IEEE SW Test Workshop
Semiconductor Wafer Test Workshop

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CVInc

Impact of Bond Pad Corrosion

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Overview

- Clean the wafer – not the probe card
- History of contamination
- Corrosion removal
- Examples of Pre and Post Cleans
- Analysis of packaged units reliability
- Summary

Clean the wafer – not the probe card

Root cause of high contact resistance (CRES) is corrosion and contamination, not the probe card. Goal should be to eliminate fluorine corrosion on bond pads

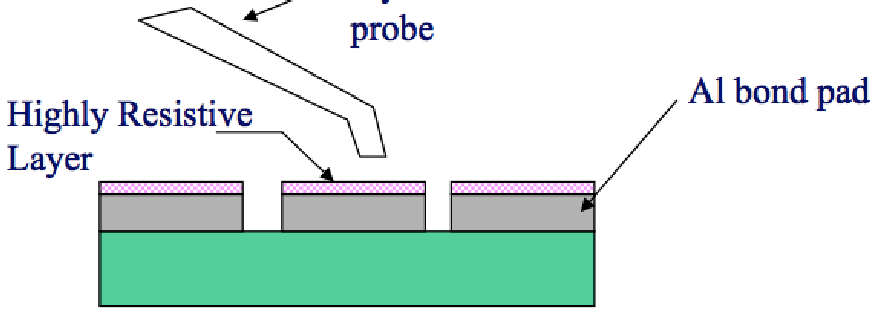
Why Clean the Wafer

- A process that will strip the corrosion/oxidation but not attack the base metals is desired. Traditional methods include plasma, phosphoric (PAN or dilute phosphoric) acid derivatives and even dilute TMAH for aluminum. Unfortunately phosphoric goes after good aluminum as well and any strong base will have a dramatic, not a good one, impact on aluminum.
- Improve cost of ownership:
  - *Extend hardware life.*
  - *Improve assembly yield.*
  - *Reduce scrap die and wafers.*
- Reduce reliability risk and regain process control.
  - *Damaged pads lead to customer returns*

History of contamination

The Problem – Contact Resistance Due to Corrosion, Not Oxidation

- Two items impact post fab yield:
  - Test hardware
  - **Bond pad conditions.**



Visualization of a typical cantilever style probe on a bond pad

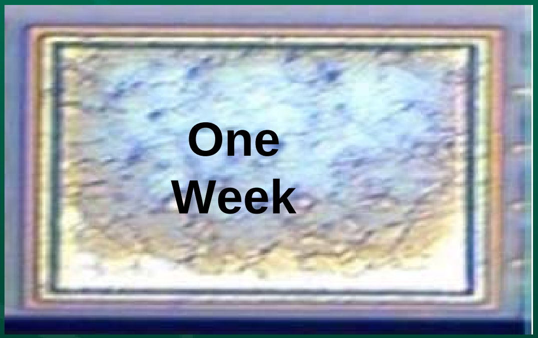
Removing the highly resistive layer can improve yield, extend probe card life, minimize reliability issues and help manage process control constraints

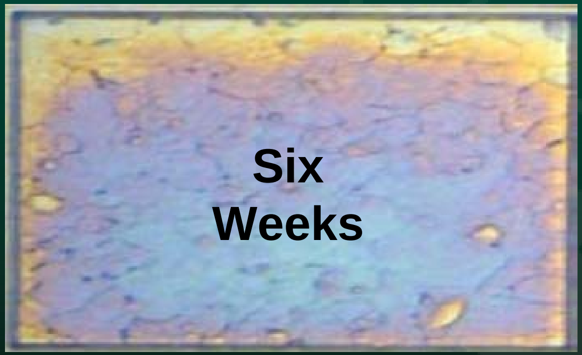
Goal: Remove the resistive layer without damaging the underlying metal layer.

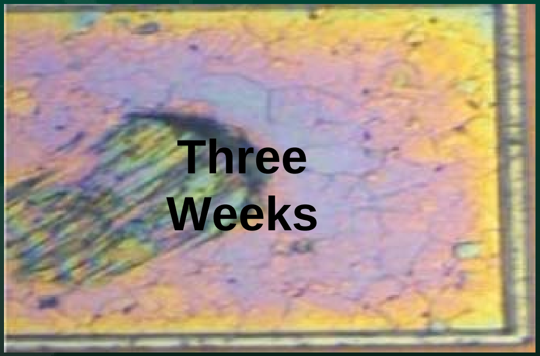
What process has the following capabilities:

- No etch rate on metals
- Low etch rate on passivation layers and Si.
- Love oxide and corrosion.

Al Bond Pad Analysis Over Time

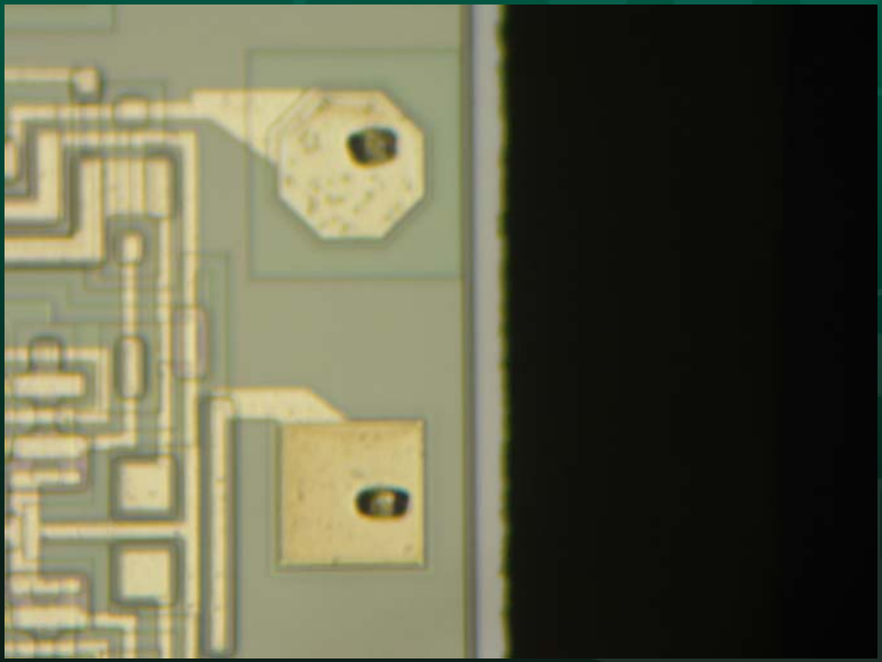






Dry Box Conditions - Fluorine contamination is apparent at time zero as received. As time continues the pads become more corroded. Conditions of these pads are typical and are the root of poor contact resistance. If the pads are not cleaned then poor yield is likely as well as die and hardware damage.

Probed Pads Prior to Clean



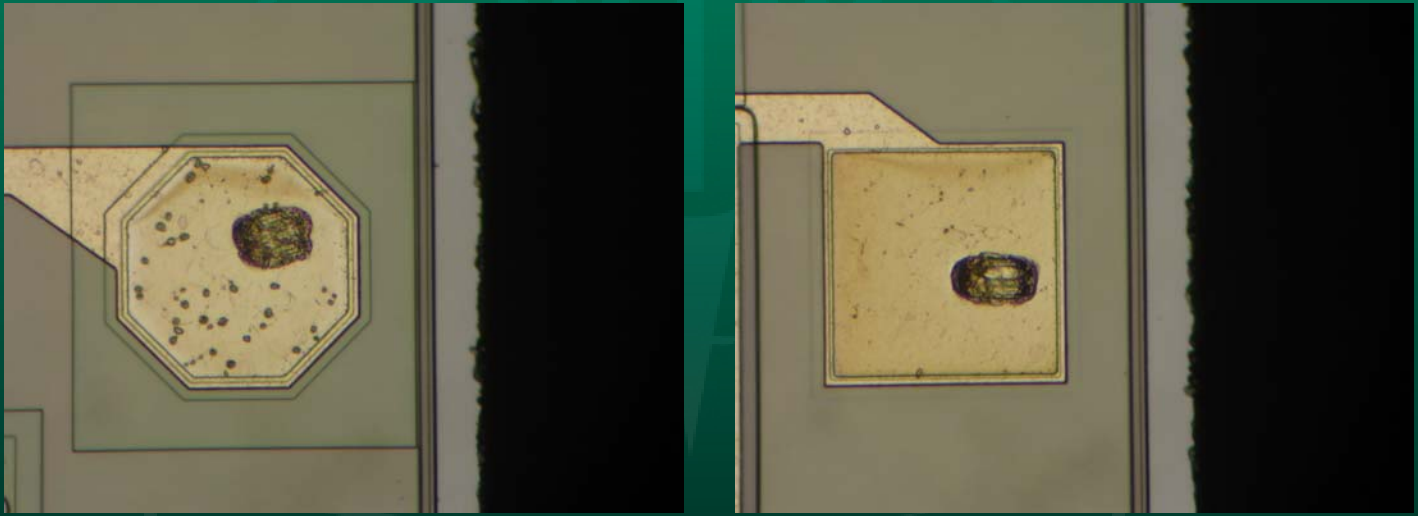
Brown corrosion layer varies from pad to pad. Some pads are more corroded than others which is why a solution is required that does not attack aluminum.

A material that attacks aluminum would likely etch away the top pad prior to reaching pure aluminum on the bottom pad.

Corrosion Removal in Five Minutes

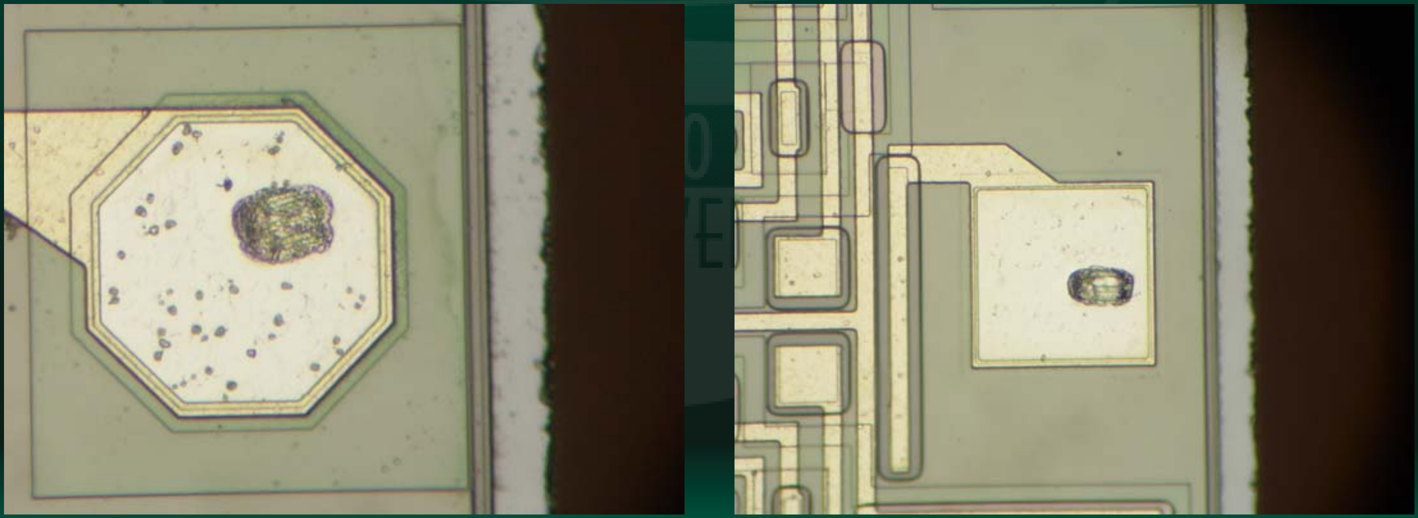
Cleaning Improvements

As
Recvd

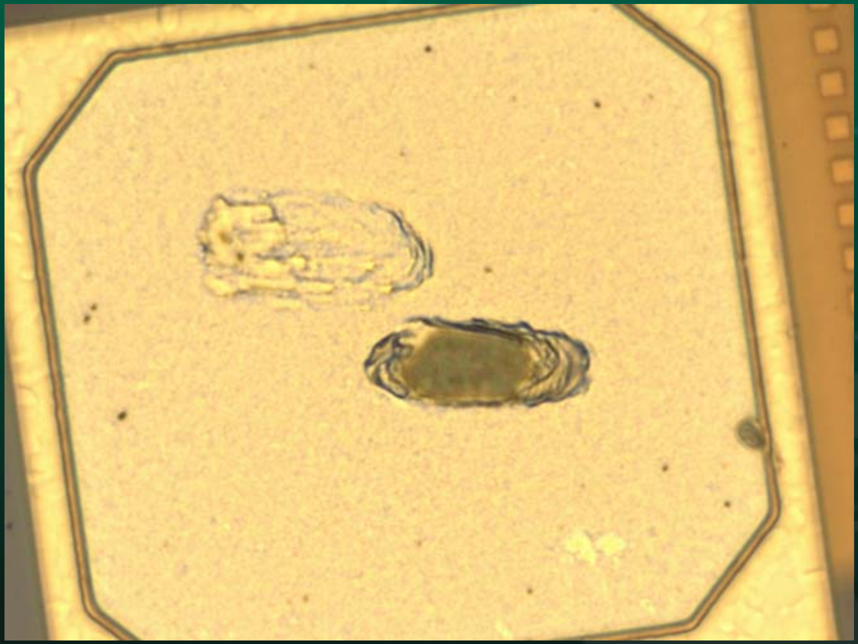


BPS100

5min



Cleaning and rinsing

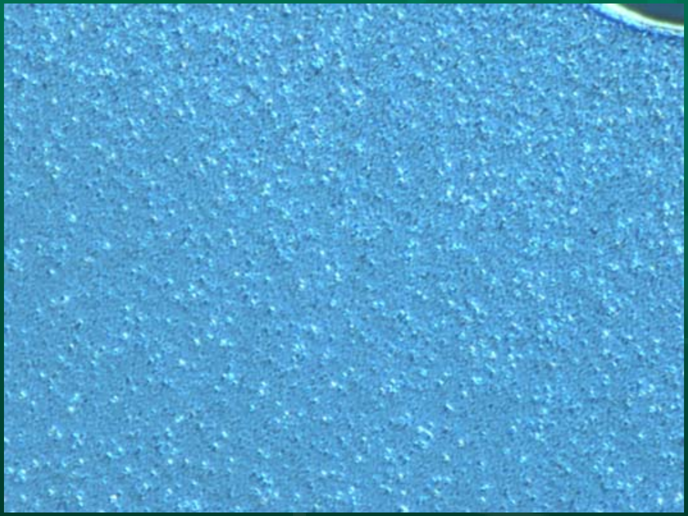


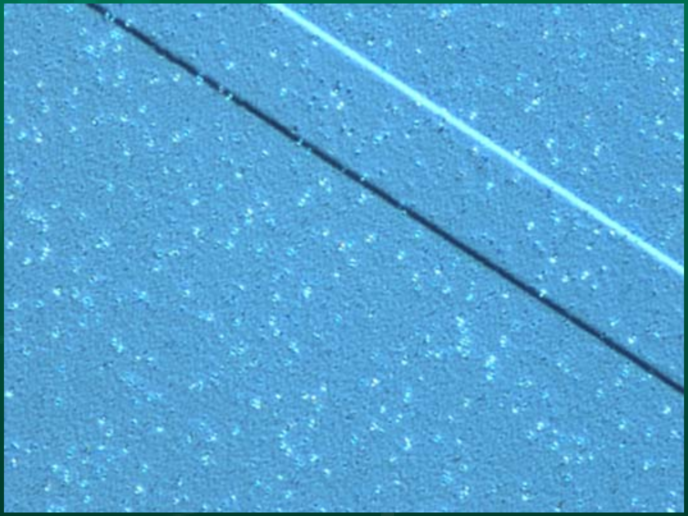
BPS100 can be used to clean the pads but as with any pure aluminum surface DI water is an enemy.

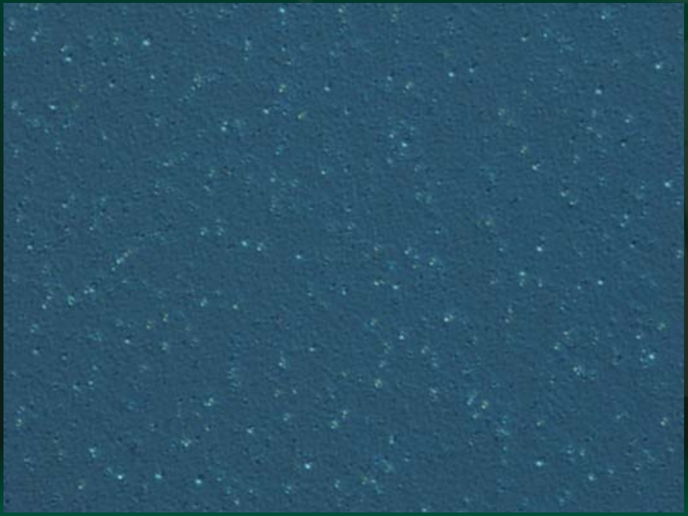
An oxidized aluminum surface will be more resilient to DI water than a fresh layer.

An example of a cleaned surface left in DI water shows the etching of the probe mark on the wafer after 90 minutes.

Comparison of Surface Texture



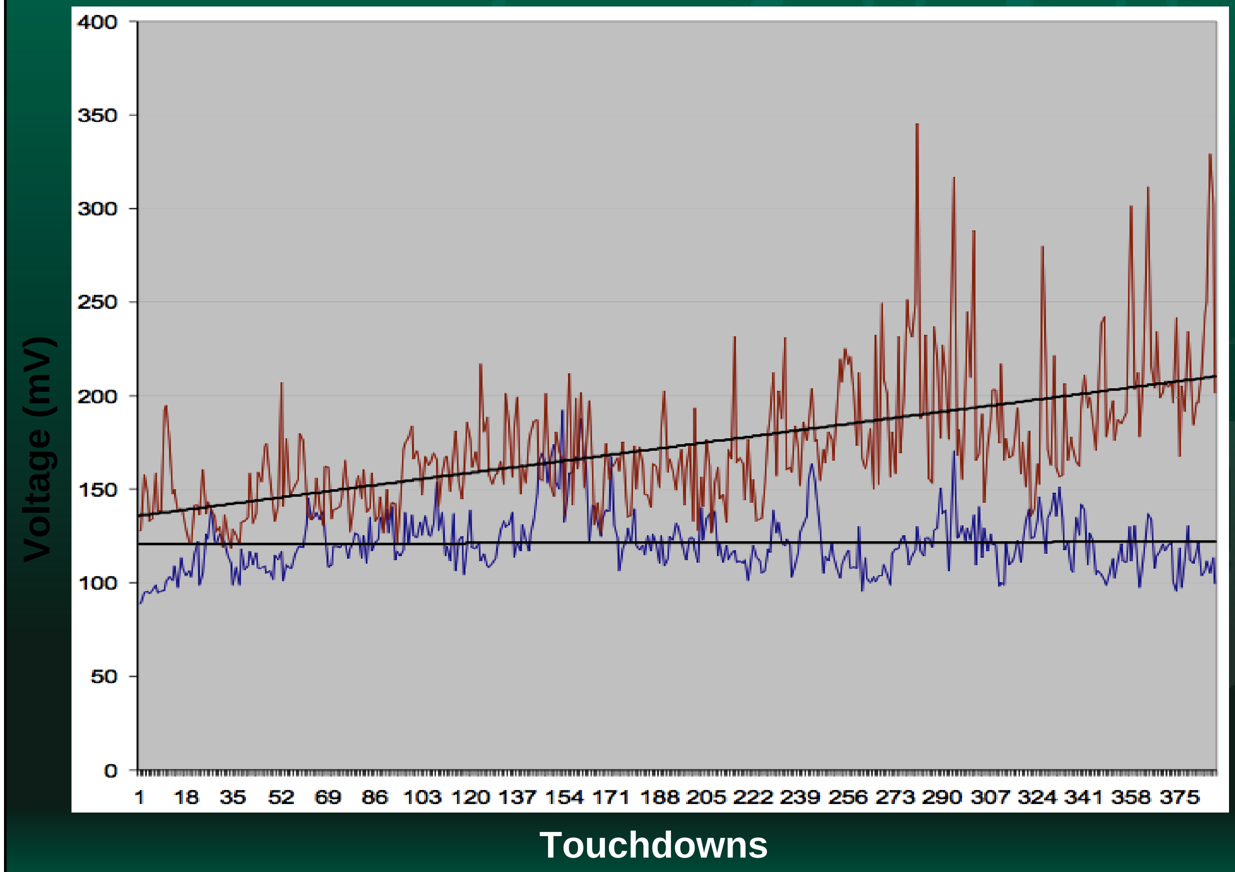




Sharp Al2O3 oxide peaks replaced by spongy corrosion layers.

Clockwise from left, Al+oxide, Al at ambient for 3 days, Al + ambient + CF4 plasma.

Dramatic Results After BPS on Al



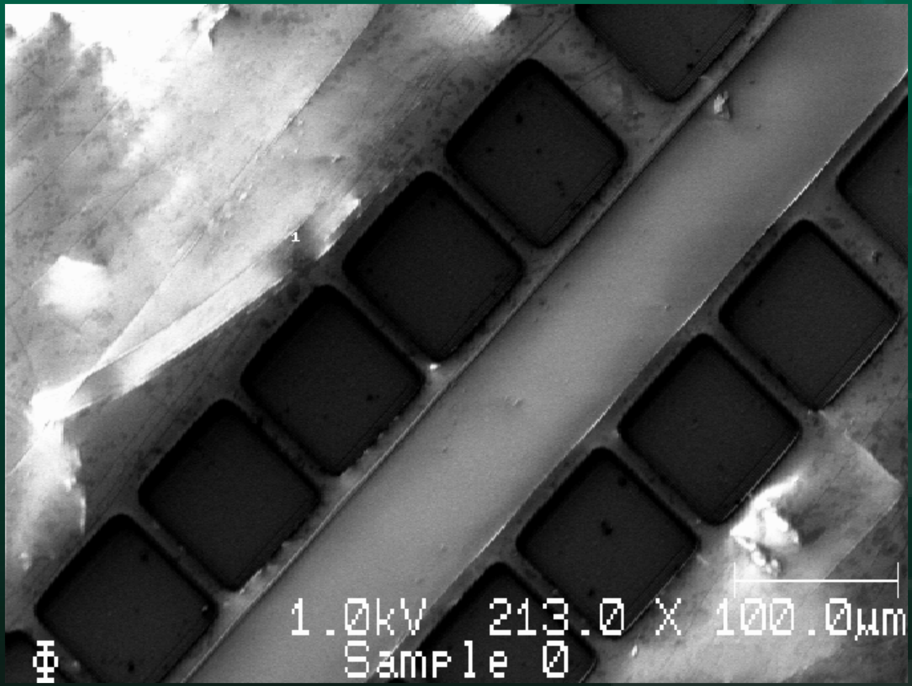
- Lower CRES
- Less Noise
- Fewer false fails
- Less CRES increase over touchdowns

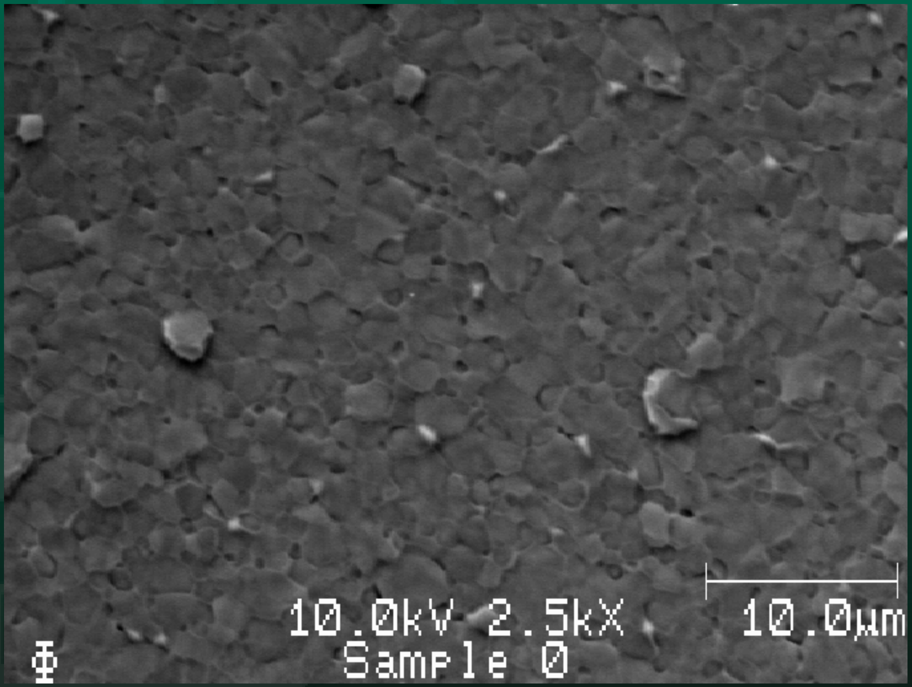
Before BPS

After BPS

Real resistance between two pins on the pad at 10um overtravel

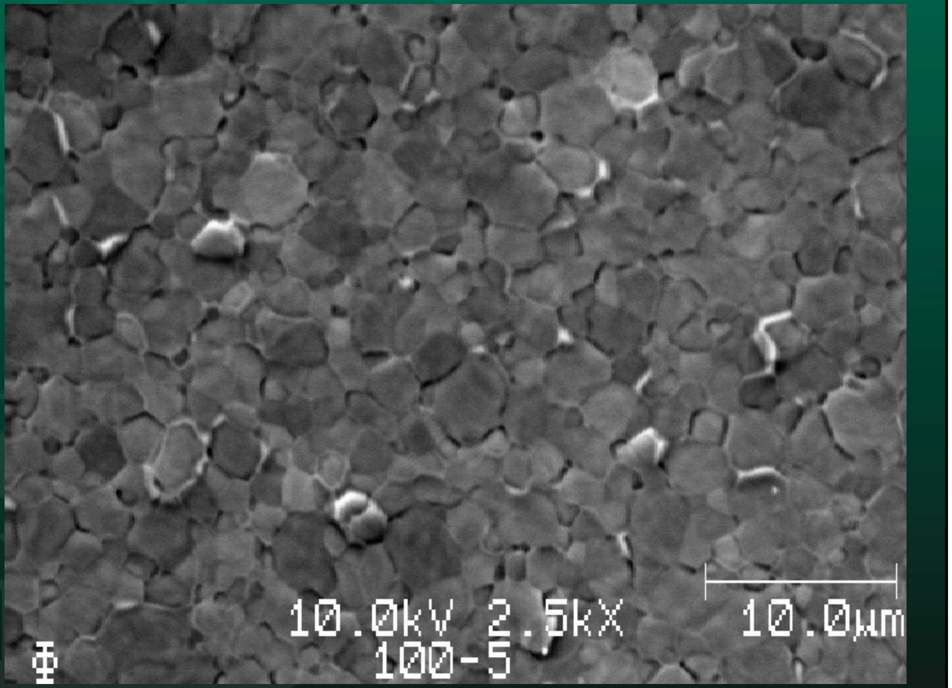
Baseline Sample; No Clean





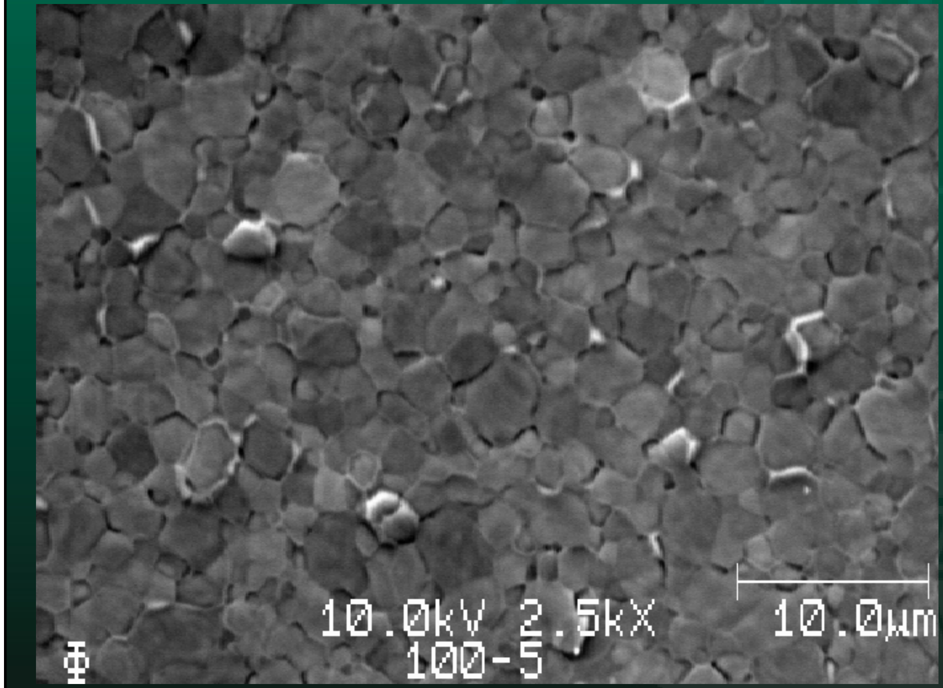
Fuzzy, oxidized aluminum pads.

BPS100 (Sample 100-5)

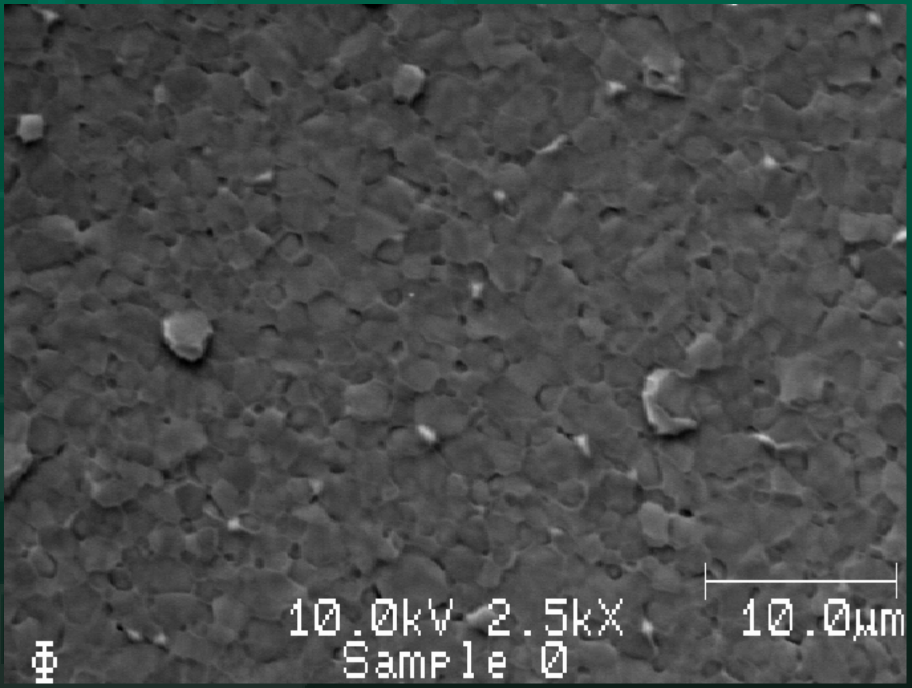


Well defined grain boundaries..

Side By Side Comparison of the Bond Pads



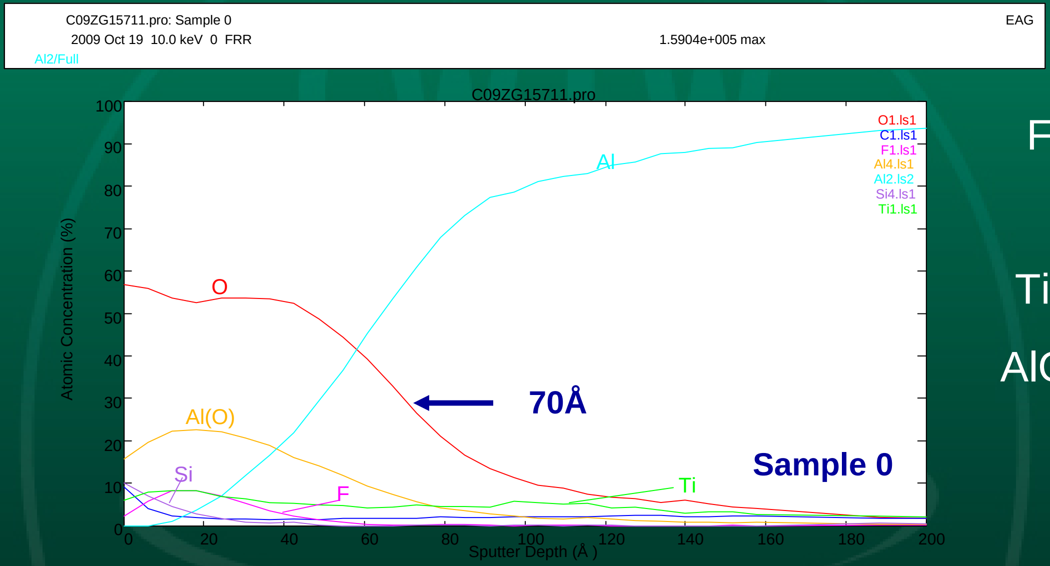
With BPS100 for 5 minutes.



As Received, without BPS100.

Auger Depth Profiles – 3Days

As Received



F present until 40A

Si3N4 at 25A

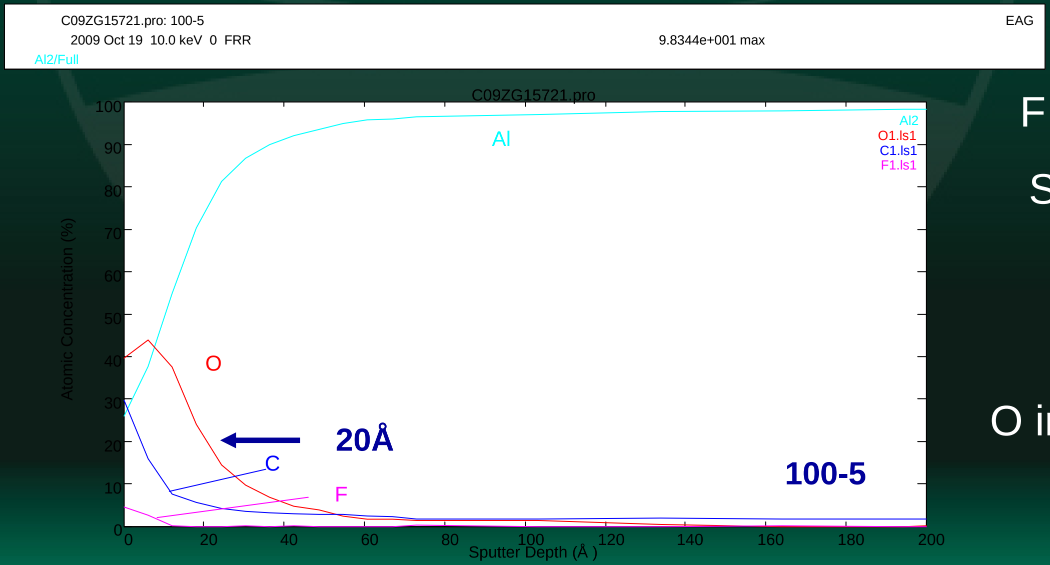
Ti unusually present

AlO up to 80A; typical for Al

O at +120A

90% Al at 200A

BPS100



F removed at 10A

Si3N4 eliminated

Ti eliminated

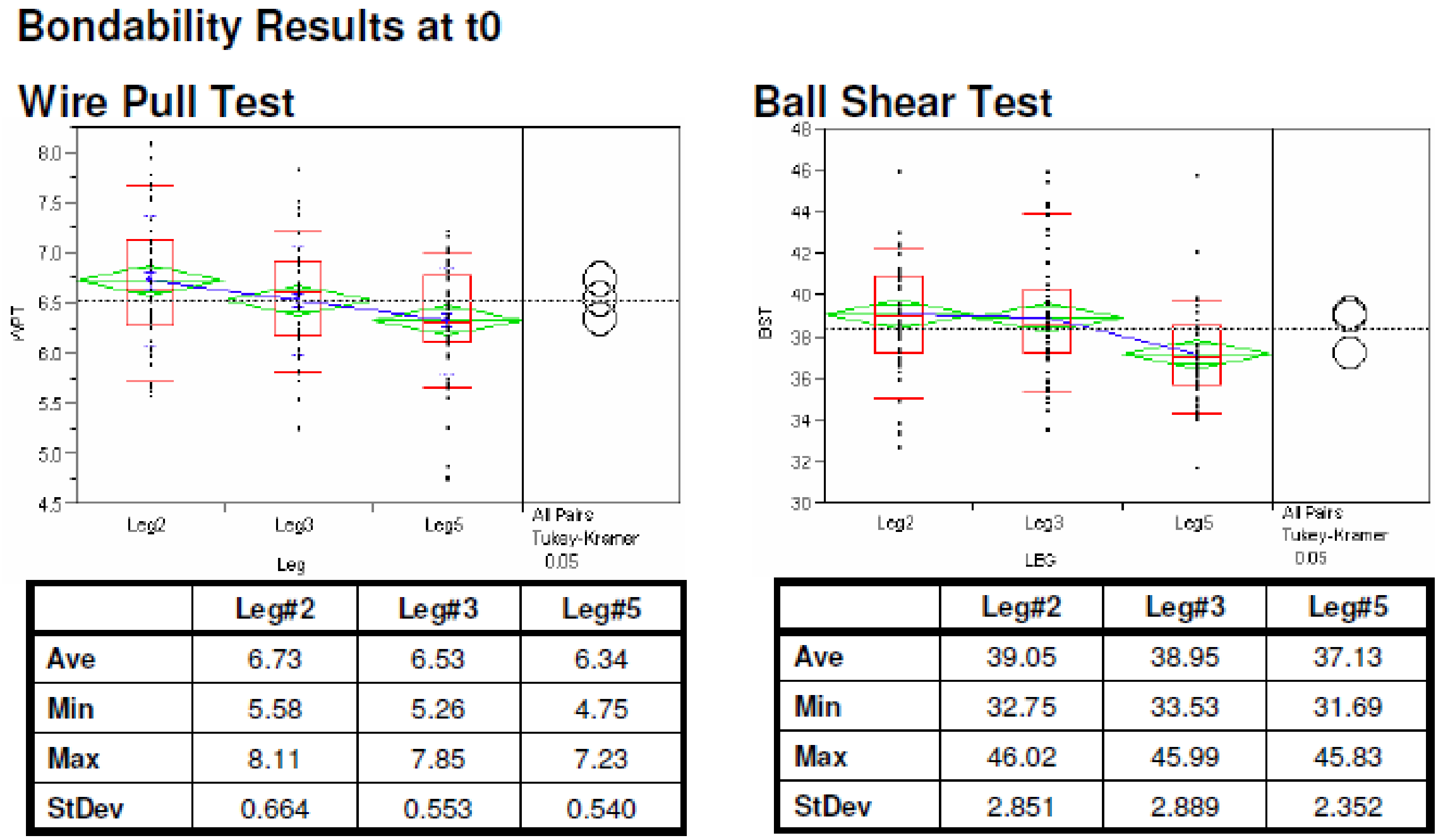
AlO eliminated

O in some form up to 40A

90% Al at 40A

Analysis of packaged units reliability

Wire Bond Evaluation



Bondability Results at t0

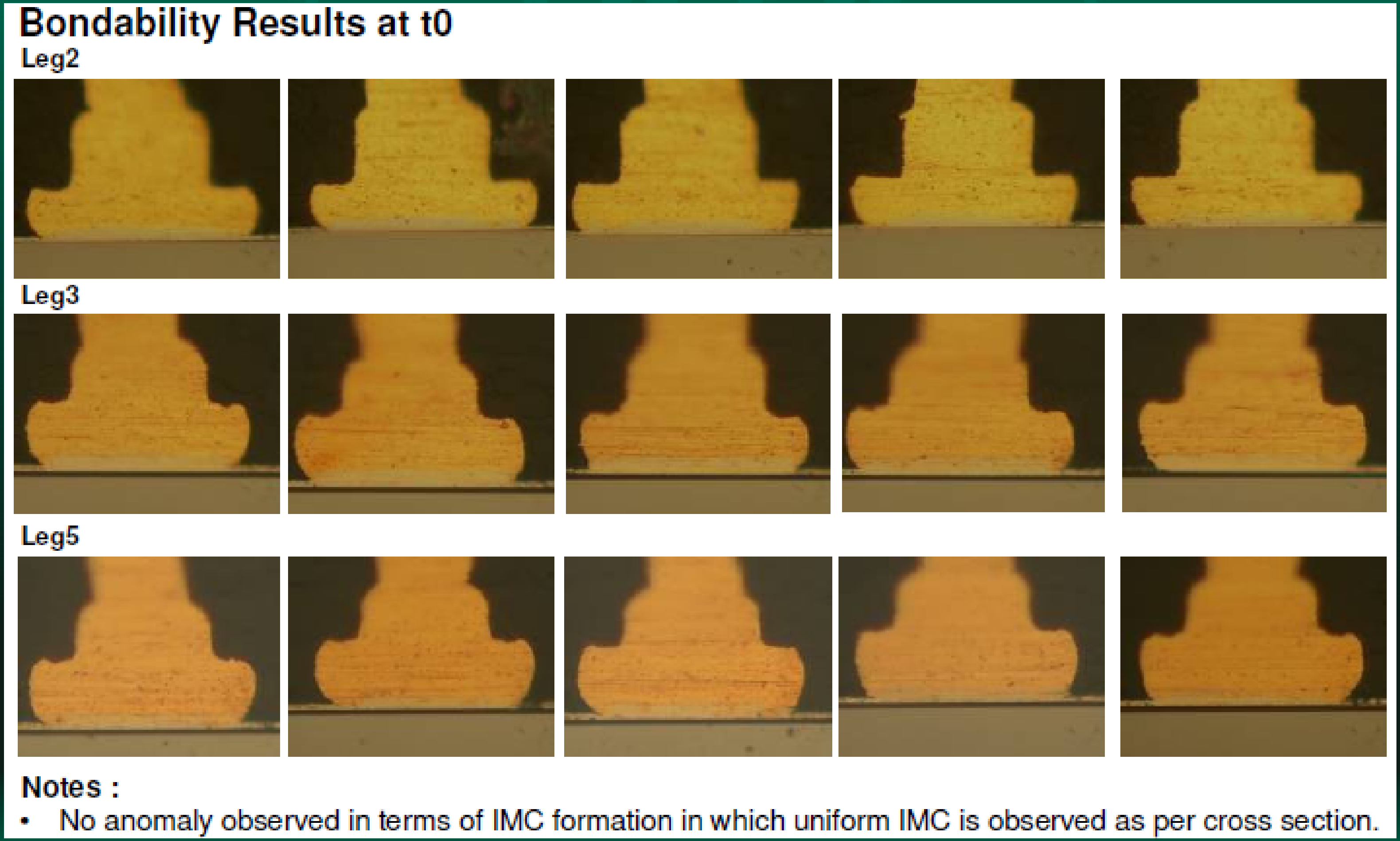
Wire Pull Test

	Leg#2	Leg#3	Leg#5
Ave	6.73	6.53	6.34
Min	5.58	5.26	4.75
Max	8.11	7.85	7.23
StDev	0.664	0.553	0.540

Ball Shear Test

	Leg#2	Leg#3	Leg#5
Ave	39.05	38.95	37.13
Min	32.75	33.53	31.69
Max	46.02	45.99	45.83
StDev	2.851	2.889	2.352

Cross Sections



Bondability Results at t0

Leg2

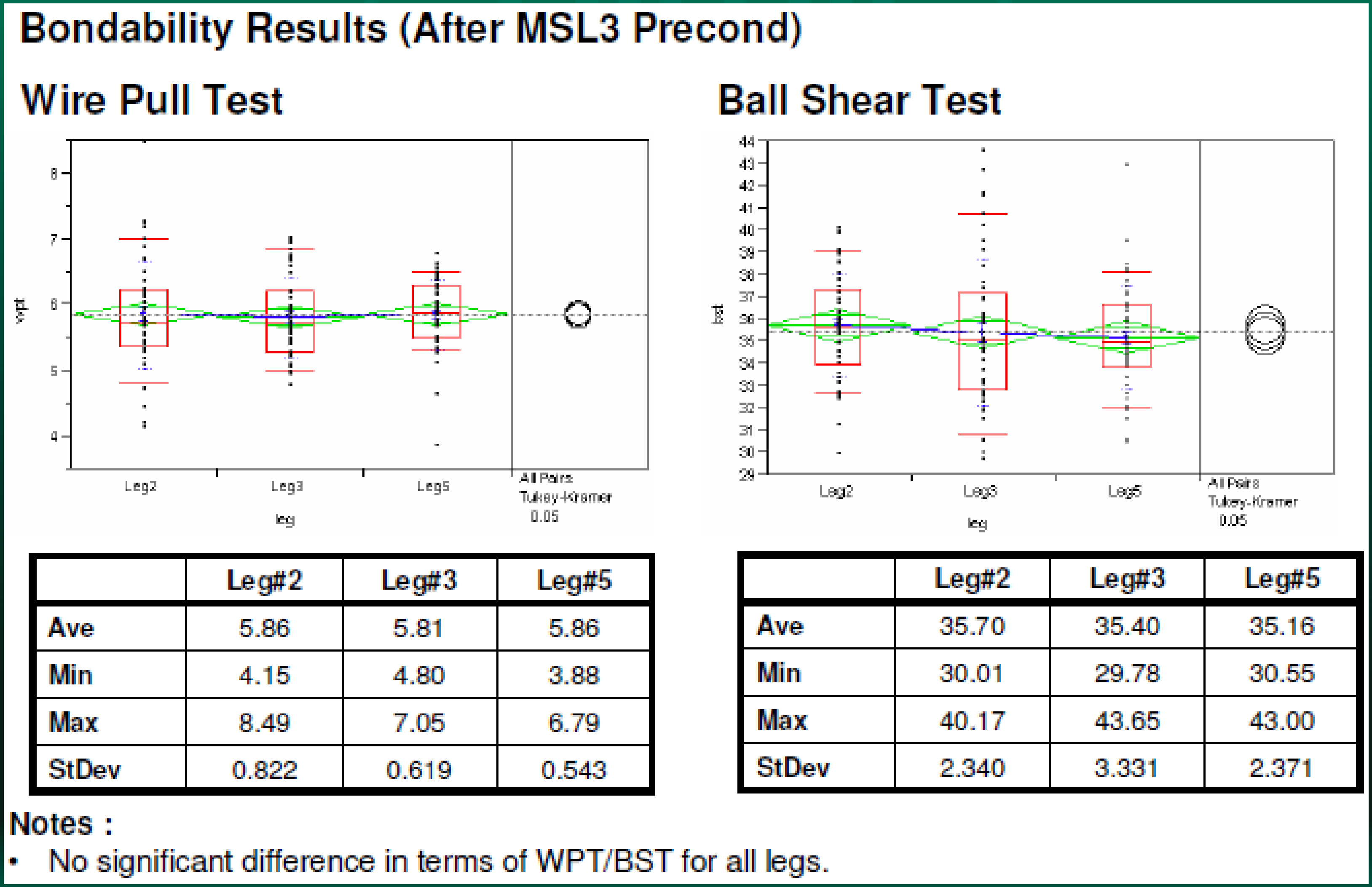
Leg3

Leg5

Notes :

- No anomaly observed in terms of IMC formation in which uniform IMC is observed as per cross section.

Wire Bond Test at MSL3



Bondability Results (After MSL3 Precond)

Wire Pull Test

	Leg#2	Leg#3	Leg#5
Ave	5.86	5.81	5.86
Min	4.15	4.80	3.88
Max	8.49	7.05	6.79
StDev	0.822	0.619	0.543

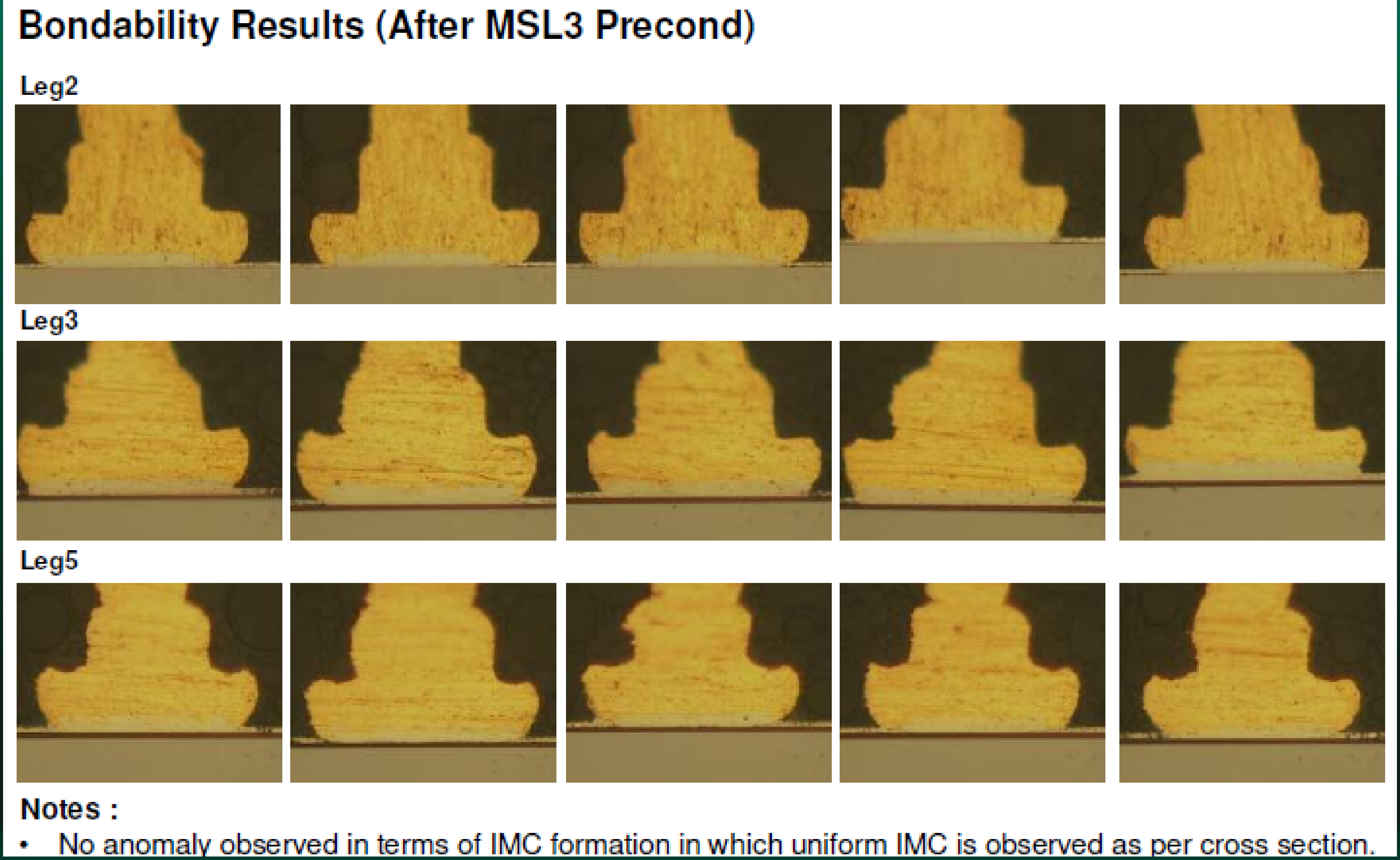
Ball Shear Test

	Leg#2	Leg#3	Leg#5
Ave	35.70	35.40	35.16
Min	30.01	29.78	30.55
Max	40.17	43.65	43.00
StDev	2.340	3.331	2.371

Notes :

- No significant difference in terms of WPT/BST for all legs.

Cross Sections at MSL3



Bondability Results (After MSL3 Precond)

Leg2

Leg3

Leg5

Notes :

- No anomaly observed in terms of IMC formation in which uniform IMC is observed as per cross section.

Summary

Clean the wafer, not the probes!

- Low etch rate on baseline aluminum pad.
- Five minutes in BPS will remove CRES layer for up to 3-4 days.
- Pads can be brought to t=0 from nitride etch.
- Reduces bottlenecks and hardware costs.
- Improves yield and cycle time.
- Decreases reliability risks with no detrimental impact to assembly

Thank You!

Thank you for taking time to listing to this presentation.

The author would also like to thank the following folks at Air Products for their help and support:

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Questions?