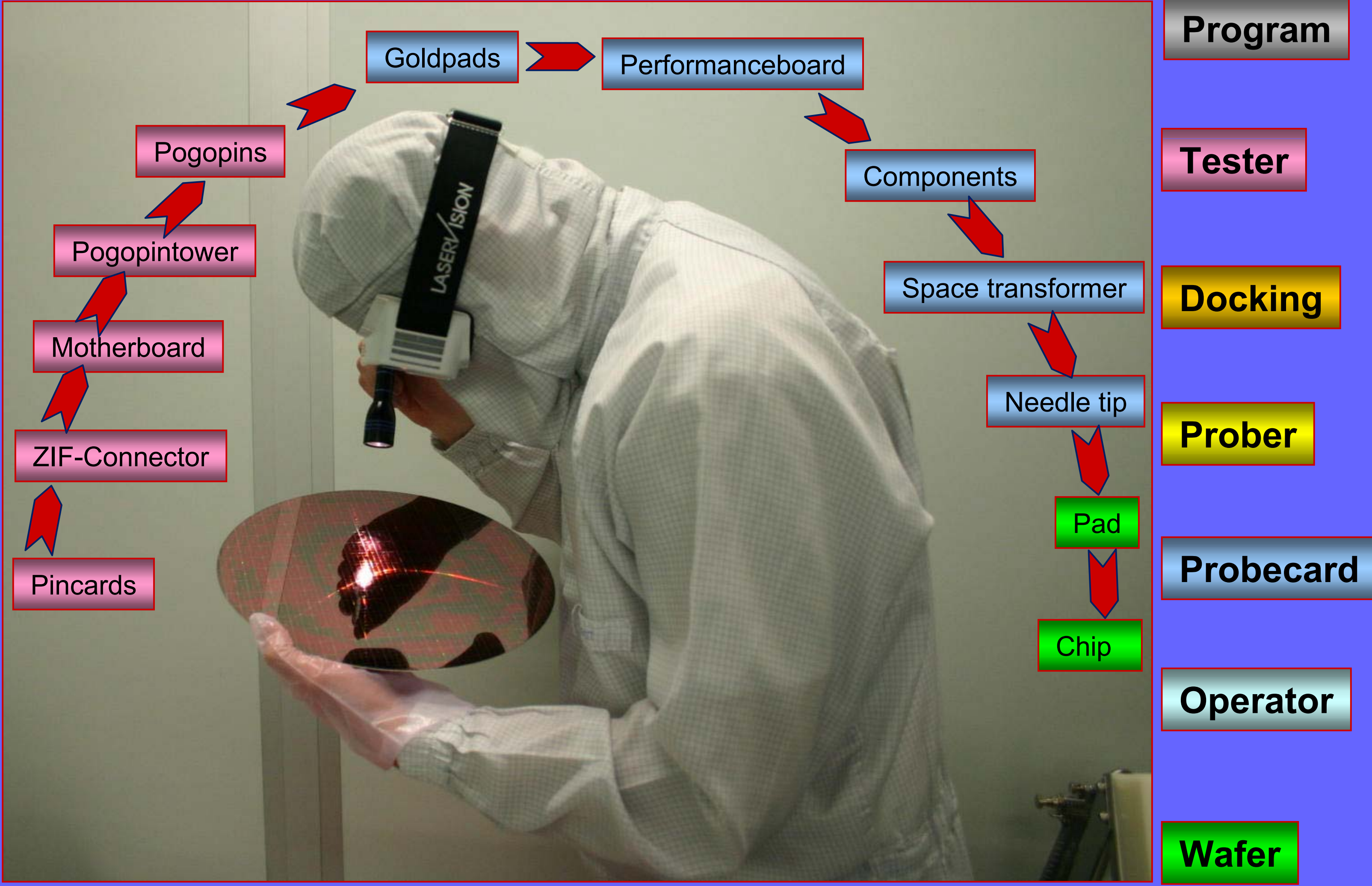
1st & only guess is always probe card and start a cleaning!

But… there are more than 20 different reasons!

There Remains a Gap Between Yield Monitor Software & Root Cause Analysis

F.Pietzschmann
SWTW2005

The „probe card signature" – syndrome or who has the "old maid"

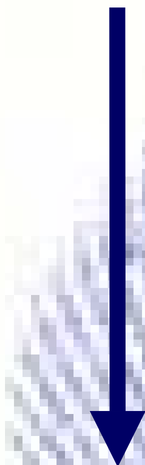


Program
Tester
Docking
Prober
Probecard
Operator
Wafer

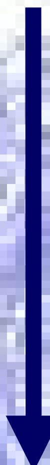
Each WT Failure (yield loss) Has a Unique Root Cause Signature

The „probe card signature" – syndrome or who has the "old maid"

1. Fixed DUT pattern



2. Statistical pattern

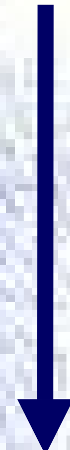


@ preferred wafer regions
@ preferred touchdowns
@ preferred DUT's

Focus on:
the most difficult section

Goal:
rapid root cause analysis

3. Whole wafer w/o pattern



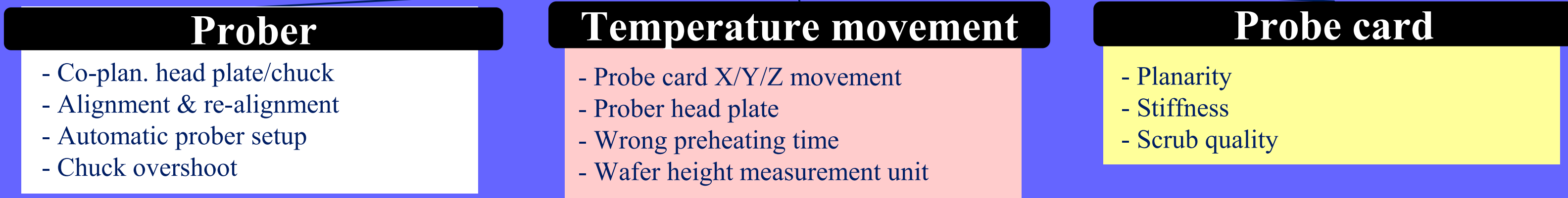
Advanced Analysis Tool

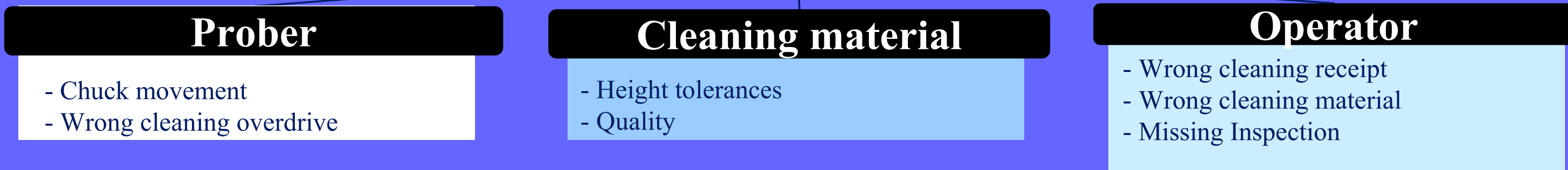
"There is a correlation between the performance and the scrub quality"

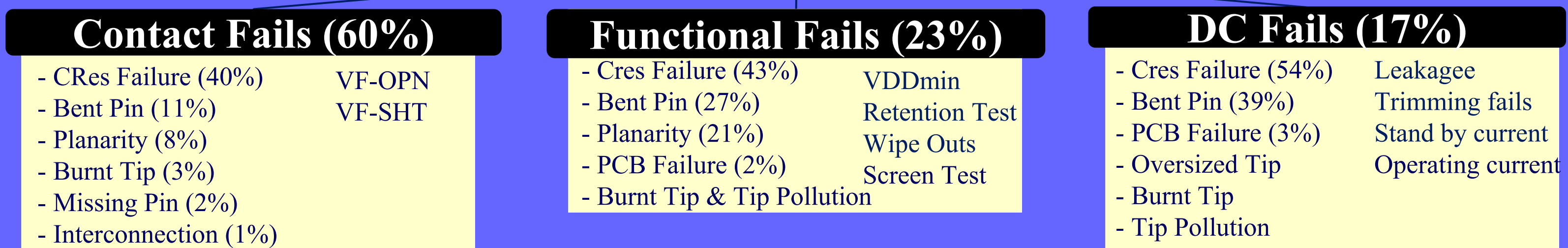
Scrub Marks are the Fingerprints of the Probing Process

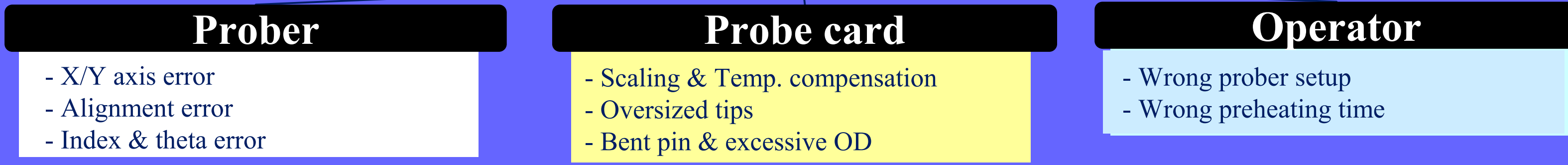
The „probe card signature" – syndrome or who has the "old maid"

most important ➡



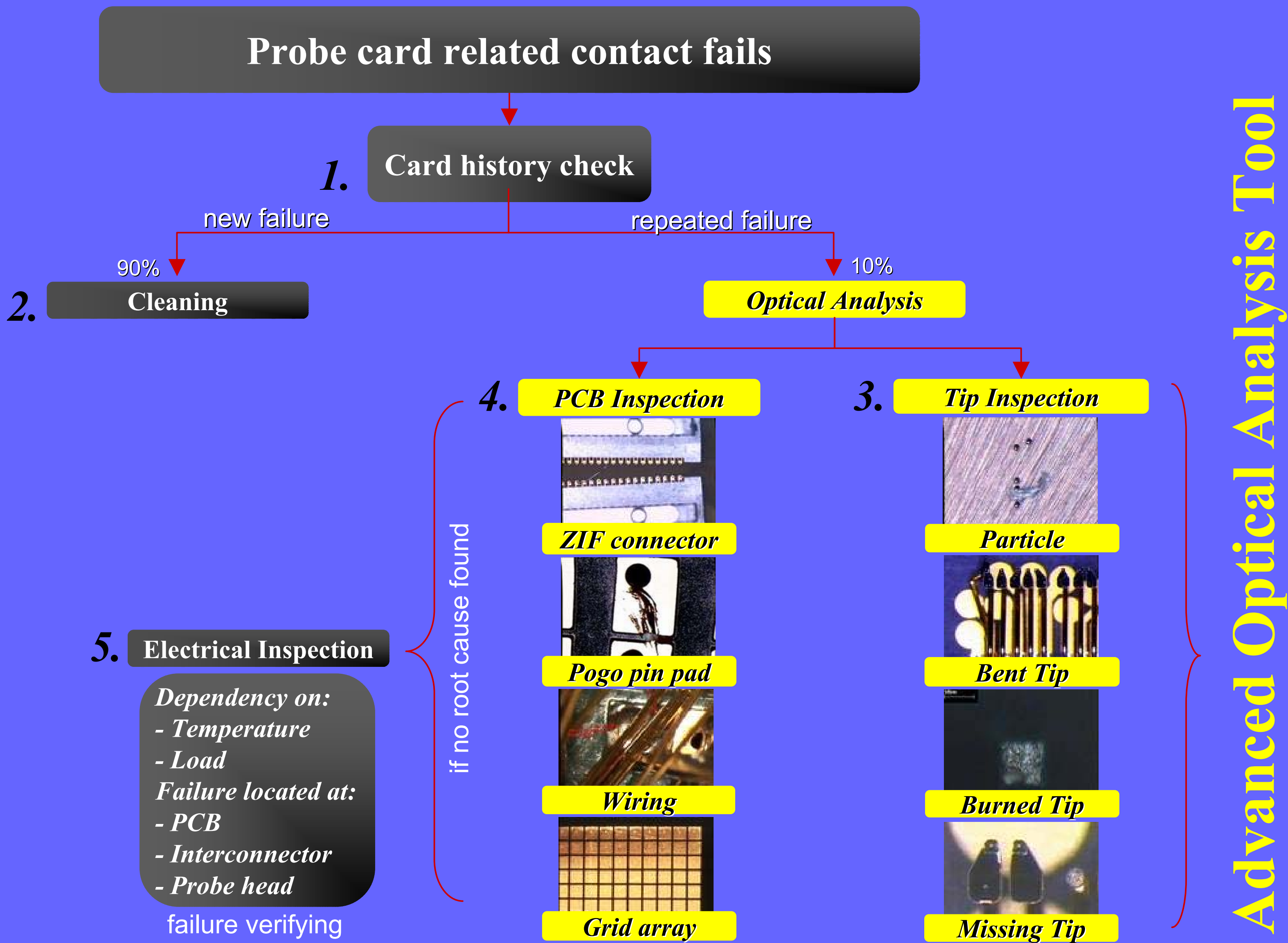






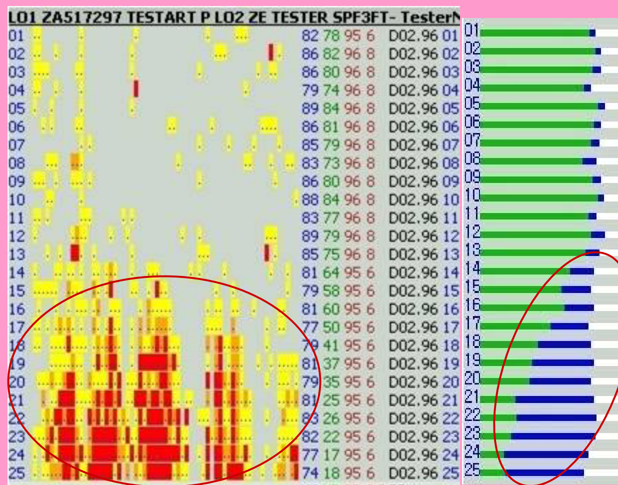
Wafer Test Failure/Yield Loss Classifications

The „probe card signature“ – syndrome or who has the “old maid”



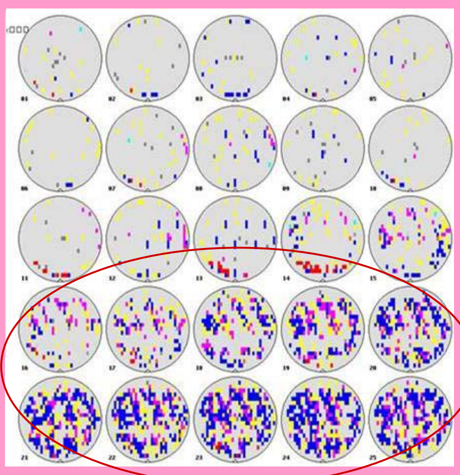
Process Flow Example used to Rapidly Determine Yield-Loss Root Cause Using Advanced Optical Analysis

The „probe card signature“ – syndrome or who has the “old maid”

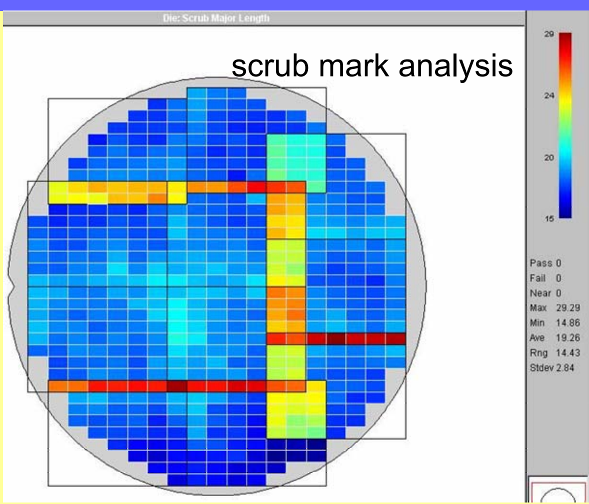


Wafer test tool (Wagner)

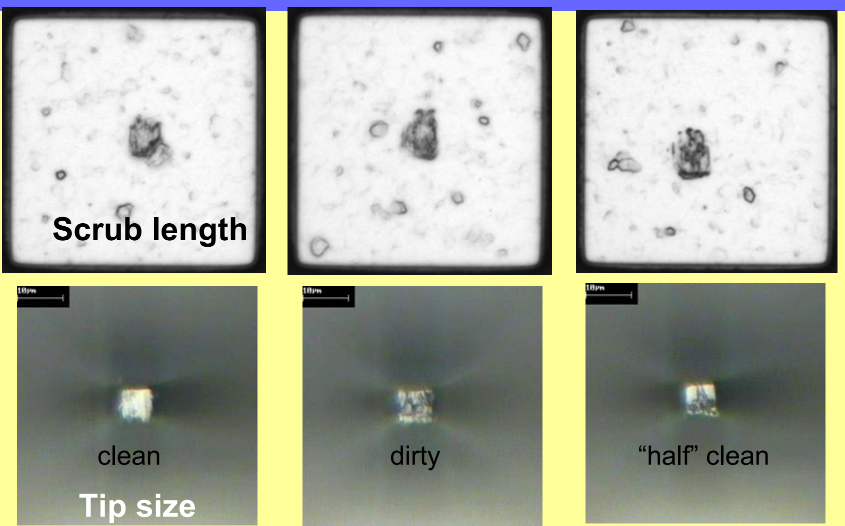
Cres online control



PE map viewer



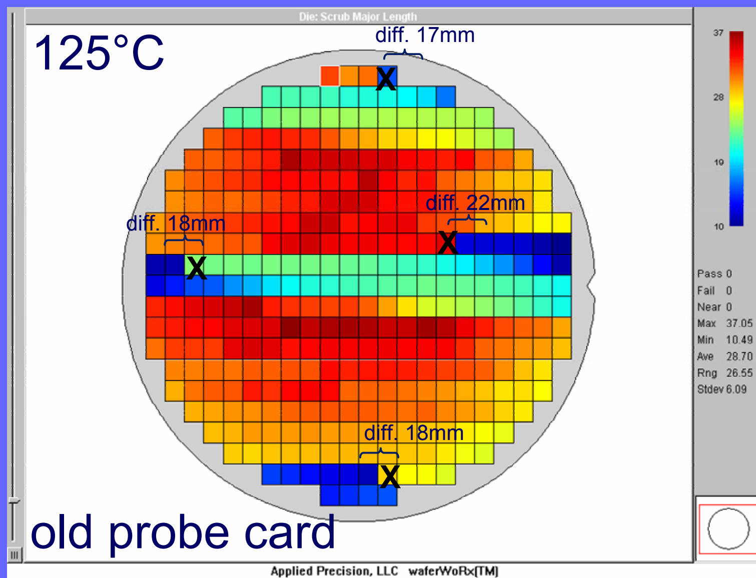
20 …. 30mm OD is missing!

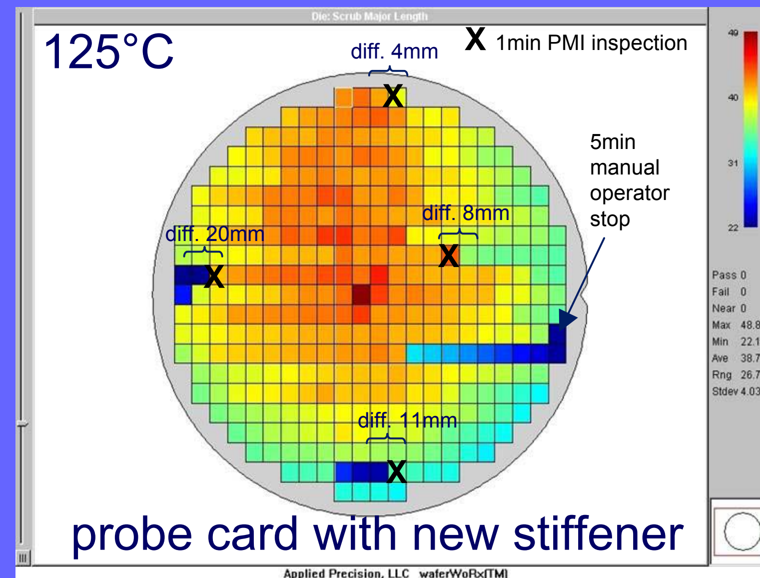


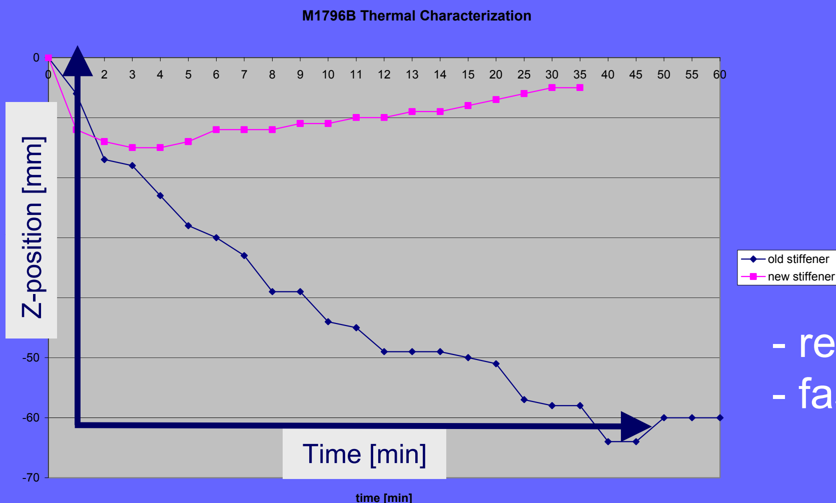
Failure Signature Example – overdrive (prober)

The „probe card signature“ – syndrome or who has the “old maid”

Comparison Major Scrub Lengths







-reduced scrub length
differences x1,6 …x4,3

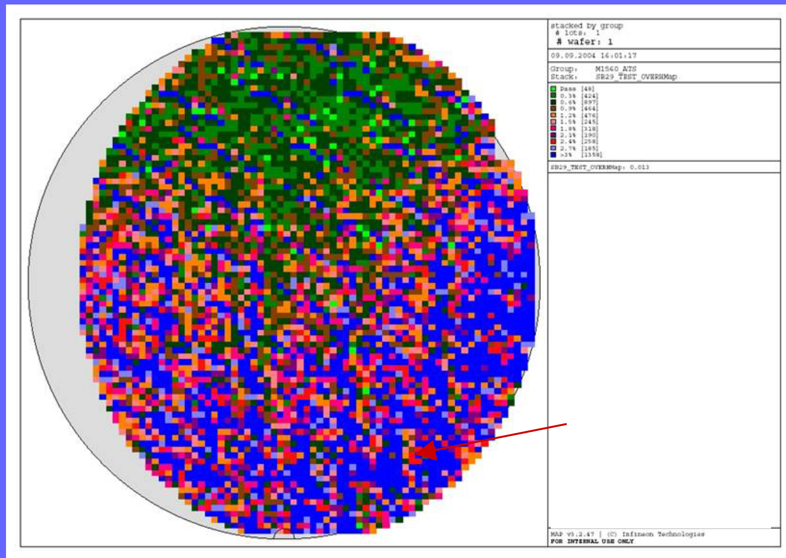
-faster recovery time
up to x3

- reduced z-movement range x4,3
- faster return point x10

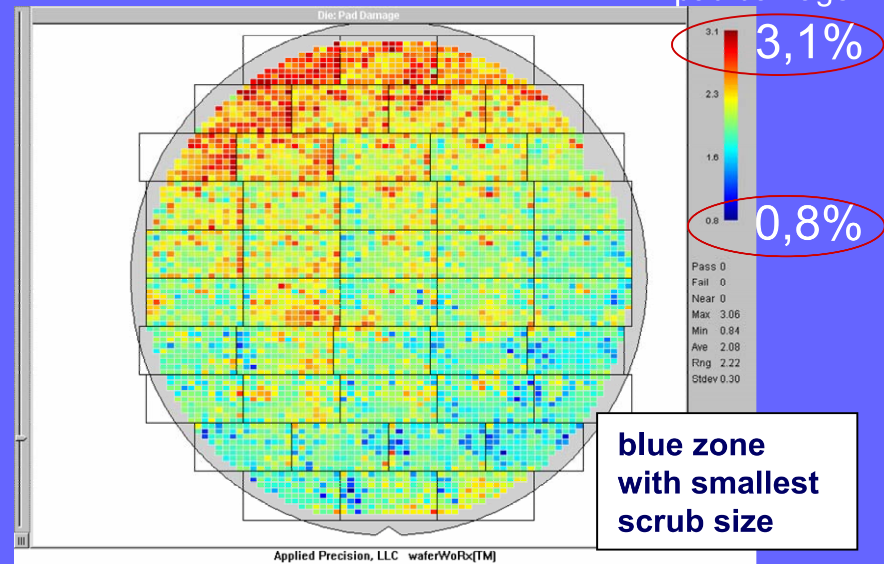
Failure Signature Example – overdrive (probe card thermal z-movement)

The „probe card signature" – syndrome or who has the "old maid"

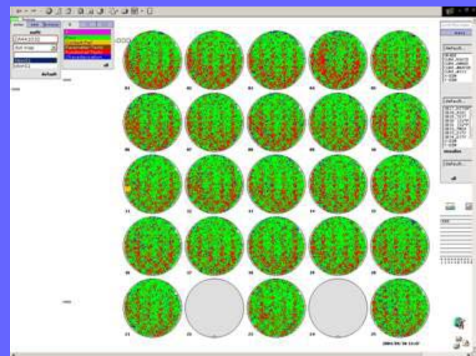
yield stacked map 23 wafers



scrub mark analysis 1 wafer

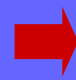


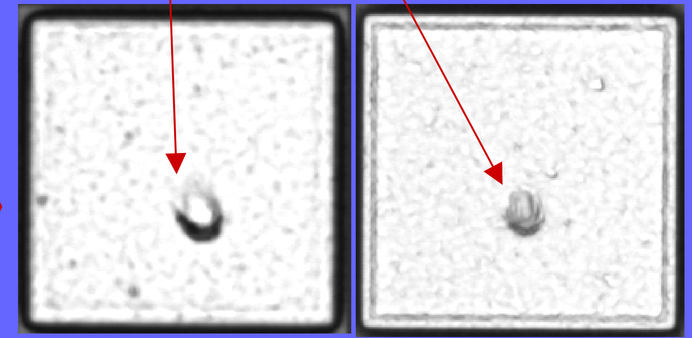
blue zone with smallest scrub size



matched pattern!

same pin with different scrub sizes over the wafer!





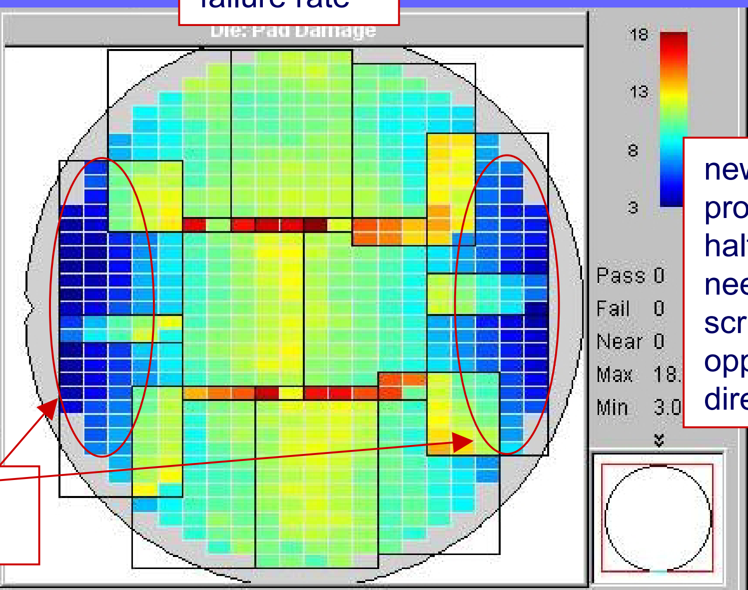
Failure Signature Example – chuck movement (shift)

The „probe card signature“ – syndrome or who has the “old maid”

Inconsistent pad damage = higher failure rate

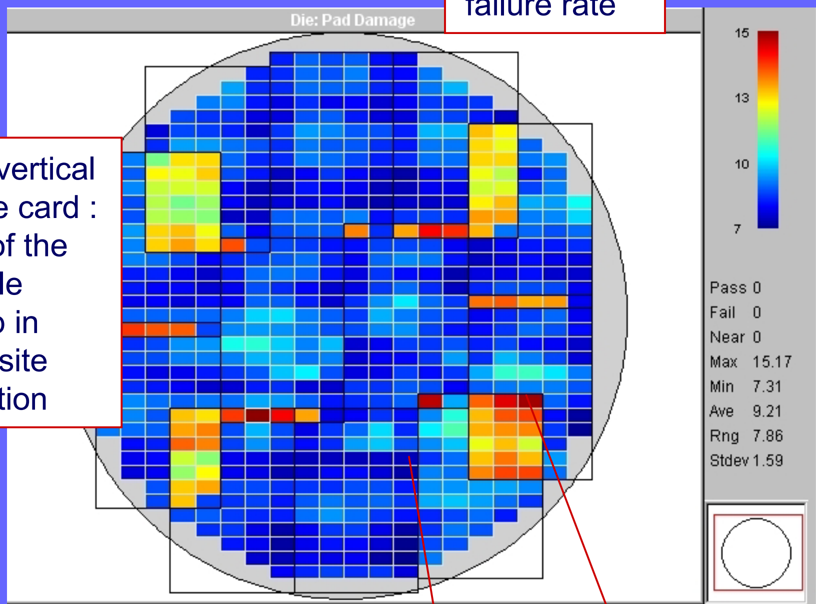
Consistent pad damage = lower failure rate

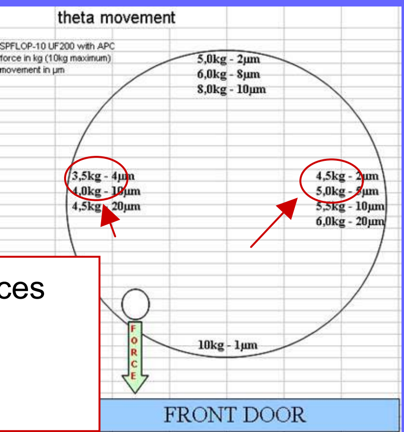
standard vertical probe card : all needles scrub in one direction



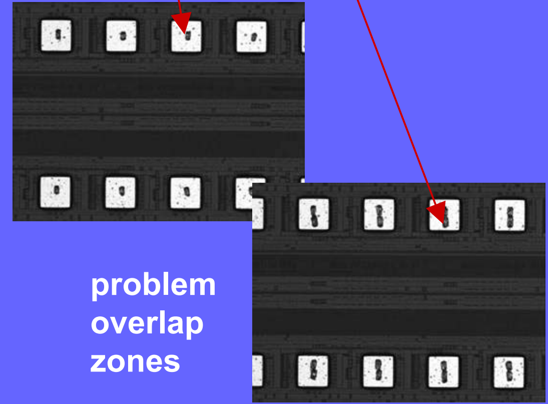
highest failure rate

new vertical probe card : half of the needle scrub in opposite direction





This movement reduces the scrub length = online cleaning necessary

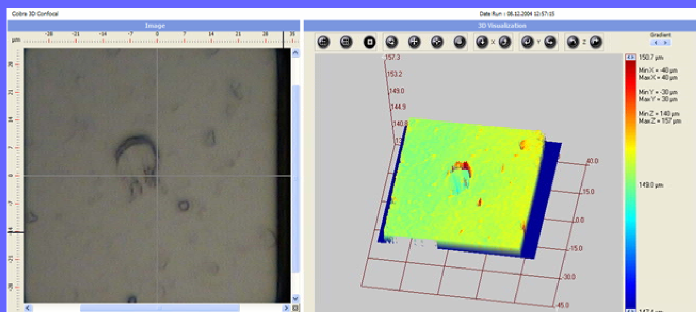


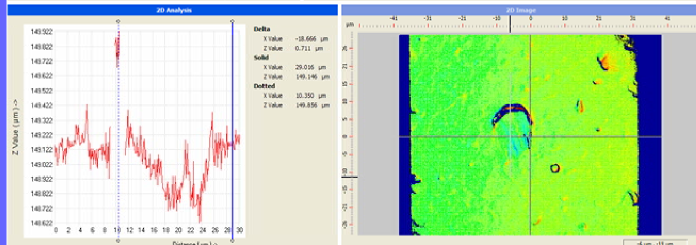
problem overlap zones

Failure Signature Example – chuck movement (theta)

The „probe card signature“ – syndrome or who has the “old maid”

Problem: increased number of function fails @ preferred wafer region

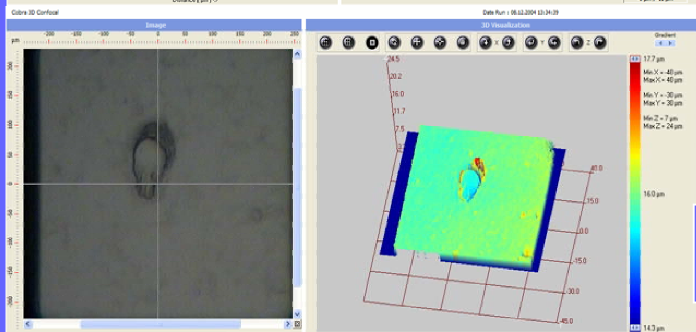


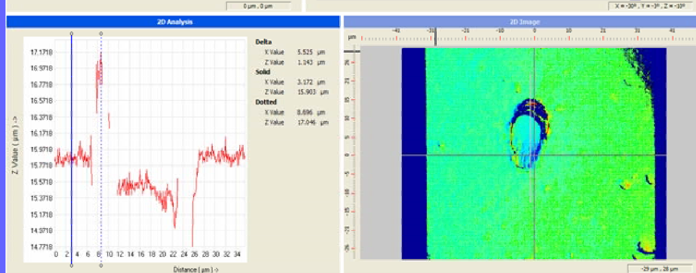


Chip 03/08
DUT 49, Pin 25

Scrub heel = 547 nm
Scrub valleys = 492 nm*)

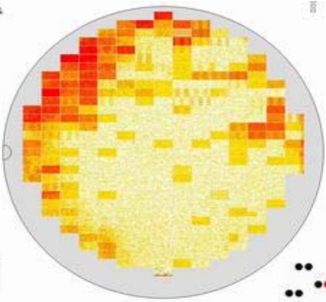
scrub height
-675nm
penetration depth
-583nm

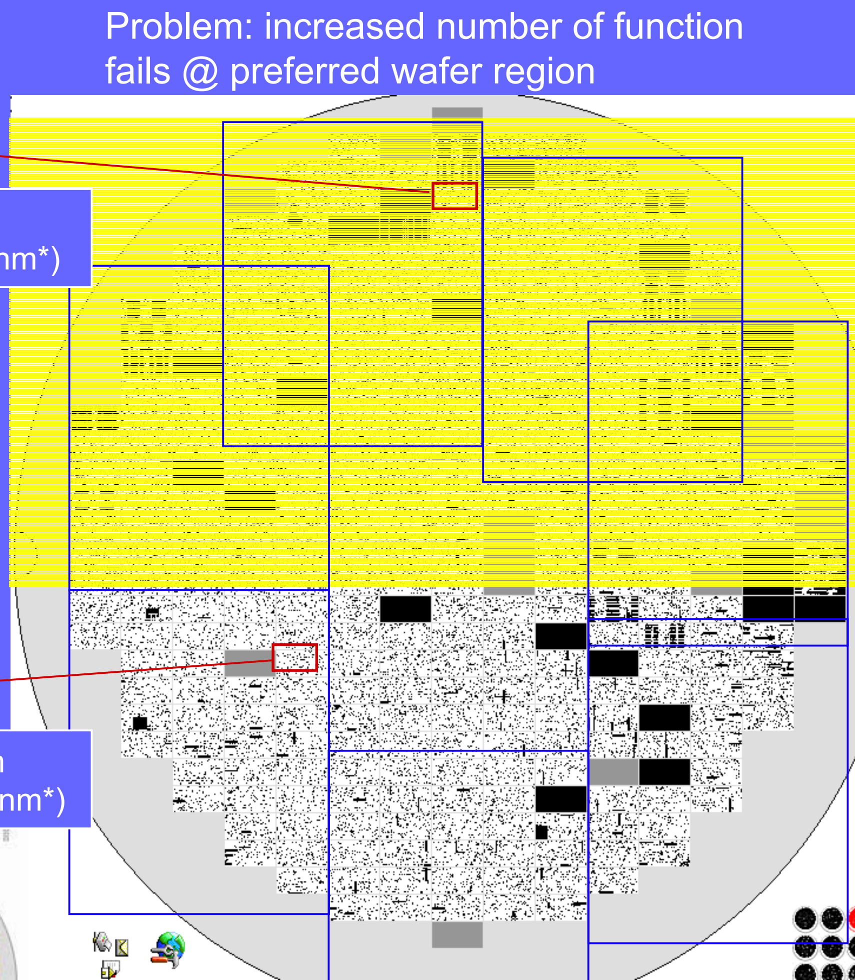




Chip 20/05
DUT 49, Pin 25

Scrub heel = 1285 nm
Scrub valleys = 1075 nm*)





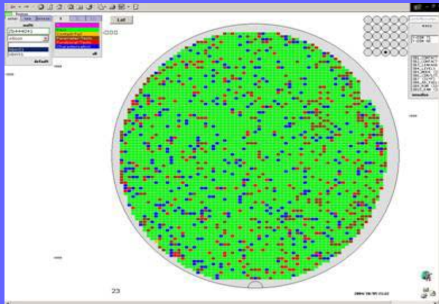
yield stack map

*) ave. number of measurements/ pins: 12/6

Failure Signature Example – chuck movement (tilt)

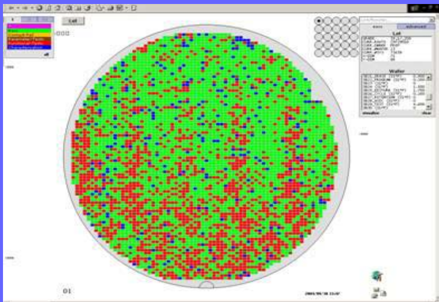
The „probe card signature“ – syndrome or who has the “old maid”

SB29 fails

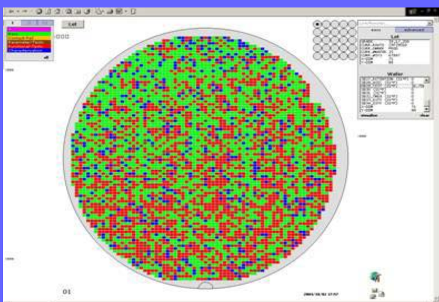


optical tip inspections

level 1: <2,5%
new or clean probe tips



level 2: “moon signature”
normal tip stage after 3 weeks w/o cleaning



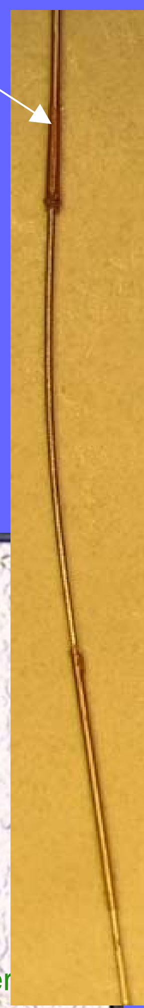
level 3: >5…30%
random distribution
tips contaminated: “black dots” visible

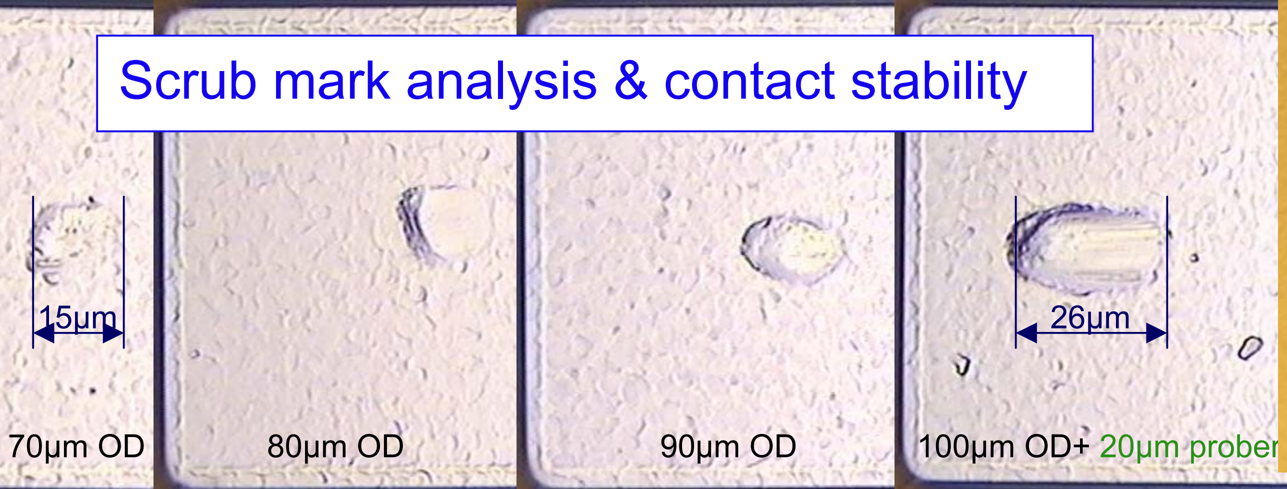
Must Clean On-line More Often

Failure Signature Example – Chuck Movement (Cleaning)

Root Cause Analysis Contact Problems

“First thing to obtain a good test is the good contact... It’s unbelievable how much time production spends on this point. Therefore it’s possible to improve the contacts in electrical way, which is in the hands of test engineer”



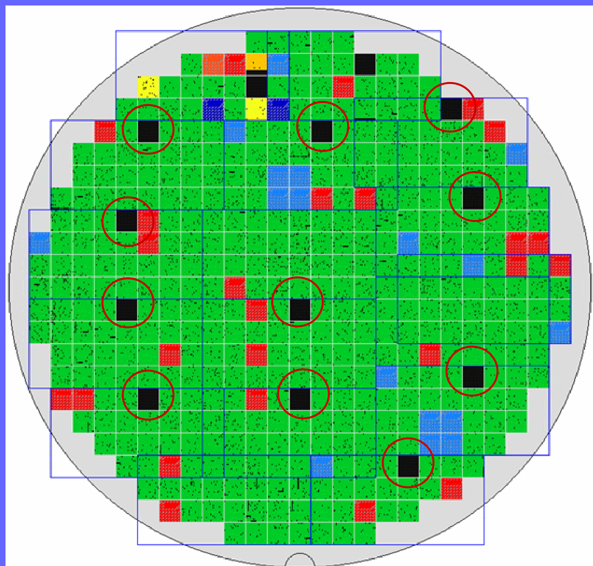


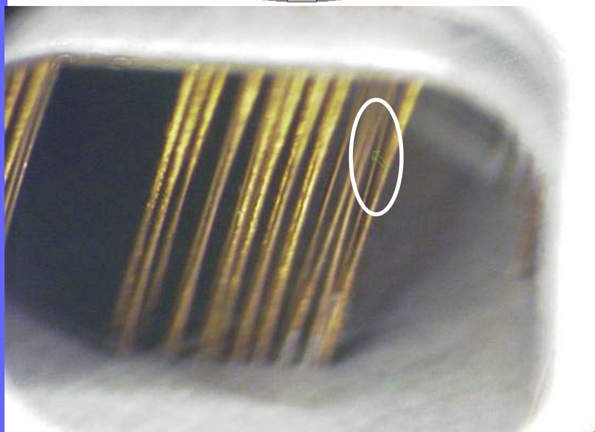
Implemented test:
Test forces -5mA pin-by-pin at every BPMU card. The forcing voltage can reach -24V. Number of simultaneously forced pins is equal to BPMU cards attached to device. On contact problem first the Al2O3 is electrically broken, than small current is forced to clean the contact and decrease the contact resistance.

! IMPORTANT ! GND and all supply voltages must be forced to 0V.

Failure Signature Example – Signal Pin Burning

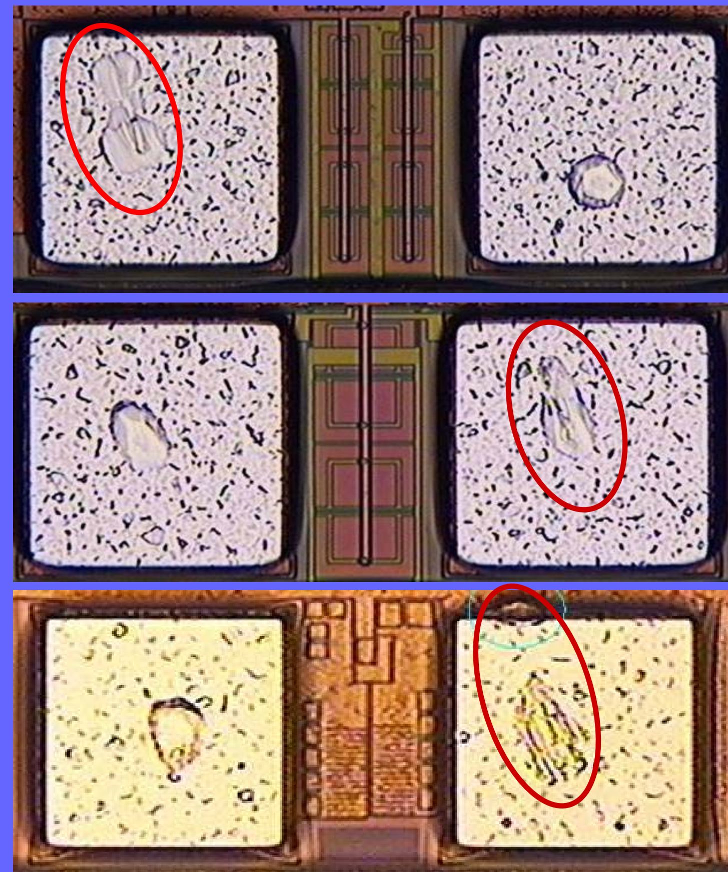
The „probe card signature“ – syndrome or who has the “old maid”





neighboring VDD,GND-beams sticks on each other
root cause: current clamp value not valid during bump test = 400mA/20s

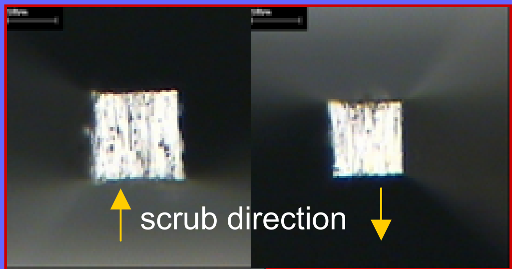
TSLY Wipeouts at VDDmin on one DUT



scrub shape changes due to burning

Failure Signature Example – VDD/GND Burning

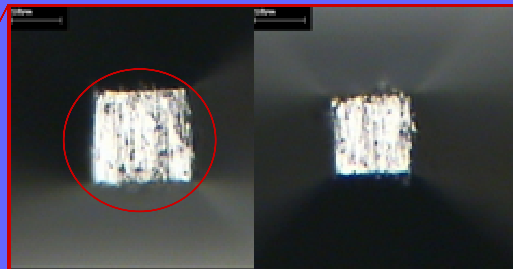
The „probe card signature" – syndrome or who has the "old maid"



tip size max. 17mm

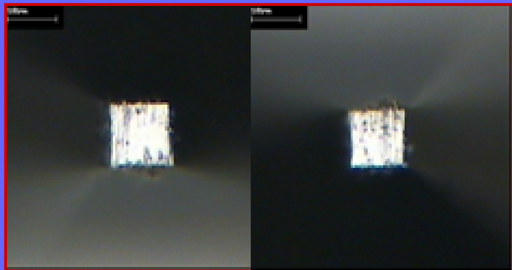
non uniform tip size increasing over the time

dependency on:
- scrub direction
- probe array location

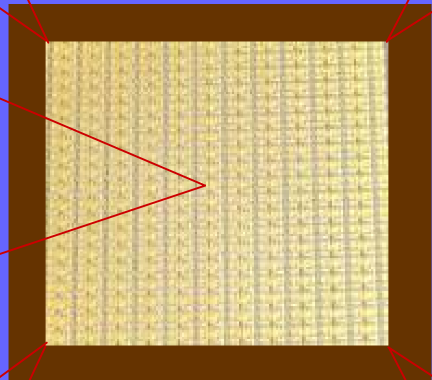


tip size max. 19mm

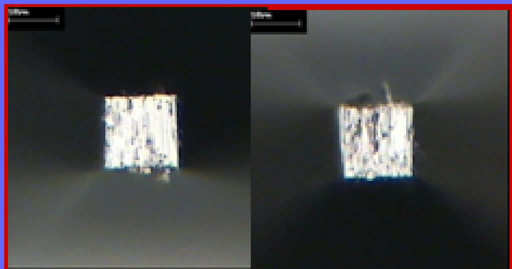
end of live 22mm



tip size max. 11mm

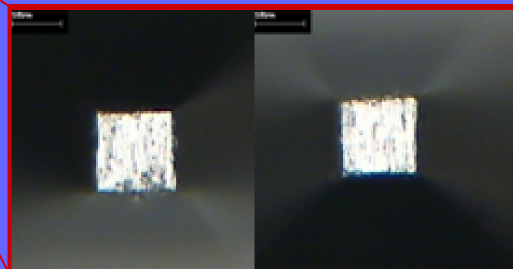


after one year &
22 abrasive cleanings



tip size max. 14mm

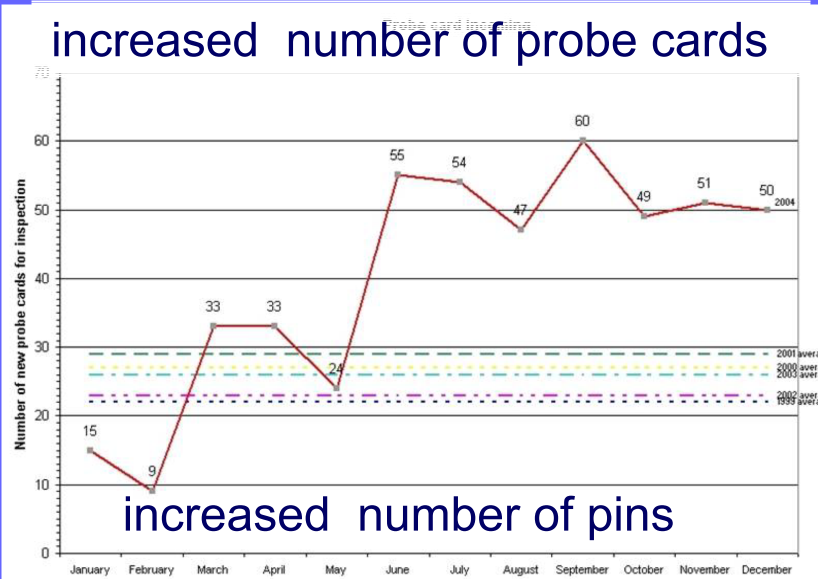
early detection of burning, wear, quality issues can reduce repair cost >50.000 €/year



tip size max. 14mm

Mechanical Related Yield Loss Example - Tip Size Alert

The „probe card signature“ – syndrome or who has the “old maid”



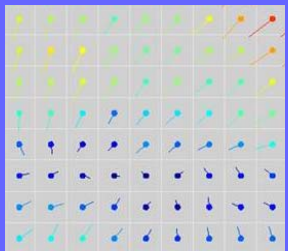
Advanced Optical Analysis Tool

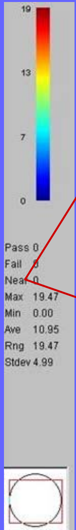
scrub mark analysis enhances incoming inspection

Advanced Optical Analysis Strategy for Incoming Probe Cards

The „probe card signature“ – syndrome or who has the “old maid”

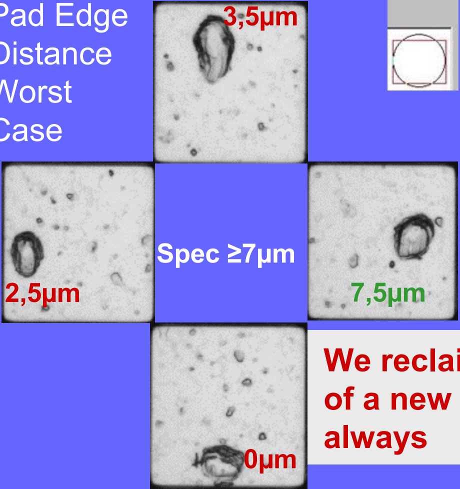
Scrub X/Y-Position Error – Ave. per die





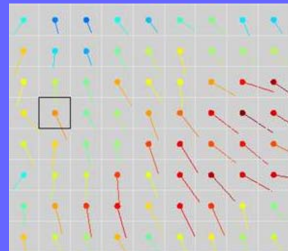
max. 19,5mm
ave. 10,9mm
stdev. 5mm

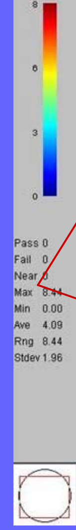
Pad Edge Distance Worst Case



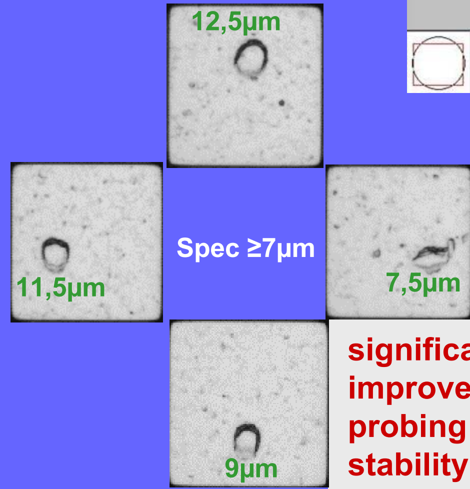
We reclaimed the first cards of a new technology step always

Scrub X/Y-Position Error – Ave. per die





max. 8,4mm
ave. 4,0mm
stdev. 1,9mm

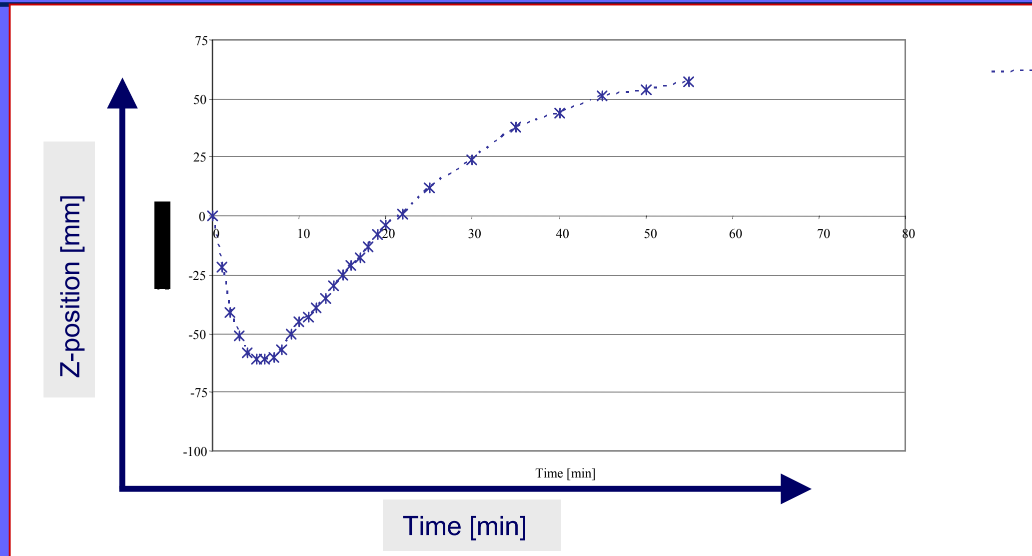


significant improvement for probing process stability

The „probe card signature" – syndrome or who has the "old maid"

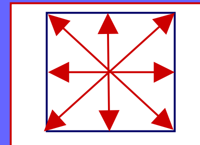
(1) Z movement probe array

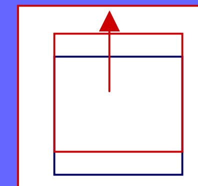
range: up to 110um
time: over 2h preheating
direction: -Z or/and +Z



(2) X & Y material expansion

range: up to 15um / 150mm
time: < 20min of preheating
direction: star like





dependency on:

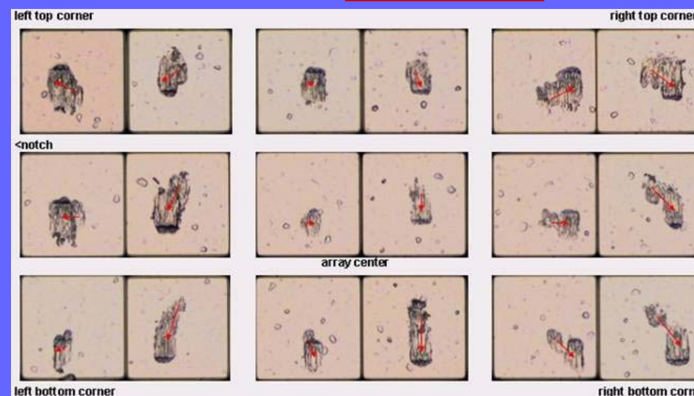
- probe card construction
- used stiffener material
- PCB properties

(3) X or Y drift probe array

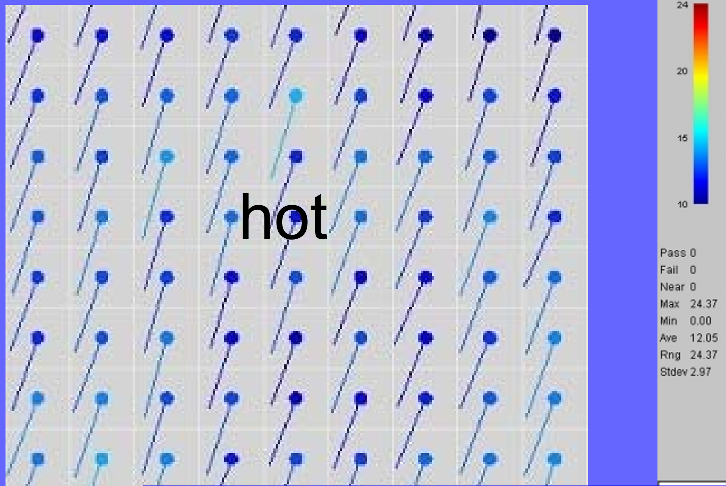
range: up to 35um
time: over 5h preheating
direction: X or Y

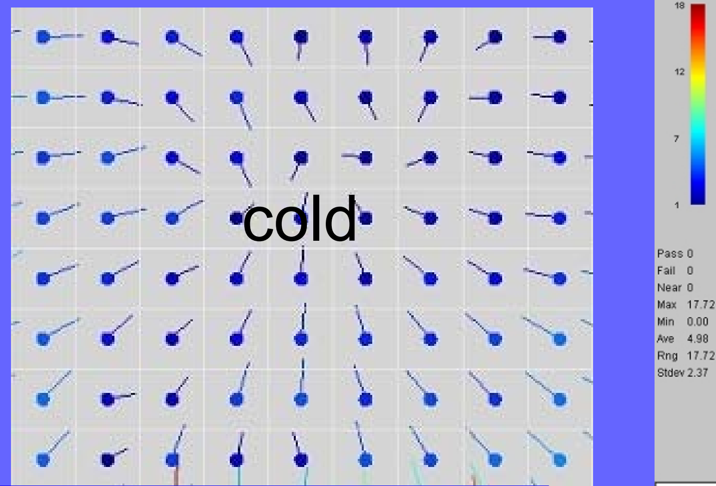
(4) Single needle movement

range: 3…15um
time: 1st h of preheating
direction: each needle different

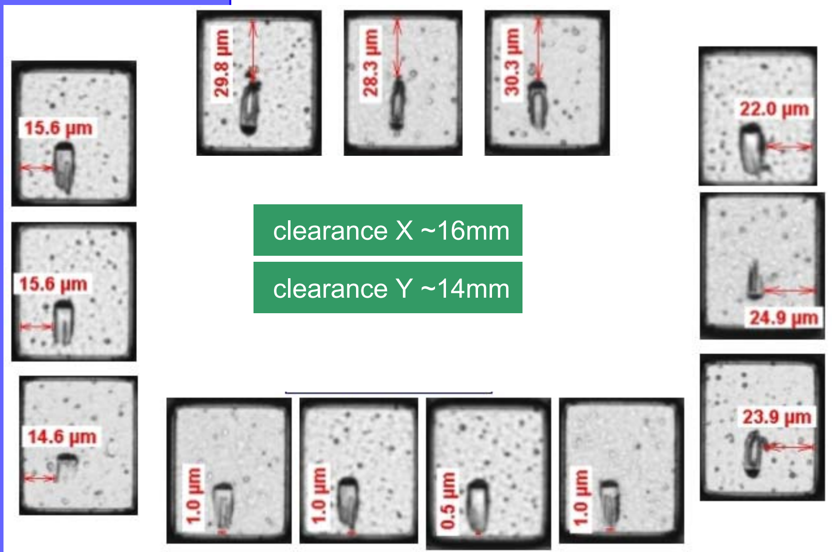


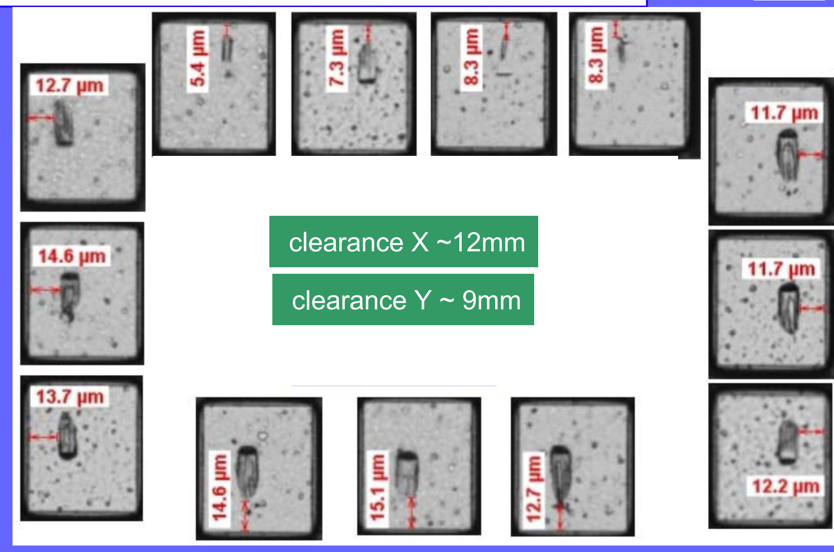
The „probe card signature“ – syndrome or who has the “old maid”





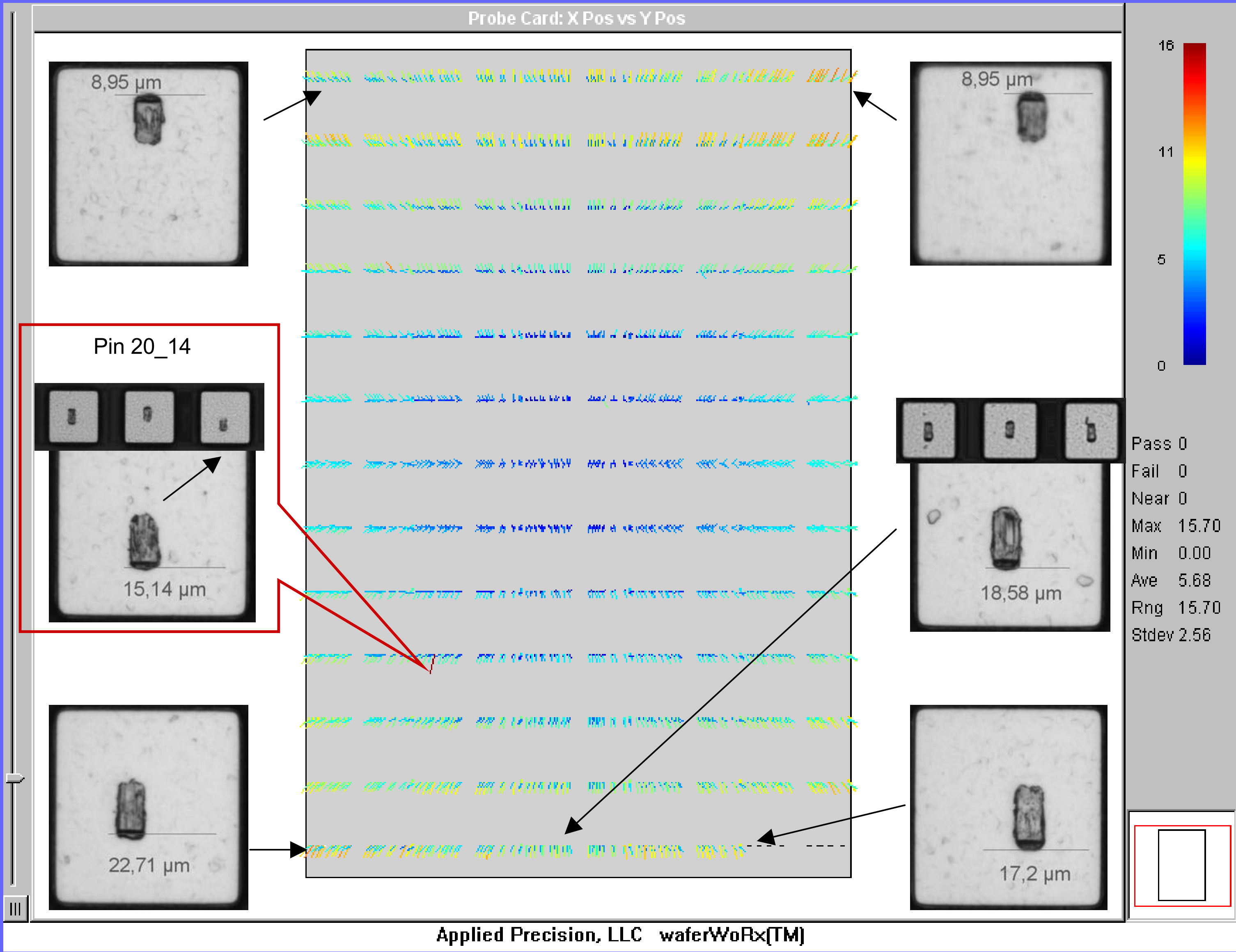
PC-Manufacturer measure the probe card @ room temperature





Advanced Optical Analysis - Offset/scaling @ temp Assessment

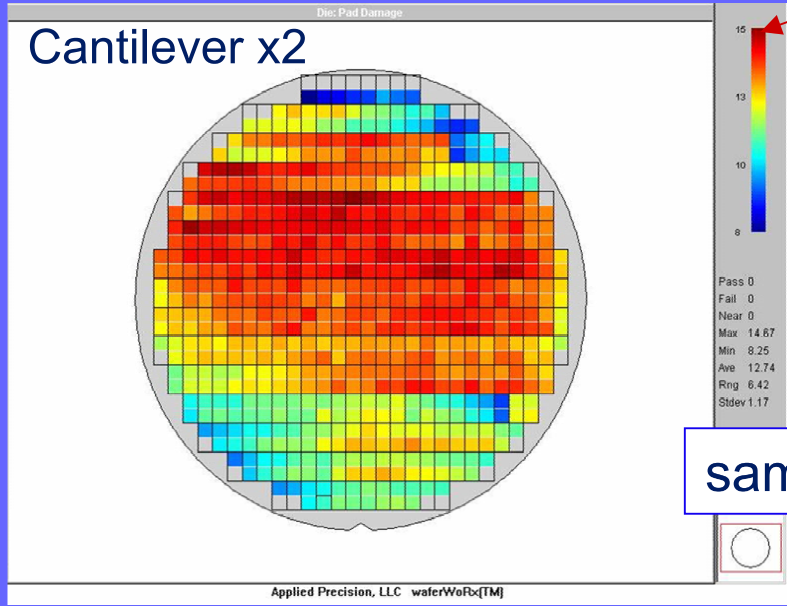
The „probe card signature“ – syndrome or who has the “old maid”



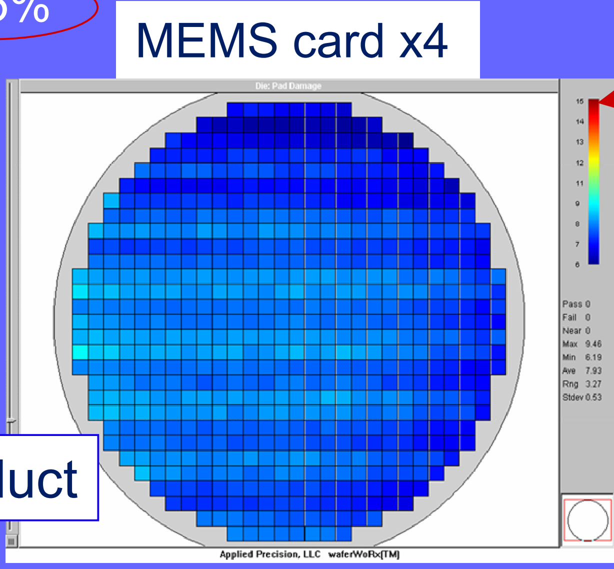
Advanced Optical Analysis - Single Needle Assessment

F.Pietzschmann
SWTW2005

The „probe card signature“ – syndrome or who has the “old maid”

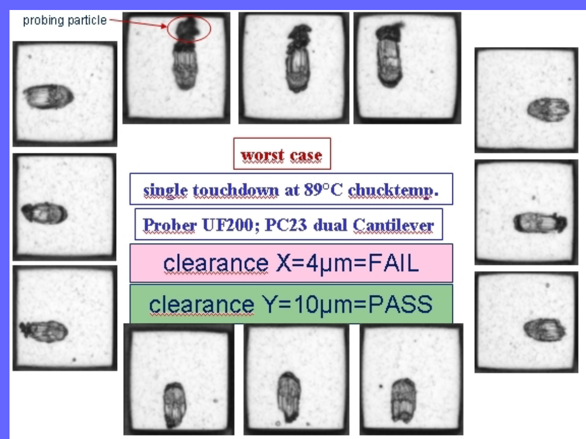


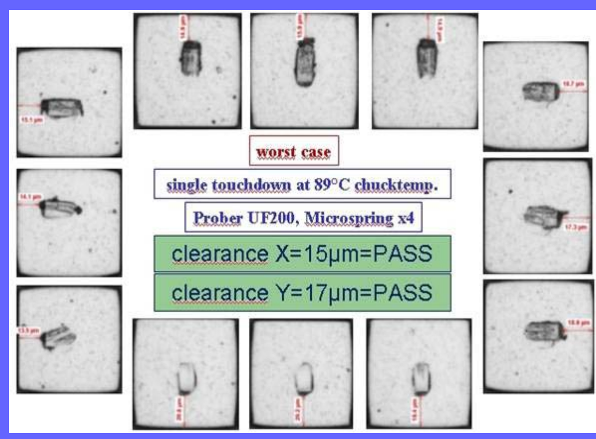
same product



reduced pad damage -5%

worst case distance scrub end to pad edge

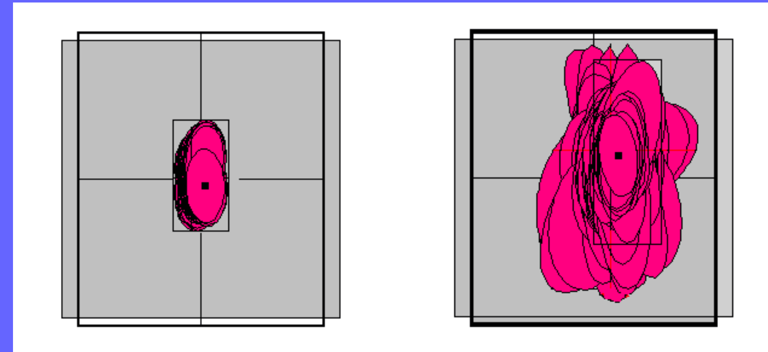




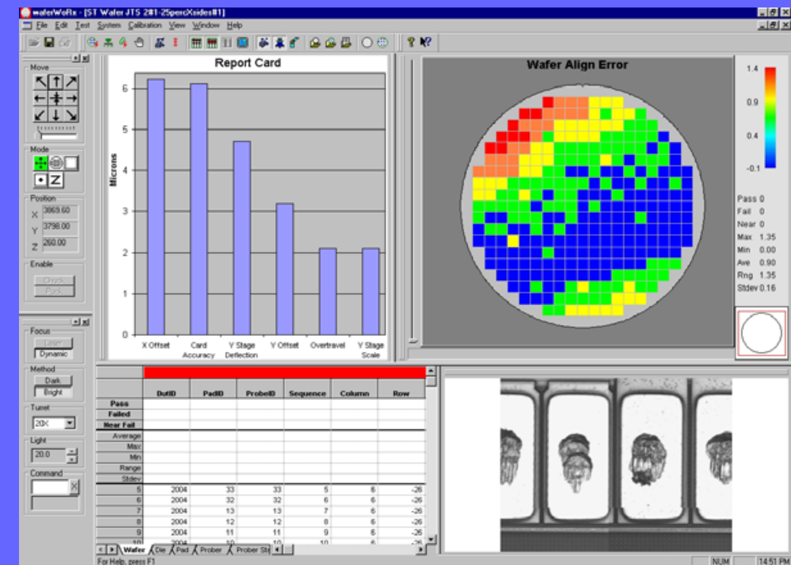
What Metrology Tool Capabilities are Required to Bridge the Gaps Between Yield Monitoring SW & Root Cause Analysis?

- **Automated 300mm Probing Process (Scrub Mark) Data Collection and Analysis (2D and 3D)**
- **Automated 3D Probe Tip Data Collection, Review, & Analysis**
- **Exposed Oxide/Pad Punch-Thru Detection**
- **Closed Loop Metrology Enabled**

300mm/200mm/150mm Probing Process (Scrub Mark) Data Collection and Analysis



- **Define Wafer Test Process Tolerance and Precision**

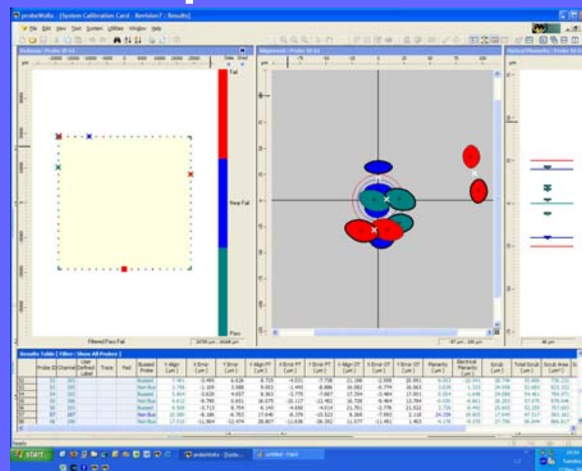


- **Identify Probing Process Issues Via Wafer Scrub Mark Analysis**
- **Quantify the Contribution of Wafer Test Cell Components Based on Scrub Mark Data**

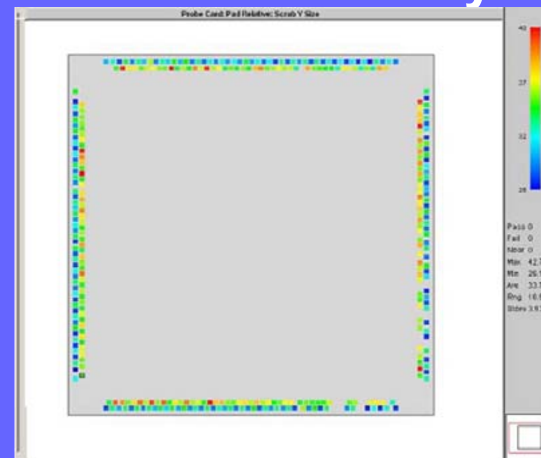
Scrub Marks are the Fingerprints of the Probing Process

Automated 2D/3D Probe Tip and Scrub Data Collection & Analysis

- **Identify Probes & Scrubs of Interest**
  - Based on PCA P/F results
  - Based on Scrub P/F Data

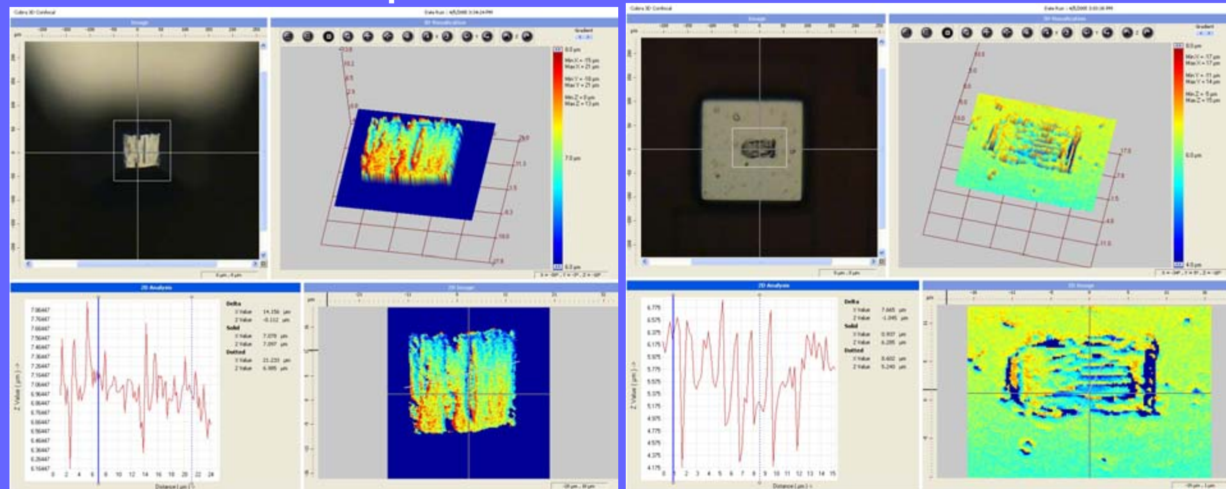


Probe Card/Tip Data



Probing Process Data

- **Rapidly:**
  - **Locate**
  - **Review**
  - **Analyze**
  - **Rework Probes**



2D/3D Probe Tip Analysis

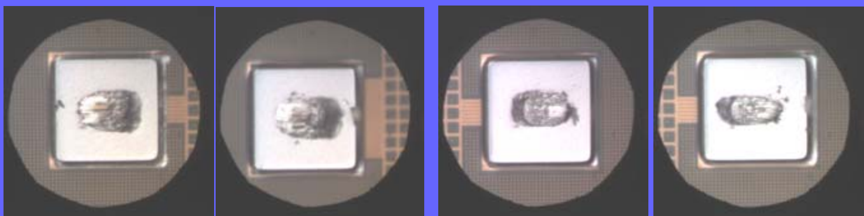
2D/3D Scrub Mark Analysis

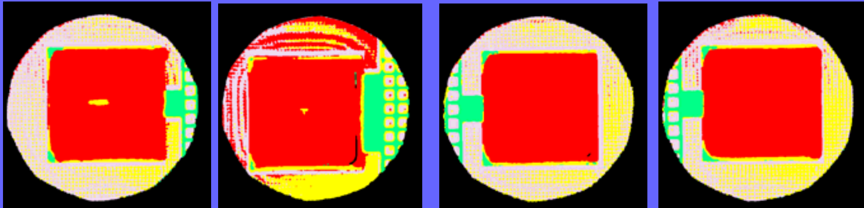
Rapid Root Cause Analysis of Yield Loss

Automated Exposed Oxide/Pad Punch-Thru Detection

Rapid Full Wafer Punch-Thru Detection Via Spectral Analysis – "Go-No-Go"

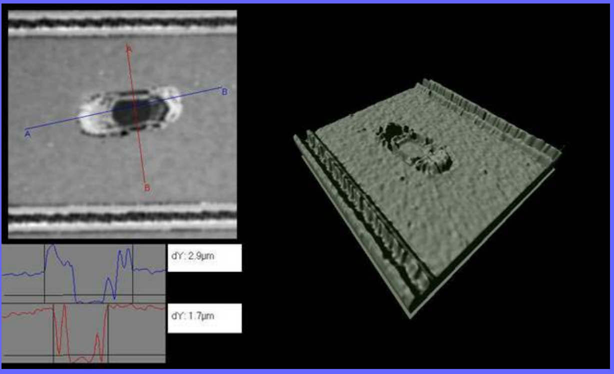
Discovery





Exposed Copper Detected | Acceptable Pad Damage

Root Cause Analysis



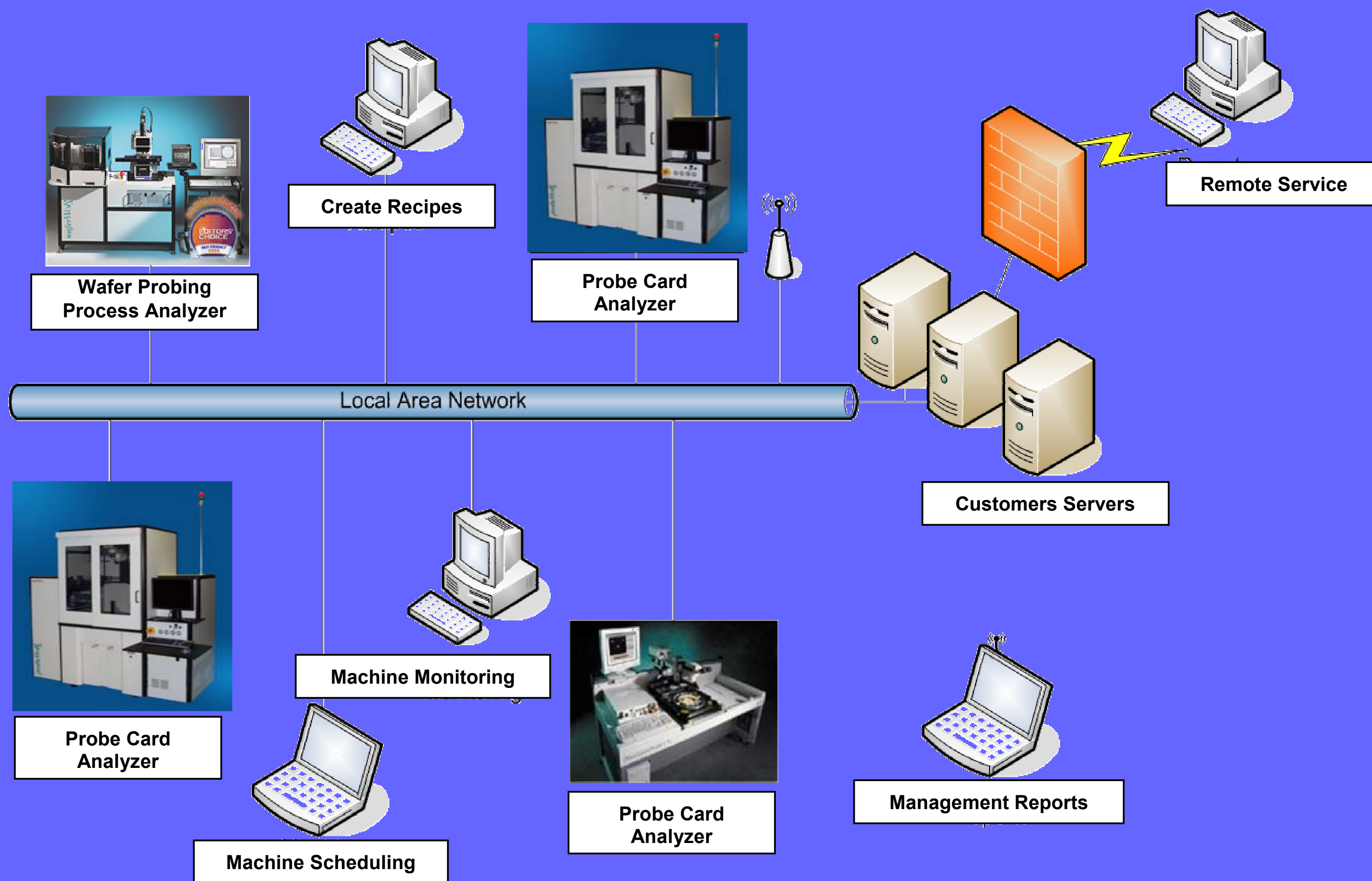
Automated and/or Manual 3D Scan Capability

Reasons for exposed oxide
=> too many insertions
=> excessive overdrive
=> too thin aluminum
=> too soft aluminum

Advanced Optical Analysis - Yield Loss
(Related to Wafer Fab or Wafer Test Process)

Closed Loop Metrology Enabled

All Data Centrally Located and Linked



The „probe card signature“ – syndrome or who has the “old maid”

Problem

- The Need to Rapidly Determine and Resolve the Causes of Yield Loss

Solution

- Advanced Scrub Mark Analysis (including pad punch-thru)
- Advanced Probe Tip Analysis
- Close the Gap Between PC Manufacturers and the Fabs Via CLM

Result

- Increased Wafer Test Yield!!!

Solutions Require Close Working Relationships and Collaborations