


**FALCON PCB GROUP**

**CONTROL OF THE ELECTROLESS NICKEL –  
IMMERSION GOLD (ENIG) PROCESS, FROM A  
FABRICATOR'S PROSPECTIVE**

**Dennis Price -- Merlin Circuit Technology Ltd.**




# Falcon PCB Group

**FALCON PCB GROUP**

**FALCON PCB GROUP**

- Offshore PCB Solutions
- Flexible Circuits
- Rigid PCB Manufacture

- UK Based Private Company
- Group Turnover £20M+
- 200+ Employees



Merlin Circuit Technology  
Dorset

Merlin Flex-analogy  
Warrington

Elite Circuits  
Cranbrook

Merlin Flexible Circuits  
Purvis

Merlin Artech  
Littlehampton

Kestrel International Circuits  
Lancing

Seminar presentation from [Bobwillisonline.com](http://Bobwillisonline.com)

## Start of ENIG Process Control

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Process control of the ENIG plating process (like all other solderable surface finishes) starts at the copper surface preparation stage prior to solder mask application.

A variety of mechanical brushing and chemical cleaning solutions are available.

Merlin use low pressure pumice with Nylon bristle brush scrubbing for copper surface preparation.

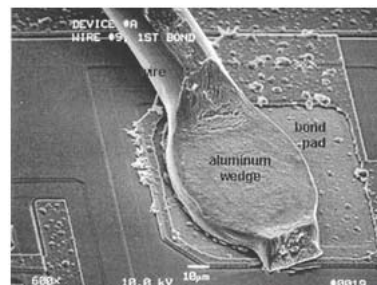
## Pumice Brush Surface Topography

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An increasing number of ENIG solderable finish boards now support Aluminium wedge wire Bonding. Although the electroless Nickel has a degree of self levelling a coarse Copper finish can be detrimental to bond pull strengths.



Pumice brushed surface X2500



Aluminium wedge wire bond

## Solder Mask Issues with ENIG

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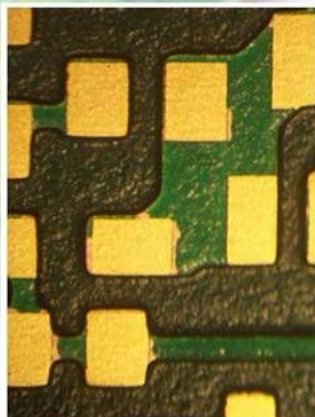
During the initial use of ENIG a major solder mask adhesion problem was experienced by many fabricators.

This was most noticeable as a visibly lighter area on large Copper areas at the solder mask and ENIG interface.

Many solutions were advocated but the most popular was part curing the solder mask to retain flexibility - -- this resulted in Sulphur containing compound contamination of the Nickel bath.

## Loss Of Solder Mask Adhesion

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Solder mask	Deposition rate of nickel (µin/min)	Corrosion i HNO <sub>3</sub>
P	10,6	35,5%
E	11,0	73,6%
T	10,7	73,6%
None	8,7	0,8%

### Effect of Leakage from Solder Mask

(Source: K. Crouse and D. Cullen, PC Fab, Feb. 2002)

Loss of solder mask adhesion

# Merlin MacDermid Planar ENIG Process

Process Sequence	Process	Time (min)	Drain (sec)	Temp (° C)
0	Load	/	/	/
1	Planar Acid Cleaner	5:35	10	48 - 54
2	Cold Water Rinse	1:32	0	RT
3	Cold Water Rinse 4	2:01	5	RT
4	Microetch	2:49	5	24 - 28
5	Cold Water Rinse	2:05	0	RT
6	Cold Water Rinse 4	2:08	10	RT
7	Hot Sulphuric Acid (10%)	6:41	5	58 - 65
8	Water Rinse	2:02	0	RT
9	Water Rinse	1:42	0	RT
10	Pre-Initiator DF	3:05	10	40 - 45
11	Water Rinse	1:00	0	RT
12	Water Rinse 4	1:00	0	RT
13	Sulphuric Post Rinse (5%)	2:10	10	RT
14	Water Rinse	2:13	0	RT
15	Water Rinse 4	1:31	0	RT
16	Planar Electroless Nickel	18:00	20	82 - 90
16	Planar Electroless Nickel	18:00	20	82 - 90
17	DI Water Rinse	3:42	0	RT
18	Planar Immersion Gold	8:40	20	75 - 90
19	Water Rinse	2:01	0	RT
20	Water Rinse 4	2:10	0	RT
21	DI Rinse	3:41	0	55 - 65
22	Hot Air Dry	9:00	/	60
23	Unload	/	/	/

## ENIG Process Control

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Acid Clean	Microetch	Hot Acid Dip	Catalyst	Post Dip	Nickel	Gold
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### Step 1: Final Finish Acid Cleaner

➤ **Function – To remove oils and fingerprints from copper surfaces.**

✓ Things to check.....

- ✓ Chemistry Concentration – Laboratory Solution level (small frequent top up's).
- ✓ Temperature



# ENIG Process Control

FALCON PCB GROUP

Acid Clean	Microetch	Hot Acid Dip	Catalyst	Post Dip	Nickel	Gold
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## Step 2: Microetch

➤ **Function** – Remove 1.5 microns of copper to give good subsequent adhesion.

✓ Things to check.....

- ✓ Chemistry Concentration – Laboratory Solution level (small frequent top up's).
- ✓ Temperature

# ENIG Process Control

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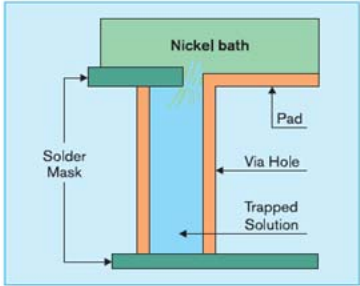
Acid Clean	Microetch	Hot Acid Dip	Catalyst	Post Dip	Nickel	Gold
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## Step 3: Hot Sulphuric Dip

➤ **Function** – To help remove microetch from partially plugged vias. This is the main cause of Skip Plating

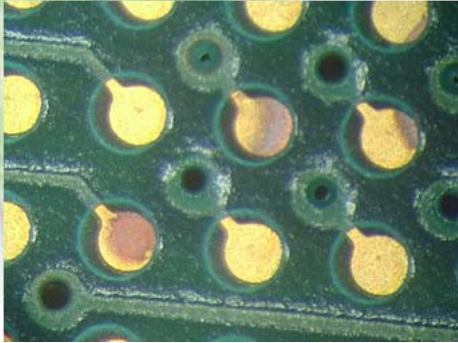
✓ Things to check.....

- ✓ Chemistry Concentration – Laboratory Solution level (small frequent top up's).
- ✓ Temperature

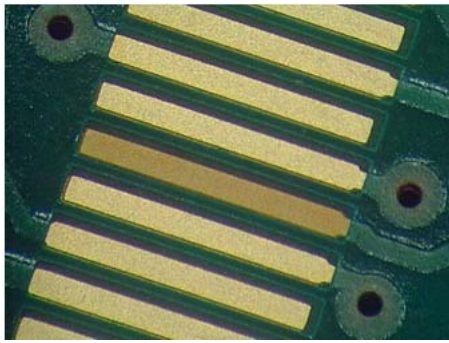


## ENIG Skip Plating

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Various degrees of partly blocked via holes by incomplete solder mask tents



Typical Skip Plated Pad  
Other ENIG plated pads on the same net can be similarly affected

## ENIG Process Control

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Acid Clean	Microetch	Hot Acid Dip	Catalyst	Post Dip	Nickel	Gold
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### Step 4: Palladium Catalyst

➤ **Function:** Deposits thin Palladium layer on copper to allow Nickel plating.

✓ Things to check.....

- ✓ Chemistry Concentration – Laboratory Solution level (small frequent top up's).
- ✓ Temperature

# ENIG Process Control

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Acid Clean	Microetch	Hot Acid Dip	Catalyst	<b>Post Dip</b>	Nickel	Gold
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## Step 5: Sulphuric Acid Post Rinse

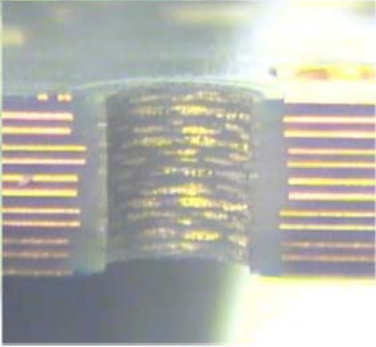
➤ **Function:** Helps remove Palladium residues from laminate areas.

✓ Things to check.....

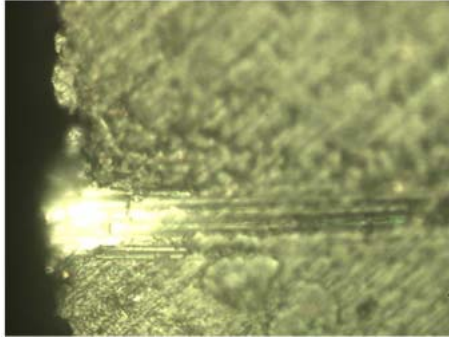
- ✓ Chemistry Concentration – Laboratory Solution level (small frequent top up's).
- ✓ Temperature

# Residual Catalyst Deposits

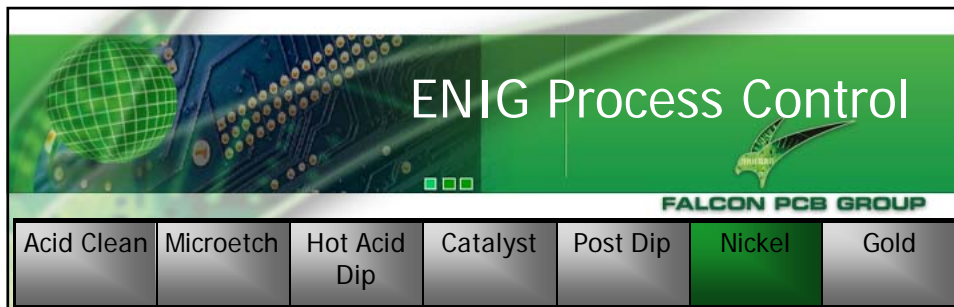
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**ENIG pick-up in non-plated tooling hole**



**Excessive wicking of catalyst along hole-wall glass bundles allows plating of extraneous ENIG deposits**



## ENIG Process Control


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Acid Clean	Microetch	Hot Acid Dip	Catalyst	Post Dip	<b>Nickel</b>	Gold
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### Step 6: Electroless Nickel

- **Function: To deposit 3 – 6 microns of Electroless Nickel**
- ✓ The electroless Nickel stage has a high rate of chemical change.
- ✓ This is typically the area where most problems occur.
- ✓ A PALM controller will maintain the chemistry within specification as long as the start up is undertaken correctly.

Any replenishment chemistry is added back correctly.  
The operating parameters are correct



## ENIG Process Control

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Acid Clean	Microetch	Hot Acid Dip	Catalyst	Post Dip	<b>Nickel</b>	Gold
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### Step 6: Electroless Nickel

- **Function: To deposit 3 – 6 microns of Electroless Nickel**
- ✓ Other things to check.....
  - ✓ Dummy procedure is followed correctly.
  - ✓ No Nitric Acid left in the tank after cleaning.
  - ✓ Evaporation losses are topped up frequently.
  - ✓ Replenishment drums contain enough Nickel A, C and Ammonia
  - ✓ Temperature is maintained within specification.





The slide features a green header with a circuit board and a globe graphic. The title 'ENIG Process Control' is in white. Below the header is a navigation bar with seven buttons: 'Acid Clean', 'Microetch', 'Hot Acid Dip', 'Catalyst', 'Post Dip', 'Nickel' (highlighted in green), and 'Gold'. The 'FALCON PCB GROUP' logo is in the bottom right of the header.

## ENIG Process Control

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Acid Clean	Microetch	Hot Acid Dip	Catalyst	Post Dip	Nickel	Gold
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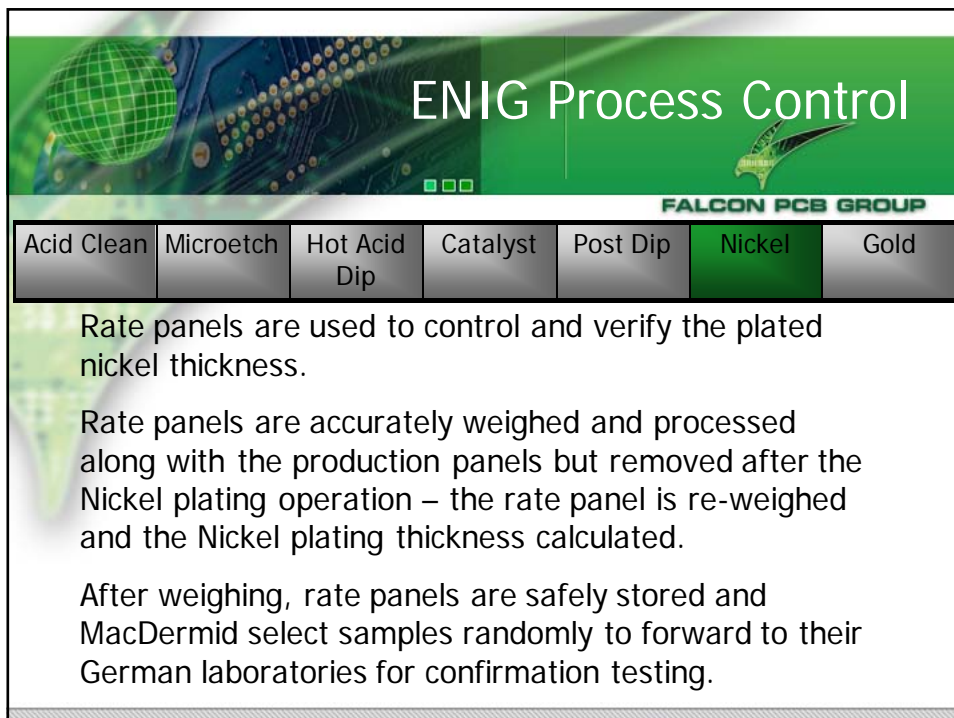
### Step 6: Palm Controller

➤ **Function: Analyses and Replenishes Electroless Nickel Chemistry**

✓ Things to check.....

- ✓ Nickel and pH analysis agrees with display.
- ✓ Solution is being circulated through the controller.
- ✓ The replenishment pumps are delivering solution Nickel A to Nickel C ratio must be 1:1

**Note:** If the controller fails during production, regular analysis of the Nickel bath must be undertaken and additions made according to laboratory control documents. (For every litre of Nickel A 1 Litre of Nickel C **MUST** be added).



This slide has the same header and navigation bar as the previous one. The 'Nickel' button is highlighted in green.

## ENIG Process Control

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Acid Clean	Microetch	Hot Acid Dip	Catalyst	Post Dip	Nickel	Gold
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Rate panels are used to control and verify the plated nickel thickness.

Rate panels are accurately weighed and processed along with the production panels but removed after the Nickel plating operation – the rate panel is re-weighed and the Nickel plating thickness calculated.

After weighing, rate panels are safely stored and MacDermid select samples randomly to forward to their German laboratories for confirmation testing.

## Bath Metal Turn-Over (MTO)

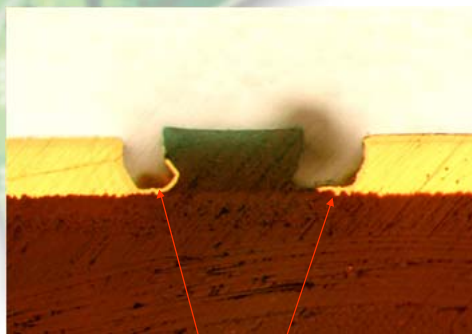
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Although high metal turn-overs reduce process costs it has been shown that Nickel baths operated at high MTOs are more prone to hyper-corrosion of the Nickel surface during Immersion Gold plate.

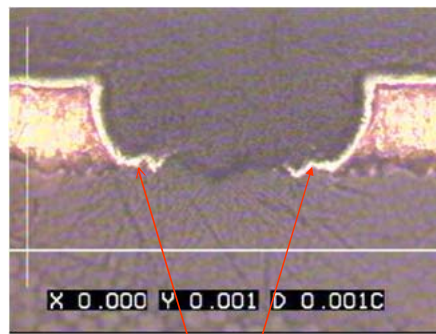
It has been suggested that the steady increase of bath contaminants could be partially responsible.

## Electroless Nickel Creep

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Nickel creep with solder mask dam



Nickel creep with no solder mask dam

Nickel creep can be caused by under-etching (leaving residual Copper spots in the laminate surface), poor catalyst removal or an overactive Nickel bath.

## Passivated Nickel Surface

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Care must be taken when transferring the work basket between Electroless Nickel to the Immersion Gold tank.

Drip / drain times must not allow any drying out of the Nickel surface during the rinsing operations, which should not be excessive.

If the Nickel surface is allowed to passivate, subsequent solder joints can appear to suffer from a black pad type problem.

## ENIG Process Control

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Acid Clean	Microetch	Hot Acid Dip	Catalyst	Post Dip	Nickel	Gold
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### Step 7: Immersion Gold

➤ **Function: Exchanges Gold for Nickel at EN surface – Deposits Gold**

▼ Things to check.....

- ✓ Chemistry Concentration – Laboratory Solution level (small frequent top up's).
- ✓ Temperature



# ENIG Process Control


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Acid Clean	Microetch	Hot Acid Dip	Catalyst	Post Dip	Nickel	Gold
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## Step 8: Immersion Gold Drag Out

This is a very important stage to reduce process cost.

A Labmaster pump filled with Ion Exchange Resin continuously circulates the drag out solution to reclaim any Gold compounds.



# ENIG Process Control

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- ENIG process has many process variables that need to be continually monitored.
- There are several stages that run hot – Evaporation losses must be replaced frequently.
- The Electroless Nickel Stage has a high rate of change - the effects of this are minimised by the use of a PALM controller.
- On start up make sure.....
  - Working bath is replenished using correct chemistry / procedure.
  - Dummy panels are processed using correct procedure.

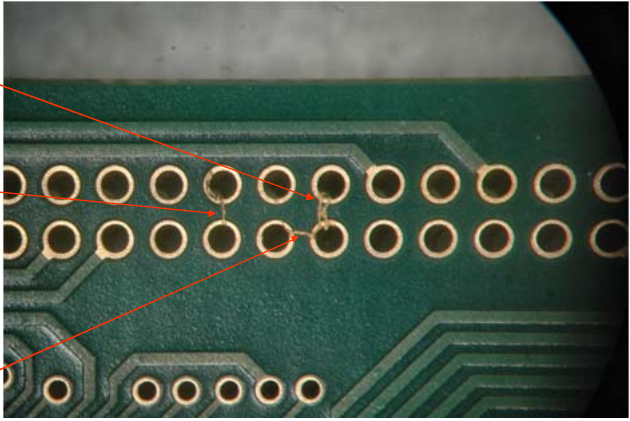


## ENIG QA Process Control

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Breakdown of work basket protective coating can result in extraneous ENIG deposits which become detached and adhere to adjacent board surfaces.


Can also be caused by residual Palladium activator which has not been fully removed




## ENIG QA Process Control

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- Solderability – **Quality Department**  
solder float, edge dip, rotary dip (J-003)
- Physical Testing – **Process Operator**  
tape test adhesion (metal, soldermask)  
XRF thickness / Rate Panel



**MUST II Wetting Balance**



**Fischer XRF**

The header of the slide features a green background with a stylized circuit board and a globe on the left. The title 'ENIG QA Process Control' is centered in white. On the right, there is a logo for 'FALCON PCB GROUP' which includes a stylized bird icon.

## ENIG QA Process Control

- Surface Cleanliness – **Quality Department**  
Ionograph testing
- Gold Strip Test – **Chemistry & Quality Laboratories**  
Use 20 g / Litre DEGUSSA Gold Stripper 645 plus  
10 g / Litre Potassium Cyanide at room temperature.  
Note time to strip and review exposed nickel surface  
for any signs of corrosion.
- Appearance – **Process Operator**  
Visual – final check for any rinse water drying stains &  
extraneous ENIG flecks on the board surface.  
Low magnification microscopy

The header of the slide features a green background with a stylized circuit board and a globe on the left. The title 'ENIG Process Control Black Pad' is centered in white. On the right, there is a logo for 'FALCON PCB GROUP' which includes a stylized bird icon.

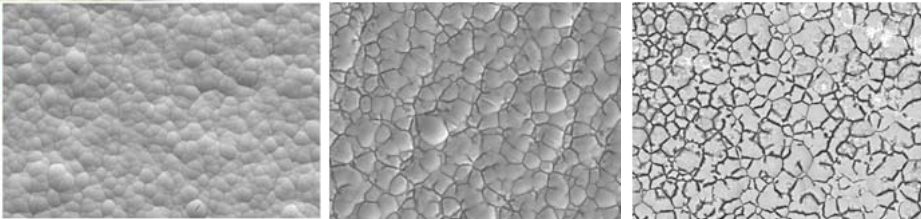
## ENIG Process Control Black Pad

The gold strip test boards are subjected to our maximum visual magnification checks. If any indication of Nickel surface corrosion is evident and cannot be quantified at our maximum magnification the boards are forwarded to Quantum Micromet for ESM and EDAX analysis.

# ENIG Process Control Black Pad

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Nickel surface ESM evaluation after Gold strip test

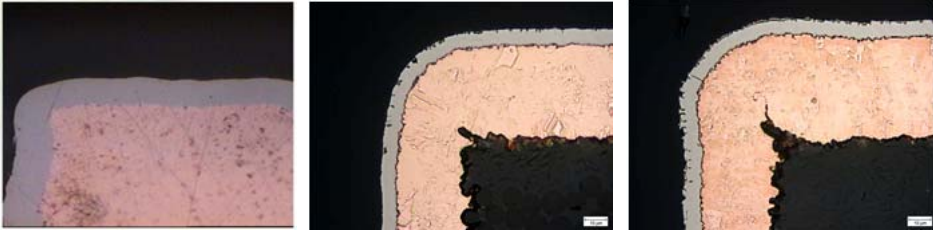


No hyper-corrosion      Moderate hyper-corrosion      Serious hyper-corrosion

# ENIG Process control Black Pad

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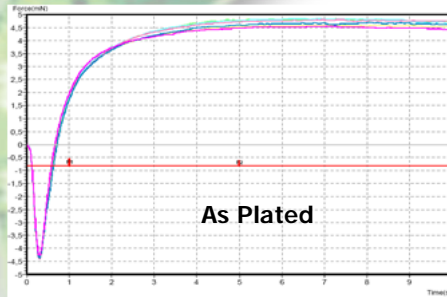
Microsection analysis of the various degrees of Nickel corrosion



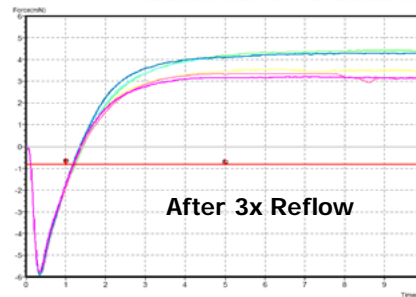
No corrosion spikes      Serious corrosion spikes      Very serious corrosion spikes, some penetrating to the copper plating

# ENIG Process Control Solderability

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As Plated



After 3x Reflow

Typical MUST II Wetting Balance curves which demonstrate the longer wetting times as heat is applied to the ENIG surface --- this can easily be reversed if bare boards require stoving for long periods as a 10% Sulphuric Acid clean will remove Nickel oxide / hydroxide surface contamination and restore the original solderability.