FOURTEENTH ANNUAL BiTS 2013 Burn-in & Test Strategies Workshop

Archive
Tutorial

PACKAGE TEST IS A DIRTY BUSINESS

Socket Cleaning Strategies to Reduce Cost of Test and Improve Overall Equipment Effectiveness (OEE)

by

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VP World Wide Applications
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Get down and dirty with Jerry Broz, Ph.D. of International Test Solutions, as he shares his strategies for socket cleaning, thereby reducing the cost of test and improving equipment effectiveness in his presentation titled, "Package Test is a Dirty Business !!!". In this broad tutorial, Broz will discuss various off-line and on-line socket cleaning practices, including high volume testing challenges and solutions for on-line cleaning to maintain high yield and throughput, reduce socket repairs, and control contactor damage.

ABSTRACT

During assembled device testing with new socketing solutions, the connectors are clean and have stable resistance values. With continuous testing, contamination accumulated within the socket and materials are transferred to the contactor. Sources of resistive contamination are numerous and may include oxides, accumulated metals, residues from processing, or debris from the test environment. Over time, these adherent materials will form non-conductive "layers" that dramatically affect the electrical performance of the contactor. Experience has shown that over 70% of device yield fallout and re-screen can be attributed to electrical contact related issues.

To avoid multiple rescreen resulting in increased Cost of Test (COT), sockets have been historically maintained with various off-line cleaning practices combined with frequent pin replacement. Clearly off-line methods reduce throughput and increase tool downtime, so socket makers and pin designers have focused on robust technologies (e.g., tip geometries, platings, alloys, etc.).

In recent years, the major handler suppliers have developed tools with programmable auto clean functionalities capable of regular socket cleaning without substantial downtime. Such improvements in test infrastructure are critical for lowering COT and the recent developments support this trend.

In this broad tutorial, various off-line and on-line socket cleaning practices will be surveyed and discussed. High volume testing challenges and solutions for on-line cleaning to maintain high yield and throughput, reduce socket repairs, and control contactor damage will be covered. Key information regarding the auto clean functionalities from the major handler suppliers as well as recommendations for implementation will be presented and several case studies will be reviewed.

Package Test is a Dirty Business

Cleaning Strategies to Reduce Cost of Test and Improve Overall Equipment Effectiveness (OEE)

Jerry Broz, Ph.D.
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International Test Solutions, Inc.

BiTS Burn-in & Test Strategies Workshop

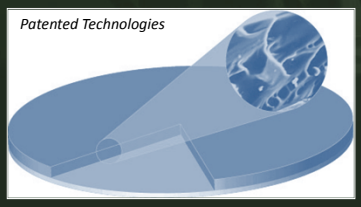
2013 BiTS Workshop
March 3 - 6, 2013

international TEST SOLUTIONS

International Test Solutions (ITS)

Innovation and Expertise

- **Technological Leadership**
  - Cleaning solutions for front end, wafer test, and package test
- **Market Share**
  - #1 supplier of advanced cleaning solutions



Core Strengths

- **Unique Product Portfolio**
  - Engineered, advanced polymer materials
- **Global Presence**
  - US, China, Korea, Taiwan, Japan, and Singapore
- **Customer Collaboration**
  - History of performance and support

ITS – Who Are We ?

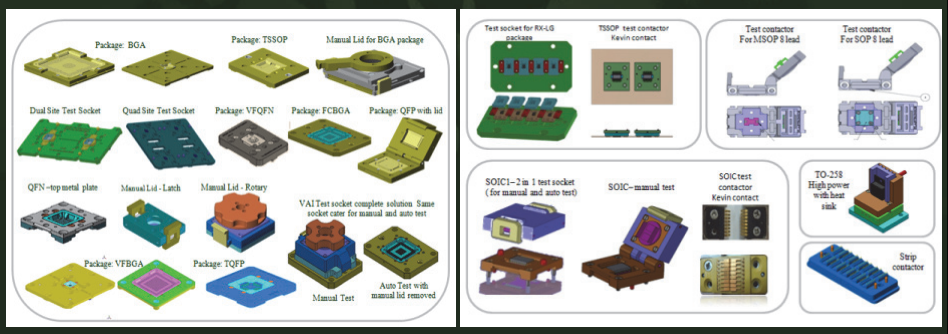
- Global supplier of highly engineered cleaning materials for the wafer sort, package test, and front-end tools since 1997.
- Cost-effective cleaning solutions and technical services focused on process improvement solutions and cost savings.
- "Manufacturing Center" for with innovative manufacturing technologies and advanced polymer materials R&D.
- "Test Analysis Center" for performance characterization and cleaning process development.
- Global technical services, expertise, and product support.

Outline

- Fundamentals
  - Package Test is a "Dirty Business"
  - Contact Resistance (CRES) – a very basic review
  - Offline and Online Methods of Probe Cleaning
- High Volume Testfloor Implementation
  - Auto Contact Cleaning (ACC) Utilization
  - Examples of Implementation
  - Approach to "Recipe" Development
- Summary

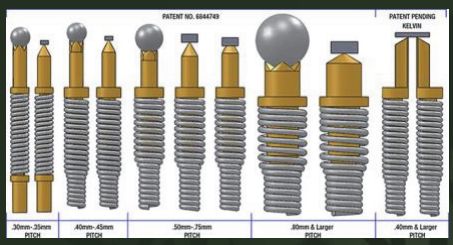
Test Socket

- Test Socket provides a "real-world" interface between a DUT (device under test) and the tester (ATE)
- Test programs determine the pass / fail status of the DUT
- Upon test completion, the device binned, and so on …

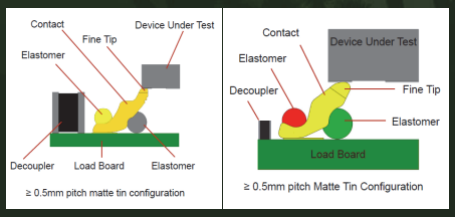


Source: VA Innovation Pte Ltd

Making Contact



Source: Aries Electronics



Source: Johnstech International

- Various types of contactors are brought into physical contact with I/O's of a DUT.
- Test programs are run to determine the DUT pass / fail under the assumption of "perfect" contact.
- Multiple re-screen is performed to recover DUTs that failed during first pass testing.

Package Test is a "Dirty Business"

- Semiconductor packages carry adherent debris and other contaminants that affect electrical contact integrity.
- Debris / contaminants will be found on tip contact surfaces, around the pins, along guide plates, and across the socket bed.
- Contactors must physically touch the I/O's (pads, bumps, pillars, etc.) of the DUT for test programs to be executed.
- "Contact and mechanical motion" is CRITICAL to break surface oxide(s), but creates more debris and material transfer to contactors.

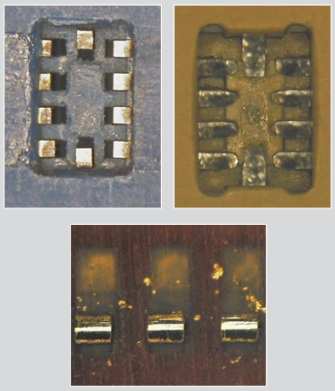
Many Sources of Contamination

- Material transfer from the device
- Localized material loss and pick-up
- Debris accumulation on contacts and across socket bed
- Intermetallic formation on the test pin contact area
- Oxidation (thick and thin non-conductive films)
- Mechanical wear and tip shape change over time
- Plating related issues (cracking, flaking, etc.)

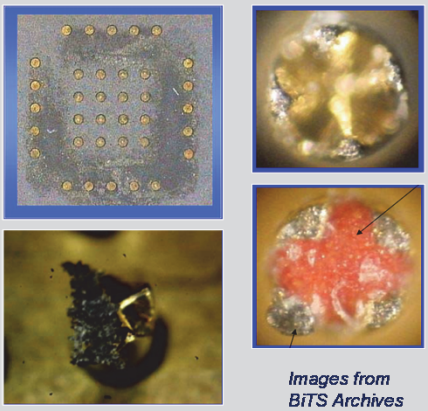
Contamination generates more contamination !

Just a Few Examples …

CONTACTORS



SPRING PINS



Images from BiTS Archives

3/2013 Tutorial: Package Test is a Dirty Business 9

Contact Resistance

"a.k.a., CRES"

3/2013 Tutorial: Package Test is a Dirty Business 10

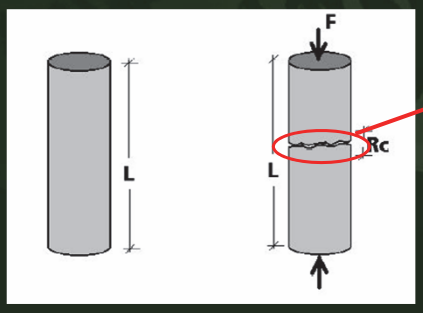
For a detailed discussion …
Ask the Expert …

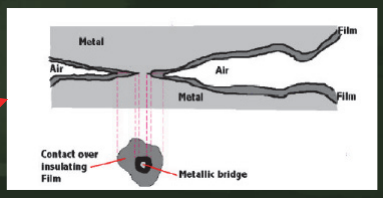
Contact Resistance (CRES)

- "Contactors Touch the Device and the Current Flows"
- Contact Resistance (CRES) is the most CRITICAL parameter in all electrical testing
  - "Metal on Metal Contact" between a probe tip and the pads, bumps, pillars, etc.
  - Non-conductive films will build-up and interfere with the "Metal on Metal Contact"
  - Film resistance is affected by absorbed materials various oxides and compounds, and miscellaneous contaminants
  - Film resistance will eventually dominate contact reliability

Contact Resistance (CRES)

- Contact Resistance Fundamentals …
  - CRES occurs between two bodies in contact
  - Creates losses in electrical and thermal systems





- Current flow is constricted to the inter-metallic contacts
- Localized joule heating

Classical CRES Definition

- Contact Resistance (CRES)
  - CRES stability (and instability) is entirely attributable to interfacial phenomena across contact areas (Metallic Contact) and with adherent contaminants (Film Resistance)

METALLIC CONTACT

$$C_{RES} = \frac{\left(\rho_{probe} + \rho_{pad}\right)}{4}\sqrt{\frac{\pi H}{P}} + \frac{\sigma_{film} H}{P}$$

R. Holm, 1967

FILM RESISTANCE

Major Parameters

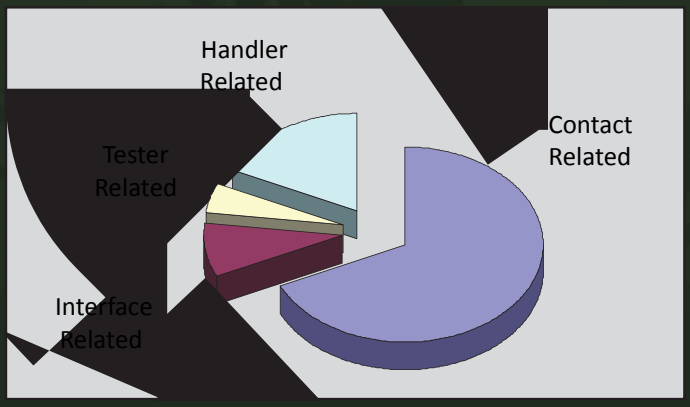
- Surface Roughness
- Surface Hardness
- Electroplates for surface modification
- Inter-diffusion
- A-spot Temperature (localized Joule heating)
- Elevated Test Temperatures
- Signal Frequency ("Skin Effect")
- Small Contacts

Key Mechanisms

- Surface Insulating Films
  - Affect contact performance since these layers add to contact resistance
- Contact Degeneration
  - Oxidation, corrosion, fretting corrosion, intermetallic growth, differential thermal expansion, etc., eventually will limit connector life

Unstable Contact Affects Performance

- Clear majority of yield fallout and re-screen problems can be attributed to contact related issues



B. Gibbs, BiTS 2006

Revised CRES Definition

- High CRES results in low First Pass Yield (FPY), high rescreen rates, and continuity fallout

$$C_{RES} = \frac{(\rho_{probe} + \rho_{pad})}{4}\sqrt{\frac{\pi H}{P} + \frac{\sigma_{film} H}{P}} \propto \$\$\$\$$$

FPY, Throughput, Up-time, Rescreen Socket Wear, Etc.

Controlling Film Resistance Is CRITICAL for Performance

R. Holm, 1967
J. Forster, BiTS 2011
J. Broz, BiTS 2012

No Cleaning Methods

- No cleaning … just replace !

Socket Cleaning Is Needed !

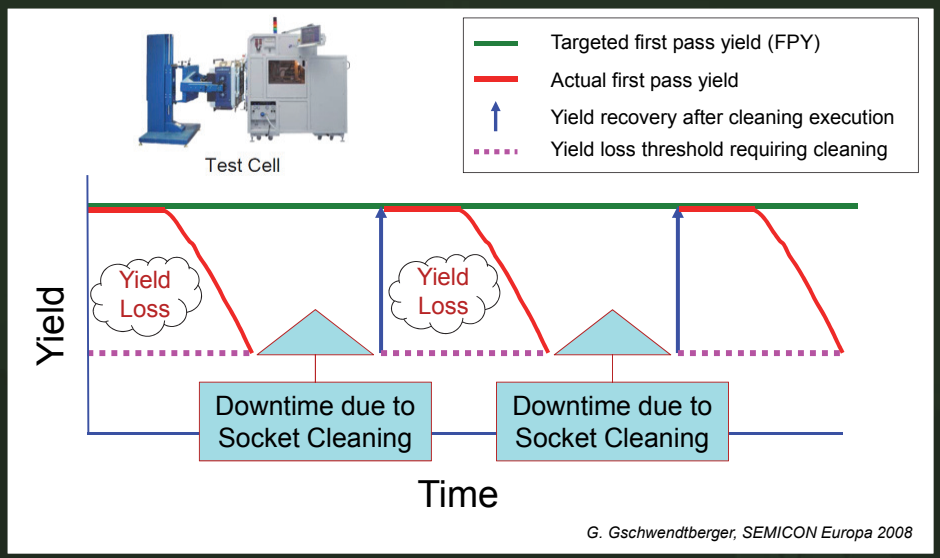
To enhance electrical contact reliability, do not tolerate surface contaminant films (i.e. do not expect conduction though them), abrade/remove all surface films, in particular oxide layers.

- R.S. Timsit (Fundamental Properties of Electrical Contacts)

Film Resistance is Controlled with Contactor / Socket Cleaning

- Socket maintenance is critical to control CRES and maximize contactor electrical performance
- Off-line cleaning (idle state with potentially long downtime)
  - Pins in sockets and sockets in load-boards are replaced at added cost
  - Socket lifetime can be reduced due to cleaning related damage
  - Excessive cleaning can reduce test throughput without yield benefits
- On-line cleaning (consistent CRES control and limited downtime)
  - Socket and load boards remain docked (no idle state needed)
  - Debris and adherent materials are removed from socket in-situ
  - Consistent cleaning to maintain high FPY yields and without downtime

Unstable CRES + Cleaning = LO$$



G. Gschwendtberger, SEMICON Europa 2008

Cleaning Impacts Cost of Test

Cleaning Impact
Useful lifetime
Replacement

Cleaning Impact
Labor
Maintenance
Spare parts

$$CoT = \frac{\left[\frac{\text{Cap. Cost}}{\text{Lifetime}}\right] + \text{Variable Cost} + \text{Overhead}}{\text{Yield} \times \text{Utilization} \times \text{Throughput}}$$

Data "quality"
Open / shorts rate
FPY/ retest rate
Cleaning Impact

Uptime
Operator assist
Socket replacement
MTBR, MTTA, MTTR
Cleaning Impact

Test Time
Index Time
Number of Sites
Effective Throughput
Cleaning Imapct

See appendix for this slide without the overlay

G. Jeserer, ECS Transactions, 18 (1) 255-260 (2009)
G. Jeserer, Semicon West 2010

Off-line Socket Cleaning Methods

Offline Cleaning Methods

- Manual Methods
  - Abrasive cleaning
  - Dry brushing with various fiber / metallic brushes
  - Taping with "3M Scotch Mending Tape"
  - Rubber eraser ("Magic Eraser")
- Chemical Methods
  - Ultrasonic in various detergents + DI water
  - De-Ox methods
  - Replating / restoration
- Non-Contact Methods
  - CO2 Snow Blasting
  - Laser Ablation

Abrasive Lapping Method

- 3M Imperial Lapping films are used for plastic, metals, fiber optics connectors, metallographic, and other lapping and polishing applications … like sockets (?)
- Entry of these lapping materials was most likely a "crossover" from probe card cleaning.

Source: 3M Micro-abrasives

Abrasive Damage

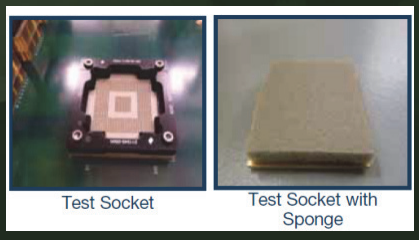
Plating Removed
Tips Damaged (flattened)

Source: International Test Solutions

3M Sanding Sponge

- Abrasively coated sponge with micro-fine abrasives ranges from grade 1200 to 1500.
- Flexible foam pad enables user to sand hard-to-reach areas such as headlight openings, around door handles, door jambs, and … sockets (?)
- Can be used wet or dry for chemical cleaning

Source: The WoodCraft Shop



Source: Interconnect Devices, Inc. (IDI)

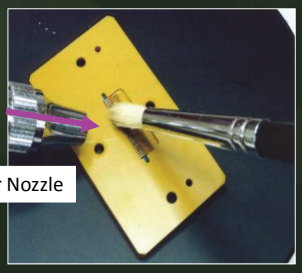
What is the "Industry Standard" ?

- "Brush and Blow" is the common method.
  - Brush the pins and the pocket
  - Compressed air to "remove" the debris.

"Light Cleaning" with a soft nylon or sable brush

"Heavy Cleaning" with a brass brush

Air Nozzle



Typical Brushing Cycles

- Light cleaning cycle performance
  - Executed based on reduced test yield (FPY < 80 to 90%)
  - Empirically time based (once per shift or once per day)
  - Socket insertion based (~10, ~50K, or ~100K insertions)
- Heavy cleaning cycle performance
  - Midpoint probe mid-life (~150K to ~250K insertions)
  - Immediately before long-term storage
  - Immediately when pulled from storage prior to use

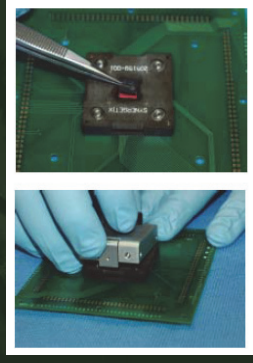
Source: IDI / Synergetix

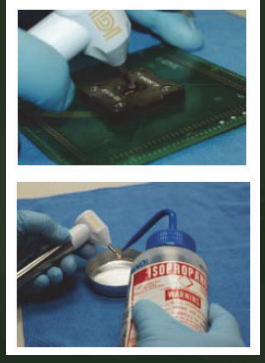
Brushing (spring contacts)

Cleaning Tools

Equipment Included in the IDI Cleaning Kit:

- Rotary tool
- Nylon brush tips
- Nylon hand brush
- Saturated cleaning cloth
- Batteries





Source: IDI / Synergetix

NOTE – Always consult the socket supplier service engineer regarding recommended and socket specific procedures.

Brushing (sliding contacts)

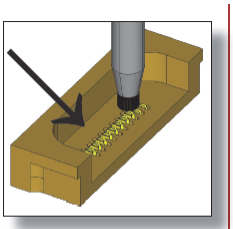


Figure 17: Correct direction for Contact brushing on the Top Side of the Contactor

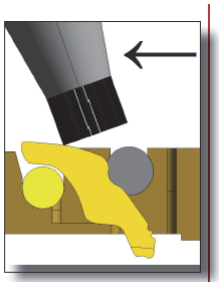


Figure 18: Correct direction for Contact brushing on the Bottom Side of the Contactor

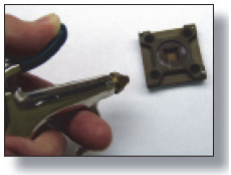


Figure 19: Compressed Air Cleaning

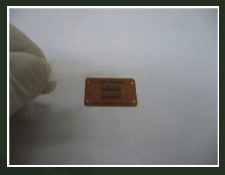
Source: Johnstech International

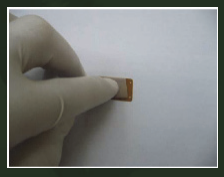
NOTE – Always consult the socket supplier service engineer regarding recommended and socket specific procedures.

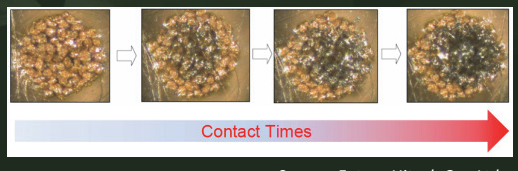
"Captain, you're asking me to work with equipment which is hardly very far ahead of stone knives and bearskins."

"3M Tape" for Rubber Sockets

- Contact elements are softly cleaned with "*3M Magic Mending Tape*" to remove adherent debris and process residuals.
- High adhesive, cellophane tapes could damage the contactors or leave residues and are not recommended
- Daily cleaning is suggested
- Contactors will eventually become contaminated and need to be replaced.







Source: Future Hitech Co., Ltd.

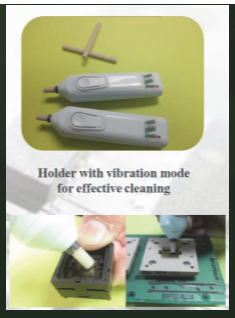
"Magic Eraser"

- Proprietary silicone rubber compound cartridge
- Designed for off line socket cleaning
  - Magic Eraser Square for QFN / BGA sockets
  - Magic Eraser Rod for Burn In / TSSOP / SOIC / Contact Finger
  - Magic Motorized Eraser Rod for Burn In / TSSOP / SOIC / Contact Finger

Eraser Square

Eraser Rod

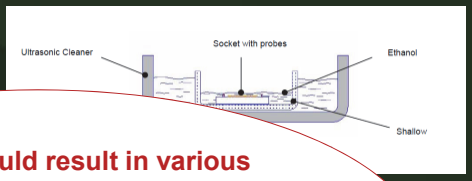
Motorized Eraser Rod



Source: VA Innovation Pte Ltd.

Ultra Sonic Cleaning

- Various cleaning solutions
  - Pure ethyl alcohol
  - Diluted isopropyl alc
  - Heated, mil
    with a 7
- Manua
  to rem
- Air-dry, i
  gun, or dry t
- Adherent debris is remove
  however, with limited effects on
  solder contamination.



Co., LTD

Immersion could result in various residuals, calcium deposits, and may compromise internal lubricants of spring pins !

Please consult the appropriate Applications Engineer

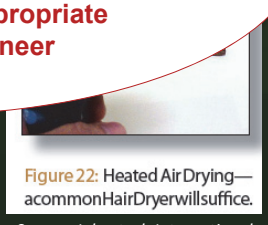


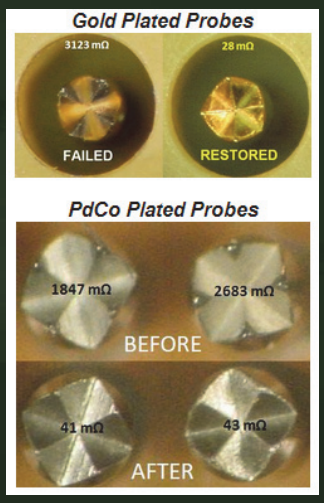
Figure 22: Heated Air Drying—a common Hair Dryer will suffice.

Source: Johnstech International

See appendix for this slide without the overlay

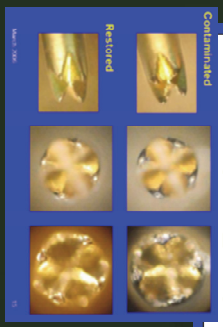
Chemical Restoration

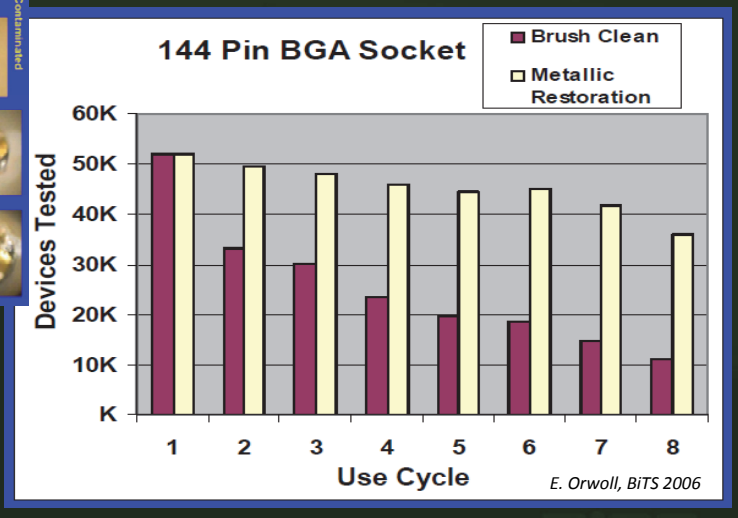
- Nu Signal removes solder contamination while rebuilding critical contact surfaces with a re-metallization process.
- Electro-chemical process that selectively removes Tin and Lead contamination without damaging contact materials.
- Sockets can usually be treated 3-10 times.
- The socket body is unchanged, and the socket features remain dimensionally unaffected.



Source: Nu Signal, LLC

Re-metallization Process Extends Socket Lifetime





Chemical Clean

Source: RD Chemical Co.

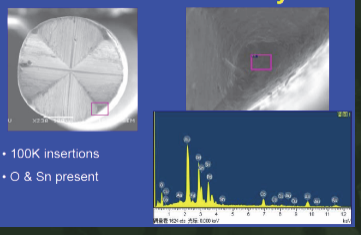
rison with existing methods:

	C_{res} Pre-Clean (mΩ)	C_{res} Post-Clean (mΩ)	% Change
Acetone	1017	382	-62%
IPA	1345	651	-51%
Methanol	810	560	-31%
De-Ox 1699	1200	238	-80%
De-Ox 1556	1238	273	-78%

N. Langston, BiTS 2008

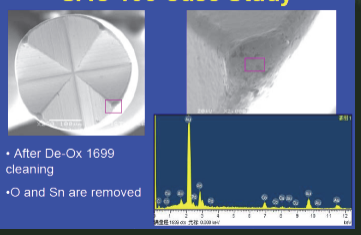
Chemical Clean

SAC 105 Case Study



- 100K insertions
- O & Sn present

SAC 105 Case Study



- After De-Ox 1699 cleaning
- O and Sn are removed

Cleaned Pin Resistance Measurements

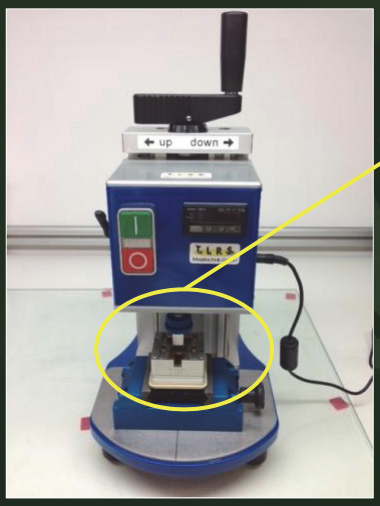
	C_{res} Pre-Clean	C_{res} Post-Clean
Avg	120 mΩ	51.5 mΩ
Std Dev	23.5 mΩ	11 mΩ
Avg+2 Std Dev	167 mΩ	73 mΩ

New Pin Resistance Spec

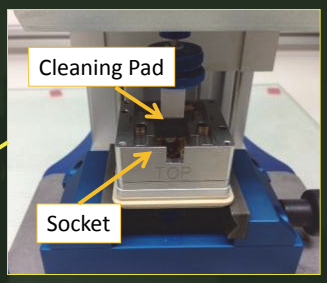
Avg	60mΩ
Avg+2 Std Dev	110mΩ

N. Langston, BiTS 2008

Offline "Socket Refresher"



Courtesy of T.I.P.S. GmbH



- Socket installed / clamped into holder
- Polymer cleaning pad actuated Z-up / Z-down within socket
- Debris removal performed from socket and contactors cleaned
- Polymer effectively removed debris and conditions contact or surface

CO2 Snow Clean (non-contact)

CO2 Jet Cleaning Mechanisms

1. Physical blasting: momentum transfer => particle removal
2. Thermal shock/freezing (-78.5C): layer cracking & breaking
3. Sublimation expansion (x800): layer lifting & destroying
4. Organic solubility (S.Coeff: ~23): Oil and flux removal

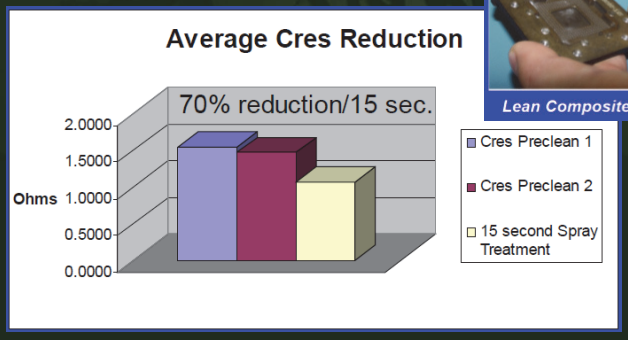
R. Lee, BiTS 2011

CO2 Snow Clean (non-contact)

- Removes residues from contacts and socket surface after assembly without inducing any damages on socket and pins.

Lean Composite CO_2 Sprays, used in cooperation.

D. Jackson, BiTS 2008



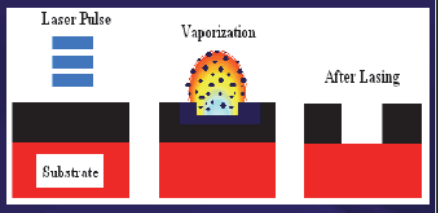
Laser Clean (non-contact)

- **Advantages of Laser Cleaning**
  - In-situ cleaning possible
  - Cleaning Time = 10 sec/socket
  - Test yield increase >2%
  - Portable for test floor
  - Low cost of ownership
  - Removes lead based surface contamination

Source: IMT / SemiConsultants

Laser Clean (non-contact)

- **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

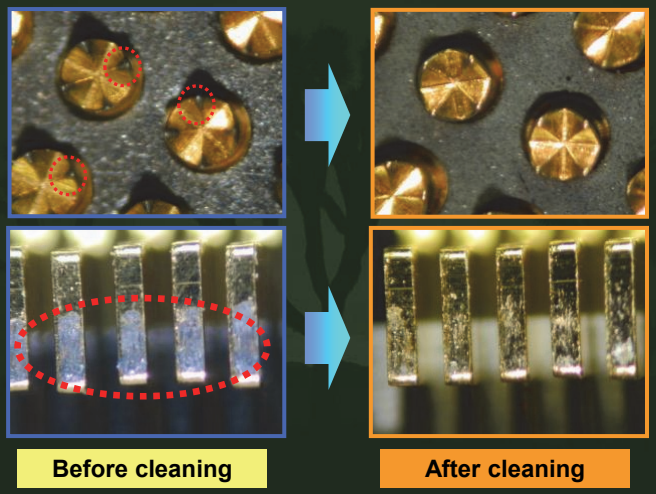


- **Definition of Socket laser cleaning**
  : Removal Process of Tin(Sn) based contamination from the tester socket pin surface to improve the contact performance

R. Lee, BiTS 2012

3/2013 Tutorial: Package Test is a Dirty Business 45

Tin(Sn) Based Removal

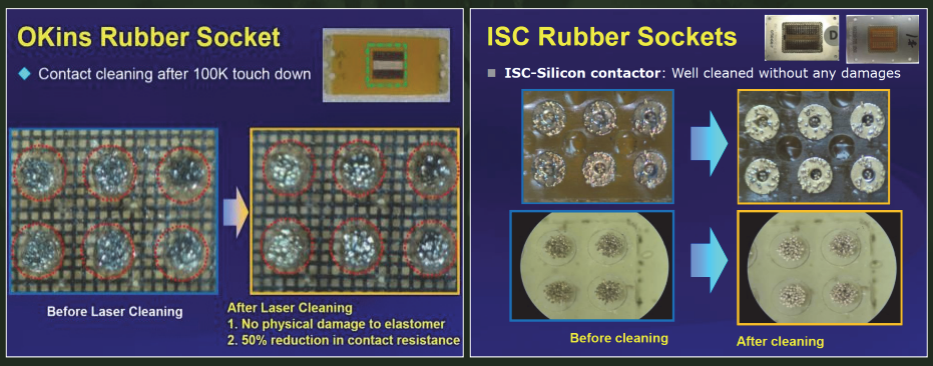


Courtesy of IMT Co. Ltd.

3/2013 Tutorial: Package Test is a Dirty Business 46

Rubber Socket

- Laser ablation removes adherent materials from rubber sockets without contactor or substrate damage.



R. Lee, BiTS 2012

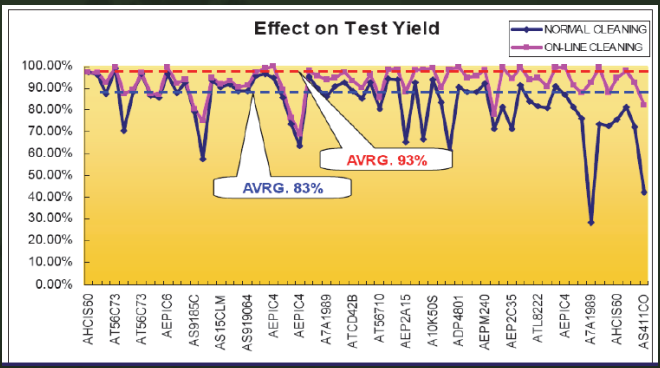
"On-line" Laser Operation

- Laser clean of contacts can performed without removing socket from the load-board.
- Handler does need idle or be taken off-line to allow operator access to socket and execute laser clean.
- Although "on-line", such cleaning does require test cell down time.

R. Lee, BiTS 2012

Overall Process Improvement

- Yield Increase
  - First Yield ~ 5%
  - Final Yield ~1%
- Productivity Increase
  - Reduced retest time
  - Reduced handler downtime

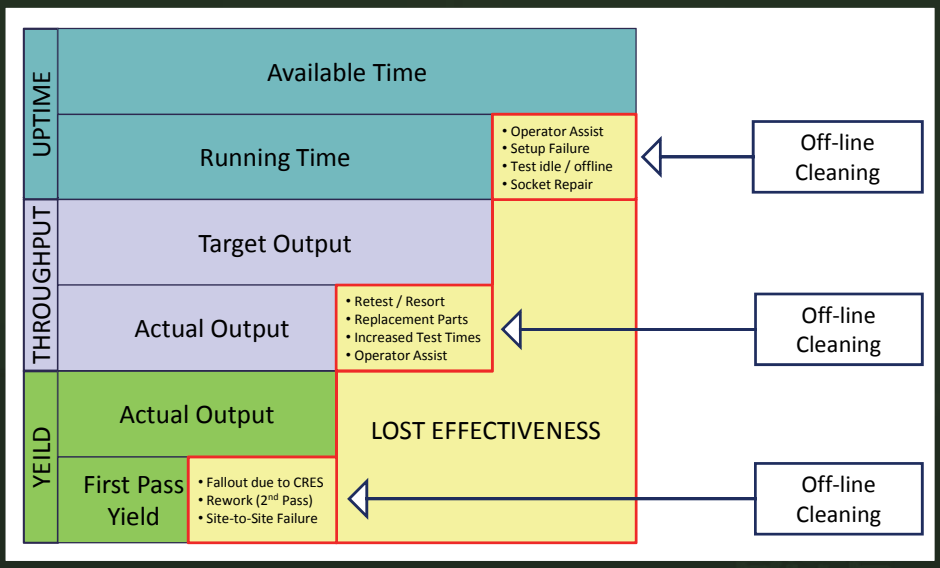


R. Lee, BiTS 2012

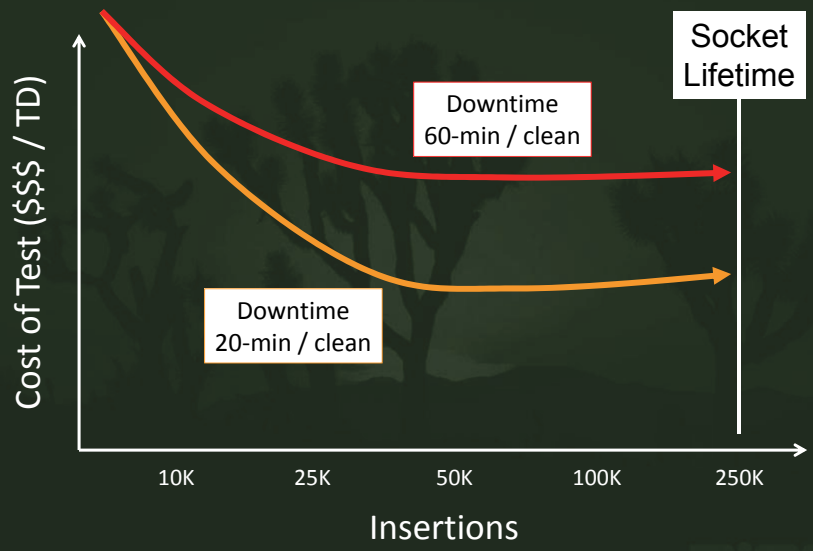
Cleaning Downtime

- Room Temperature **(~1.5 to 2-hours)**
  - Clean contactors in handler ≈ 15 minutes
  - Remove contactors ≈ 60 minutes
  - Undock, swap contactors ≈ 30 minutes
  - Re-dock and run "golden" devices ≈ 30 minutes
- High Temperature **(3 or more hours)**
  - Cool chamber to allow access ≈ 30 minutes (or more)
  - Clean contacts in handler ≈ 15 minutes
  - Remove contactors ≈ 60 minutes
  - Undock, swap contactors ≈ 30 minutes
  - Heat chamber to test temperature ≈ 30 minutes (or more)
  - Re-dock and run "golden" devices ≈ 30 minutes
- Offline cleaning requires substantial equipment downtime and will dramatically impact the Overall Equipment Effectiveness (OEE).

Manual (Idled) Cleaning OEE



In Summary …



Online Socket Cleaning Materials

High Volume Test-floors

- Overall equipment effectiveness (OEE)
  - Test-floor performance as defined by Uptime × Throughput × Yield
- Total effective equipment performance (TEEP)
  - OEE against calendar hours, i.e.: 24 hours per day, 365 days per year.

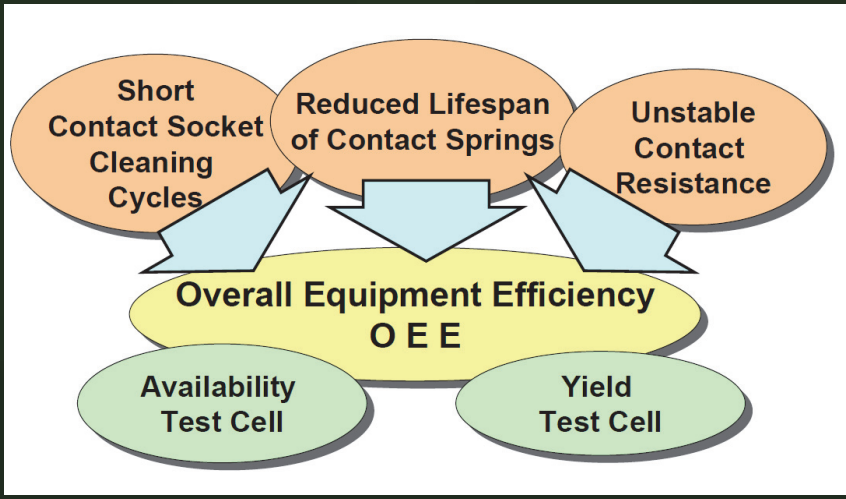
Understanding the Metrics

- OEE = Uptime × Throughput × Yield
  - "Uptime" = equipment running time vs. available time
    - For example, if a machine was available to run 16 hours but was only run for 12, then the "Availability" is 75 percent (12/16).
  - "Throughput" = running speed vs. maximum capability
    - For example, if a machine produced 70 pieces per hour but the capability of the machine is 100, then the "Performance" is 70 percent (70/100)
  - "Quality" = good parts produced vs. total number of parts tested
    - For example, if 100 parts are made and 90 of them are good, the "Quality" is 90 percent (90/100).

Improvement Opportunities

- Benefits for optimized OEE can always be found in one of the following "buckets"
  - Breakdown
  - Setup
  - Downtime
  - Speed loss
  - Small stops
  - Quality

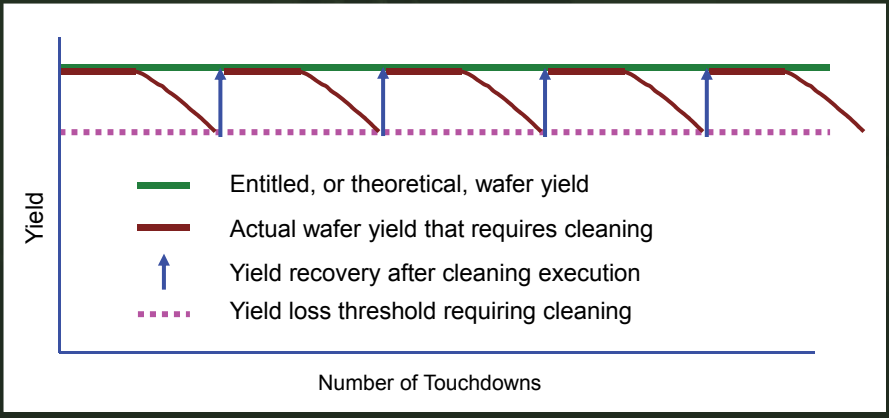
Cost of Test Issues



G. Gschwendtberger, SEMICON Europa 2008

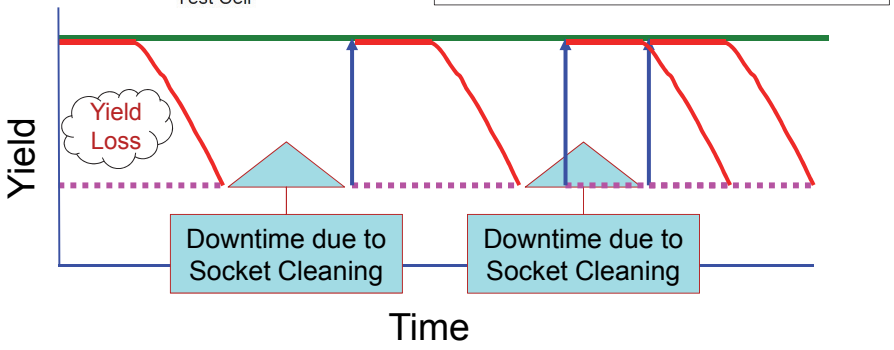
Key Lessons from Wafer Sort

- Wafer Sort has shown that consistent auto-cleaning maintains high yield, reduces rescreen, and increases uptime.



Socket Auto Clean Reduces Downtime

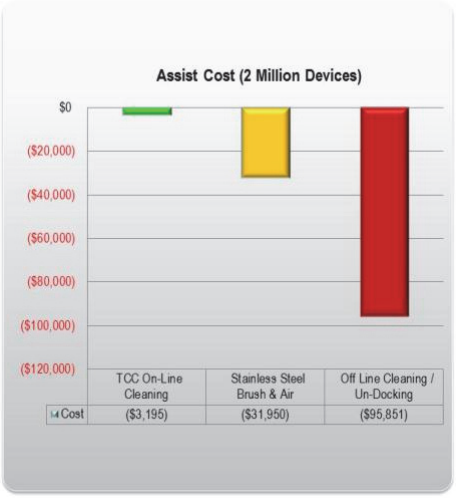
Test Cell



G. Gschwendtberger, SEMICON Europa 2008

Look at Assist Costs

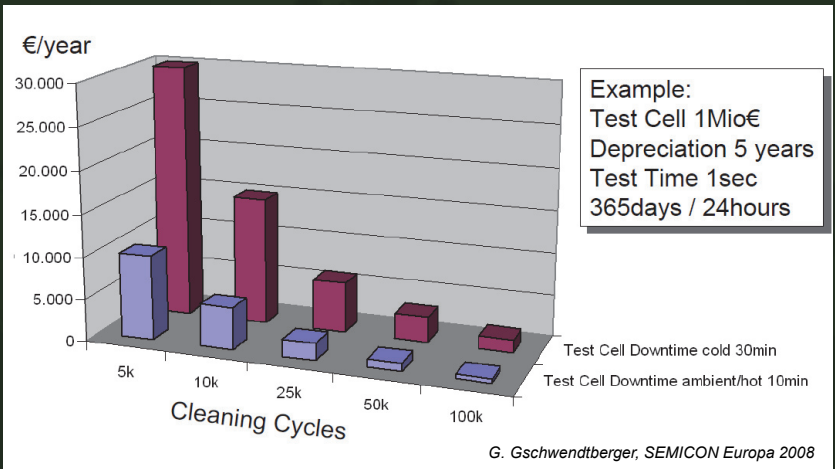
Increased Test Equipment Utilization			
Capital Equipment Cost	$1,650,000		
- Tester	$1,500,000		
- Handler	$150,000		
Amortization in Years	5		
Amortization per Hour	$50.23		
Utilization Rate	75%		
Test Floor Cost/Hour	$190		
Total Test Cost / Hour	$240.23		
		Test Flow	
Assist Time (minutes)		Standard	TCC
- TCC On-Line Cleaning	1		
- Stainless Steel Brush & Air	10		
- Off Line Cleaning / Un-Docking	30		
MTBA Cycles (Insertions)		250	250
# of Assists (2 Million Devices)		7,980	798
Assist Times for 2 Million Devices	(Minutes)		
- TCC On-Line Cleaning	798		
- Stainless Steel Brush & Air	7,980		
- Off Line Cleaning / Un-Docking	23,940		
Assist Cost for 2 Million Devices			
- TCC On-Line Cleaning	($3,195)		
- Stainless Steel Brush & Air	($31,950)		
- Off Line Cleaning / Un-Docking	($95,851)		



Source: International Test Solutions

Depreciation Cost

Test Cell Downtime vs. Socket Cleaning Cycles

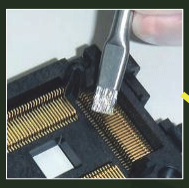


G. Gschwendtberger, SEMICON Europa 2008

Initial Barriers to Implementation

- Handlers
  - Control software to execute a consistent auto-clean function
  - Hardware to handle and store cleaning materials during test
  - Management of cleaning materials
- Yield Management
  - "Non-yielding" insertions during clean
  - UPH tracking / adjustment for non-device insertions
  - Downtime associated with auto-clean
- Consumables
  - Suitable cleaning materials for "true" on-line cleaning that did not require tester cell downtime for usage

Online Socket Cleaning



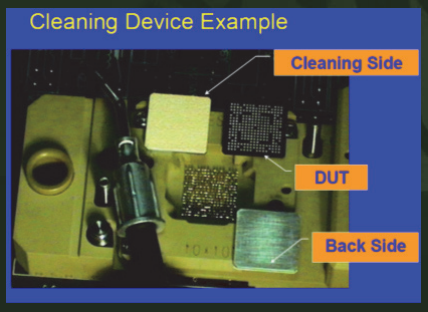
www.kita-mfg.com
or
local hardware store

www.deltad.com

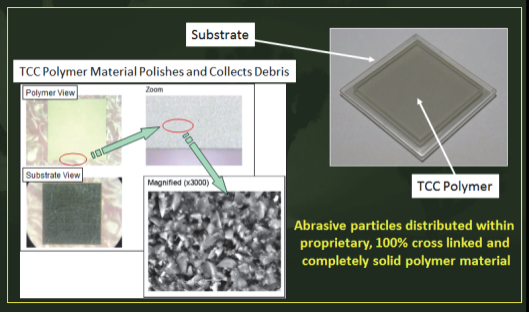
- Operators perform online socket cleaning with handler in "down state"
- 2001: Inabata discusses "contact cleaner sheet" for manual "online" cleaning.
- 2004: ITS introduces "surrogate cleaning chip" designed to collect debris / clean contactors; unsupported by handler and yield software
- 2006: Texas Instruments and Delta Design present handler supported automated contact cleaning (ACC) for "true" online cleaning function
- 2006 to 2011: High volume handlers makers incorporate automated online cleaning functionality on new units, upgrades, and retrofits

Socket Cleaning Device

- Similar in size and shape to a device under test (DUT)
- Cleaning media applied to the contact side of device
- Cleaning units are stored in JEDEC tray or a fixed "repository"

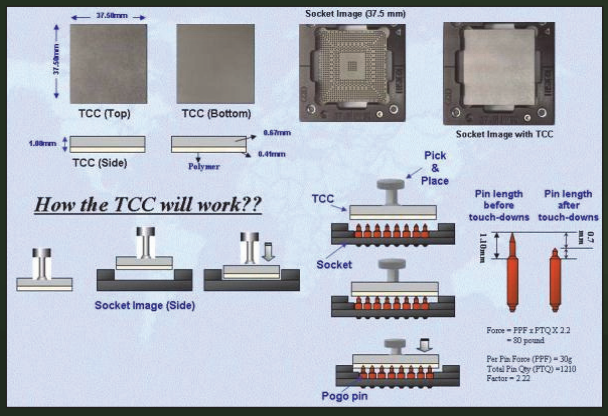


B. Gibbs, BiTS 2007



J. Broz, BiTS 2004
J. Broz, BiTS 2012

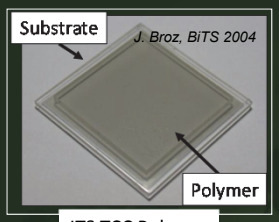
How Does It Work ?



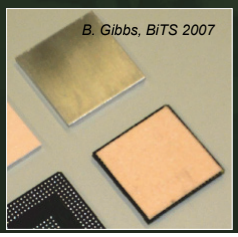
Source: International Test Solutions

- Cleaning material applied to the I/O or "bottom side" of the package.
- Cleaning material actuated into socket and the contacts to remove and collect debris.
- Cleaning material compressed against socket floor to collect loose debris.

Survey of Cleaning Media for SCD



ITS TCC Polymer



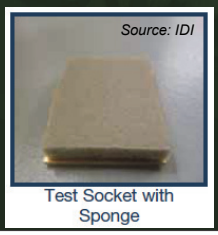
Mipox Polyurethane Foam

- ITS Polymer Materials
  - Polishing efficiency for pin cleaning and tacky surface for debris collection.
  - Precision engineered substrates and patented cleaning materials for immediate installation.
  - Turnkey solution for tri-temperature handling requirements.
- Mipox Polyurethane Foam
  - Exposed abrasive particles for pin wear and socket cleaning.
  - Cut-and-install by customer onto substrates, dummy packages, or scrapped devices.
  - Thermal stability issues of cleaning material and adhesive during tri-temperature handling.

Survey of Cleaning Media for SCD

3M Lapping Film

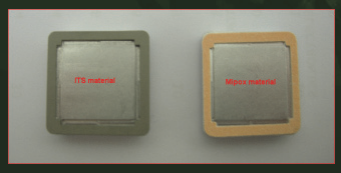
- 3M Lapping Film
  - Abrasive media adapted from other industries
  - Debris generation from dislodged particles and binder
  - Removes probe tip material, changes tip shape, and exposes pin base metal
  - Cut-and-install by customer onto substrates, dummy packages, or scrapped devices.



3M Abrasive Sponge

- 3M Sanding Sponge
  - Abrasive media adapted from other industries
  - Cut-and-install by customer onto substrates, dummy packages, or scrapped devices.

Cleaning Material Applied to Plunger

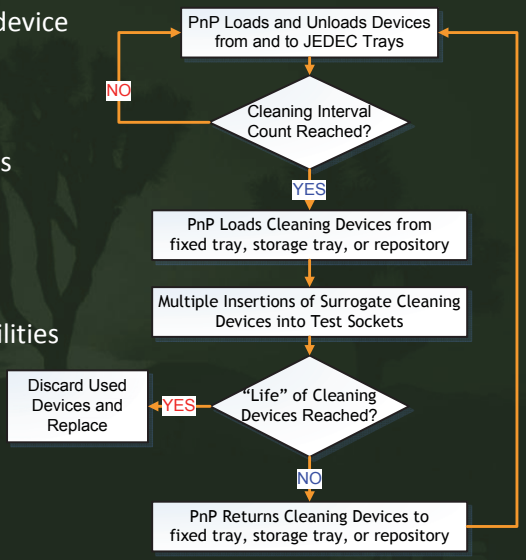


Courtesy of Multitest

- Multitest patented design for a cleaning lead-backer on plunger side.
- Available on MT9510 and MT9510XP
  - simple solution to integrate
  - conversion kit part only
  - no risk of mixing (cleaning devices / production lot)
  - individual setting of cleaning parameter
  - setup is part of device recipe

HVM Online Socket Cleaning

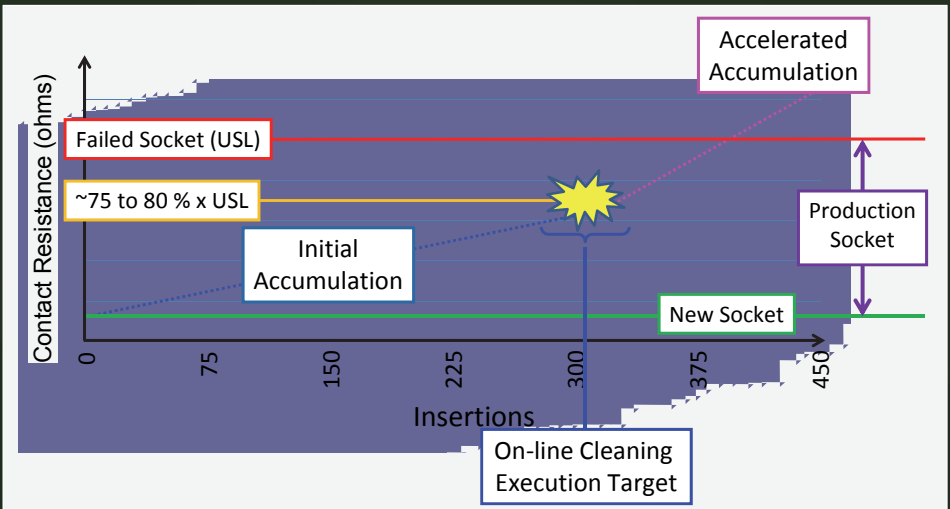
- Hardware to store cleaning device
  - Fixed trays
  - Repository
- User defined cleaning recipes
  - Cleaning materials tracked
  - Compatible with yield management software
- HVM Online Cleaning Capabilities
  - Delta Design with ACC
  - Seiko Epson
  - Multi-Test (plunger type)
  - Rasco
  - Others …



Determining Cleaning Settings

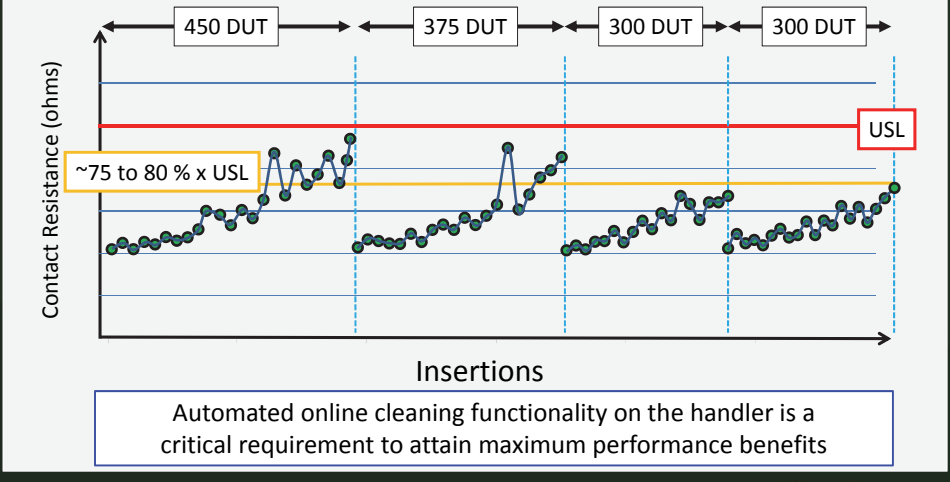
- Cleaning parameters for optimal stability and socket lifetime must be developed for each unique testing environment
  - Determine the cleaning interval to maximize stability
    - Depends on socket and contactors as well as USL for CRES
    - "Rule of Thumb" based on experience of ~75 or 80% USL for CRES
  - Determine the number of insertions per cleaning cycle
    - Depends on the dirtiness (debris, contaminations, etc.) of the socket
    - NOTE - **ALL** cleaning insertions do occur in the same location
  - Determine the optimum cleaning material lifespan
    - Over-saturation will affect cleaning efficiency
    - CRES recovery and FPY will be affected by over-saturated devices

When To Clean ???



Sanitized ITS Customer Data

Automated and Frequent Cleaning

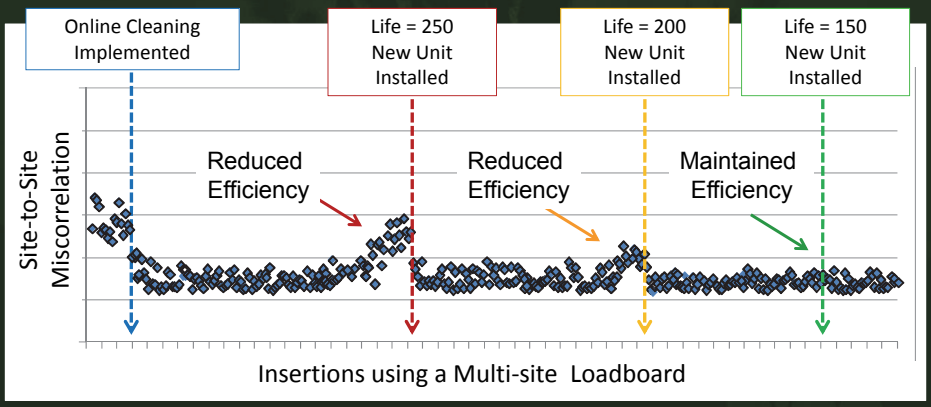


Automated online cleaning functionality on the handler is a critical requirement to attain maximum performance benefits

Sanitized Customer Data

TCC Lifetime vs. Site-to-Site Fails

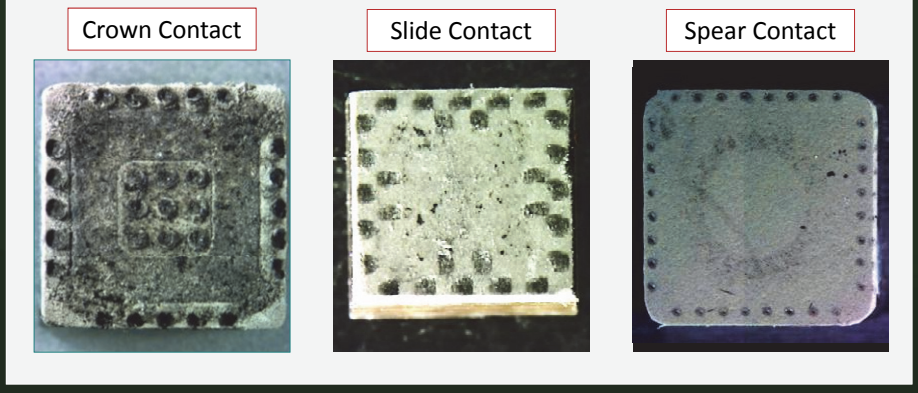
- Over-saturation and over extending will affect cleaning efficiency
- A "saturated" unit should be disposed and replaced
- Unit life depends on process "dirtiness", socket type, CRES limits, etc.



Sanitized ITS Customer Data

SCD Overutilization Examples

- "Saturated" units will have poor cleaning efficiency



Online Socket Cleaning Implementation a.k.a. Auto Contact Cleaning (ACC)

Delta Design PnP Handlers

- Delta Design worked with Texas Instruments on automated contact cleaning (ACC) for "true" online cleaning function.
- Byron Gibbs (TI) and Kevin McNamara (Delta) "*Auto Contact Cleaning Engineering Study Applied To Package Test*", BiTS 2007

Delta Matrix

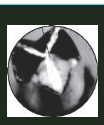
Delta Edge

Delta Castle

Source: Delta Design

MATRiX Handler

23 Customer Sites
~ 60% Tri-Temp
Multiple X32 Customers



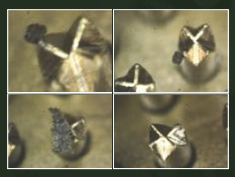
Auto Contactor Cleaning

- 10,000 UPH to 16,000 UPH
- Auto Contactor Cleaning
- Temp range: -55C to +175C
- Jedec tray based packages sized 3×3mm up to 51×51mm
- Productivity:
  - Continuous Load/Unload
  - Auto Re-Probe and Re-test
  - Lot Cascading
- Various V-Core options
- Modular Architecture

Source: Delta Design

Cleaning Efficiency

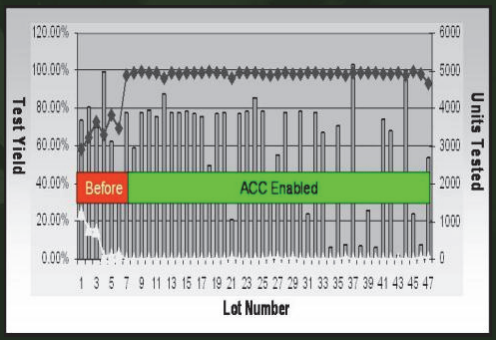
- Proprietary "Auto-Contactor Cleaning" reduces retest
- Predictive maintenance to avoid downtime (Available in 2013)
  - Monitor machine performance
  - Identify corrective actions during assist



Before Cleaning

After Cleaning

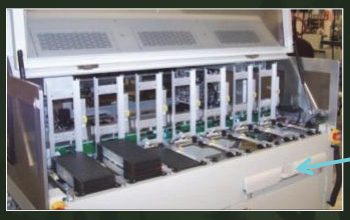
~ 75% of loose debris removed



Source: Delta Design

SCD Storage Options

- SCDs loaded in Manual Tray drawers (3 trays capacity)



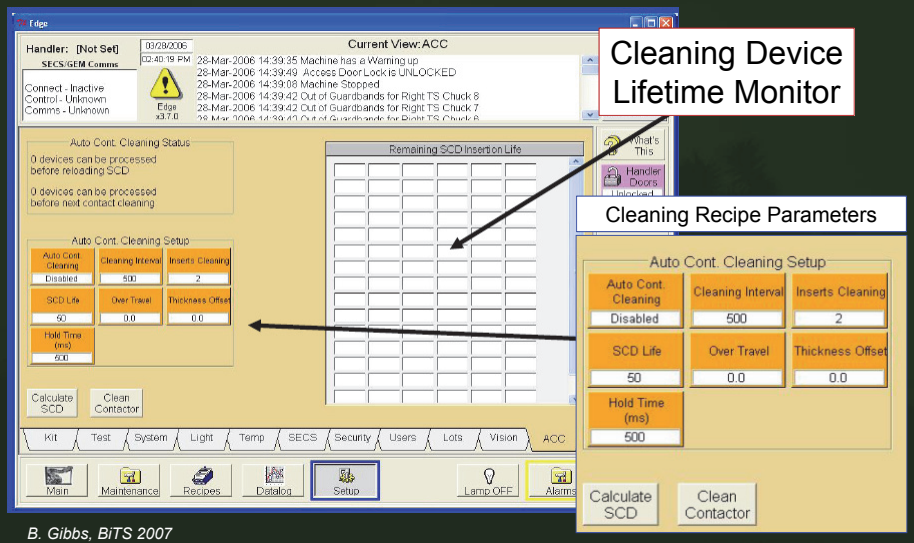
Manual Tray Drawer

- Reserved SCD pockets in specially designed shuttles

Additional SCD pockets and enhanced software

Source: Delta Design

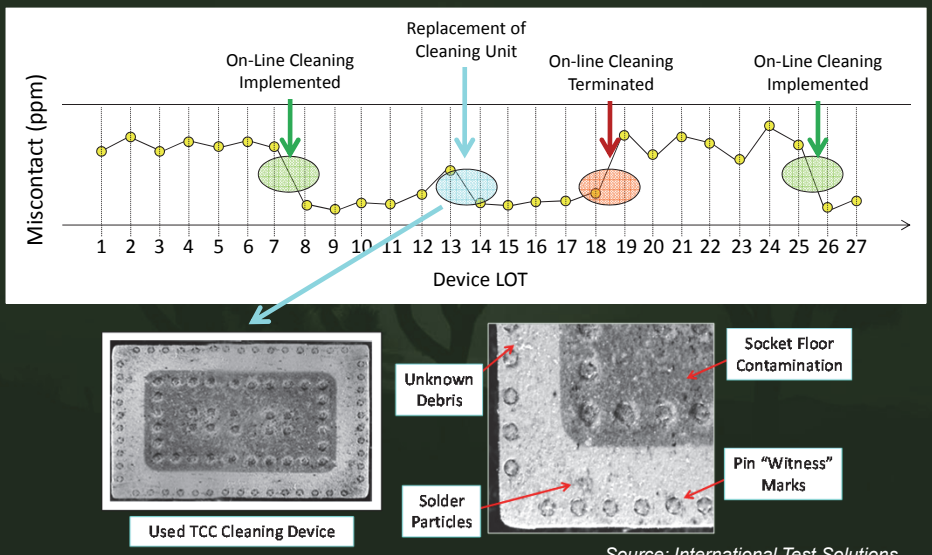
Cleaning Parameters Defined



B. Gibbs, BiTS 2007

Sanitized ITS Customer Data with Delta Handler

Reduced Mis-contact (ppm)



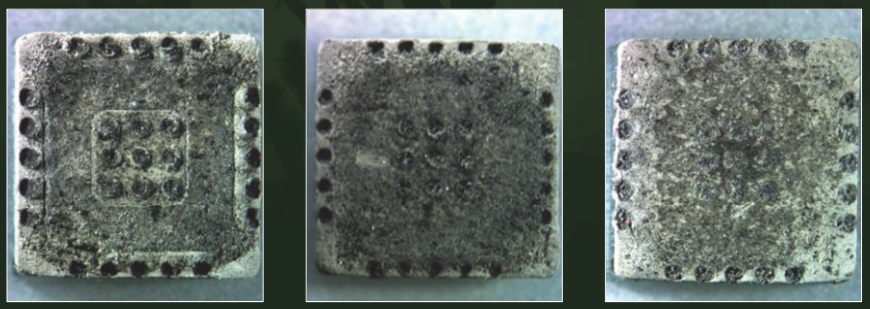
Source: International Test Solutions

Sanitized ITS Customer Data with Delta Handler

SCD Overutilization Examples

- A "saturated" SCD will have poor cleaning efficiency.
  - Cleaning Frequency = 150 DUT insertions
  - Cleaning TDs / cycle = 3 TDs per cycle
  - 250 TD SCD Lifetime = 12500 Devices Tested
  - 500 TD SCD Lifetime = over-saturated with reduced performance

SCD Usage = 500 TDs | SCD Usage = 500 TDs | SCD Usage = 500 TDs



Source: International Test Solutions

Advantest

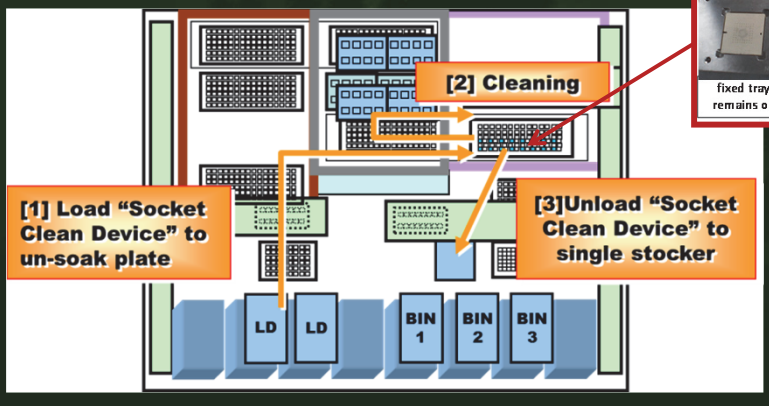
M4841 Dynamic Test Handler

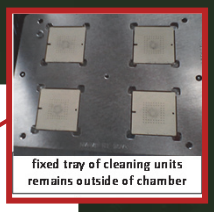
- High-throughput device handler for volume testing of BGA, CSP, QFP, etc., package types.
- 16-device parallel test capable of high throughput of 18,500 UPH
- 3 seconds test time or less for reduced Cost of Test
- Wide temperature range -40C to +125C
- Soft Touch Handling mechanism for a high-accuracy test environment.

Courtesy of Advantest

Socket Cleaning Sequence

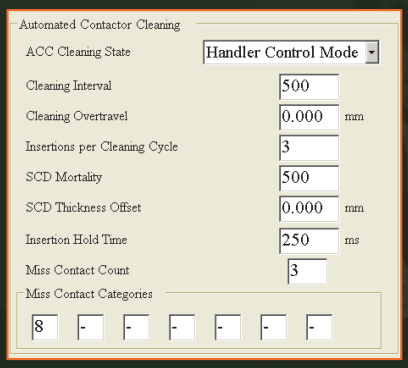
- Fixed cleaning sequence (frequency, TDs, on-call)
- Short index time and devices are stored close to chuck
- Small effects on the UPH when cleaning is getting executed





Courtesy of Advantest

ACC Parameter Setting

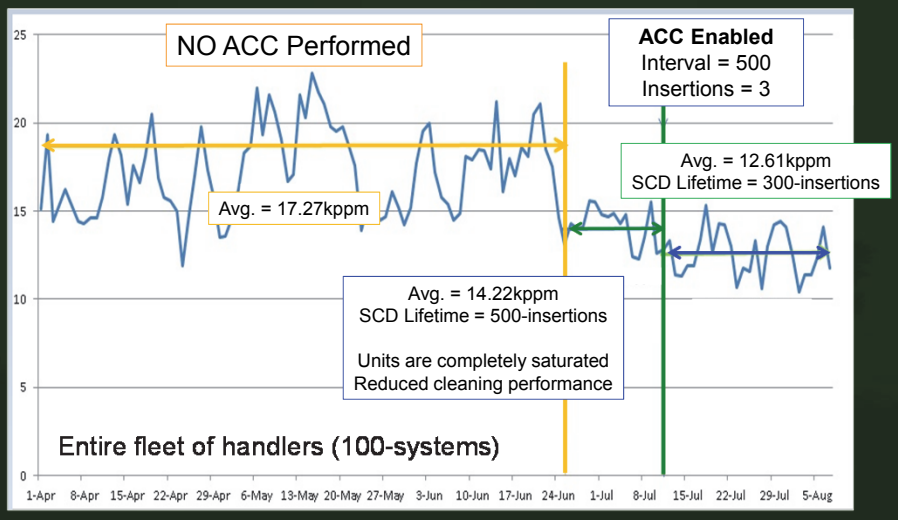


Courtesy of Advantest

- ACC Cleaning State = Control Mode
  - Handler, Miss Contact, etc.
- Cleaning Interval = DUT insertion frequency
- Cleaning Overtravel = cleaning actuation into SCD
- Cleaning insertions = number SCD insertions into test socket
- SCD Mortality = number of insertions for SCD "end-of-life" and discard
- SCD Thickness Offset = thickness difference of SCD vs. package thickness
- Insertion Hold Time = amount of time that SCD stays in contact with socket
- Miss Contact Count / Categories = miss-contact mode controls
  - Example – 3 × Bin-8 will initiate ACC cleaning sequence.

Sanitized Advantest Customer Data

Reduced Mis-contact (ppm)



Courtesy of Advantest

Seiko Epson

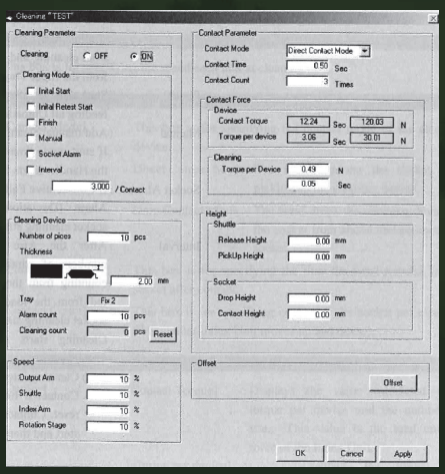
Basic Specifications			
Model	NS8020	NS8040	NS8080
Device Type/ Size	QFP, TSOP, CSP, WLCSP, BGA, QFN, PLCC, LGA, PGA Min. 2x2mm - Max. 50x50mm (Lead Pitch: 0.4mm or more)		
Max. Throughput	5400UPH (Quad)	8000UPH (Quad)	8300UPH (Octal)
Temperature	Ambient/ Hot +50°C - +90°C ±2°C +90°C - +130°C ±3°C		
Binning	6 Hardware Binning \ (3 Auto/ 3 Manual)		5 Hardware Binning (3 Auto/ 2 Manual)
Auto Clean	Cleaning Units in Fixed Tray		

Basic Specifications				
Model	NS7000	NS7080	NS7080W	NS7160W
Device Type/ Size	QFP, TSOP, CSP, WLCSP, BGA, QFN, PLCC, LGA, PGA Min. 3x3mm - Max. 50x50mm (Lead Pitch: 0.4mm or more)			
Max. Throughput	7300UPH (Octal/ Quad)			
Temperature	Ambient/ Hot +50°C - +90°C ±2°C +90°C - +130°C ±3°C			
Binning	6 Hardware Binning (3 Auto/ 3 Manual)		5 Hardware Binning (3 Auto/ 2 Manual)	
Auto Clean	Cleaning Units Stored in Fixed Tracy			

Courtesy of Kanematsu USA

Cleaning Execution Overview

- Clean Execution Sequence / Operation
- DUT interval for cleaning execution
- Number of cleaning devices in fixed tray
- Thickness of cleaning device
- Cleaning device tray location
- Alarm for operator to refill fixed cleaning tray
- Speed settings for transporting the cleaning devices

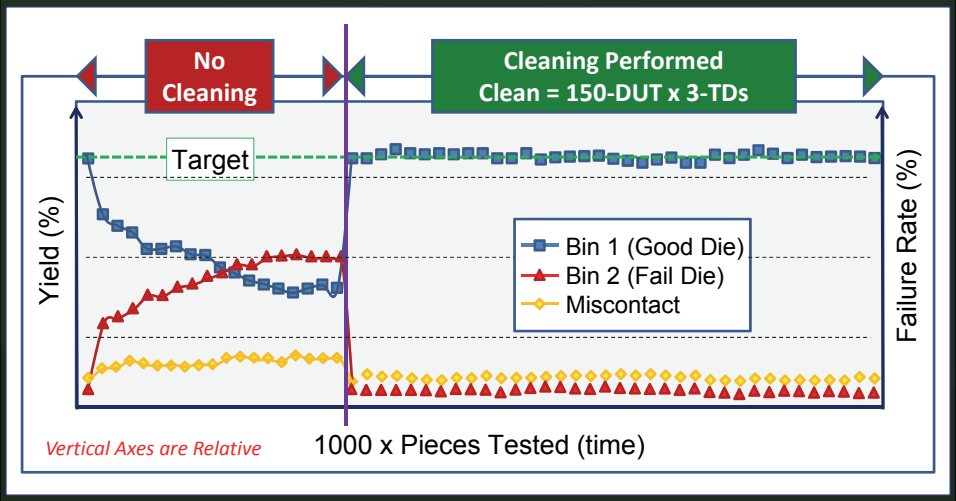


- Cleaning mode execution
- How long and the number of times the cleaning unit contacts the socket
- Contact forces and cleaning torque during cleaning execution
- Release Height and Pickup Height
- Socket Drop Height and Contact Height
- Cleaning Device vs. Socket offset height

Courtesy of Kanematsu USA

Sanitized ITS Customer Data with Seiko Epson Handler

Plated Spring Pin Performance

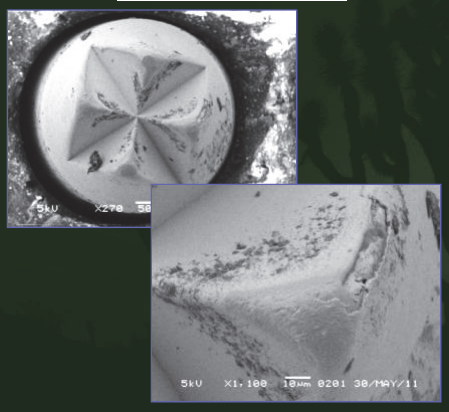


J. Broz , BiTS 2012

Sanitized ITS Customer Data with Seiko Epson Handler

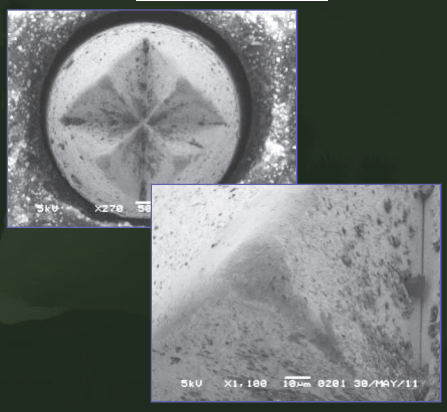
Plated Spring Pin

No Online Cleaning



- Debris = much
- Plating = degraded

Online Cleaning



- Debris = small
- Plating = unaffected

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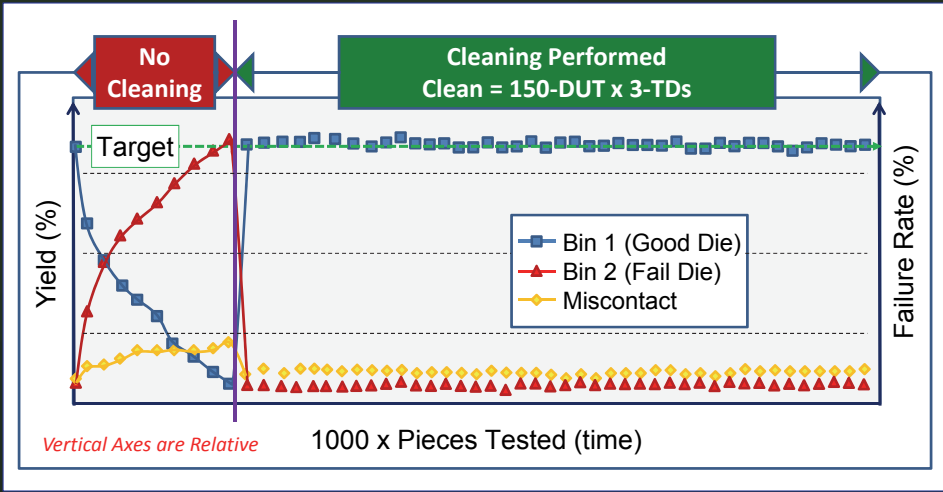
Sanitized ITS Customer Data with Seiko Epson Handler

Alloy Spring Pin Performance



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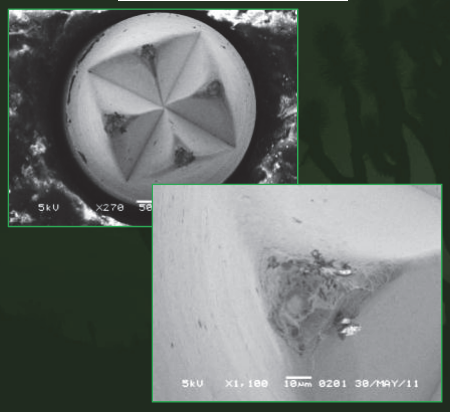
Sanitized ITS Customer Data with Seiko Epson Handler

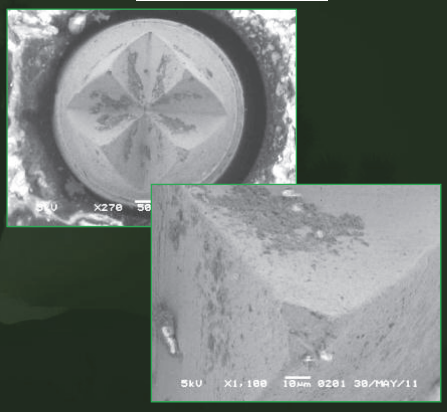
Alloy Spring Pin

No Online Cleaning



- Debris = much
- Tip = damaged

Online Cleaning



- Debris = slight
- Tip = unaffected

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MultiTest PnP Handler

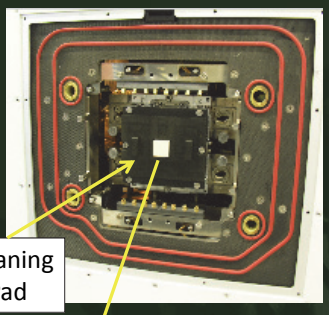
MT9510
MT9510XP

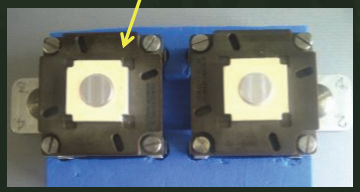
- X8 contact site (MT9510) and X16 (MT9510XP)
- Tri-temp capable from -55 to +175°C
- Throughput up to 5,300 UPH
- Packages from 3×3mm to 70×70mm
- Installed MT9510 base > 600 systems

- ACC feature for MT9510 and MT9510XP
  - Fully automated concept which does not require opening, undocking, or down-time during execution.
  - User can define preventative cleaning execution to perform the cleaning before yield loss occurs without significant throughput effects
  - No modifications to handler base unit and hardware can be installed into existing equipment.

Courtesy of Multitest

Auto Cleaning Implementation



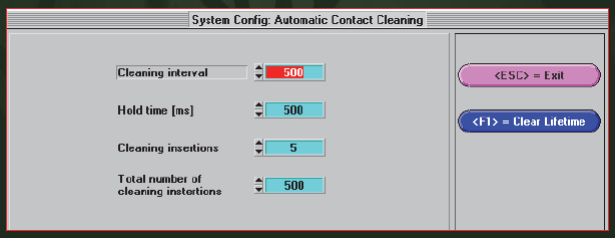


- Cleaning plunger is installed onto one of the 4 rotary plunger sides.
- Cleaning pad is affixed onto the plunger head so there is no risk of sorting the cleaning devices into an output BIN.
- User programs the cleaning recipe for each device as part of the setup process.

Courtesy of Multitest

Cleaning Parameters Defined

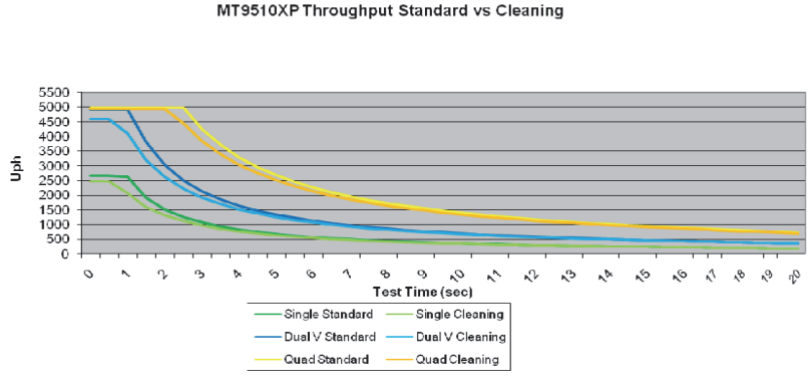
- Cleaning interval = determines after how many DUT insertions (device into contact socket) the contact socket will be cleaned
- Hold time = amount of time that cleaning pad stays in contact with socket
- Cleaning insertions = number of times cleaning pad will be inserted into the contact socket
- Total numbers = cleaning material lifetime and after which number a message appear to exchange the cleaning pad



Courtesy of Multitest

Throughput Comparison

Example: QFP64 / 10x10; 160 devices / tray; 100% yield



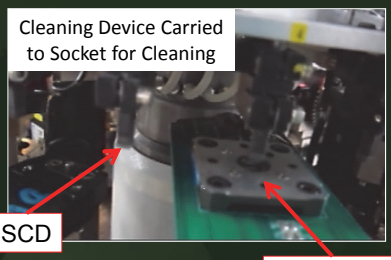
Courtesy of Multitest

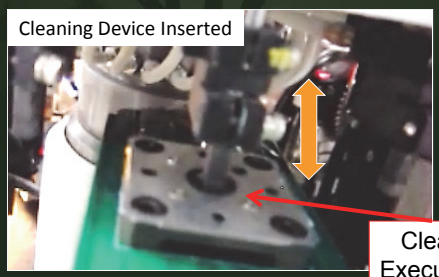
SRM Bowl Feed

Model :	XD248	XDH24
Type :	Bowl Input	Bowl Input (with Hot Test) NEW !
Applicable Packages :	QFN/MLP (Size: From 1.0x0.6 to 12x12), SOIC, SOT23, SC70, SOT89, SOT223	QFN (Size: From 1.5x1.5 to 6x6), SOT23, SC70,SOT223, SOT89, MSOP
UPH :	36K	Up to 20K
Input :	Bowl Feed	Bowl Feed
Output :	Tape and Reel	Tape and Reel
No. of Test Site :	Maximum 8	2 Hot Test Site; 1 Ambient Test Site (Optional)
Cleaning Execution	Hardware / software upgrade	Hardware / software upgrade

Courtesy of SRM

ACC Process





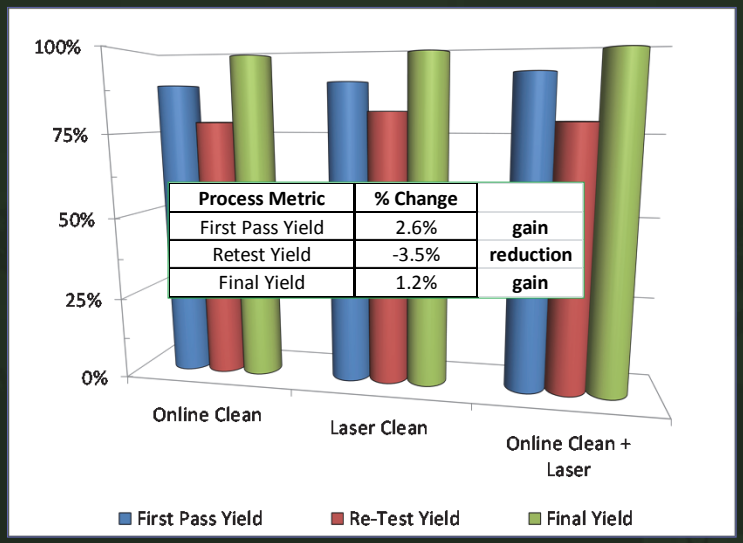
Courtesy of SRM

Laser + Online Cleaning

- Problem Overview
  - Periodic laser cleaning of sockets has been shown effective for socket performance recovery and contactor maintenance
  - Handlers must be idled (although socket is not removed) to implement manual laser cleaning (~10-min to 30-min)
  - Debris accumulation from packages does create contact issues
- Objectives for Process Improvement
  - Implement regular online cleaning to reduce debris buildup
  - Supplement laser cleaning to further improve yield metrics.
  - Extend the interval between laser cleaning operations.

Sanitized Customer Data

Yield Gains with Online Debris Removal



Process Metric	% Change	
First Pass Yield	2.6%	gain
Retest Yield	-3.5%	reduction
Final Yield	1.2%	gain

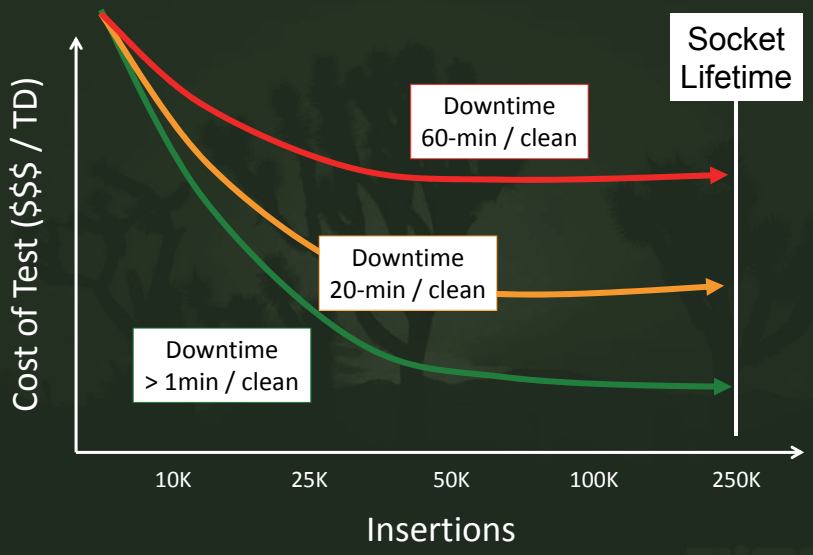
Auto Cleaning as a Technology Enabler

- Historically, socket and pin maker have focused on technologies that are robust and do not require frequent cleaning (i.e., minimal handler downtime).
- Auto-Cleaning is an enabler for "new pin technologies" which can be engineered with critical performance properties (metalluargy, tip shape, scrub characteristics, etc.) to optimize test practices.
- Lessons from wafer sort … cost of test reduction requirements + effective on-line clean enabled proliferation of MEMS technologies.

In Summary / Conclusion …

- Offline socket cleaning is a "tried and true" method for maintaining sockets; however, handler downtime affects HVM production and increased CoT.
  - Non-optimized cleaning processes compromise test results, reduce test hardware life, affect throughput, and affect equipment up-time.
- Automated handler driven cleaning clearly improves first-pass yield, reduces rescreening rates, and improves equipment utilization.
  - Development of customized online cleaning devices can provide the high volume manufacturer a substantial competitive advantage.
- Users expect and demand processes that increase overall performance metrics to maximize OEE and reduce the overall cost of test.
  - With auto-cleaning, an HVM test-floor with 20 testers can increase utilization by 5% and basically have a "free" test cell for reduced cost of test.

In Summary …



"You've got a lot to take away"

Acknowledgements …

- BiTS Workshop Chair (Fred Taber) and Program Committee
- ITS WW Applications Team …
  - Bret Humphrey (TCC Product Manager)
- ITS Technical Partners … THANKS !
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- Alphabetical contributors …
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  - IMT Co. Ltd.: Rocky Lee and Nick Gullet (SemiConsultants)
  - Multitest: Barbara Loferer and Valts Treiberg
  - Seiko Epson: William Mowry (Kanamatsu USA)
  - Texas Instruments: Byron Gibbs
  - T.I.P.S. GmBH: Dr. Rainer Gaggl
  - SRM: China service team

Learn about Wafer Sort

- IEEE SW Test Workshop 2013
  - http://www.swtest.org
  - Abstract submission is open!
  - San Diego, CA, for June 9 to 12

- IEEE / CPMT sponsored probe technology forum where attendees come to learn about recent developments in wafer sort industry, exchange ideas, and get some answers to crtical technical challenges.

About the Author

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Jerry Broz, Ph.D., has been the Applications Engineering Team Leader and VP of Applications at International Test Solutions since 2003. Dr. Broz is responsible for the ITS branch office teams located in Taiwan, Korea, Japan, China, and Singapore that are focused on optimal on-line cleaning solutions for wafer sort and package test. Previously, Dr. Broz was a Member of Technical Staff with the Worldwide Probe Development Team at Texas Instruments, Inc. He has authored numerous publications and presentations in the areas of wafer level test, package test, and IC packaging. Dr. Broz holds a number of US and International patents as well as several pending patent applications related to wafer sort, package test, and front-end processes. Dr. Broz earned a Ph.D. in Mechanical Engineering from the University of Colorado at Boulder and has over 20 years of experience in various high volume manufacturing and applied research environments.

Dr. Broz is the General Chair for IEEE SW Test Workshop and a Sr. Member of the IEEE as well as an IEEE Golden Core member. The SW Test web site http://www.swtest.org is an on-line repository for many probe technology presentations.

Appendix

Cleaning Impacts Cost of Test

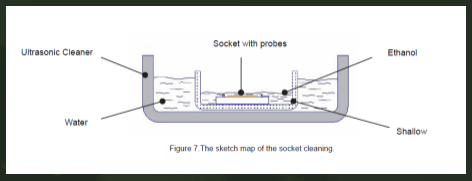
$$CoT = \frac{\left[\frac{\text{Capital Cost}}{\text{Lifetime}}\right] + \text{Variable Cost} + \text{Overhead}}{\text{Yield} \times \text{Utilization} \times \text{Throughput}}$$

This is slide 23 without the overlay

G. Jeserer, ECS Transactions, 18 (1) 255-260 (2009)
G. Jeserer, Semicon West 2010

Ultra Sonic Cleaning

- Various cleaning solutions
  - Pure ethyl alcohol
  - Diluted isopropyl alcohol (70/30)
  - Heated, mild acidic solution (40-50C max with a 7.1 > pH > 3.0)
- Manually wipe with a lint-free cloth to remove extra fluid or particles.
- Air-dry, heated air dry with a heat gun, or dry the socket in an oven.
- Adherent debris is removed; however, with limited effects on solder contamination.



Source: WinWay Technology Co., LTD

Figure 22: Heated Air Drying—a common Hair Dryer will suffice.

Source: Johnstech International

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