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Test Yield Control by On-line Laser Cleaning

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TestConX中国 China

Suzhou ▪ October 23, 2018

Shenzhen ▪ October 25, 2018

IMT /주/아이엠티 Innovative Manufacturing Technology

Slide 1

IF1 Replace with your title

Ira Feldman, 7/7/2018

Contents

- Physics of Contact Resistance
- Laser Cleaning
- Comparison with Other Cleanings
- How to Clean
- Conclusions

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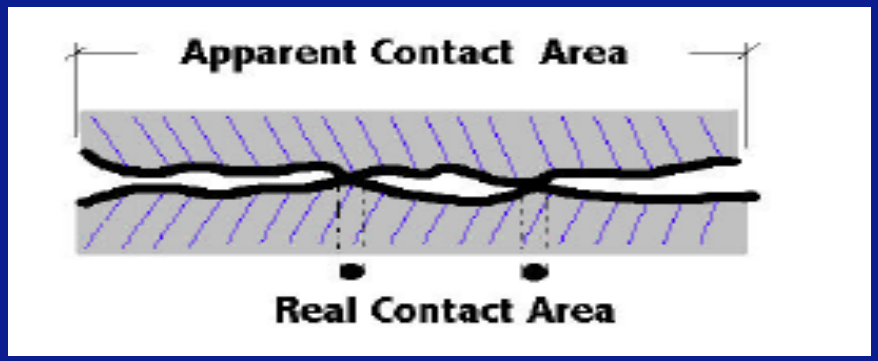
2

Physics of Contact Resistance



→ Contact Shape is very important

Real Contact Area << Apparent Contact Area

Surface Contamination ↑ ⟶ Cres ↑

Contact Force ↓ ⟶ Cres ↑

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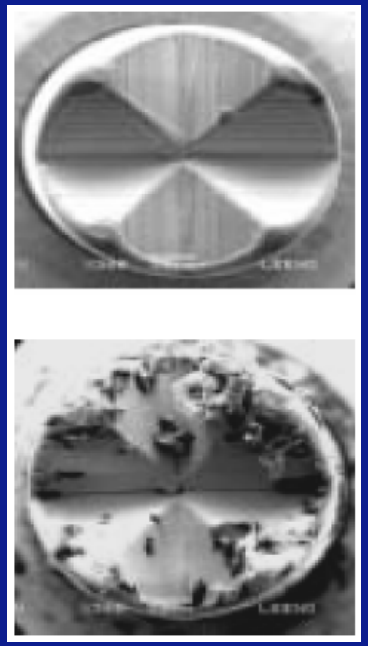
3

Surface Contamination Factor



Number of TD increases

↓

Contact surface is contaminated

↓

Cres increases

↓

Test Yield drops

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Hard Materials Factor

To comply with RoHS (Restriction of Hazardous Substance),

- Leadframe & Ball & Pad Material Change
  : Leaded → Lead-free

- Leaded leadframe & ball & pad: Soft (SnPb)
- Lead-free leadframe & ball & pad: Hard (Sn, NiPdAu, Pd alloy…)

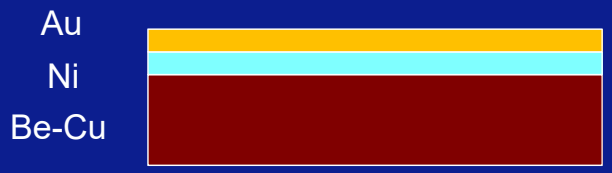
*** Pin contact cleanliness and sharpness become more important for lead free package test

Test Temperature Factor

- More High Temperature Test required
  - ➢ High Temperature : Material activated → more pin contamination & alloy formation

*** Pin surface cleaning becomes more important at high temp test

Metal layers of the Pin Surface



- Au layer is most important to flow current
- Ni Layer is used for Cu diffusion Barrier
- If Au layer is worn or cracked, Ni comes out to form Ni Oxide
- Ni Oxide is not conductive and Cres is increased

➢ Very important to maintain Au layer clean for high Yield Testing → Periodic Cleaning

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7

Conventional Cleaning

Brush Cleaning

- Cleaning Performance is not enough
- Cause Au Layer Surface Wear
- Pin Lifetime is reduced
- Remaining debris make a leakage

Ultrasonic Cleaning

- Cleaning Performance is not enough
- Cause Crack Growth in the Au Layer
- Long cleaning time due to off-line cleaning
- Water make oxidation/rust issue

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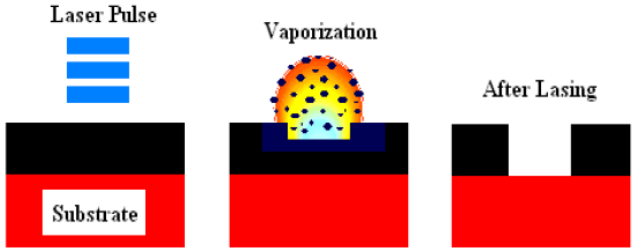
8

What is Laser Cleaning?

What is a laser cleaning?

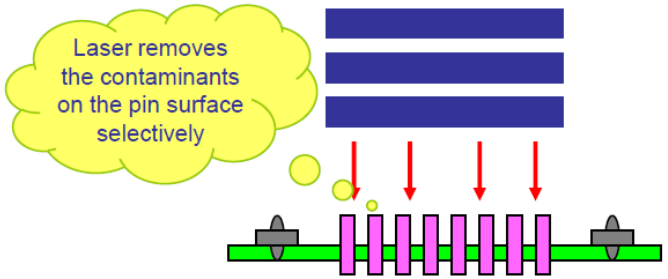
→ Dry cleaning technique to remove the surface contamination selectively without inducing any substrate damage by using proper laser beam interaction.



Ref: Lasers & Cleaning process, J.M.Lee, Hanrimwon Publ. 2002

Definition of Socket laser cleaning

→ Removal process of Tin(Sn) based contamination from the tester socket pin surface to enhance the test yield.



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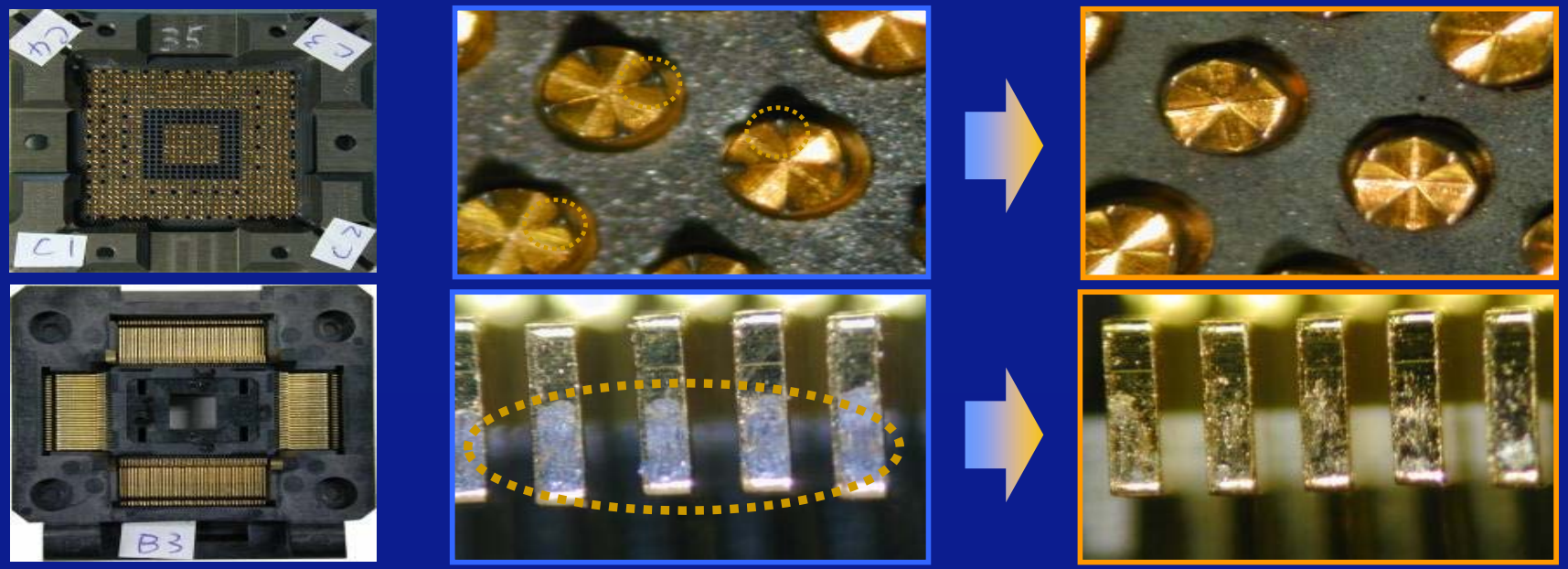
Advantage of Laser Cleaning

- In-situ cleaning without removing the socket
- High speed cleaning: approx. 10 sec/socket
- Excellent cleaning performance
- Immediate test yield increase (Approx. >2%)
- Very fast response process for emergency cleaning
- Very simple and easy handling process
- Low cost of ownership

Cleaning Results (Logic Sockets)

- **Target : T**o remove Tin(Sn) based contamination



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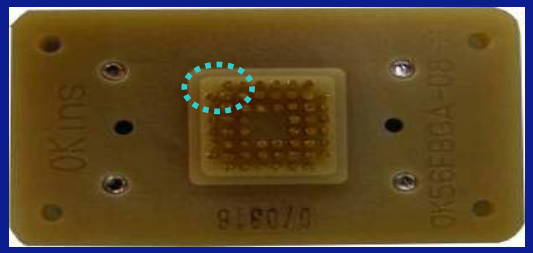
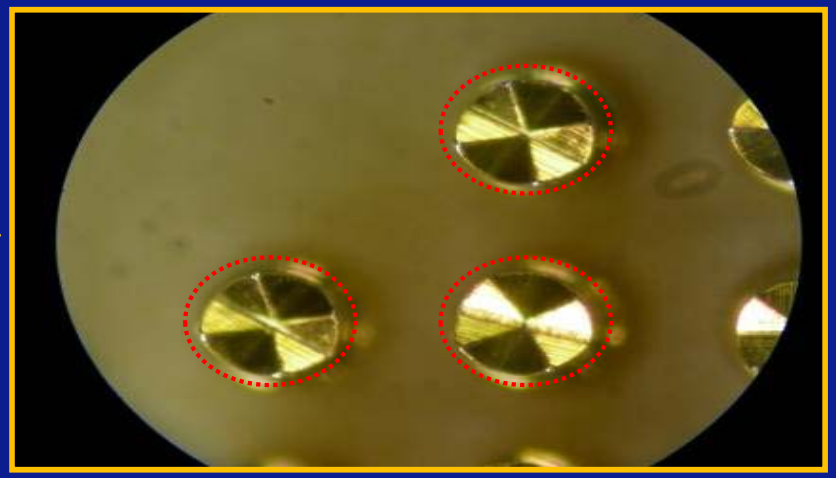
11

Memory BGA Socket





Before Laser Cleaning

After Laser Cleaning

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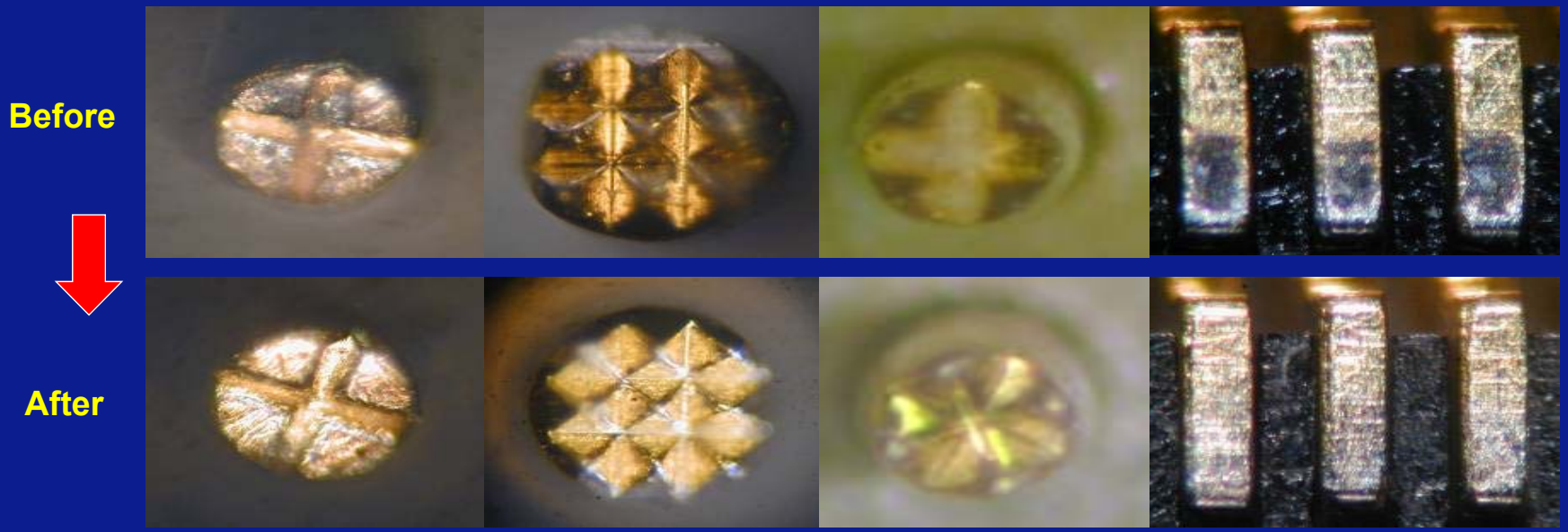
12

Various Contact Pins

- Laser can clean most of pin types without causing any substrate damages in the test sockets.



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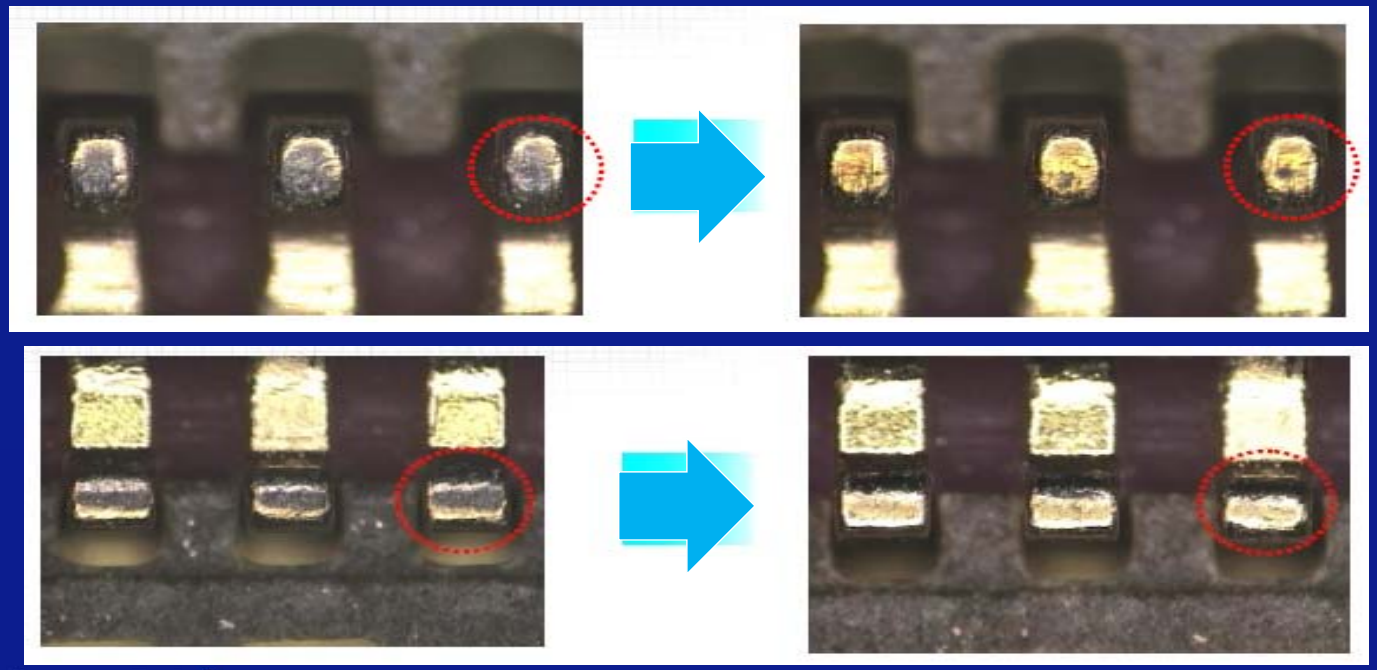
13

RF Device Socket

- **J-com, S pin**: Pins can be cleaned without any damages of the Elastomer



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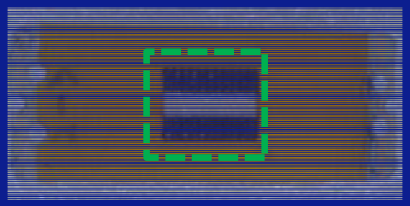
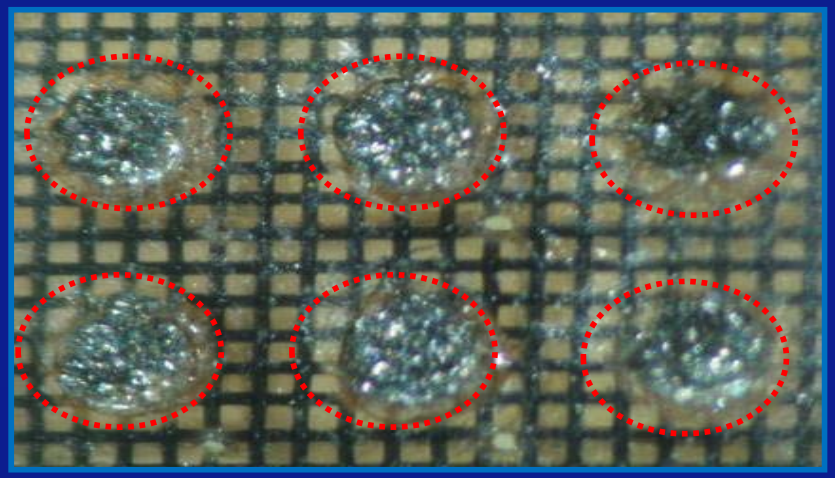
14

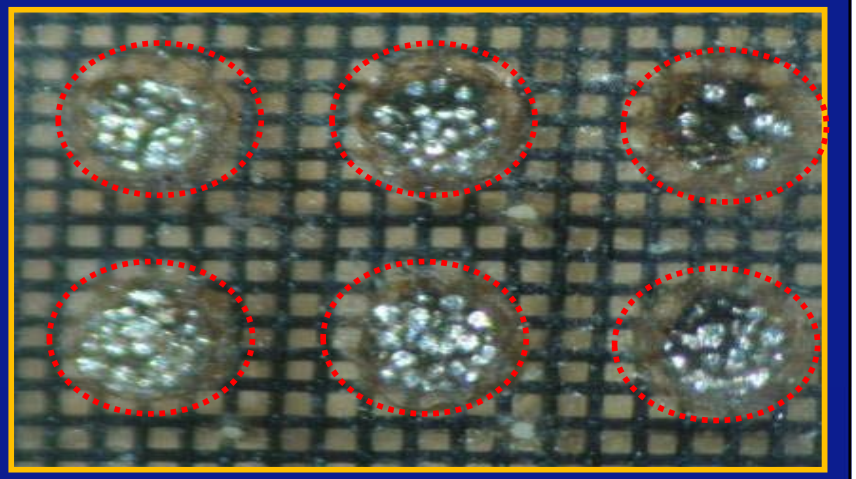
Rubber Socket



- Laser cleaning after 100K touch down



Before Laser Cleaning



After Laser Cleaning

1. No physical damage to rubber
2. 50% reduction in Cres

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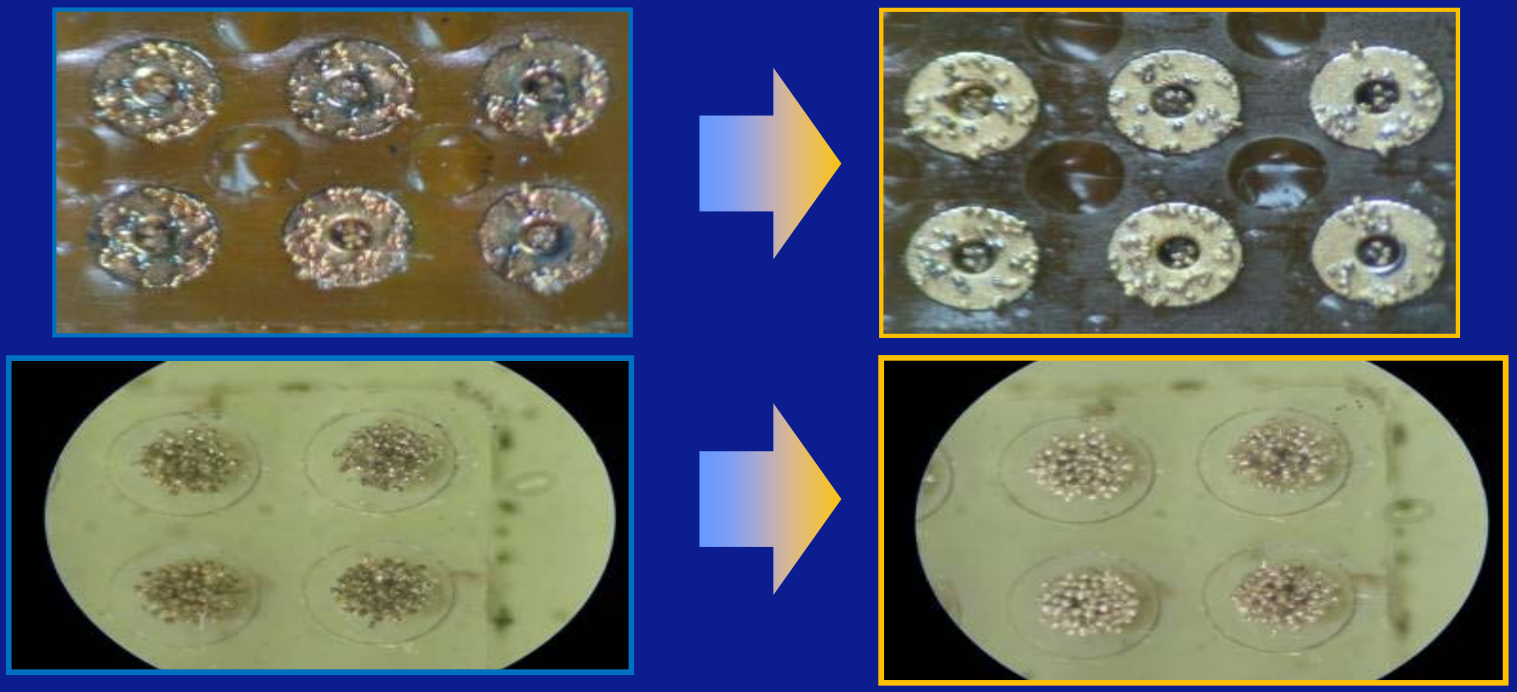
15

Rubber Socket – Au, Ag Powder



→ Well cleaned without any damages

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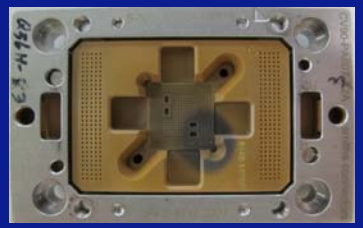
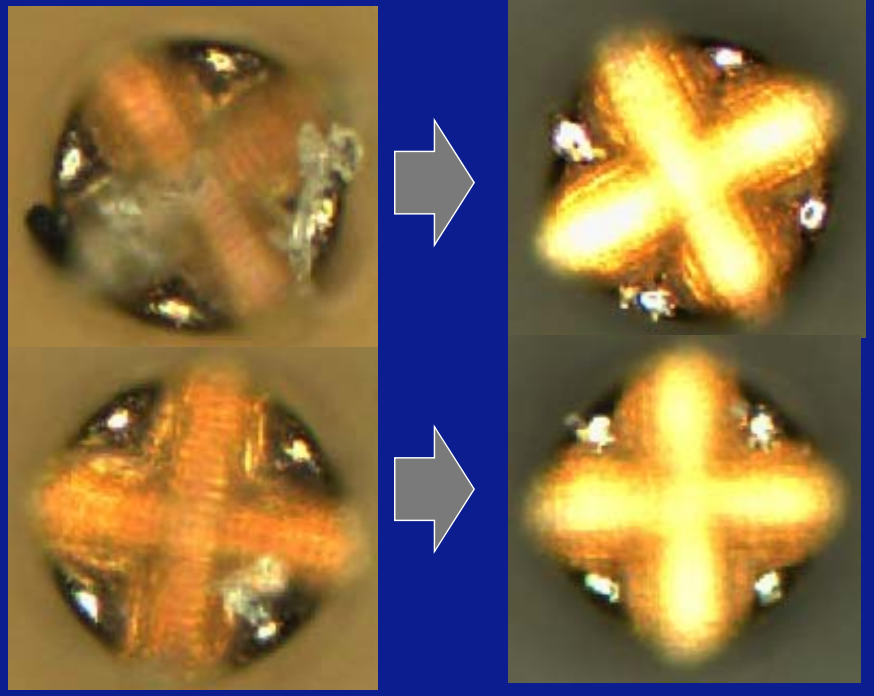
16

Pd Alloy Pin





→ Well cleaned without any damages

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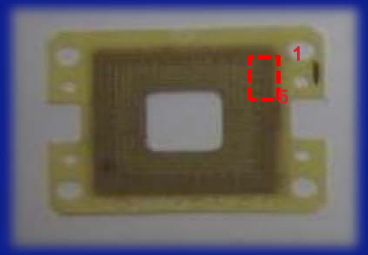
17

Contact Resistance – Rubber socket

Pin No.	Before Laser Cleaning	After Laser Cleaning	Reduced Percent
1	320 mΩ	142 mΩ	55.6 %
2	275 mΩ	153 mΩ	44.4%
3	404 mΩ	197 mΩ	51.2%
4	358 mΩ	164 mΩ	54.2%
5	362 mΩ	166 mΩ	54.1%
Average			51.9%



Resistance tester

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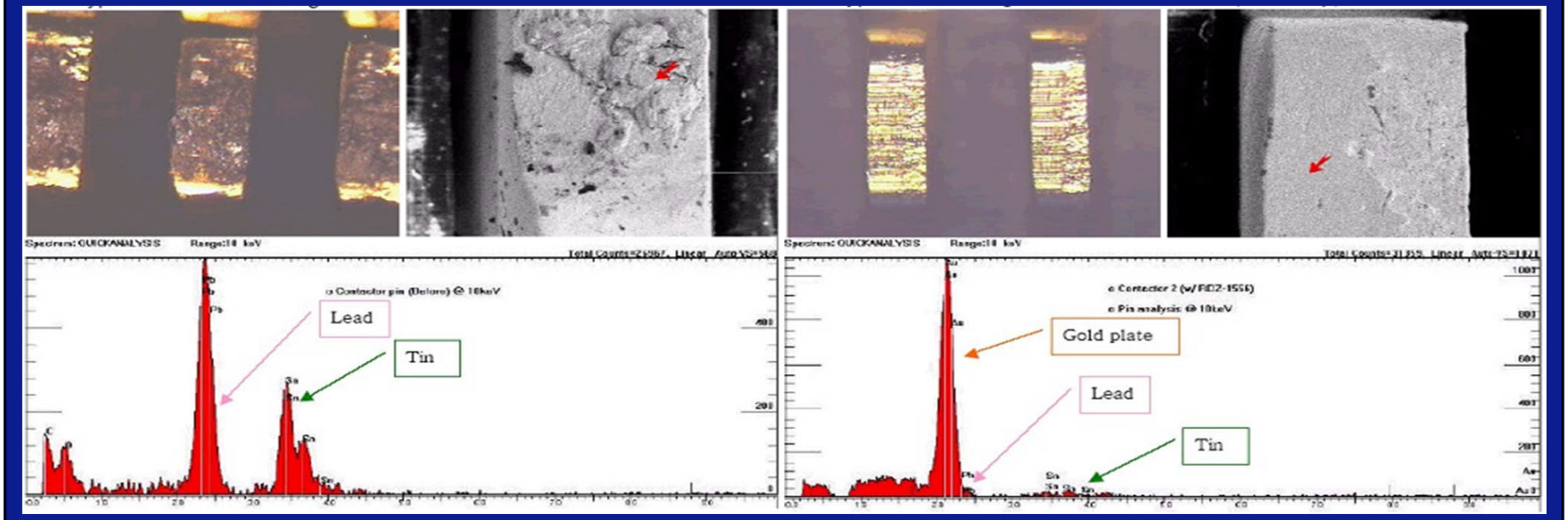
18

Composition Analysis

- EDS Analysis Results



Before Cleaning

After Laser Cleaning: Most Sn, Pb removed

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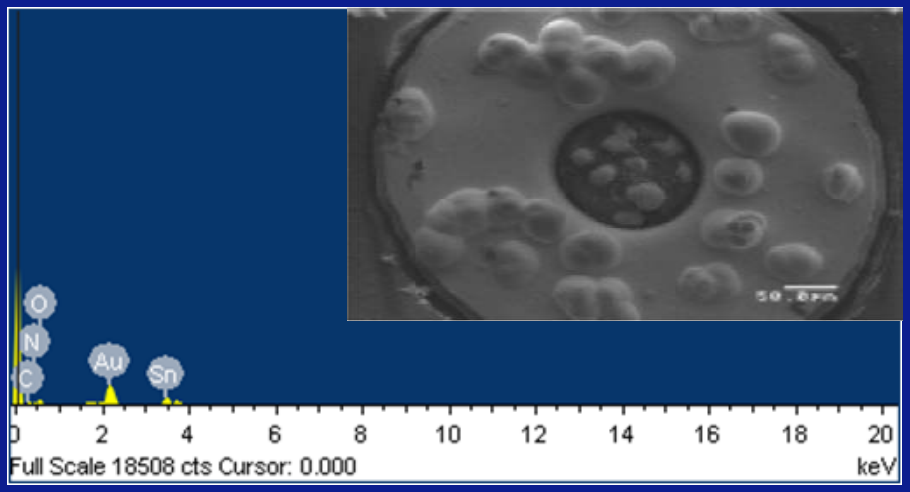
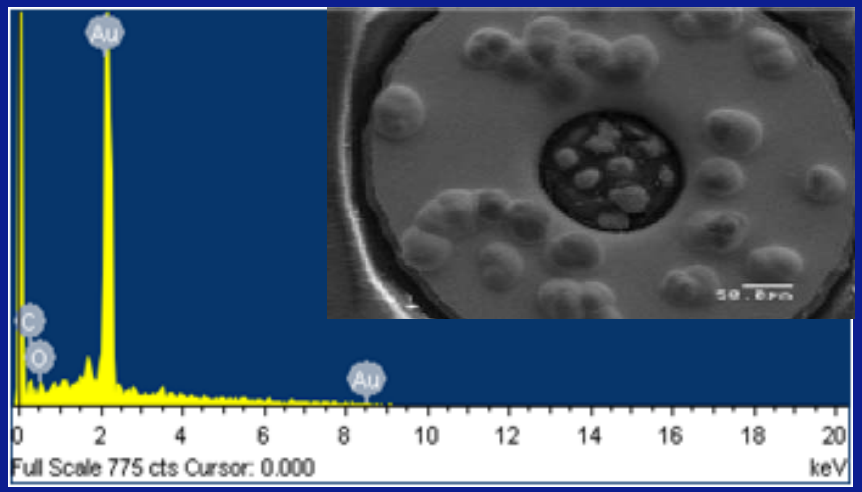
19

Composition – Rubber Socket





Element	Weight%	Atomic%
C K	5.97	23.46
N K	0.00	0.00
O K	17.52	51.64
Sn L	27.51	10.93
Au M	49.00	13.97
Totals	100.00	

Element	Weight%	Atomic%
C K	7.89	35.16
O K	4.09	27.88
Au M	88.02	36.96
Totals	100.00	

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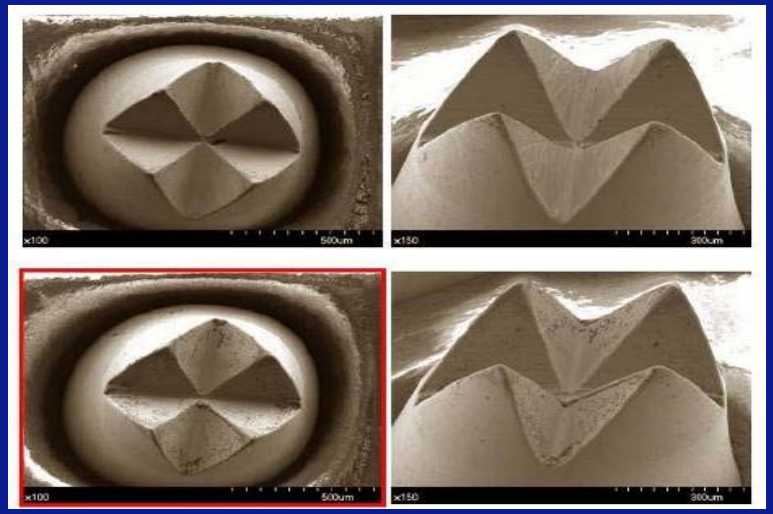
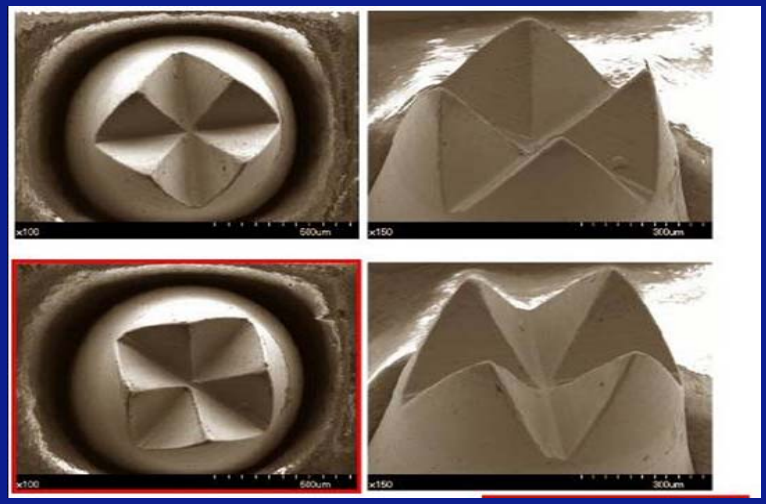
20

SEM Analysis after 100 times laser cleaning

- Crown type Pogo Pin



Before Cleaning



After 100 times Cleaning

After 100 times Laser Cleaning, No visual damage was shown

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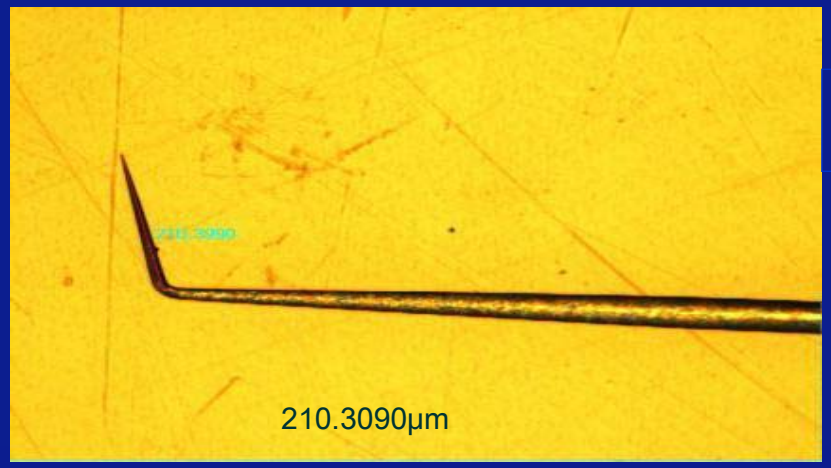
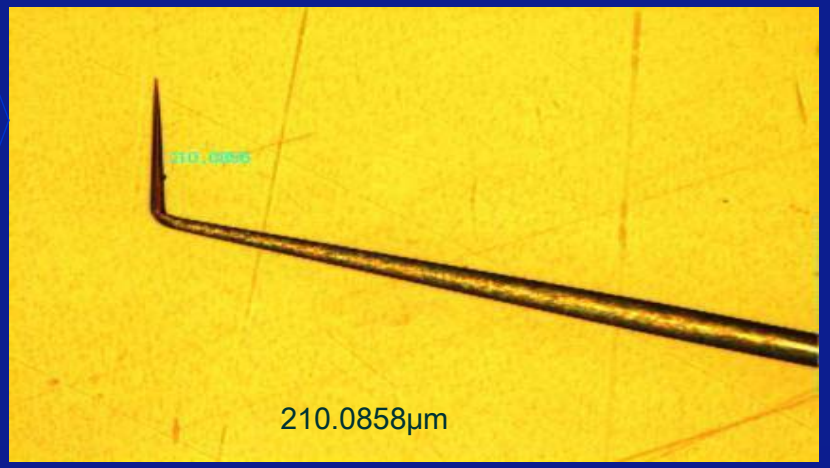
21

Dimension & Deformation Analysis

◆ Probe dimension before & after 1000 laser shots at cleaning condition



Before Cleaning



After 1000 laser shots

*** There was **no any dimensional change** after 1000 times of laser cleaning => No physical damage by laser

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22

Au Coating Thickness Measurement

1. Measurement Instrument

> XRD: X-Ray Diffractometry

> Model: MaXXi5

> Measurement spot size

: approx. 100x100um

2. Measurement Process

1) Thickness measurement before laser treatment

2) Laser cleaning with 350mJ, 100 shots

3) Thickness measurement after the laser treatment

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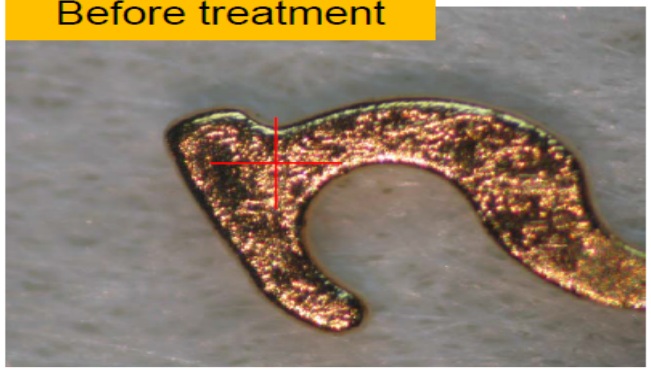
23

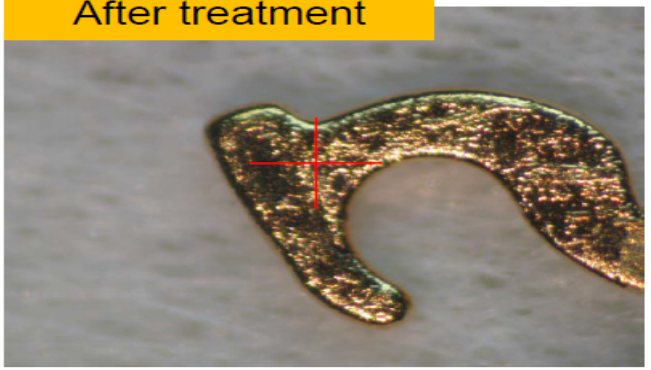
Au Coating Thickness Measurement

Johnstech Pins

Before treatment



After treatment



	1	2	3	Average
Before laser treatment	1.49 μm	1.62 μm	1.56 μm	1.56 μm
After laser treatment	1.60 μm	1.52 μm	1.58 μm	1.57 μm

*** There is no difference on Au coating thickness of Johnstech pin before and after the harsh laser treatment.

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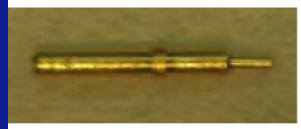
24

Au Coating Thickness Measurement



Spring Probe Pins

Before treatment

After treatment

	1	2	3	Average
Before laser treatment	1.24 μm	1.32 μm	1.29 μm	1.28 μm
After laser treatment	1.27 μm	1.30 μm	1.25 μm	1.27 μm

*** There is no difference on Au coating thickness of pogo pin before and after the harsh laser treatment.

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25

Laser Cleaning after 160K Touchdown

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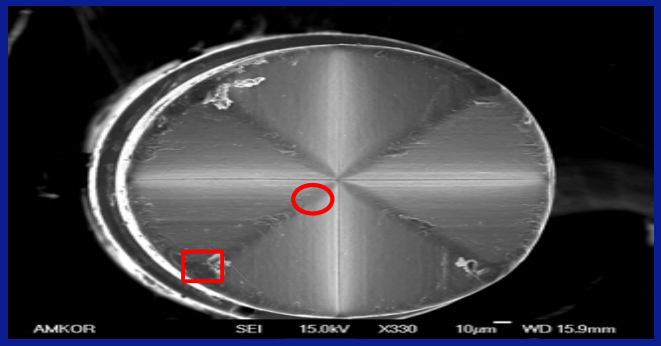
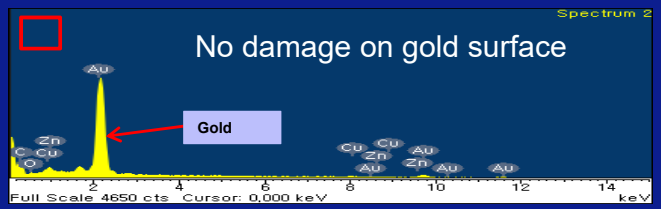
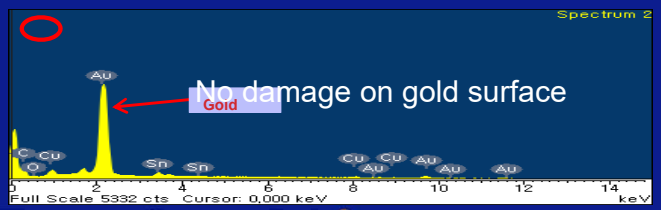
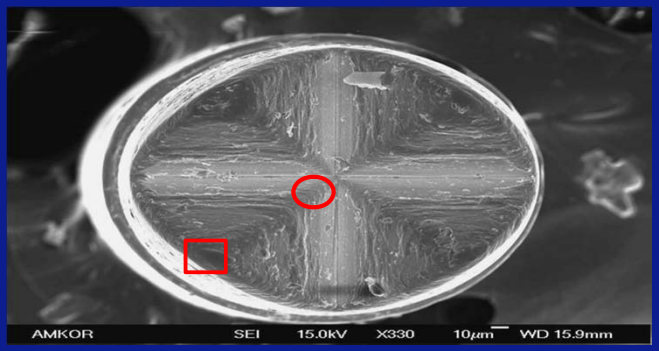
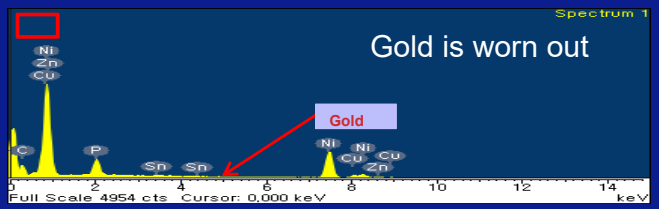
Metal Brush Cleaning after 150K Touchdown

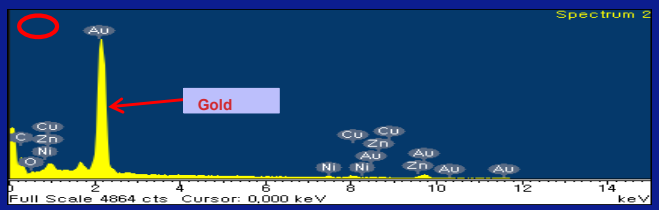












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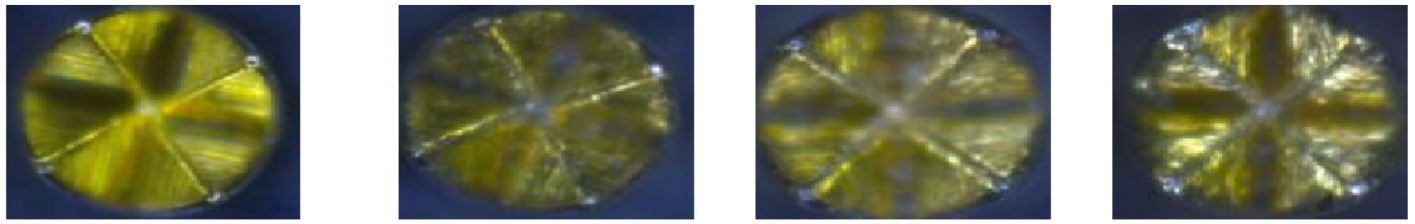
26

Microscopic Investigation

Brush Cleaning

A significant surface change was found even after 60 shots.

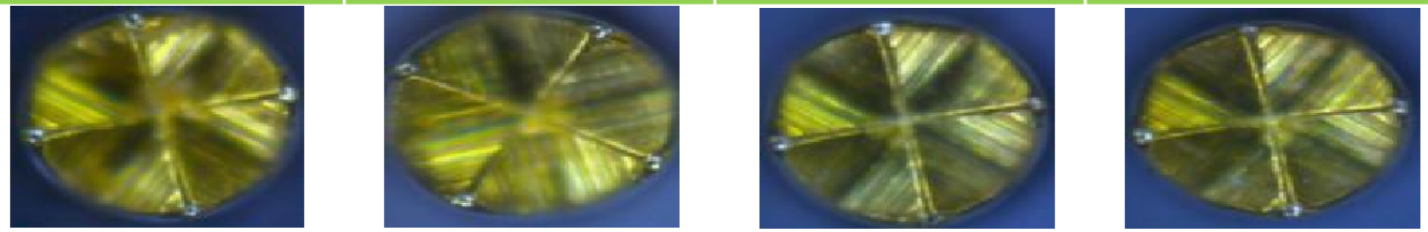
Initial	60 times	150 times	300 times



Laser Cleaning

A significant surface change was not found even after 300 shots.

Before	After 60 shots	After 150 shots	After 300 shots



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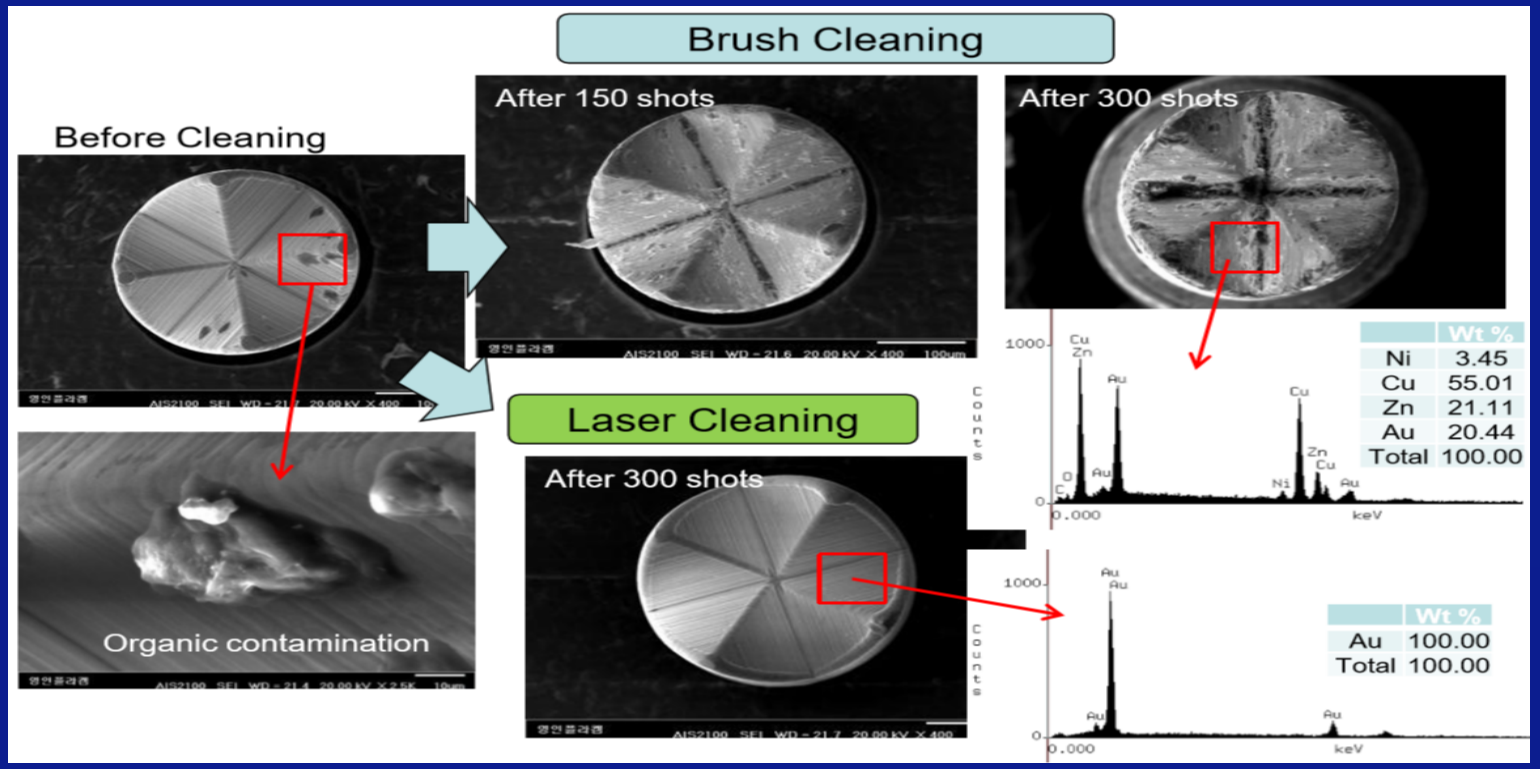
2018

27

SEM/EDS Investigation after 300 times



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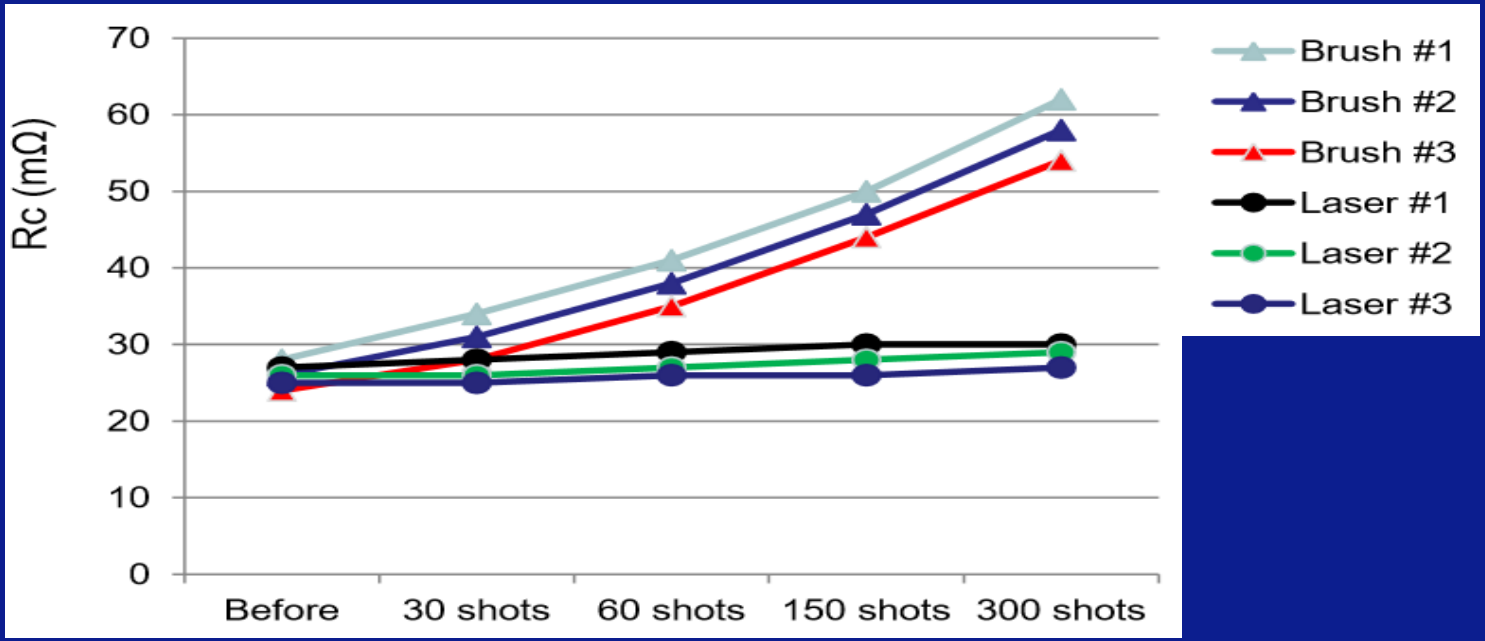
2018

28

Contact Resistance Change with Cleaning



- In brush cleaning, Contact Resistance (Rc) increased even after 30 shots and more than 100% up after 300 shots.
- In laser cleaning, Contact Resistance (Rc) showed no significant change after 300 shots.

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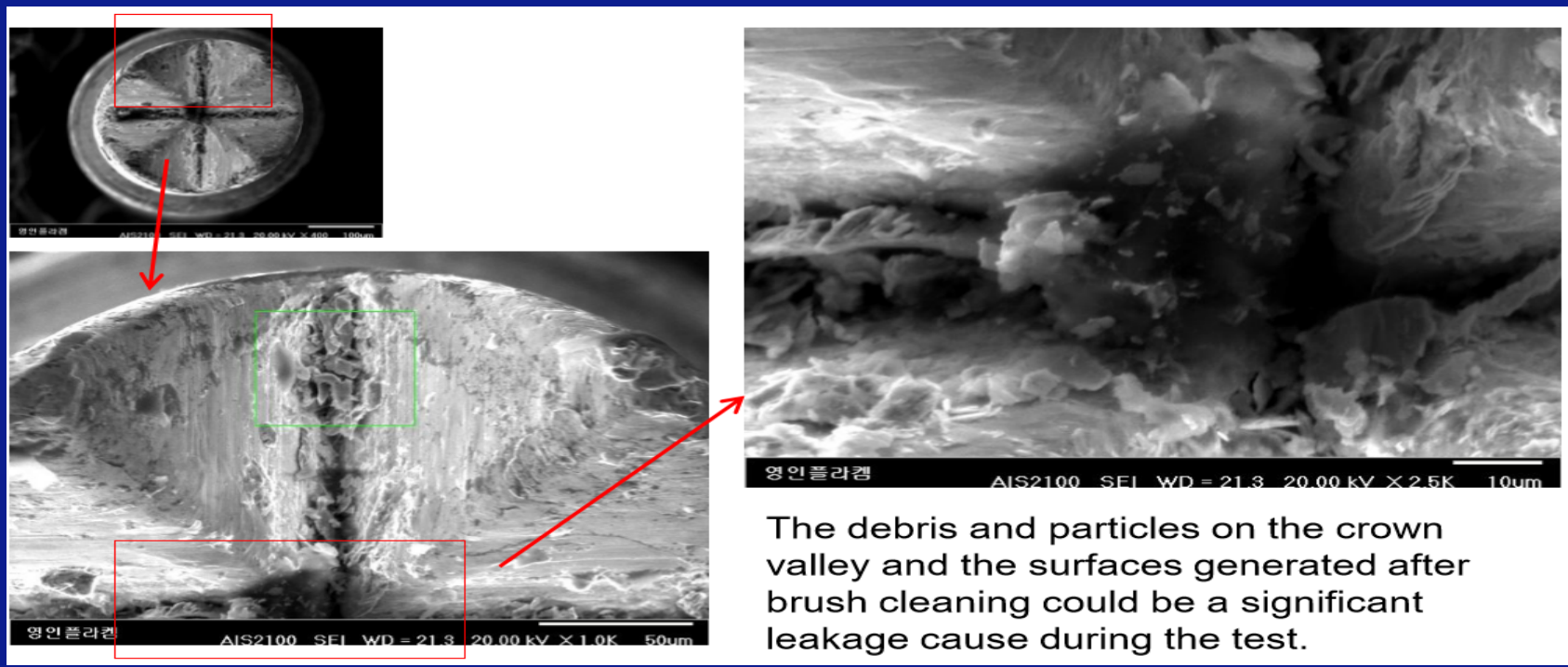
29

Significant Leakage caused by brush cleaning



The debris and particles on the crown valley and the surfaces generated after brush cleaning could be a significant leakage cause during the test.

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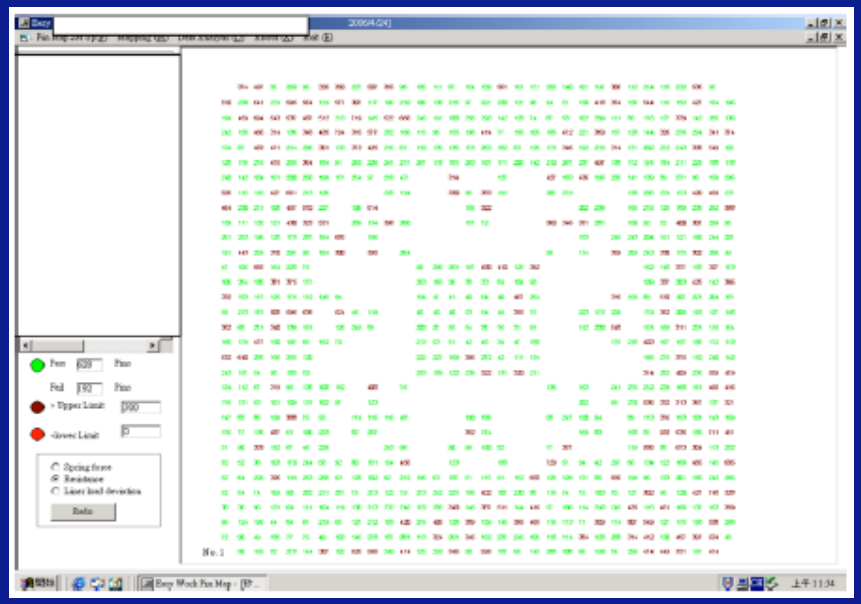
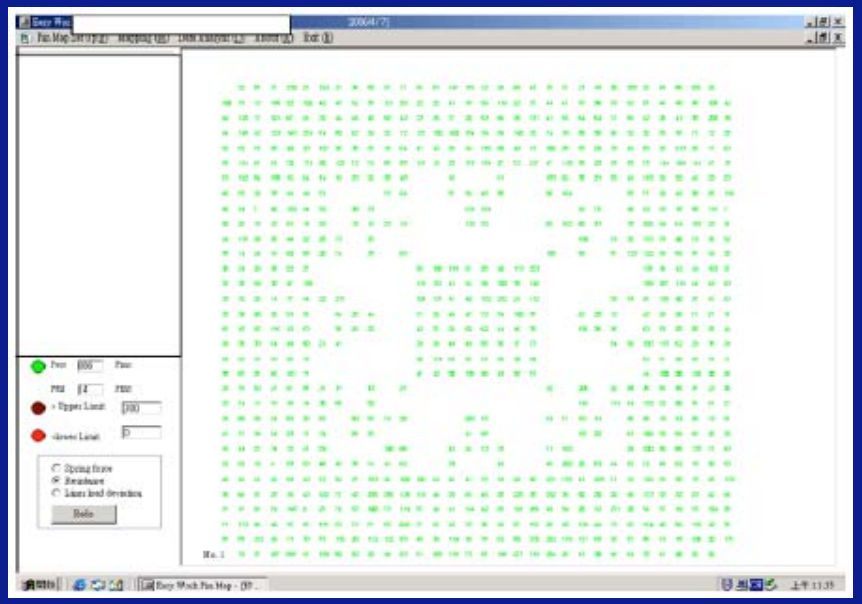
30

Verification of Cres

- S-com test data before and after laser cleaning



Before Laser Cleaning



After Laser Cleaning:
All Cres within spec.

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2018

31

Yield Enhancement

#06 => MLF10x10_64LD (Pogo)						
Before LC	Total: 2,572 Unit			After LC	Total: 3,896 Unit	
Good	(BIN1) 2,314	90%		Good	(BIN1) 3,752	96.3%
Reject	(BIN5) 167	6.5%		Reject	(BIN5) 128	3.3%
	(BIN6) 13	0.5%			(BIN6) 13	0.3%
	(BIN5) 8	0.3%			(BIN5) 9	0.2%
#11 => BGA 13x13 (Pogo)						
Before LC	Total: 1,495 Unit			After LC	Total: 3,104 Unit	
Good	(BIN1) 1,265	84.6%		Good	(BIN1) 2,809	90.5%
Reject	(BIN3) 42	2.8%		Reject	(BIN3) 50	1.6%
	(BIN5) 19	1.3%			(BIN5) 25	0.8%
	(BIN6) 97	6.5%			(BIN6) 109	3.5%
	(BIN7) 81	5.4%			(BIN7) 118	3.8%

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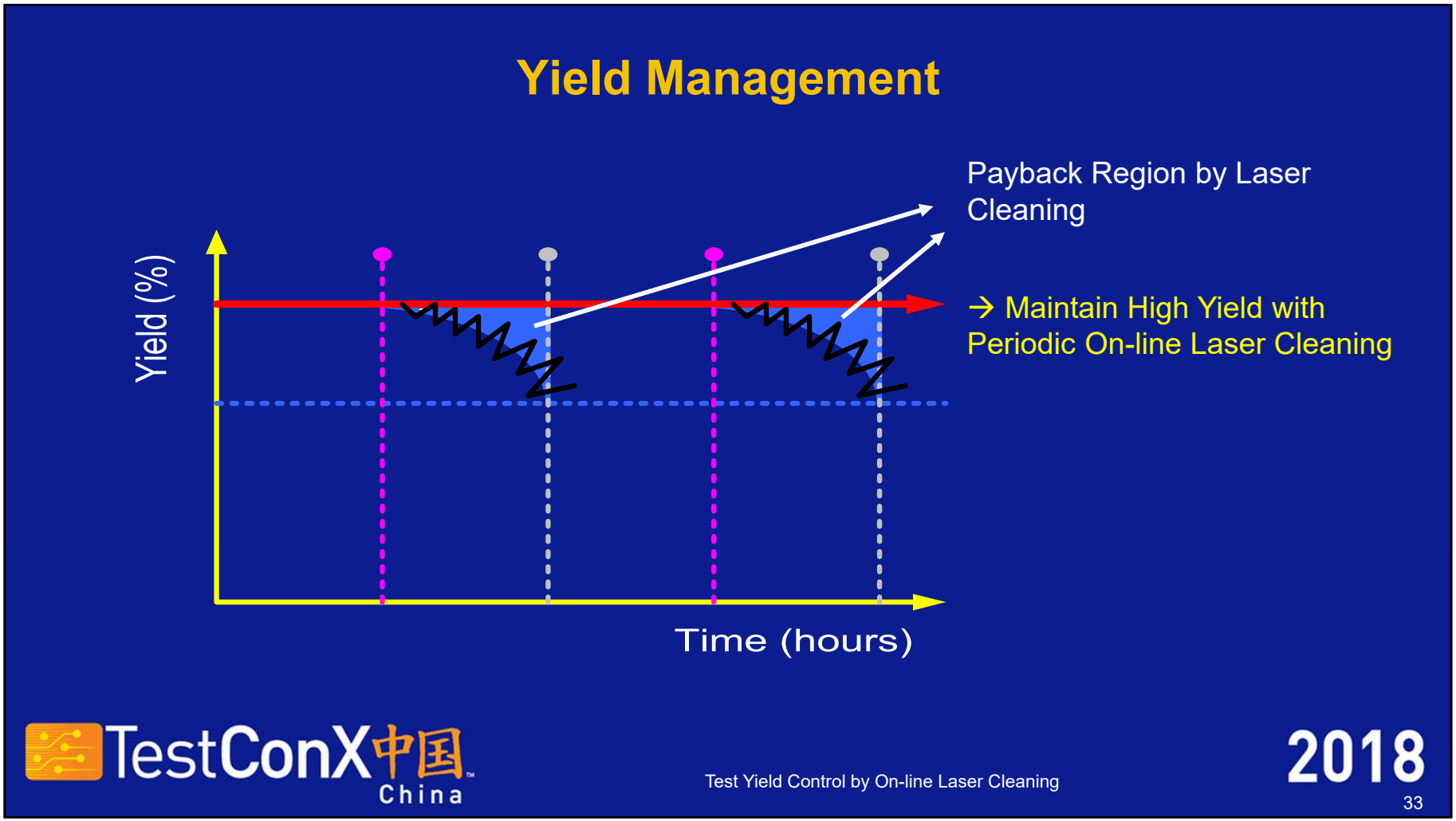
2018

32


Yield Management
Payback Region by Laser Cleaning
→ Maintain High Yield with Periodic On-line Laser Cleaning
Yield (%)
Time (hours)
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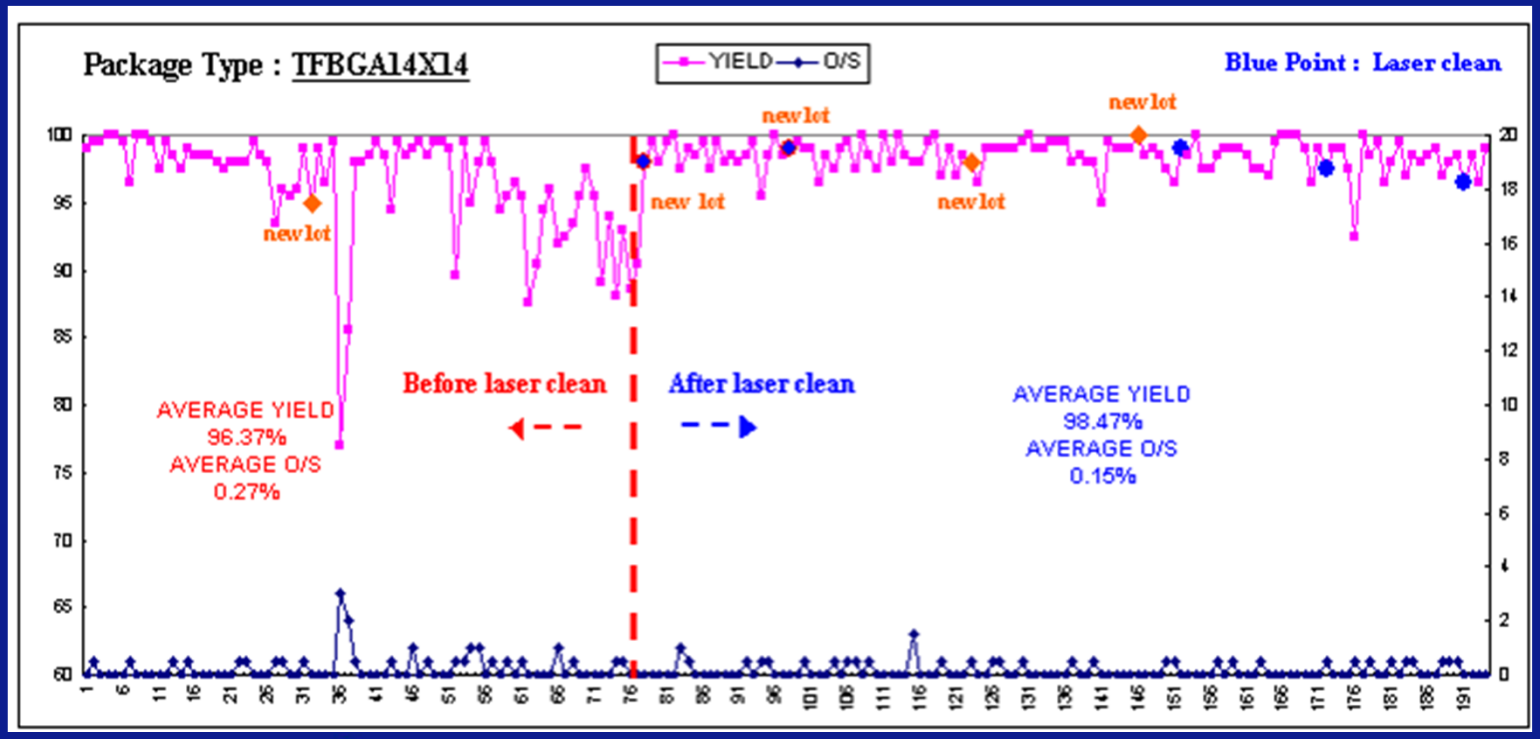
2018
33

Yield Management – Real Data



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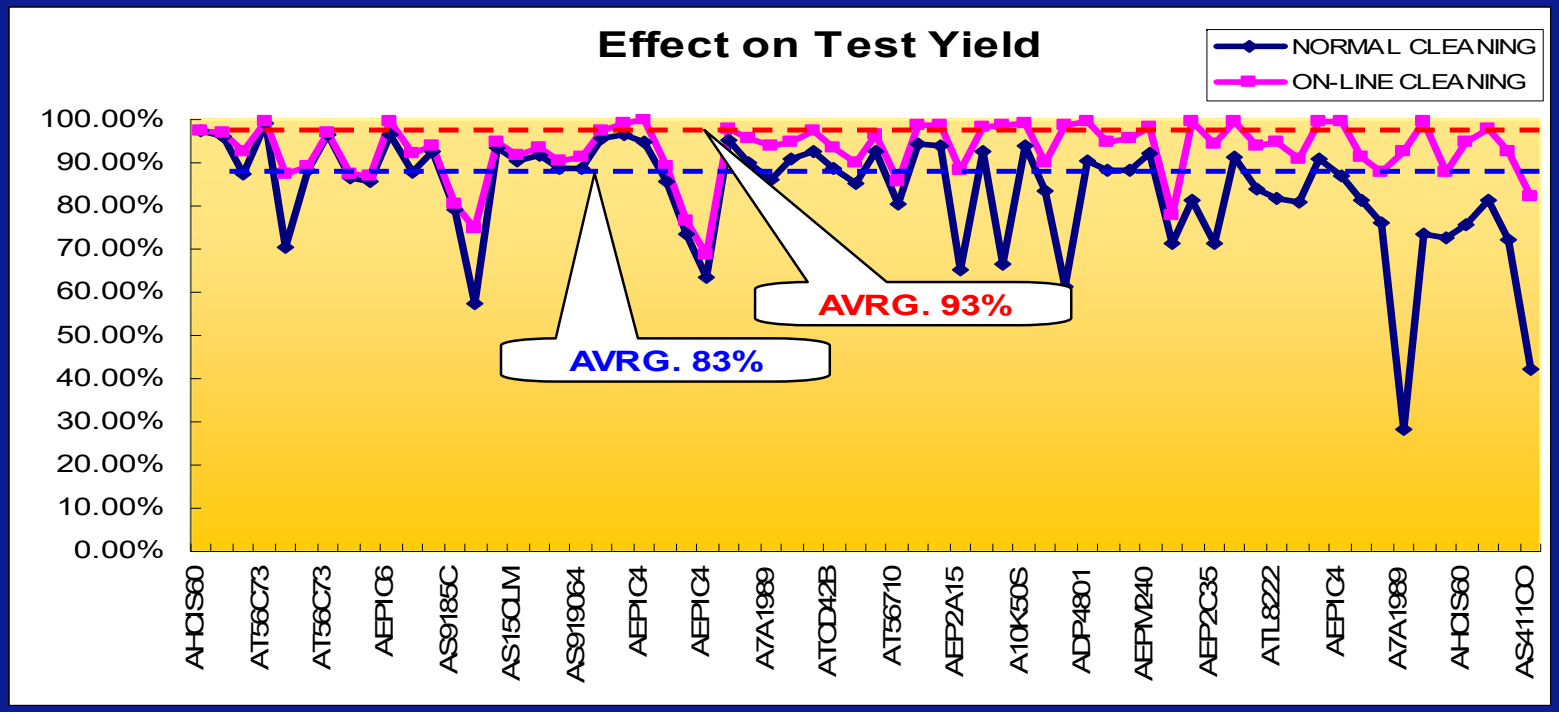
2018

34

On-line Cleaning Effect



→ Test yield increased 10% with on-line laser cleaning

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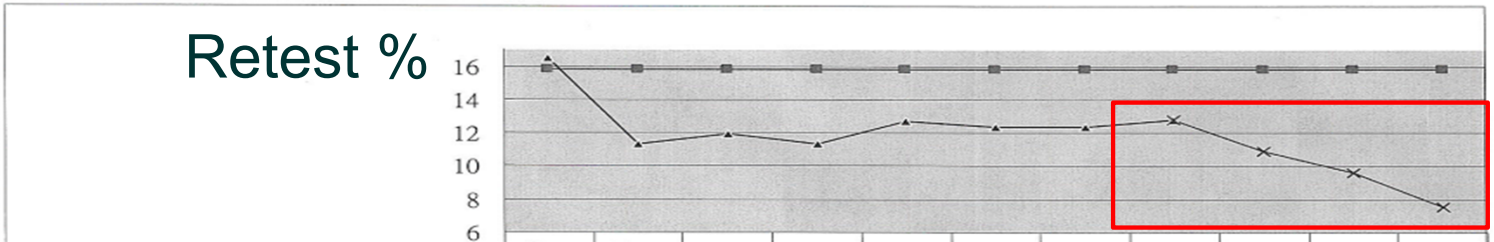
Retest Reduction

EXA R/T RATE 比較圖



Week:	第32週	第33週	第34週	第35週	第36週	第37週	第38週	第39週	第40週	第41週	第42週
7月份EXA 平均 R/T RATE	15.83	15.83	15.83	15.83	15.83	15.83	15.83	15.83	15.83	15.83	15.83
8月份第32週開始實施5大掛修條件	16.52	11.34	11.91	11.34	12.74	12.39	12.36	12.78			
9月份第39週開始雷射清潔,實施5大掛修條件持續執行								12.78	10.94	9.57	7.54

7月份EXA 平均 R/T RATE — July average, baseline

8月份第32週開始實施5大掛修條件 — Aug. weekly average at normal condition

9月份第39週開始雷射清潔,實施5大掛修條件持續執行 — **Sept. average after laser cleaning**

→ Retest reduced more than 5%

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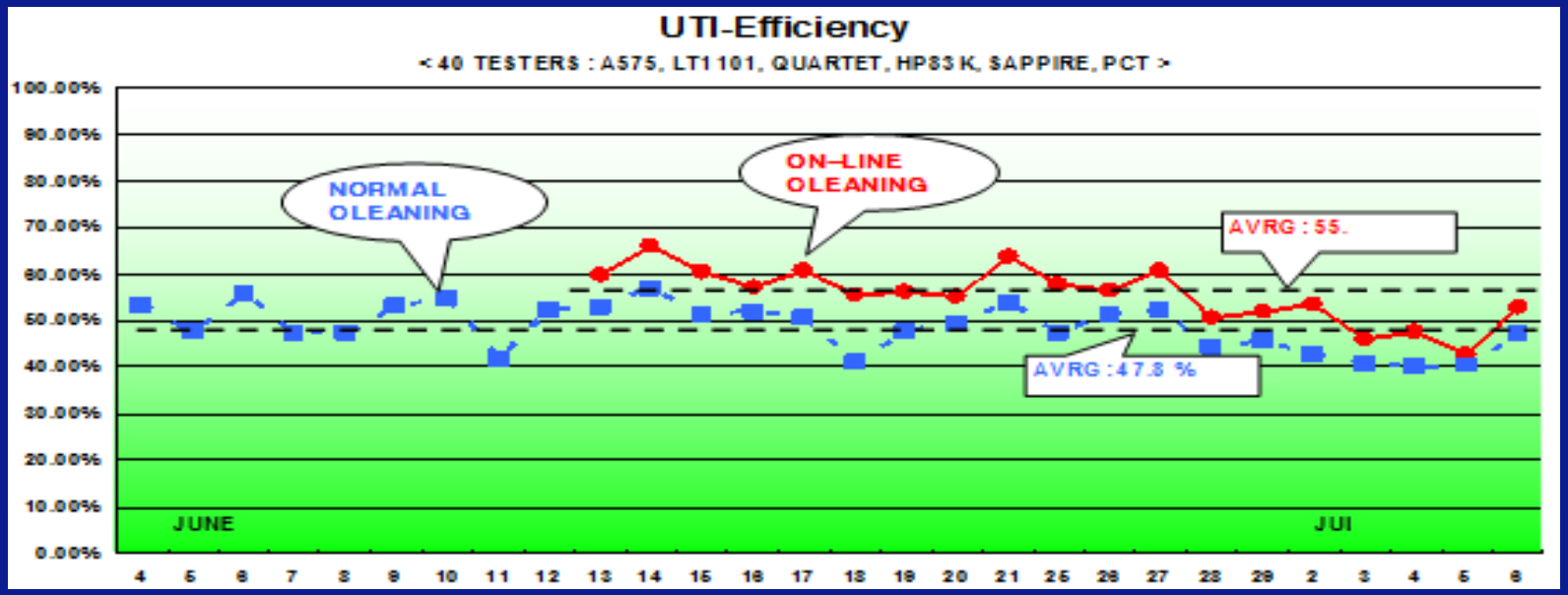
36

M/C UTI Efficiency



→ Machine Utilization Efficiency increased by ~ 7% after on-line laser cleaning, compared with normal blush cleaning –pogo socket

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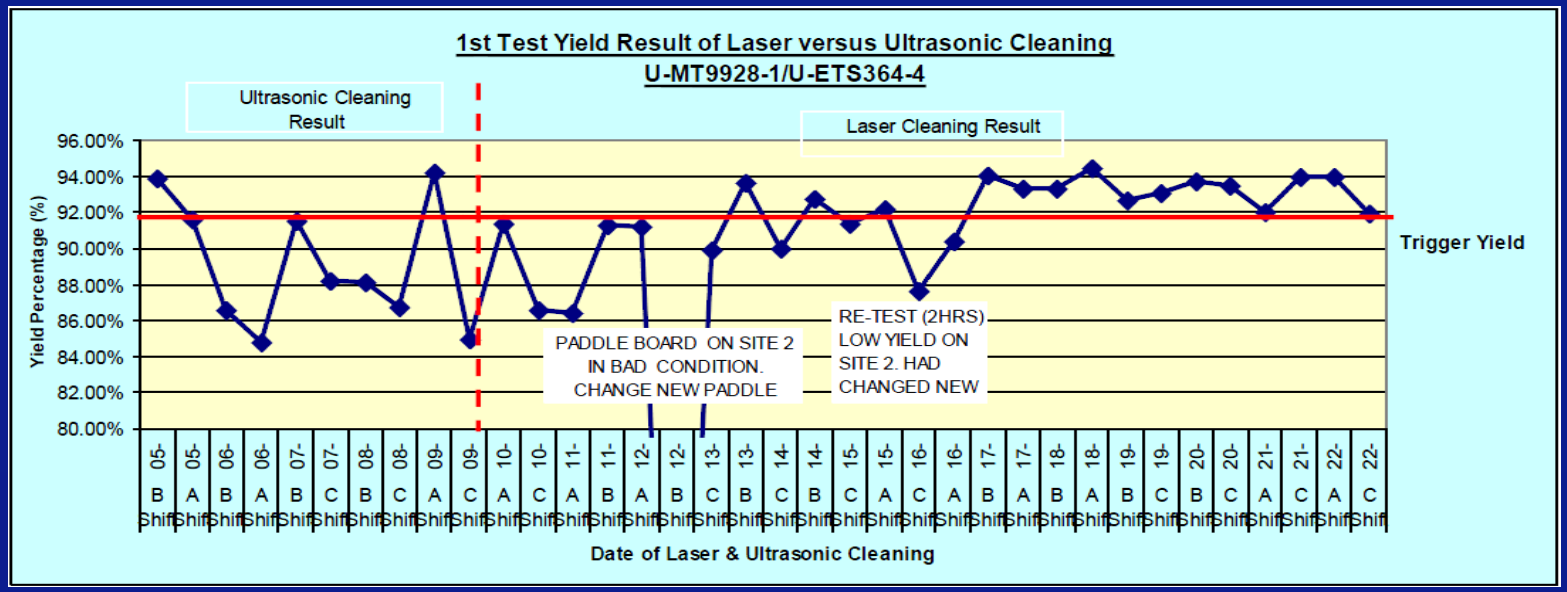
37

Comparison with Ultrasonic Cleaning



→ Laser cleaning provide stable high yield.

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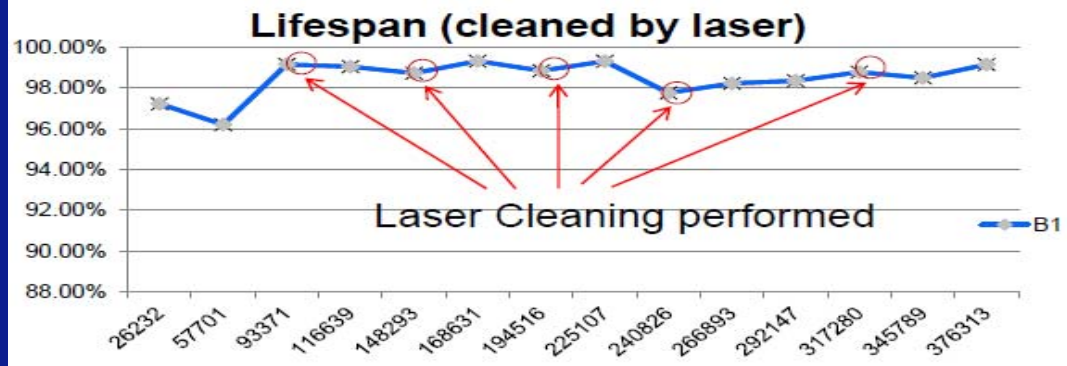
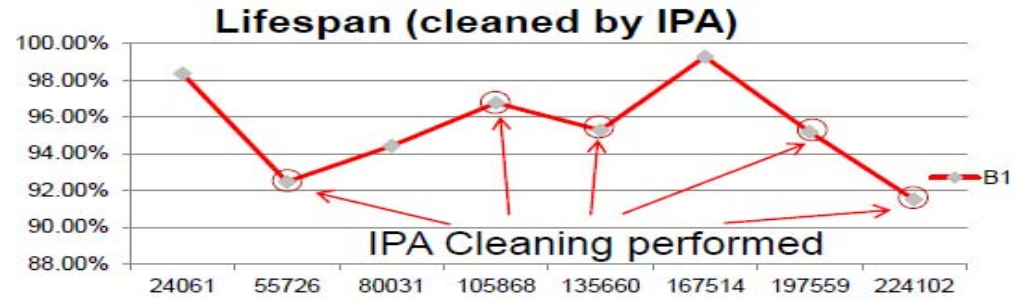
38

Comparison with IPA Cleaning





Handler : SRM
Socket : SRM Contact Finger
Device : 1x1.45 6L Kelvin

Observation (Laser Cleaning):
- Life span recorded at 376k compared to 224k insertions for IPA cleaning.
- Less contamination built up at the surface of the pins as it got removed each time laser cleaning was performed.
- Consistent yield (>95%) observed
- 50% Lower cleaning frequency

Observation (IPA Cleaning):
- Life span recorded at 224k insertions
- Solder & foreign material built up on the surface of the pins.
- Less consistent yield (92%~99%)
- High cleaning frequency

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→ Constant yield & lower cleaning frequency

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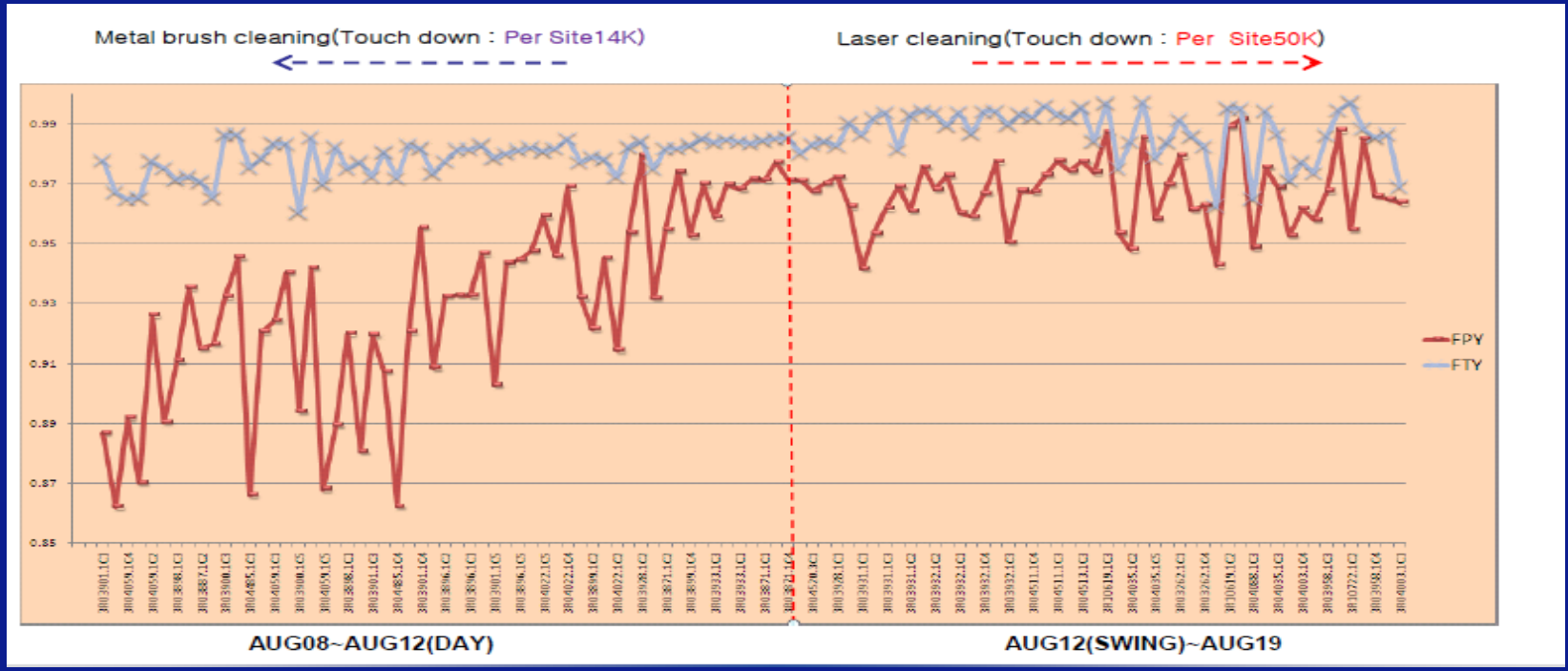
39

Comparison with Metal Brush Cleaning



→Much Higher First Test Yield

→Also Final Test Yield Up

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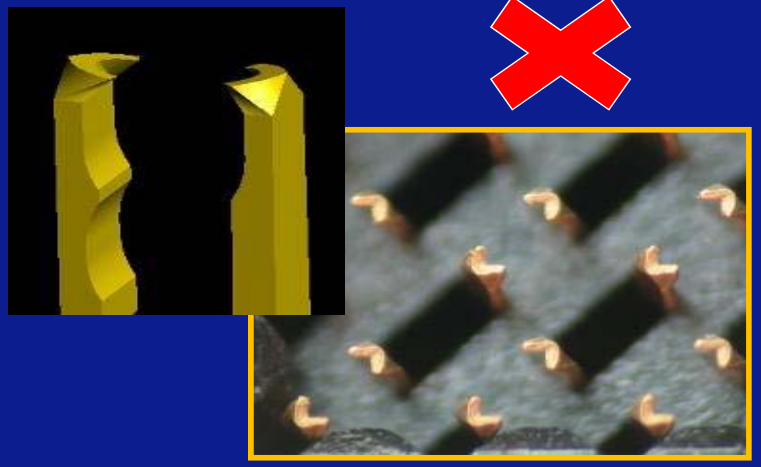
40

Burn-in Board Socket Cleaning

- Very effective for Buckle beam type BIB sockets
- Not suitable for pinch type BIB sockets



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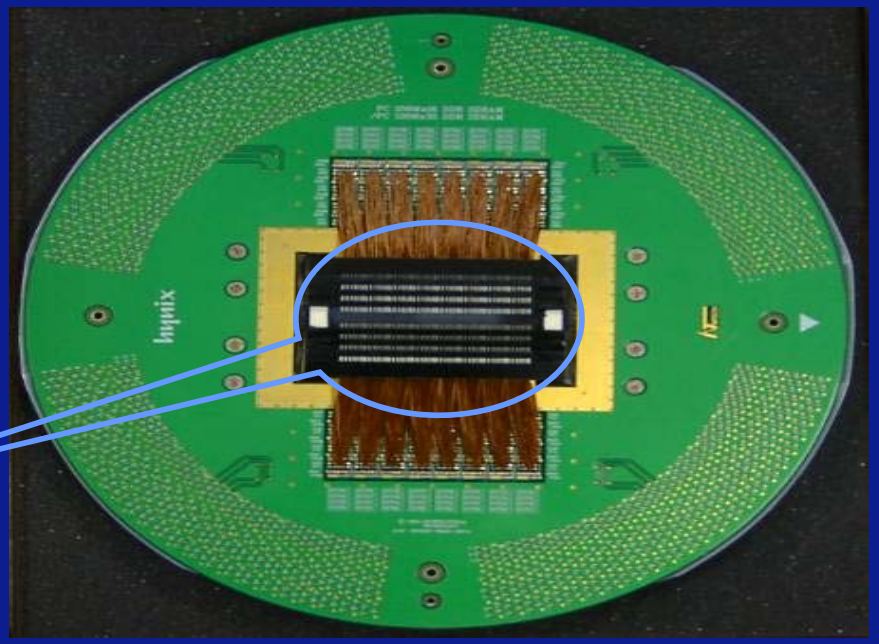
41

Cantilever Probe Card Cleaning

- Cleaning target:

  Probe Pin surface contaminated by continuous contacts with wafer



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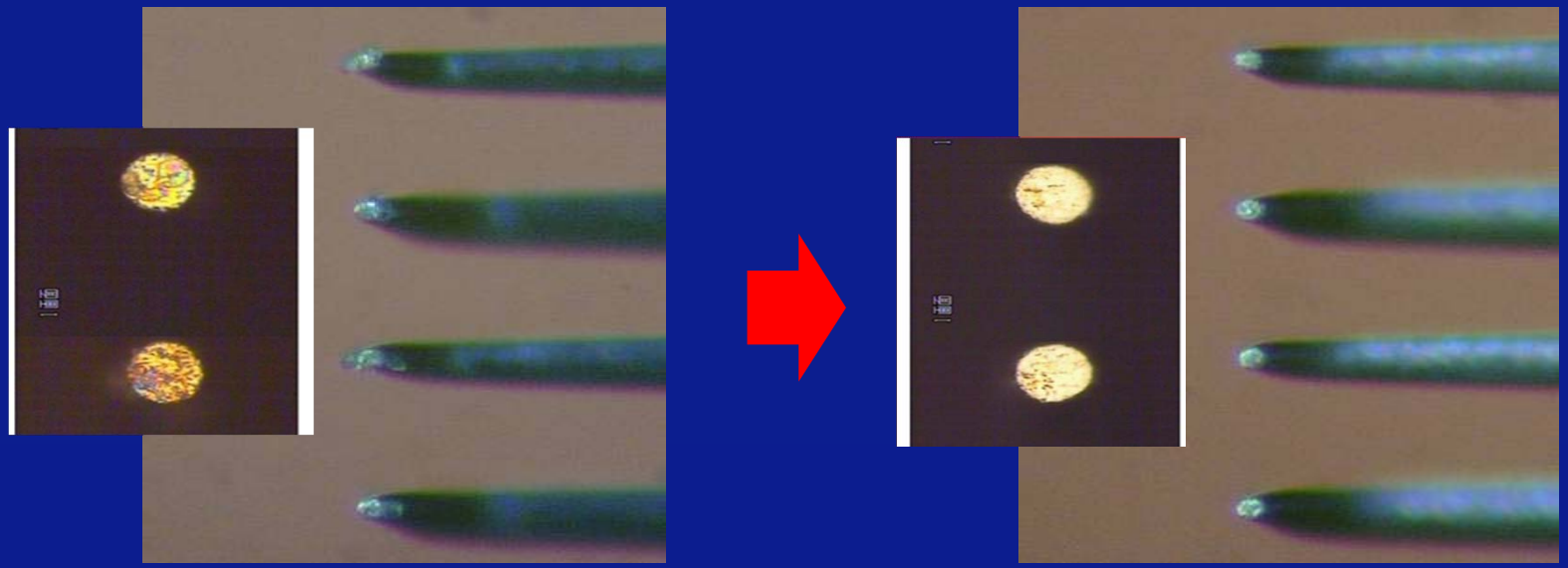
42

Cantilever Probe Card Cleaning

- Probe Surfaces Before & After Cleaning (x50)



→ Well cleaned without any probe damage

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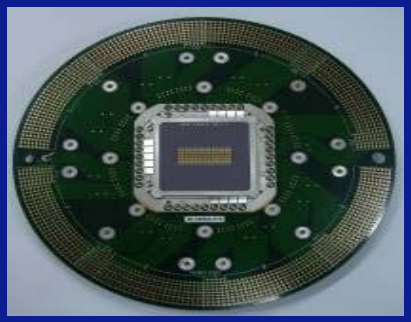
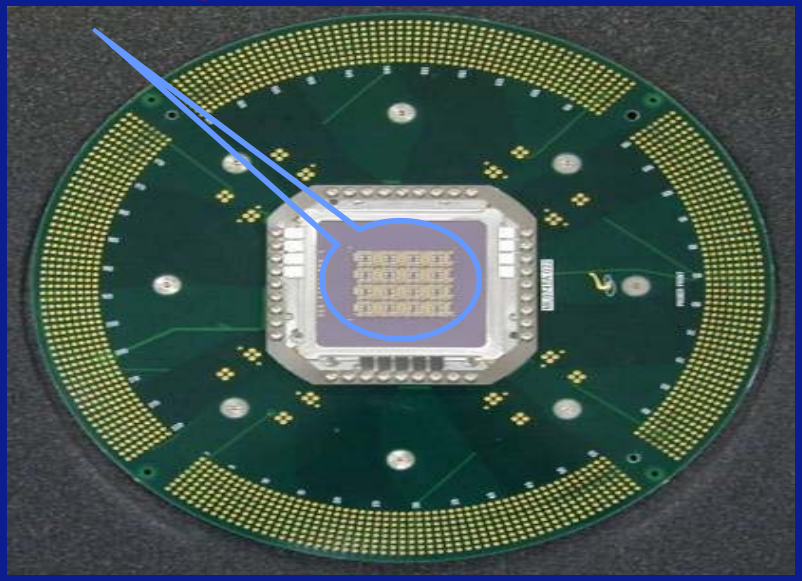
43

MEMS Probe Card Cleaning

- MEMS Probe Card (FormFactor)



Cleaning Area



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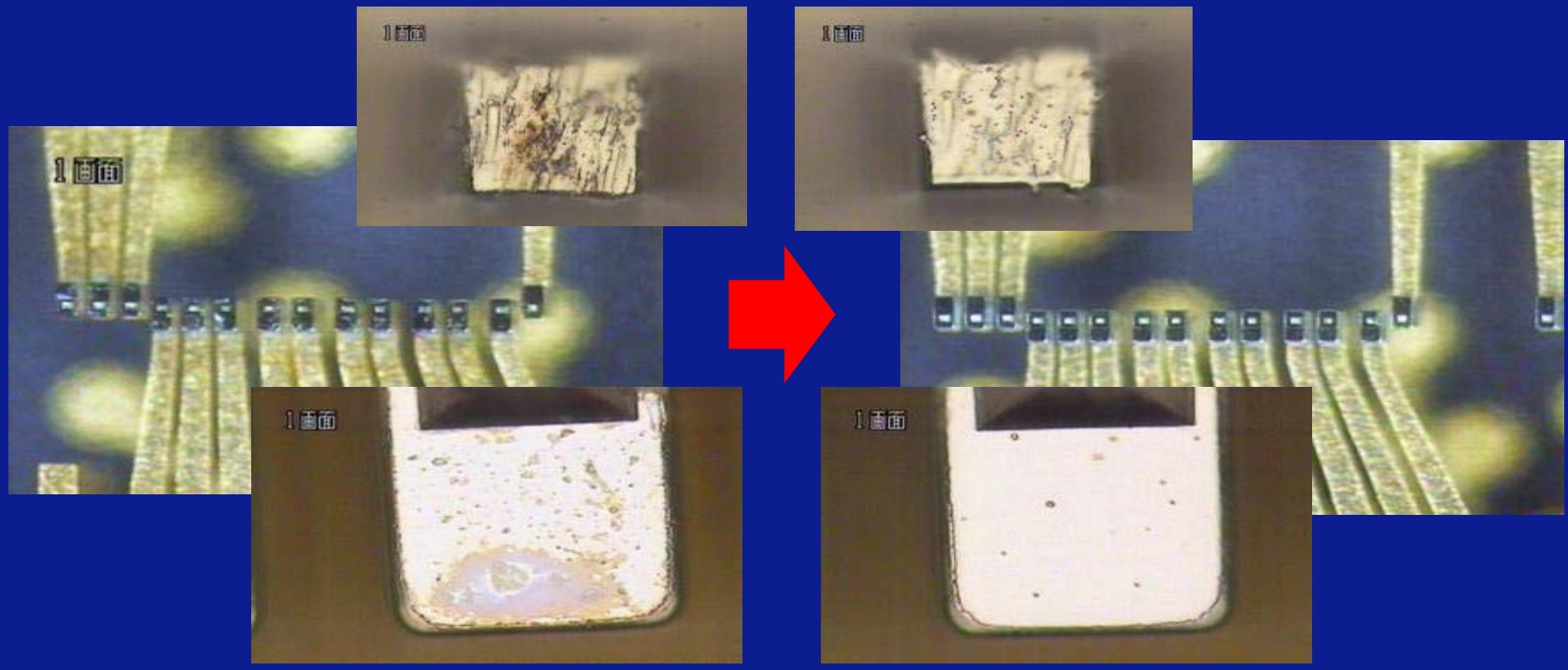
2018

44

MEMS Probe Card Cleaning



→ Well cleaned without any probe damage

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45

Examples of Commercially Available Tools

Mobile & Manual
For on-line socket cleaning

Automatic
For off-line board cleaning
– HiFix board

Socket Test & Cleaning
For socket maintenance

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46

How to Work & Laser safety

→ 2018 model for on-line cleaning
→ 300MV: very compact & economical

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47

Cost saving factors by Laser Cleaning

1. Final Test Yield Up by high quality contact by laser cleaning
2. Machine productivity increase by reduction of retest time due to high first test yield
3. Machine downtime decrease by rapid on-line cleaning without socket replacement
4. Labor time saving by on-line laser cleaning
5. Socket pin consumption down by extension of pin life time
6. No use of chemicals and water and no post-cleaning waste treatment

Conclusions – On-line laser cleaning provide

- Improvement of pin contact quality without any damage
  1. Contact resistance reduction: ~ 50%
  2. Suitable for most socket types (BGA, SOP, QFN, Rubber/Elastomeric…)

- Significant cost saving
  1. Yield Improvement: as much as 5% (dependent on sockets)
  2. Reduction in system downtime
  3. Increase of pin/socket lifetime

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2018

49