

# Controlling Test Cell Contact Resistance With Non-destructive Conditioning Practices

2004 Burn-in and Test Socket Workshop

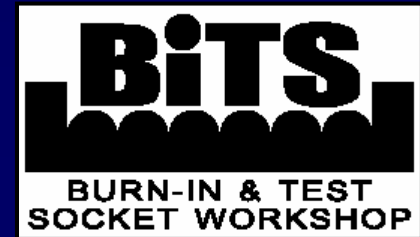
March 7 - 10, 2004

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# Overview

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- Introduction
  - Background
  - Costs of Test Cell Cleaning
- Conditioning Technology
- Methodology Development
- Characterization
- Summary

# Background

- Approximation for Contact Resistance (R. Holm, 1967)

$$C_{RES} = \frac{\rho}{4} \sqrt{\frac{\pi H}{F}} + \frac{\sigma_{film} H}{F} + R_{bulk}$$

- Constriction resistance is affected by the number and size of the “a-Spots” at the deformed asperities at the interface.
  - Film resistance is affected by film conductivity, composition, structure, thickness, and breakdown voltage.
  - Film composition = absorbed materials various oxides and compounds, and miscellaneous contaminants.
- Film resistance results in variable and unstable behavior.

# Introduction

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- High and unstable contact resistance ( $C_{RES}$ ) is one of the biggest factors in reduced test yields.
- $C_{RES}$  is entirely attributable to the interfacial phenomena across the contact area and with any adherent contaminant.
- $C_{RES}$  instability is caused by debris accumulation and a build-up of adherent contamination on the contacting surface.
- High  $C_{RES}$  values result in low performance rating and can lead to unacceptably high reject ratios.

# The Need for Contactor Cleaning?

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- Common causes of contact degradation
  - Debris on contacts and in socket bed
  - Material transfer and intermetallic formation
  - Mechanical wear
  - Localized material loss
  - Plating related issues
  - Oxidation
- Regularly scheduled cleaning operations are critical to control  $C_{RES}$  and maximize contactor electrical performance.

# Contactors Cleaning Methods

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- No cleaning ... just replace it !
- Contact methods
  - Manual brush: inconsistent and can damage contactors.
  - Abrasives: remove material and can damage contactors, platings, or base metals; do not address debris and may add debris.
- Non-contact methods
  - Compressed air or inert gas (Ar) blow-off: “Where does the debris go?”
  - Chemical: often toxic and can affect the surface characteristics of contactor, platings, or base metals.
  - Ultrasonic: effective for loose debris, but does not remove transferred metals.

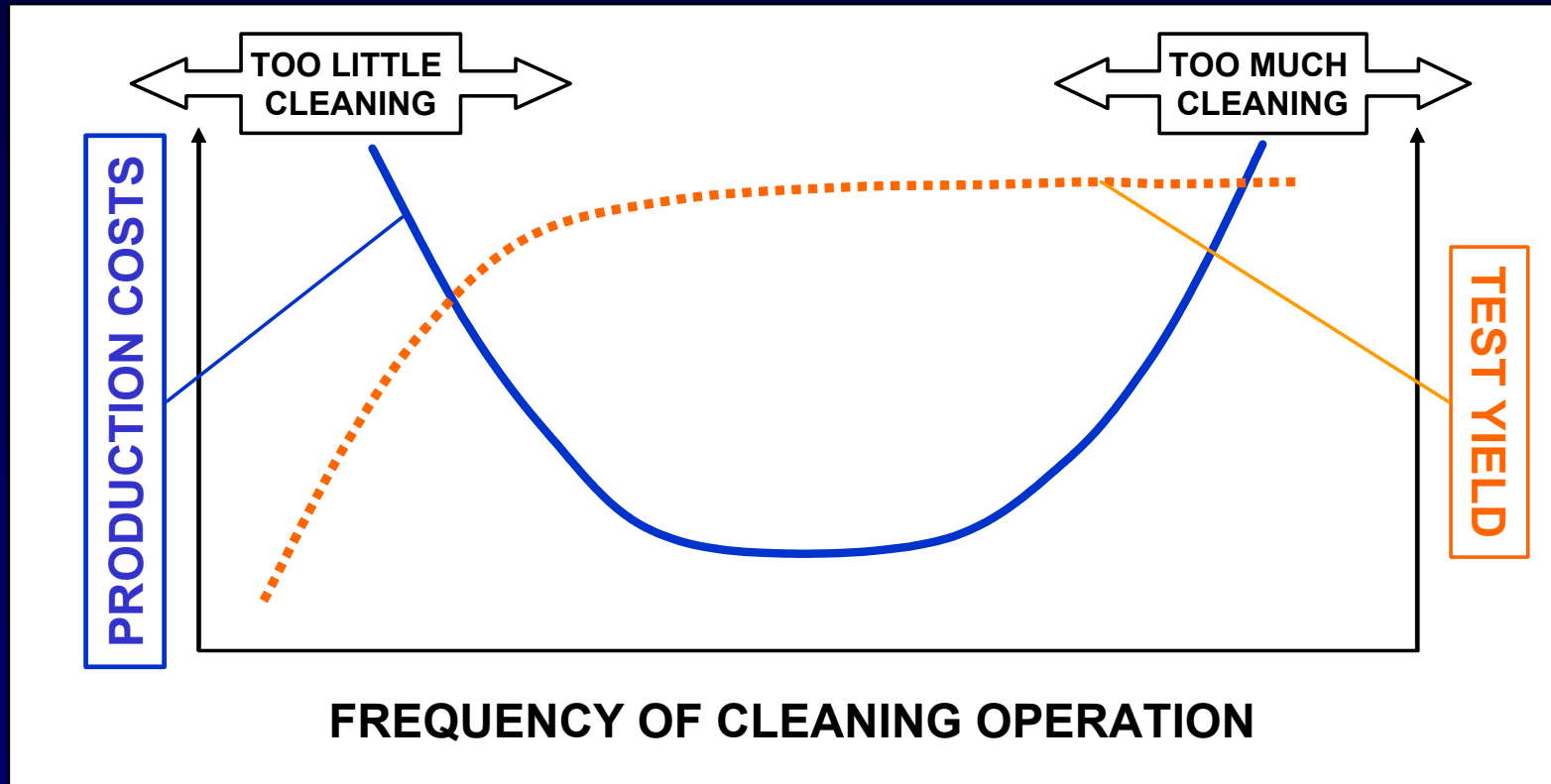
# Cleaning Economics - OEE

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- OEE (Overall Equipment Effectiveness) quantifies overall machine performance with three metrics ...
  - Availability (Average Up-Time): amount of time the machine was actually running as a proportion of time it could have been running.
  - Machine Effectiveness (Capacity): actual machine output as a percentage of theoretical output running at rated speed and actual runtime.
  - Output Quality (Yield): amount of good output as a proportion of total output.

# Cost of Ownership Model

- Frequent cleaning operations impact the OEE.
  - A set-up break is required for the cleaning operation.



# Industry Requirements

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- Achieve stable and accurate test results
- Contactor Conditioning
  - Debris collection and removal
  - Effective removal of embedded or bonded contaminants without wear
  - Contactor shape maintenance without damage
  - Environmental safety
- Economics
  - Cost effective
  - Increase overall throughput
  - Minimize machine “down” time

# Wafer Level Test - Parallelism

- Debris and adherent material accumulation are major contributors to  $C_{RES}$  instability during wafer level test.



Probes after Touchdowns on Bond Pads  
(Mag: 150X)

# Non-destructive Cleaning Solution

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- Non-Abrasive, Highly Cross-linked Polymer
  - Loose debris collected by polymeric material
    - Attractive forces of material “pull” adherent debris
  - Non-conductive and non-corrosive
    - Leaves no residue on contact surface
    - FTIR and XPS analysis do not detect any residuals
  - -50°C to 200°C Operating Temperature
- Extends the life of the probe needle “contactor”
  - No abrasive material removal from probe contacts
  - No lateral forces are applied during cleaning operation

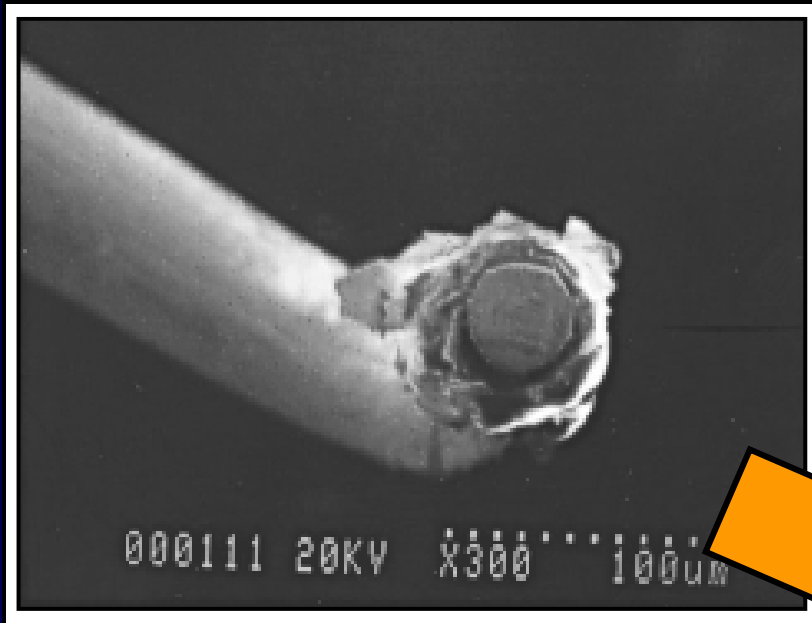
# Wafer Level Test – Debris Removal

- Sort floors utilize non-destructive cleaning materials to collect debris and remove adherent material from various probe technologies.



Probes after Non-destructive Cleaning  
(Mag: 150X)

# Wafer Level Test – Debris Removal



**Cantilevered Probe  
Adherent Debris**

**Tip Polishing and  
Debris Collection**



# Wafer Level Test – Debris Removal

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**Debris Collection on Cleaning Material Surface  
and within the Polymer Layer**

# Contactors and Socket Conditioning

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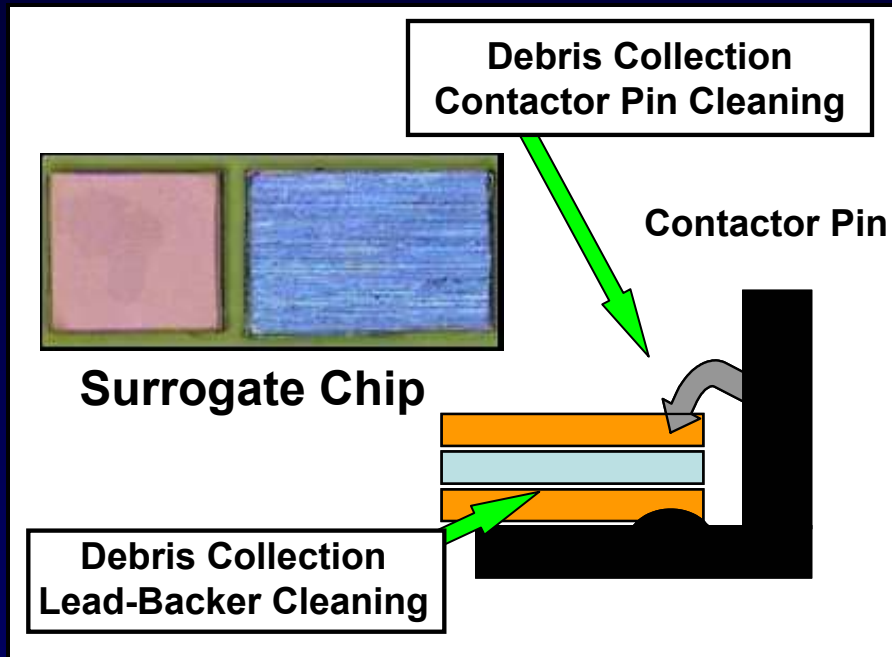
- Non-destructive cleaning materials can be adapted and utilized for test socket applications.
- Effective cleaning and maintenance of the contactor without breaking the setup during high volume production or damaging the contactor surface or socket materials.
- Yield loss due to adherent contamination is reduced, thus maximizing socket life and performance.

# Test Cell Conditioning Technology

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- IC chip “surrogate” test cell conditioning chip
  - Fits with any IC test socket
  - Pick & Place and Gravity-Feed handler compatible
- Highly cross-linked polymeric material layer
  - Non-abrasive polymer: removes and collects loose debris
  - “In suspension” abrasive particulates: remove bonded and embedded contaminants combined with loose debris collection.
- Environmentally safe for all test environments
  - Non-toxic and environmentally inert
  - Traps heavy metal particulates and debris for proper disposal

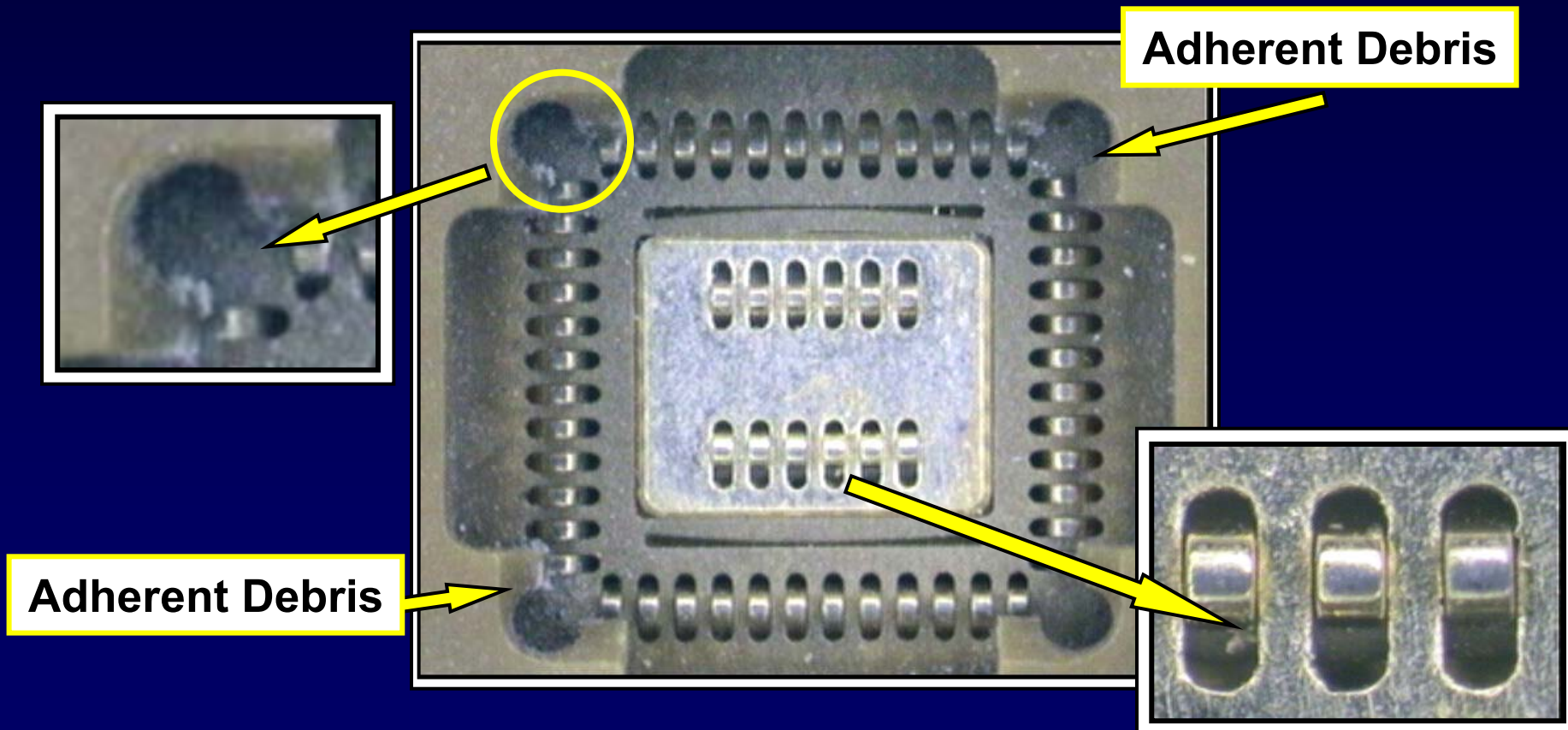
# “Surrogate” Conditioning Chip



- “Bottom side” polymer layer
  - Attracts and holds loose debris from socket interior.
  - Removes adherent contaminants from lead-backer.
- “Top side” polymer layer
  - Attracts and holds loose debris from between pins.
  - Removes adherent contaminants from contacts.
- Abrasive particles can be added to the polymer
  - “Tack” and abrasive “loading” can be modified to clean adherent debris and oxides.

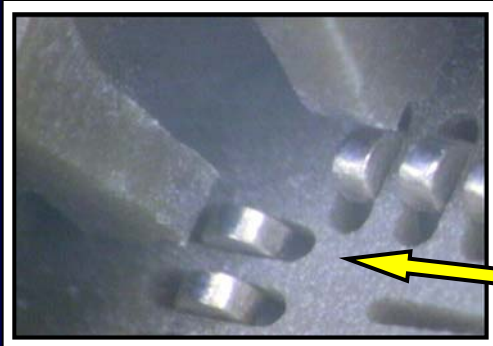
# Field Application

- 5 x 5 mm Contactor with 1 mm contacts
  - Debris accumulation after 4000 insertions

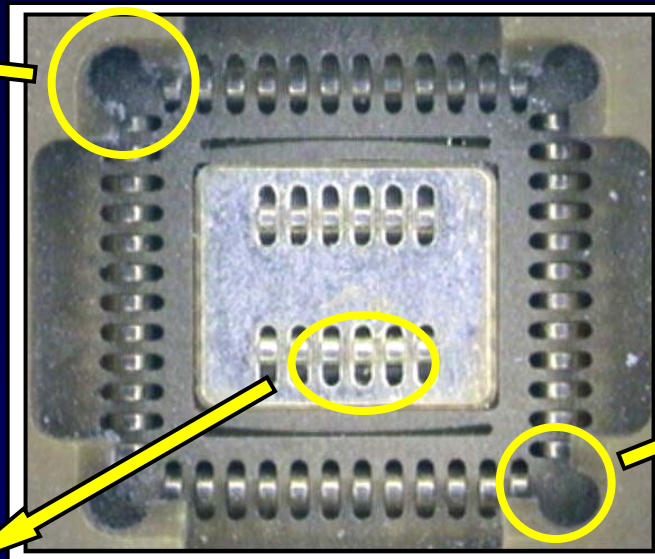


# Contactors Conditioning

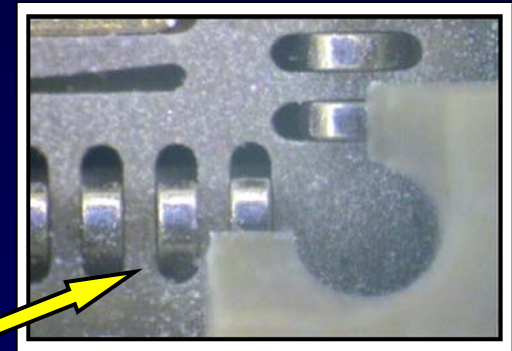
- 20 Cleaning insertions performed



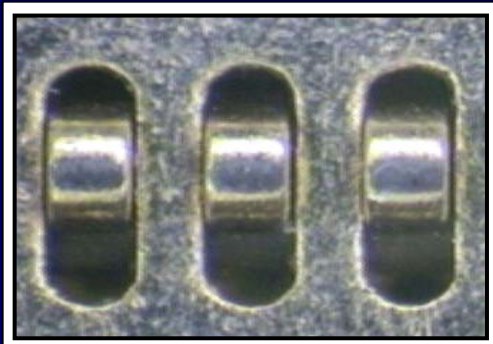
**After Conditioning**



**Before Conditioning**



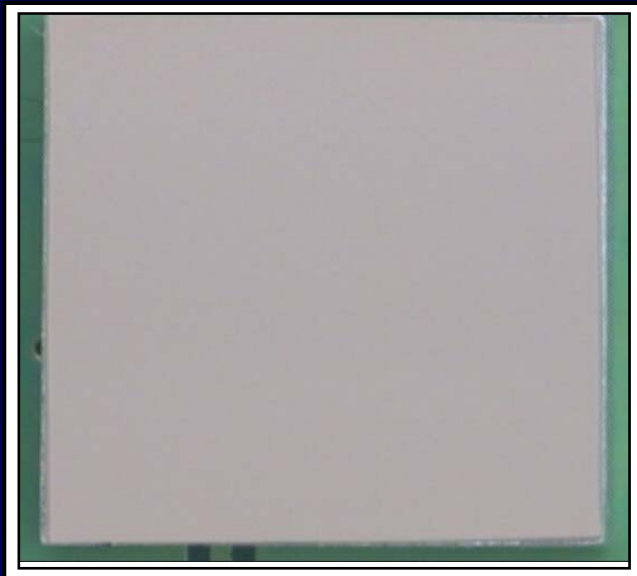
**After Conditioning**



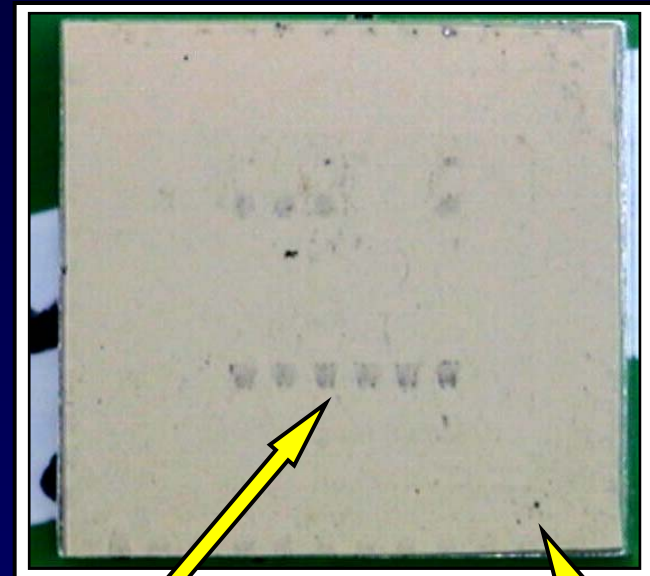
**After Conditioning**

# Debris Removal and Collection

Before Cleaning Insertions



After 20 Cleaning Insertions



**“Witness”  
Marks**

**Collected  
Debris**

# Performance Data

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- Socket Performance versus Insertions
  - Yield improvement with periodic test cell conditioning



Capt. Edward A. Murphy  
Air Force Project MX981

# Summary

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- Non-destructive cleaning technologies used during wafer level test were adapted for test socket applications.
  - Wafer sort floors utilize advanced cleaning to remove adherent materials from “fragile” probe technologies.
- Adherent particulates and debris were easily removed and collected by the polymeric cleaning material.
  - Socket malfunctions due to debris accumulation will decrease dramatically; thus, increasing throughput and production yields.

# Summary

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- “Surrogate” IC chip form-factor facilitates frequent on-line test cell conditioning without a “set-up break”
  - Cleaning frequency will be dictated by the testing conditions and the amount of debris accumulation.
- Non-destructive properties of the polymeric materials maximize socket life and performance.
  - Debris and contaminants are removed without the risk of damage to the contactors, base metal, or surface plating.

# Future Work – TCC Optimization



Highly cross-linked  
polymeric material

Spatially Distributed  
Abrasive Particles



# BiTS – 2004

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**Thank you for your attention**

**Questions ???**