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Considerations for Selecting a PCB Surface Finish

AHOT IPC Designers Council Meeting

October 8, 2013

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Importance of SF

- The selection of the surface finish on your PCBs could be the most important material decision made for the electronic assembly.
- The surface finish influences the process yield, the amount of rework, field failure rate, the ability to test, the scrap rate, and of course the cost.
- One can be lead astray by selecting the lowest cost surface finish only to find that the eventual total cost is much higher.
- The selection of a surface finish should be done with a holistic approach that considers all important aspects of the assembly.

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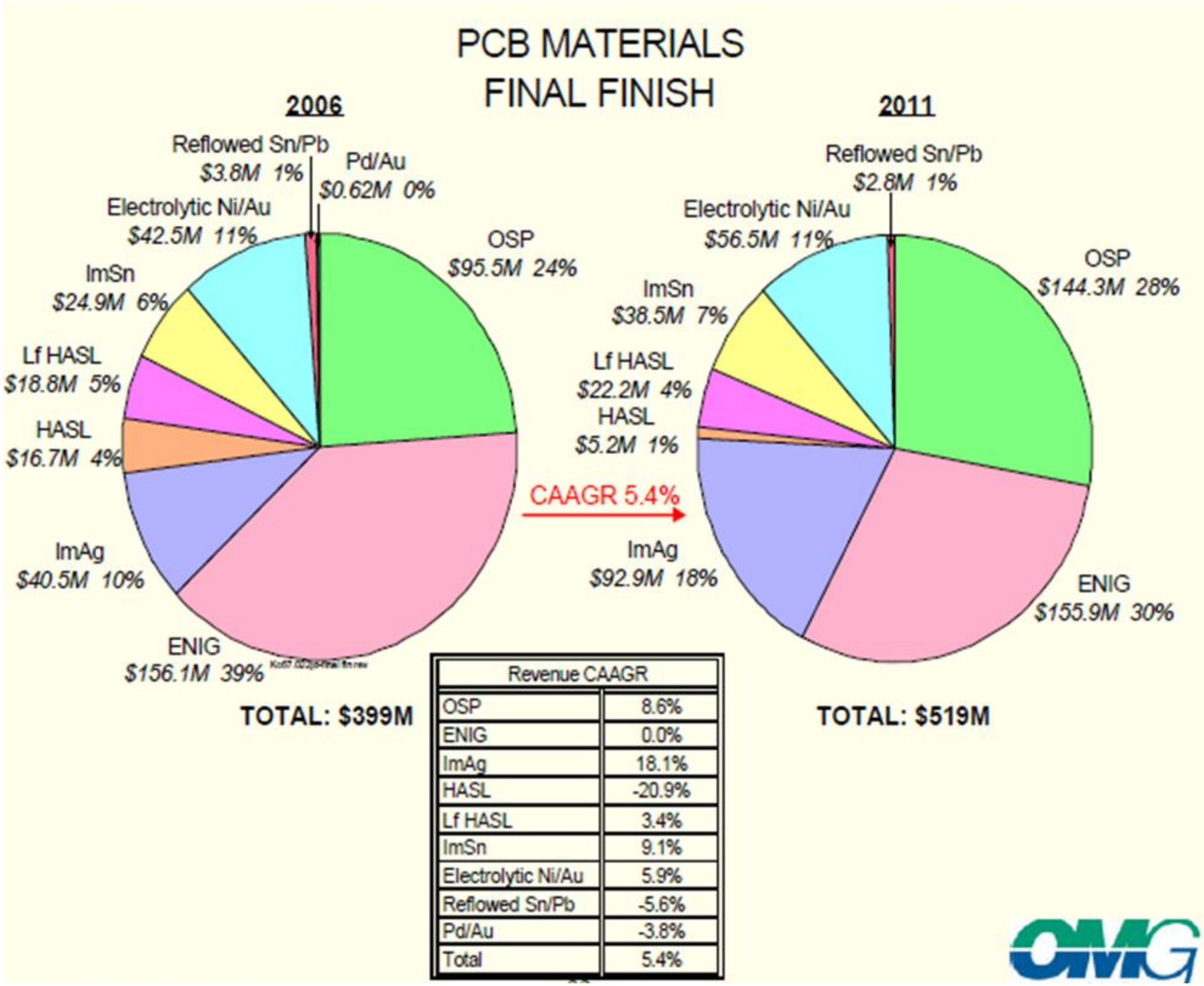
Surface Finishes - Post Pb-Free

- Multiple Pb-Free Surface Finish Options Now Exists.
  - No clear winner, no ideal solution.

- Each PCB surface has different advantages and disadvantages that affects fabrication, solderability, testability, reliability, or shelf life.

- The 5 most popular Pb-Free Surface Finishes are:
  - Electroless nickel/immersion gold (ENIG)
    - And ENEPIG (electroless Pd added)
  - Immersion silver (ImAg)
  - Immersion tin (ImSn)
  - Organic solderability preservative (OSP)
  - Pb-free HASL.
- These finishes (except for Pb-free HASL) have been in use for several years.
- Newer finishes are currently being developed (direct Pd, PTFE-like coatings, nanofinishes)

Surface Finishes - Post Pb-Free



Revenue CAAGR	
OSP	8.6%
ENIG	0.0%
ImAg	18.1%
HASL	-20.9%
Lf HASL	3.4%
ImSn	9.1%
Electrolytic Ni/Au	5.9%
Reflowed Sn/Pb	-5.6%
Pd/Au	-3.8%
Total	5.4%

What is your SF selection approach?

- **Component Procurement:** Select the cheapest one and let the engineers figure out how to use it.
- **PCB Engineer:** Select the finish that is easiest for the suppliers to provide (their sweet spot); let the assembler figure out how to use it.
- **Assembly Engineer:** Select the finish that provides the largest process window for assembly and test.
- **Sustaining Engineer:** Select the finish that minimizes field failures.
- **CEO:** Select the finish that minimizes the overall cost (including reliability risk).

Considerations with SF Selection

- Cost sensitivity
- Volume of product (finish availability)
- SnPb or LF process
- Shock/Drop a concern?
- High yield ICT is important
- Is direct wire bonding required?
- User environment (corrosion a concern)?
- Fine pitch assembly (<0.5 mm)
- Wave solder required (PCB > 0.062")
- Are cosmetics of the PCB a concern?

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Surface Finish Selection Guideline

Attributes

Cost Sensitive Product

High Volume Required

Cosmetics of Finish is Important

High Yield ICT Required

SF Type

Pb-Free Wave Solder (PCB > 62mil)

Pb-Free Shock/Drop is a Concern

Fine Pitch Components Used

Corrosion Failure is Possible

Wire bonding to Finish is Required

Capable

Not Capable

Surface Finish Selection Guideline

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High Volume Required

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OSP

Pb-Free Wave Solder (PCB > 62mil)

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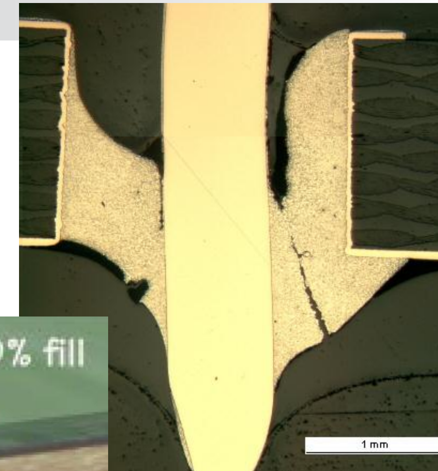
Wire bonding to Finish is Required

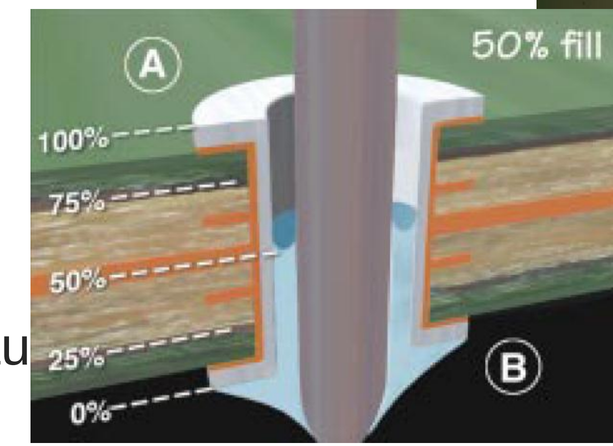
Capable

Not Capable

OSP Issues: Plated Through-Hole Fill

- Solder fill is driven by capillary action
- Important parameters
  - Hole diameter, hole aspect ratio, wetting force
  - Solder will only fill as long as its molten (key point)
- OSP has lower wetting force
  - Risk of insufficient hole fill
  - Can lead to single-sided architectu
- Solutions:
  - Changing board solderability plating
  - Increasing top-side preheat
  - Increasing solder pot temperature (some go as high as 280ºC)
    - Not recommended!
  - Changing your wave solder alloy

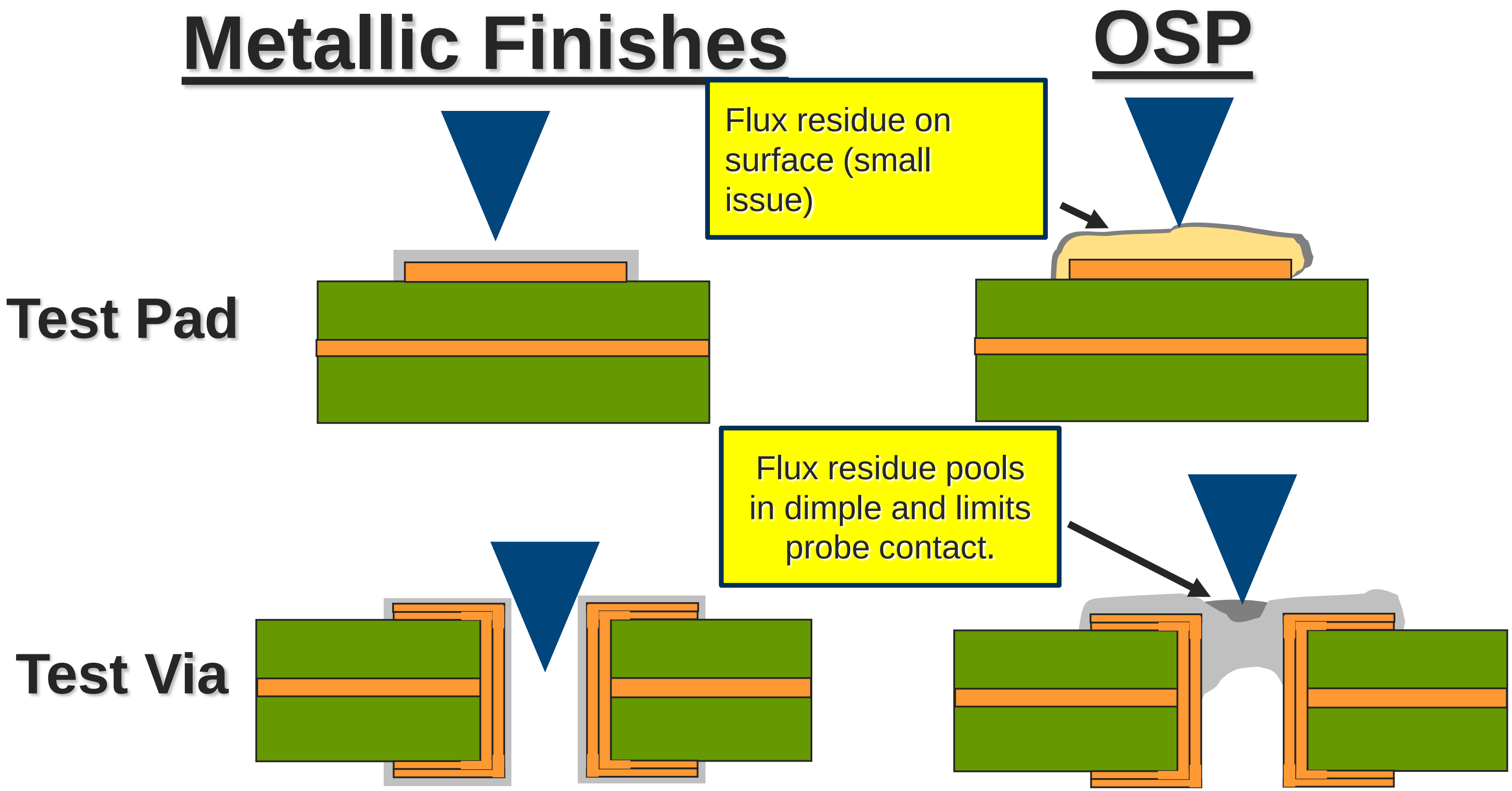





P. Biocca, Kester

In Circuit Test w/ OSP – test via challenges

- Probing through HT OSP is not recommended.
- Solder paste is printed over OSP test pads/vias (leaving flux residue with no-clean paste).



Space constraints on PCB make it difficult to eliminate test vias.

Surface Finish Selection Guideline

Product Attributes

ImAg

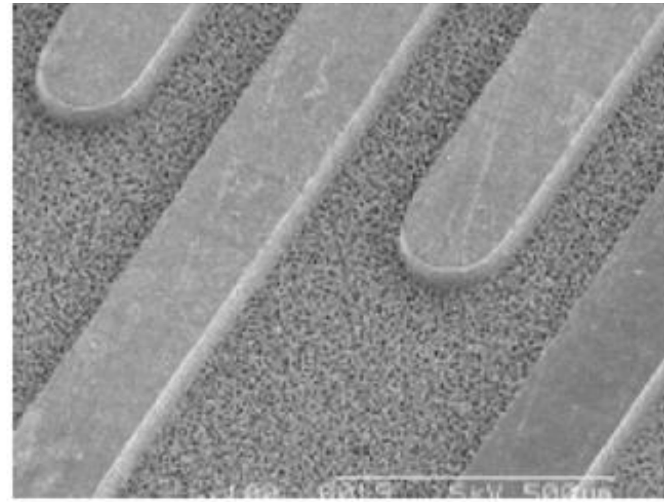
- Cost Sensitive Product
- High Volume Required
- Cosmetics of Finish is Important
- High Yield ICT Required
- Pb-Free Wave Solder (PCB > 62mil)
- Pb-Free Shock/Drop is a Concern
- Fine Pitch Components Used
- Corrosion Failure is Possible
- Wire bonding to Finish is Required

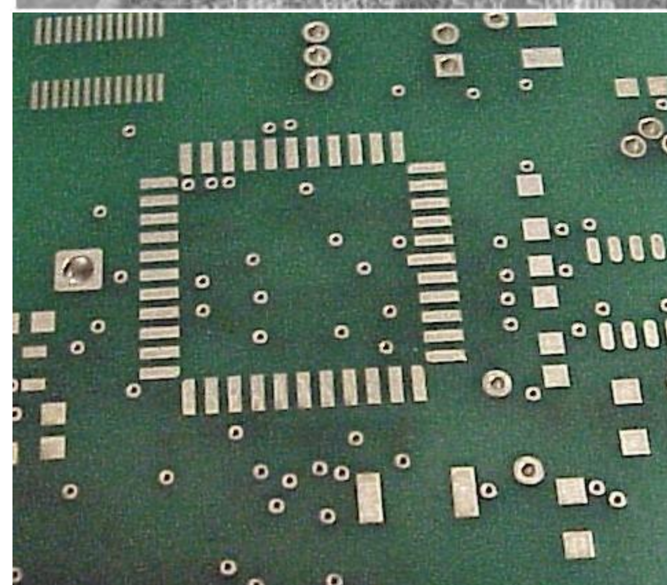
Capable

Not Capable

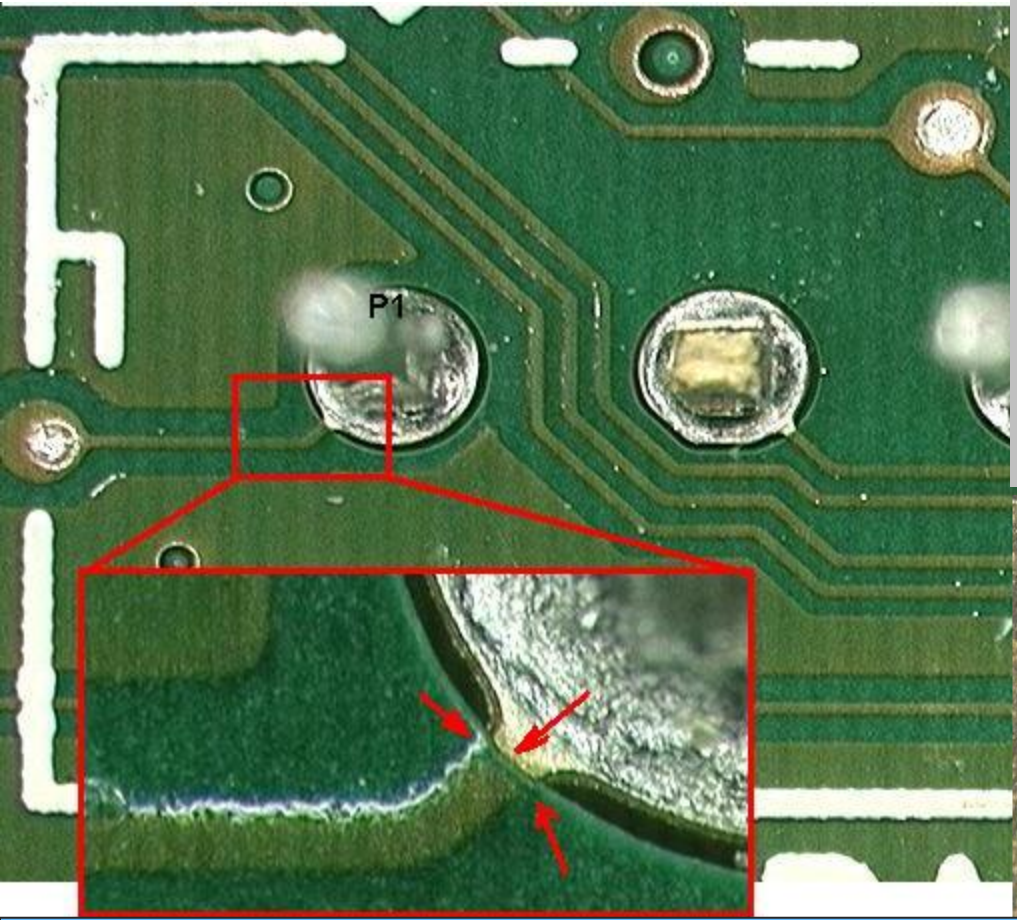
Immersion Silver Ag (ImAg)

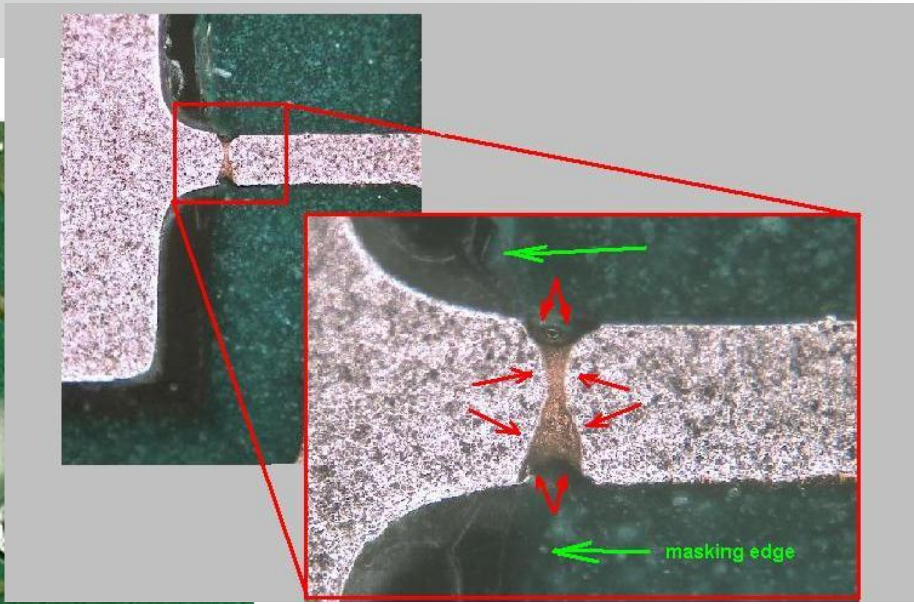
- Single material system
  - Specified by IPC-4553
- Thickness is typically 6-20 u”
- Benefits
  - Good flatness & coplanarity
  - Good shelf life if packaged properly.
  - Good oxidation resistance & shelf life.
  - Good wettability and reflow performance.
  - Good testability
  - Low cost

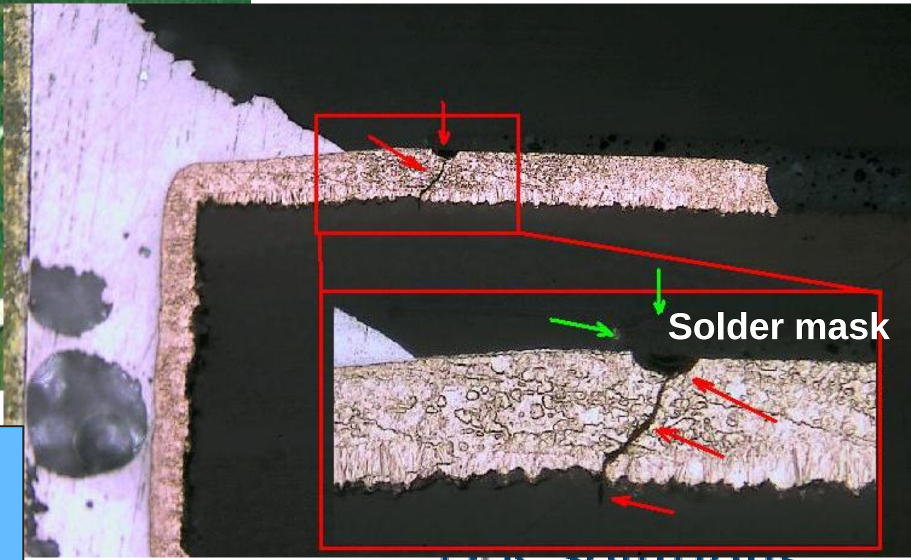




ImmAg Trace Etching

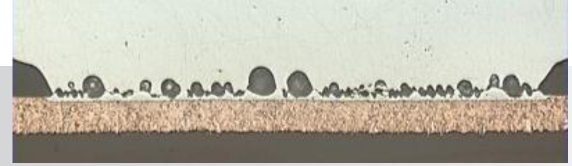






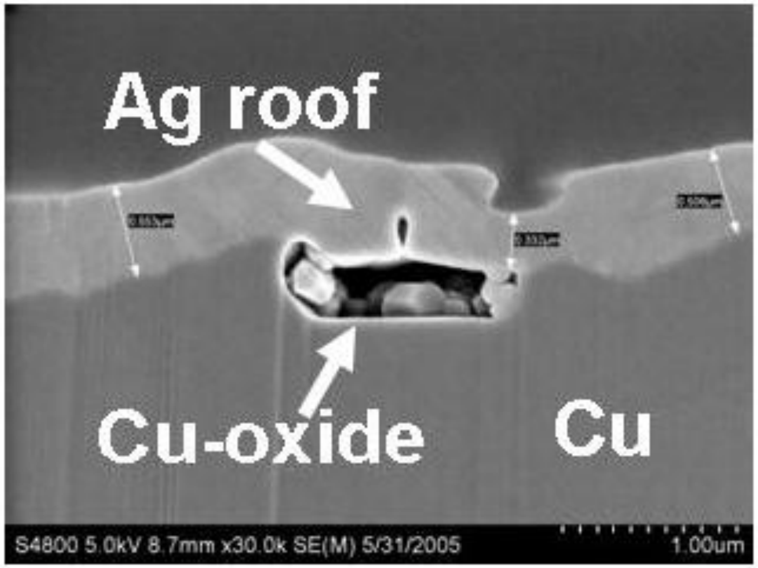
Galvanic etching can occur SM edge if PCB rinsing and drying not adequately performed.

ImAg - Microvoids



- Void under silver causes void at interface.

Microvoids survived shock testing but cause early failure in thermal cycling.



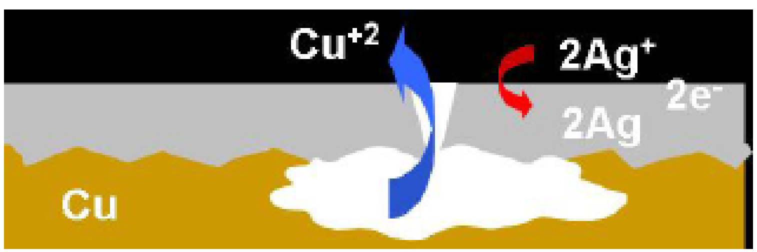
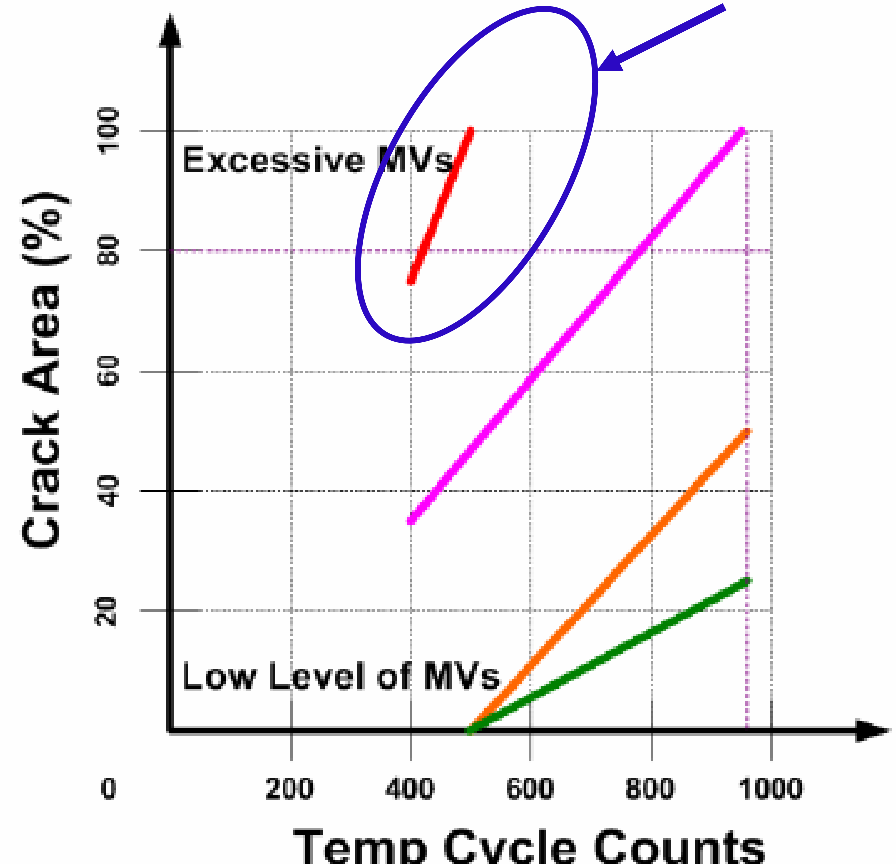
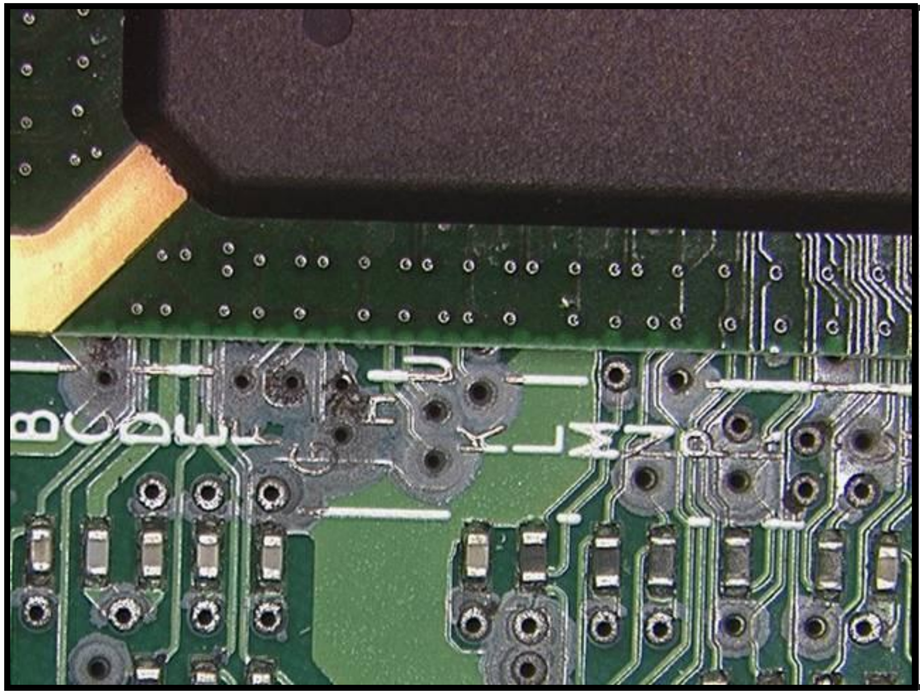


Figure 31. The small Cu area with respect to the surrounding Ag surface bias the current density causing Cu+ ions to stream-out into the ImAg bath, at the same time, the Cu- electrons re-routed to satisfy Ag+ ion reduction away from this region.

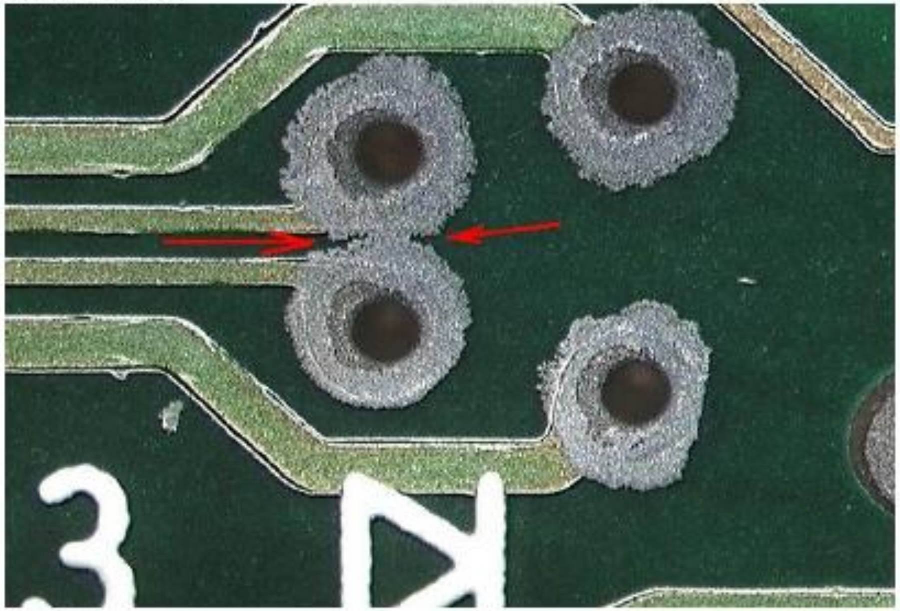


Ref: Mukadam, "Planar Microvoids in LF Solder Joints", SMTA, 2006.

Typical Creep Corrosion



PICTURE 3361_1a1 SHOWING A CLOSE-UP OF THE BRIDGING GROWTH BETWEEN VIAS.



• Corrosion product is poorly conductive (resistance of about 1Mohm).

• Conductivity is higher when the humidity is high.

• Field returns often function fine – since corrosion product has dried out.

• Features most sensitive to leakage current will trigger the system failure (failing symptoms can vary system-to-system).

• Visual inspection is often required to diagnose.

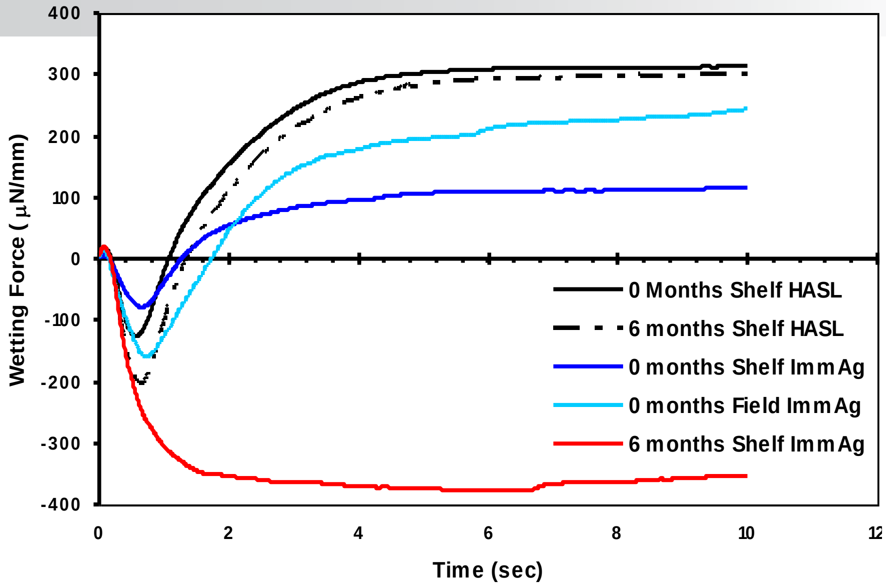
ImAg Creep Corrosion - Affected Locations

- Paper mills
- Rubber manufacturing (tires for example).
- Fertilizer
- Waste water treatment
- Mining/smelting
- Cement or asphalt production
- Petrochemical
- Clay modeling studios
- Regions of the world with poor air quality
- Etc. - includes companies nearby such industries

- Product is less impacted if airflow to PCBA is restricted.

Impact of Tarnish

- Shelf life can be an issue
  - If not stored in protective bags
  - Significant degradation when exposed to corrosive gases



- Tarnish after assembly is mostly cosmetic – but will impact perception of quality.
- If PCBA is visible to user tarnish may be an issue.
- Scrap costs may increase considerably if PCBAs are repaired and sent back into service.
  - Boards that appear black but are still functional are often thrown out.

Surface Finish Selection Guideline

Product Attributes

Cost Sensitive Product

High Volume Required

Cosmetics of Finish is Important

High Yield ICT Required

ImSn

Pb-Free Wave Solder (PCB > 62mil)

Pb-Free Shock/Drop is a Concern

Fine Pitch Components Used

Corrosion Failure is Possible

Wire bonding to Finish is Required

Capable

Not Capable

Immersion Sn (ImSn)

- A single material system
  - Specified by IPC-4554
    - Standard thickness: 1 micron (40 microinches)
    - Some companies spec up to 1.5 microns (65 microinches)

- Benefits
  - Excellent flatness, low cost

- Not as popular a choice with PCB fabricators.
  - Environmental and health concerns regarding thiourea (a known carcinogen)
  - Some concern regarding tin whiskering (minimal)

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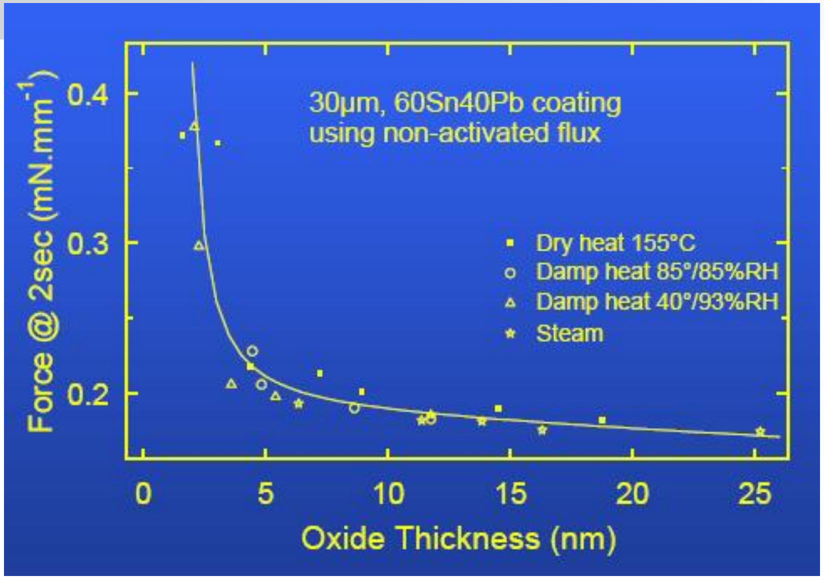
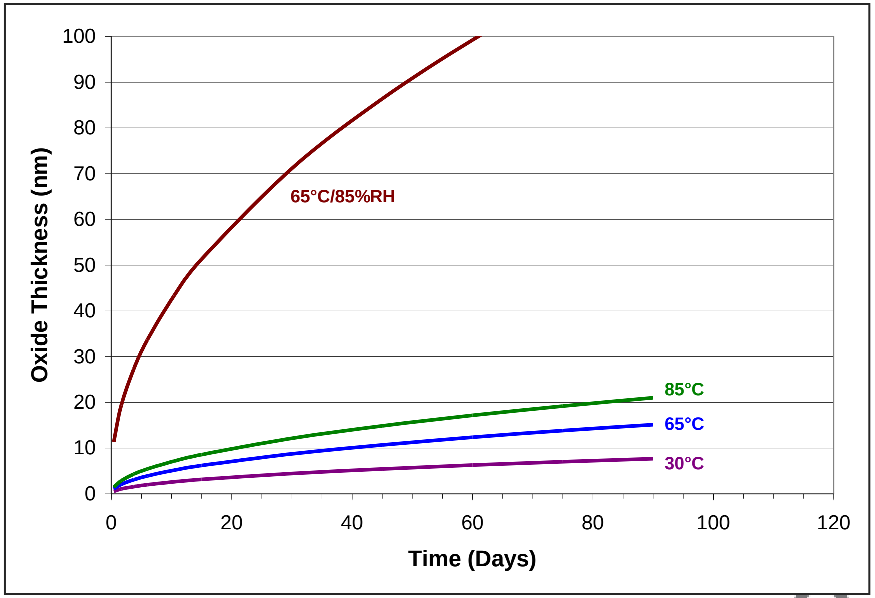
ImSn: Quality Issues & Failure Mechanisms

- Insufficient thickness.
  - **Decreases solderability during storage or after 2nd reflow – due to IMC growth through the thickness.**
- Solderability problems with Oxide thickness greater than 5 nm.
  - Excessive oxide thicknesses (50-100nm) periodically observed.
- Drivers of oxidation.
  - Exposure to humid conditions (>75%RH)
    - Greatly accelerates oxide growth through the creation of tin hydroxides.
      - Use sealed moisture/air tight wrapping for shipping and cool, low humidity storage.
  - Cleanliness of the raw board.
    - Contaminates breaks down self-limiting nature of tin oxides.
    - Accelerates oxide growth.





Surface Finish Selection Guideline

Product Attributes

Cost Sensitive Product

High Volume Required

Cosmetics of Finish is Important

High Yield ICT Required

ENIG
ENEPIG

Pb-Free Wave Solder (PCB > 62mil)

Pb-Free Shock/Drop is a Concern

Fine Pitch Components Used

Corrosion Failure is Possible

Wire bonding to Finish is Required

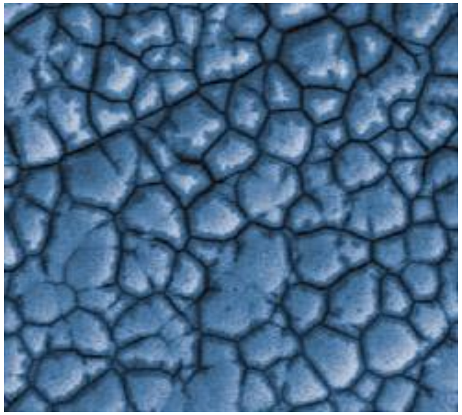
Capable

Not Capable

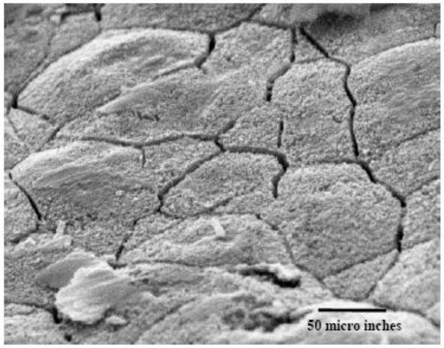
ENIG: Primary Reliability Risks

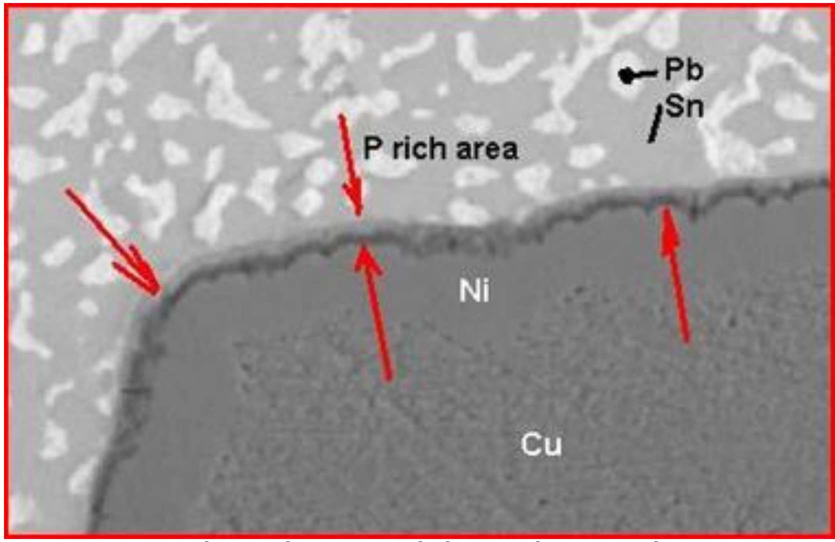
- Black pad drivers
  - Phosphorus content
    - High levels = weak, phosphorus-rich region after soldering
    - Low levels = hyper-corrosion (black pad) Insufficient Phosphorous will not prevent corrosion during the highly acidic immersion gold (IG) process.
  - Cleaning parameters
  - Gold plating parameters
  - Bond pad designs
- Causes a drop in mechanical strength
  - Difficult to screen
  - Can be random (e.g., 1 pad out of 300)

- Ni-Sn intermetallic produces a brittle interface when used with SAC solder.



Images of Black Pad





Phosphorus-Rich Dark Streak

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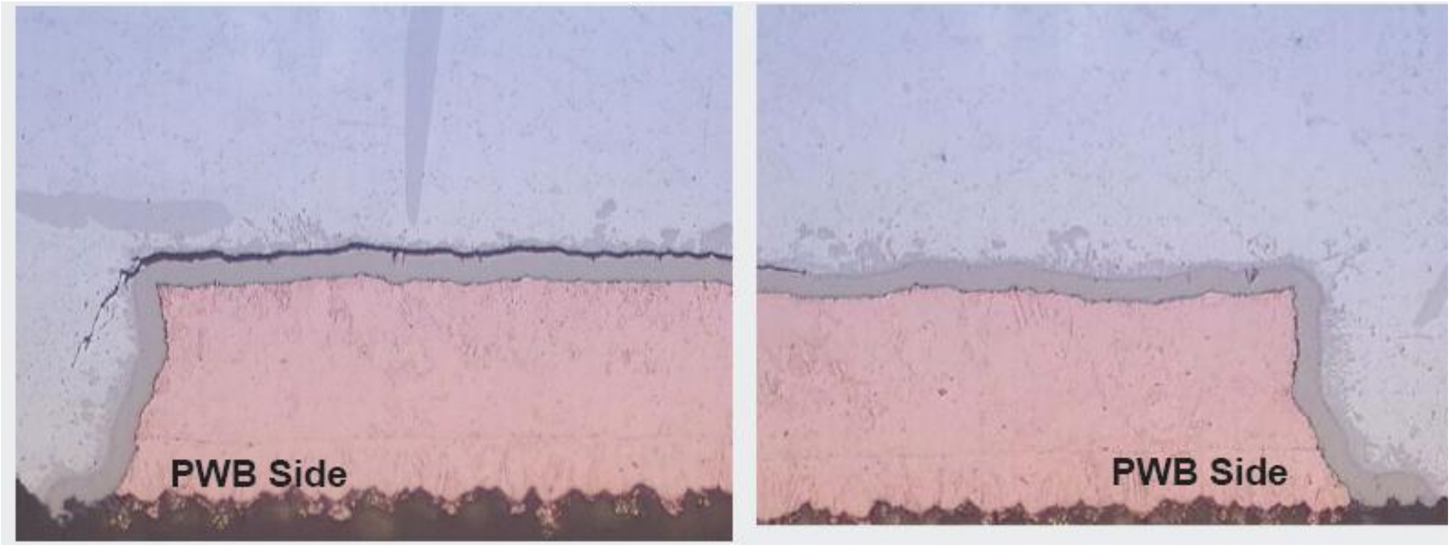
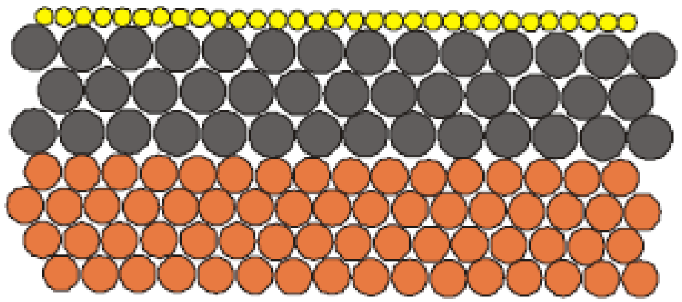
ENIG - Ni Interface Issues w/ SAC



Brittle SnNi intermetallics fail more easily with a high modulus LF solder ball. These cracks resulted from product handling.

Electroless Nickel/Immersion Gold (ENIG)

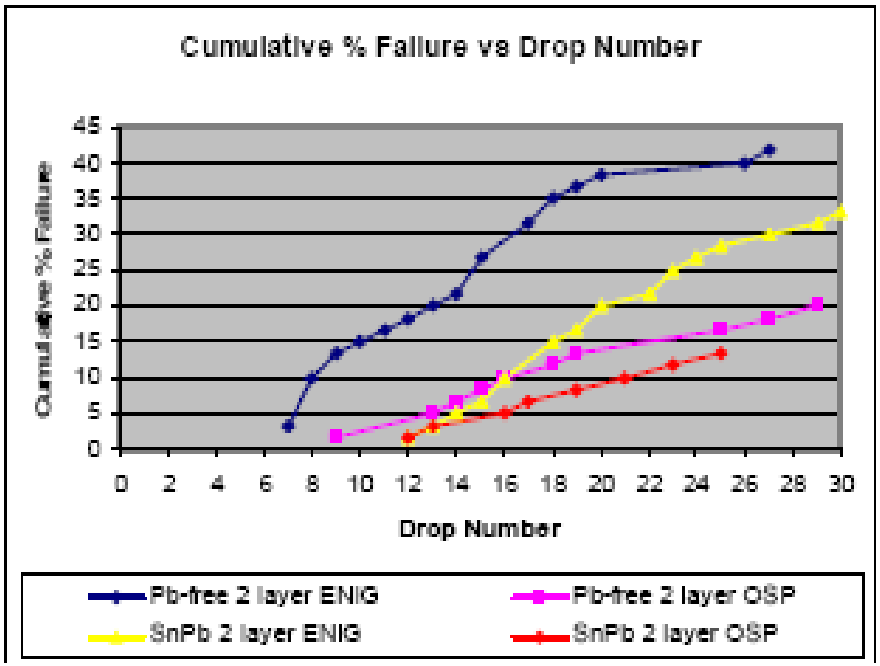
- Two material system.
  - Defined by IPC-4552 Specification for Electroless Nickel/Immersion Gold.
  - Electroless nickel.
    - 3 – 6 microns
  - Thin Immersion gold top coat
    - 0.08-0.23 microns

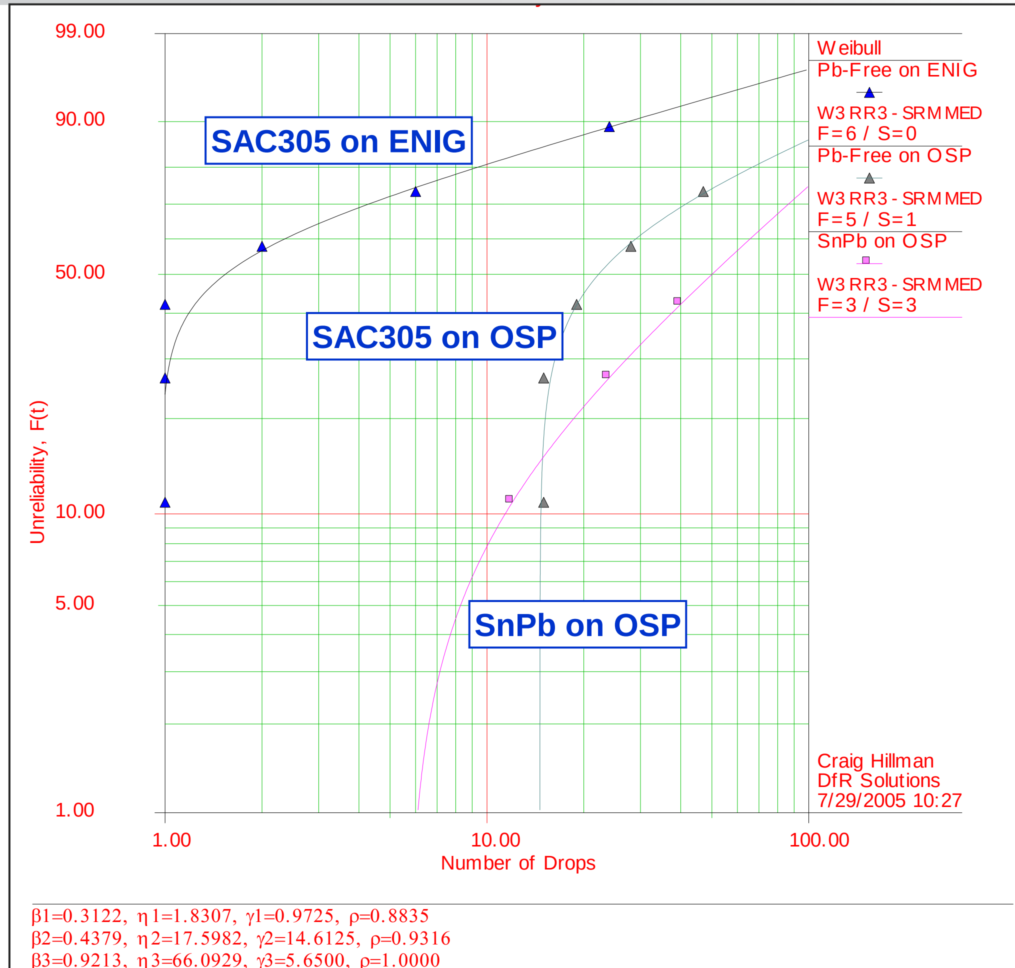


- Benefits
  - Excellent flatness and long-term storage (shelf life).
  - Excellent oxidation resistance and wetting properties.
  - Robust for multiple reflow cycles,
  - Supports alternate connections (wirebond, separable connector) & electrical testability.
  - Moderate costs.
  - Gold readily dissolves into solder and does not tarnish or oxidize making it an excellent choice for a surface finish.
    - But gold cannot be directly plated onto copper, since copper diffuses into gold, which allows the Cu to reach the surface and oxidize which reduces solderability.
    - Nickel is serves as a barrier layer to copper, the thin gold coating protects the nickel from oxidizing.

ENIG: Mechanical Shock with SAC305 solder

- ENIG Less Robust than OSP.
- SAC less robust than SnPb
- Plating is an important driver
  - SnNi vs. SnCu intermetallics





35x35mm, 312 I/O BGA

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Reliability Test Plan?

- It is the process of ensuring the product design and manufacturing process are sufficiently robust to provide the product performance and lifetime required by the customer in their use environment
- What does this mean?
  - Testing should not be performed on prototypes
  - Validate the Pb-free process before or as part of the product qualification
  - Relevant failure modes and their environmental stressors must be identified
  - Acceleration factors must be determined to calculate test parameters and length

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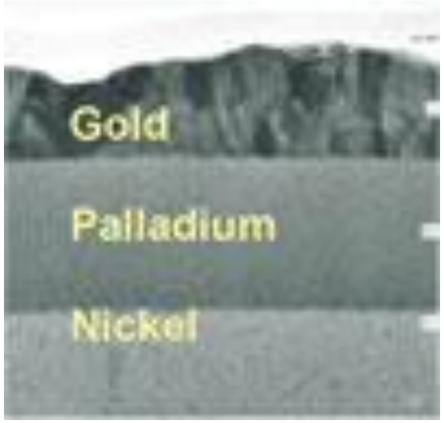
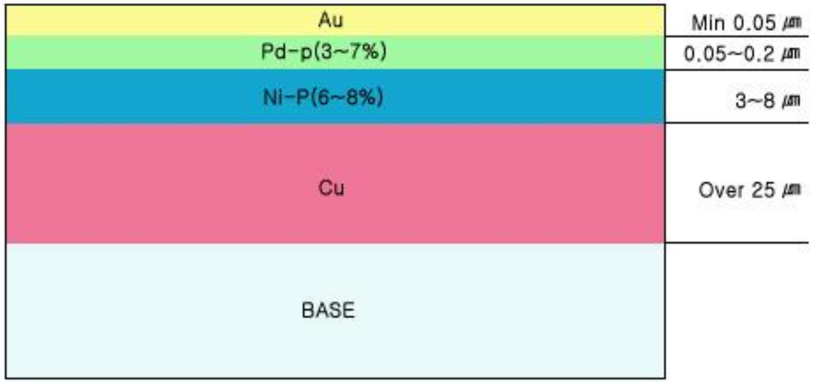
ENEPIG

- Electroless nickel, electroless palladium, immersion gold
  - Initially aimed at IC packages and microelectronics
  - Most common lead finish after tin



- Thicknesses
  - Nickel: 5um / 200 µin (120-240)
  - Palladium: 0.15um / 6 µin (2-15)
  - Gold: 0.1um / 4 µin (2 to 8)



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ENEPIG Advantages

- Long-term storage (similar to ENIG)
- Solderable and wire bondable (unlike ENIG)
  - Gold and aluminum wire bonds
  - Traditional surface finishes would require ENIG (electroless nickel, immersion gold) over the SMT pads and an additional soft bondable gold over the wire bond pads.
  - Combined cost of ENIG and soft bondable gold process can be more than the higher raw material price of ENEPIG
- NO black pad (unlike ENIG)

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ENEPIG Concerns

- Need to maintain control over palladium thickness
  - When used as lead finish, thick palladium can sometimes result in wetting issues
- Does not wet as well as HASL
- Not widely available
- More complex process
  - Three plating steps; violates keep it simple (KIS) principle

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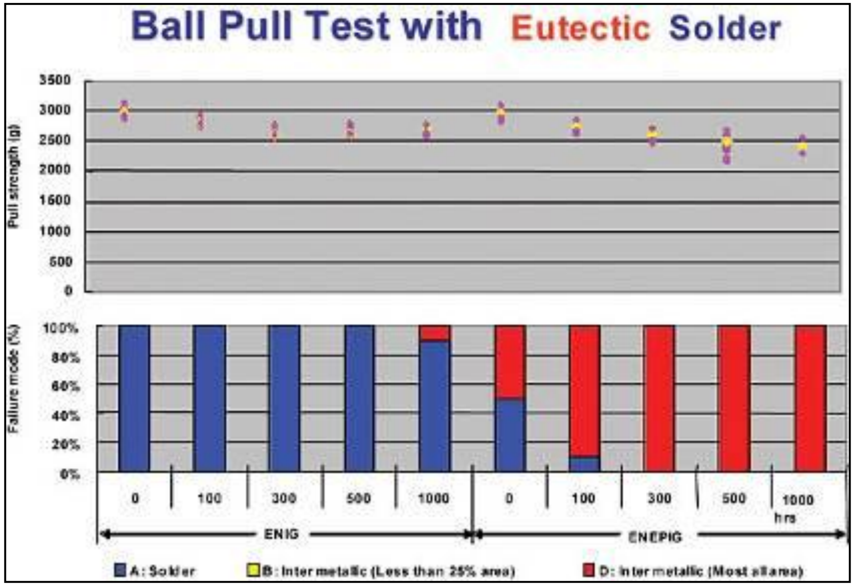
ENEPIG Concerns

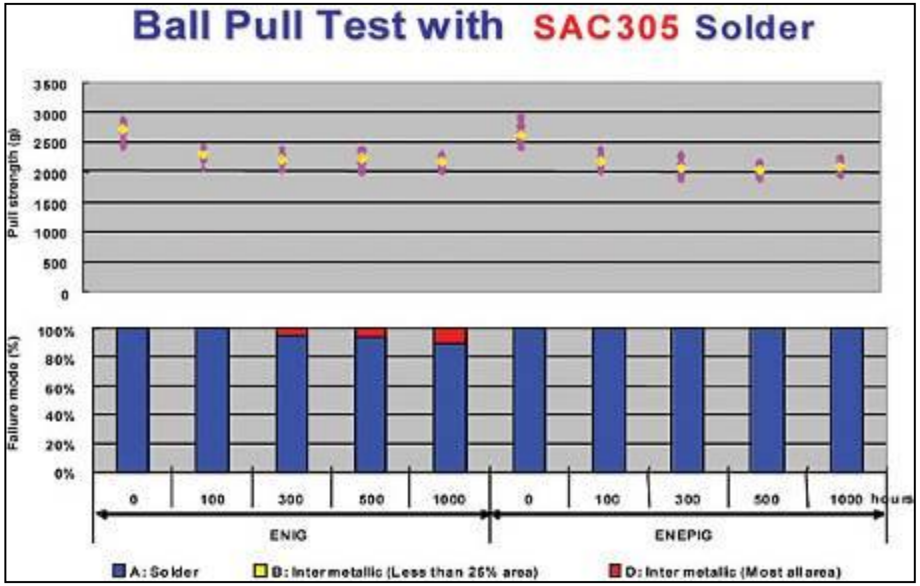
- Thick palladium can also result in decrease in solder joint strength (grams-force)

	Au um								
Pd um	0.03	0.05	0.07	0.1	0.15	0.2	0.25	0.3	0.4
0.01	90	90	90	90	90	80	80	55	60
0.02	100	100	100	100	100	90	90	90	90
0.03	100	100	100	100	100	100	100	100	90
0.05	100	100	100	100	100	100	100	100	90
0.07	100	100	100	100	100	100	90	90	90
0.10	90	90	90	90	90	90	80	80	80
0.12	85	85	83	8	80	80	60	73	55
0.15	50	60	60	55	55	55	55	60	
0.20	50	60	50	55	58	60	30	35	30
0.30	20	45	40	30	20	30	20	30	30

Uyemura, G. Milad

ENEPIG (cont.)





- Shows embrittlement with SnPb
  - Lack of copper results in uneven dispersion of Pd in intermetallic layer
  - Copper necessary for stable IMC growth, strong bond (Cu,Ni/Sn+Pd)
  - Could be an issue with low-copper Pb-free alloys (i.e., SnBi)

- Bonding of SAC305 with nickel is still suspect
  - Consistency of Pd's influence has not been validated

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ENEPIG

- Gold thickness needs to be maintained for sufficient wire bond strength
  - Compatibility with copper uncertain

	Au um								
Pd um	0.03	0.05	0.07	0.1	0.15	0.2	0.25	0.3	0.4
0.00	0.00	4.3	4.4	3.9	3.8	3.7	5.1	8.6	9.1
0.01	6.8	7.9	7.9	8.1	8.7	8.6	9.6	10.6	10.5
0.02	6.7	7.9	8.6	8.2	8.5	9.0	9.5	10.2	10.7
0.03	6.0	7.7	8.4	8.2	8.2	9.3	9.3	10.7	10.4
0.05	6.8	7.6	8.9	8.1	8.2	9.1	9.3	10.1	10.6
0.07	7.0	7.8	8.1	8.3	8.8	9.5	9.1	10.9	11.1
0.10	6.0	6.7	8.1	8.3	8.4	9.3	9.2	10.0	10.8
0.12	7.2	8.4	8.9	8.8	8.9	9.5	9.6	10.9	10.5
0.15	6.5	8.5	8.6	8	9.1	9.4	10.2	10.3	10.7
0.20	6.0	8.8	8,9	8.7	9.1	9.4	10.0	10.3	10.5
0.30	6.6	8.8	8,5	8.3	9.0	9.6	10.0	10.2	10.6

Wire pull testing: Average of 20 wires (grams-force)

Direct Immersion Gold

- Combination immersion and electroless
  - Claims of pore-free gold surface
  - Normal immersion gold has trouble properly attaching to copper surface
- Developed specifically for parts where nickel could create RF interference.
- To avoid the inherent problems of copper migration through the thin gold surface, it is necessary for these parts to go to final assembly within four months
  - Not widely used

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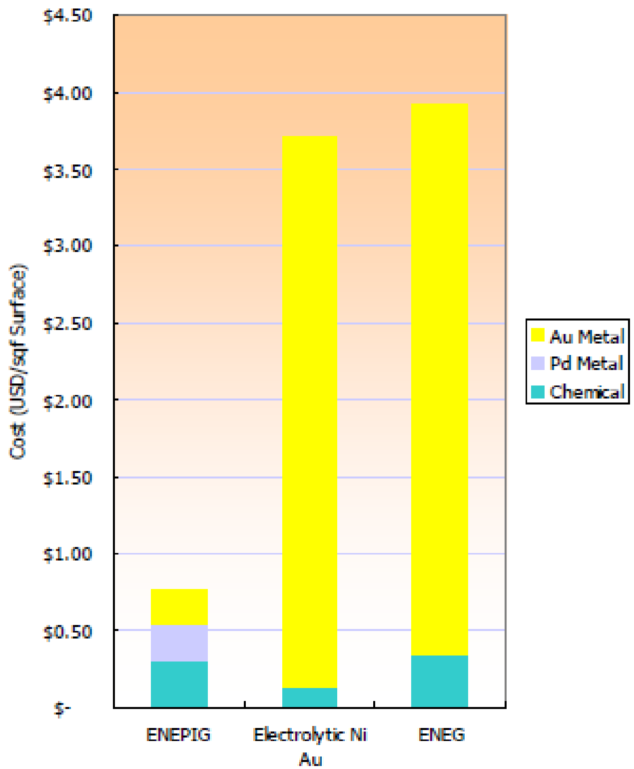
Some Comparative Cost Information

ROHM AND HAAS ELECTRONIC MATERIALS
CIRCUIT BOARD TECHNOLOGIES

Cost Comparison



Metal	Oct 06 Average Metal Price (USD/g)	Density (g/cc)		
		Metal	Electrolytic	Electroless
Gold	20.35	19.30	19.00	19.00
Palladium	10.69	12.00	11.90	10.00

Assumptions

- Plating area 15%
- Metal running cost includes processing charge

Deposit Thickness (µm)	ENEPIG	E'lytic Ni/Au	ENEG
Gold	0.03	0.5	0.5
Palladium	0.1	-	-

Dennis Yee, April 2007

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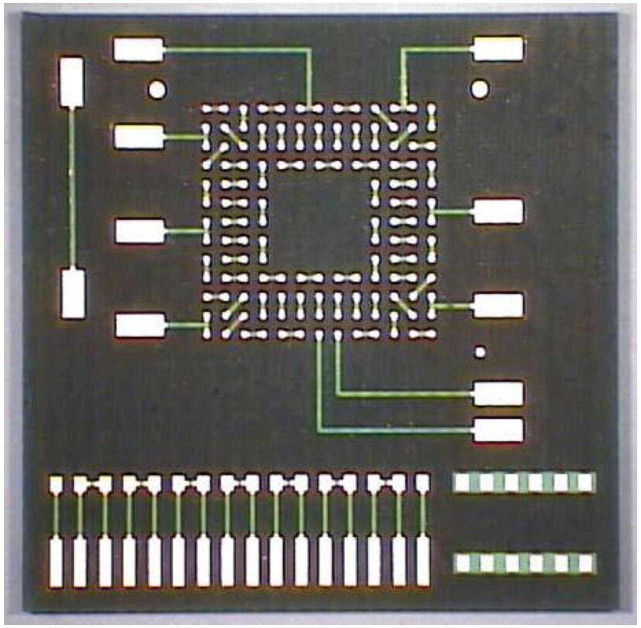
ENEPIG – Raytheon Reliability Study

- ENEPIG Reliability Conclusions
  - Visual, Functional, X-Ray and Shear Tests All Passed
  - Trace Durability Tests Passed
  - Pd Thickness Had No Effect on Wire Bond Results
  - Suppliers, Designs and Applications Outside the Scope of the Work Seek Further Validation
  - ENEPIG Has Potential as a Viable Low Cost Board Finish for Wire Bonding and Sn63 Soldering



Surface Finish Selection Guideline

Product Attributes

Cost Sensitive Product

High Volume Required

Cosmetics of Finish is Important

High Yield ICT Required

Pb-Free HASL

Pb-Free Wave Solder (PCB > 62mil)

Pb-Free Shock/Drop is a Concern

Fine Pitch Components Used

Corrosion Failure is Possible

Wire bonding to Finish is Required

Capable

Not Capable

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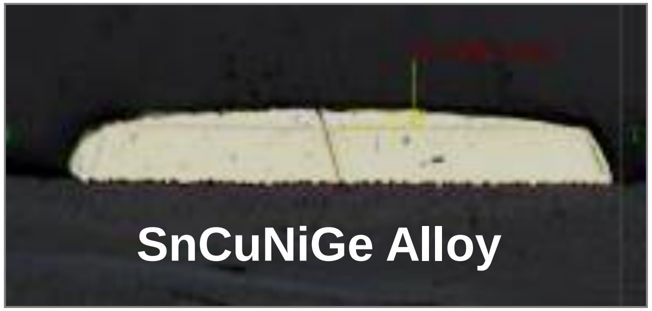
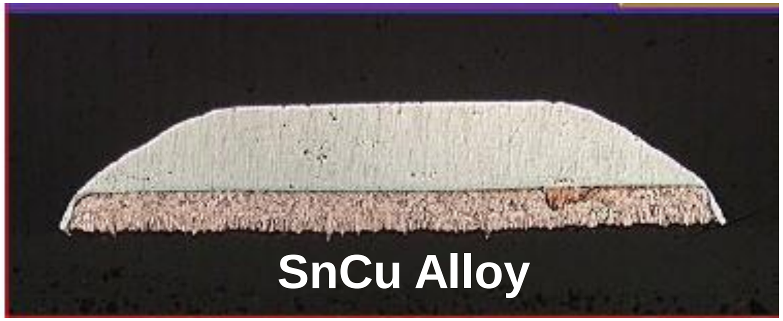
Solderability Plating: Pb-Free HASL

- Increasing Pb-free solderability plating of choice
- Primary material is Ni-modified SnCu (SN100CL)
  - Initial installations of SAC being replaced
  - Only Vicor recently identified as using SAC HASL (Electronic Design, Nov 2007)
  - Co-modified SnCu also being offered (claim of 80 installations [Metallic Resources])
- Selection driven by
  - Storage
  - Reliability
  - Solderability
  - Planarity
  - Copper Dissolution

Pb-Free HASL: Ni-modified SnCu

- Alloy selection is critical.
  - Sn-Cu will result in high Cu dissolution and poor planarity.
  - SnCuNiGe provides high fluidity and reduced Cu dissolution.





- Role of constituents
  - **Cu** creates a eutectic alloy with lower melt temp (227C vs. 232C), forms intermetallics for strength, and reduces copper dissolution
  - **Ni** suppresses formation of β-Sn dendrites, controls intermetallic growth, grain refiner
  - **Ge** prevents oxide formation (dross inhibitor), grain refiner

Pb-free HASL: Storage

- PCBs with SnPb HASL have storage times of 1 to 4 years
  - Driven by intermetallic growth and oxide formation
- SN100CL demonstrates similar behavior
  - Intermetallic growth is suppressed through Ni-addition
  - Oxide formation process is dominated by Sn element (similar to SnPb)
- Limited storage times for alternative Pb-free platings (OSP, Immersion Tin, Immersion Silver)

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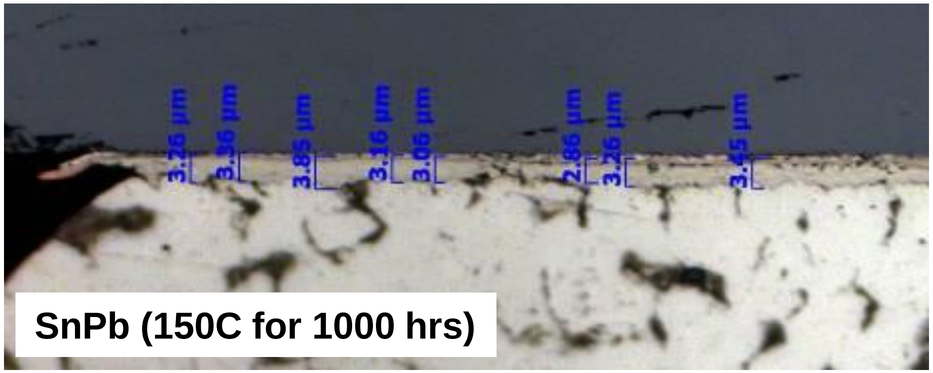
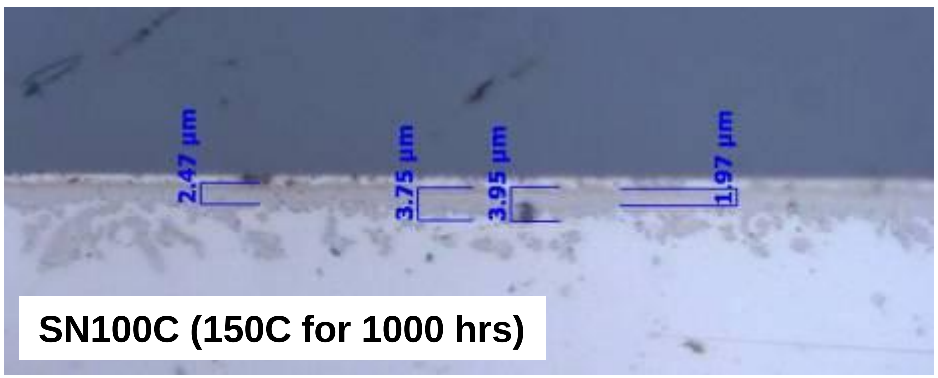
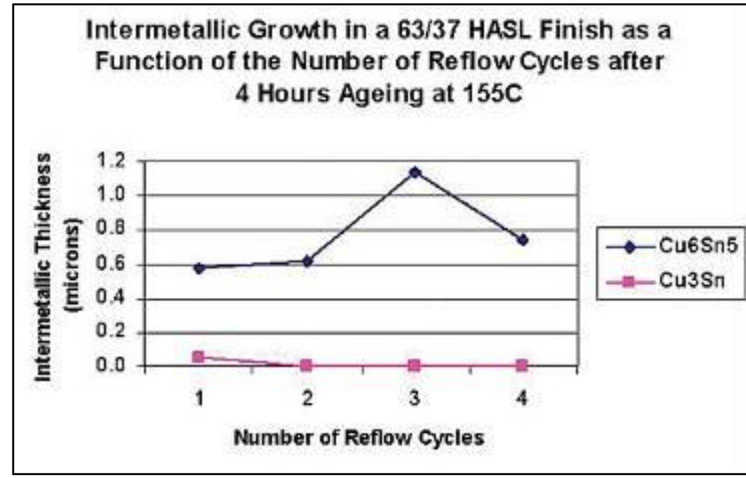
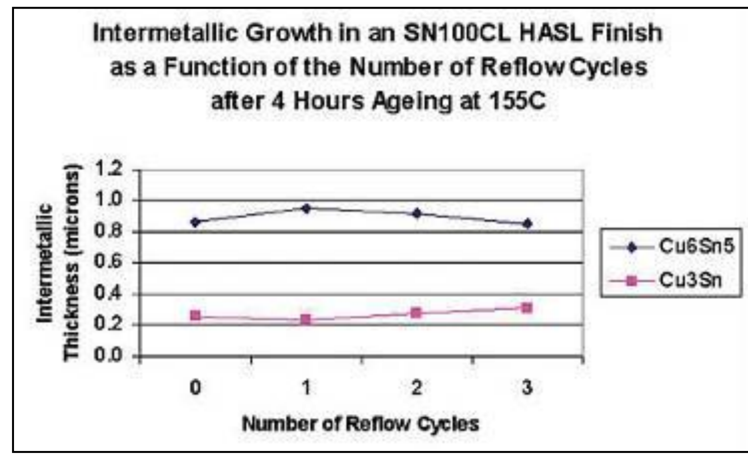
Pb-Free HASL: Intermetallic Growth









- Similar intermetallic thickness as SnPb after long-term aging and multiple reflows

HASL and Flow: A Lead-Free Alternative, T. Lentz, et. al., Circuitree, Feb 2008, http://www.circuitree.com/Articles/Feature_Article/BNP_GUID_9-5-2006_A_10000000000000243033

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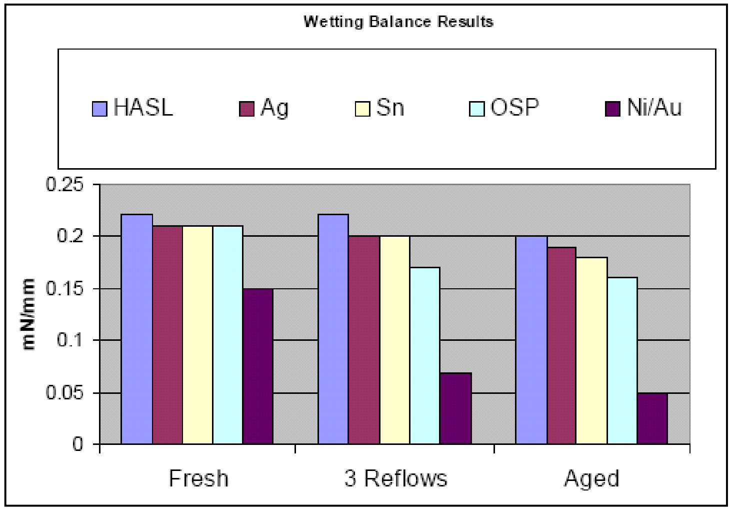
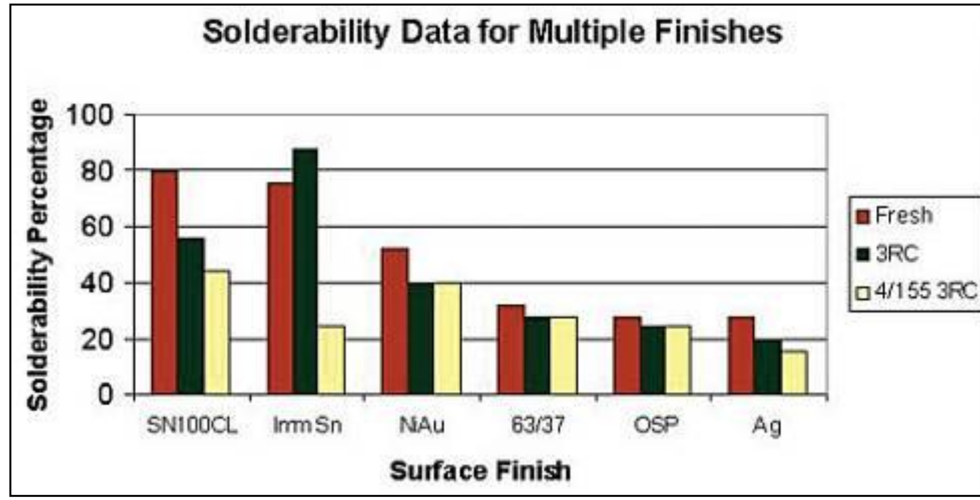
Pb-Free HASL: Solderability

- Industry adage: Nothing solders like solder





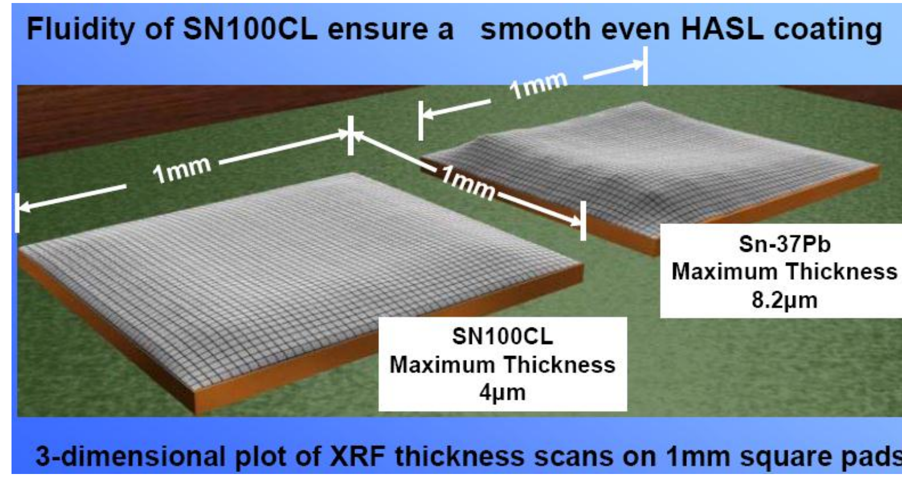
- Discussions with CMs and OEMs seem to indicate satisfaction with Pb-free HASL performance
  - Additional independent, quantitative data should be gathered
- Improved solderability could improve hole fill

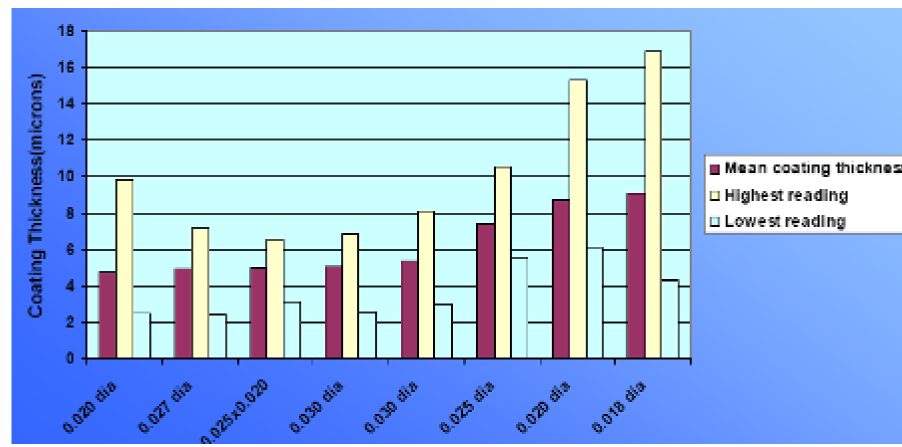
http://www.daleba.co.uk/download%20section%20-%20lead%20free.pdf

HASL and Flow: A Lead-Free Alternative, T. Lentz, et. al., Circuitree, Feb 2008, http://www.circuitree.com/Articles/Feature_Article/BNP_GUID_9-5-2006_A_10000000000000243033

Pb-Free HASL: Planarity

- Recommended minimum thickness
  - 100 uin (4 microns)
  - Lower minimums can result in exposed intermetallic
- Primary issue is thickness variability
  - Greatest variation is among different pad designs
  - 100 uin over small pads (BGA bond pads); over 1000 uin over large pads
- Can be controlled through air knife pressure, pot temperatures, and nickel content





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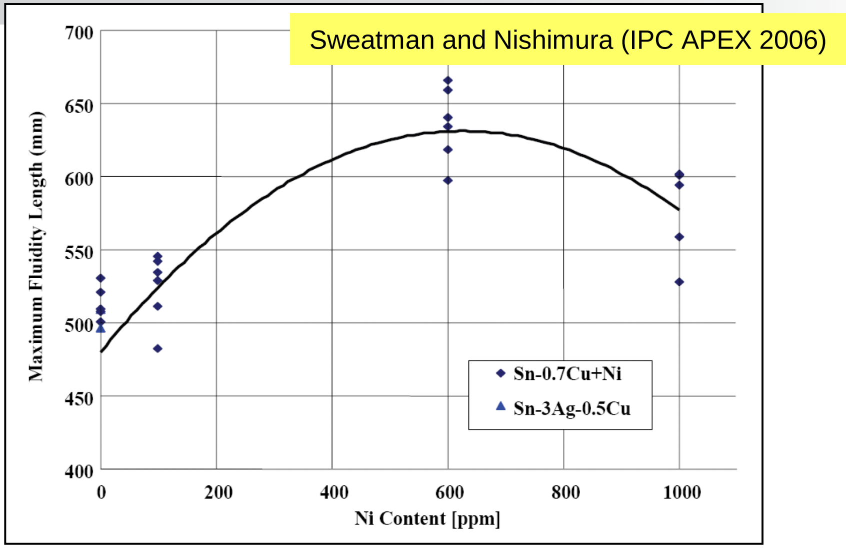
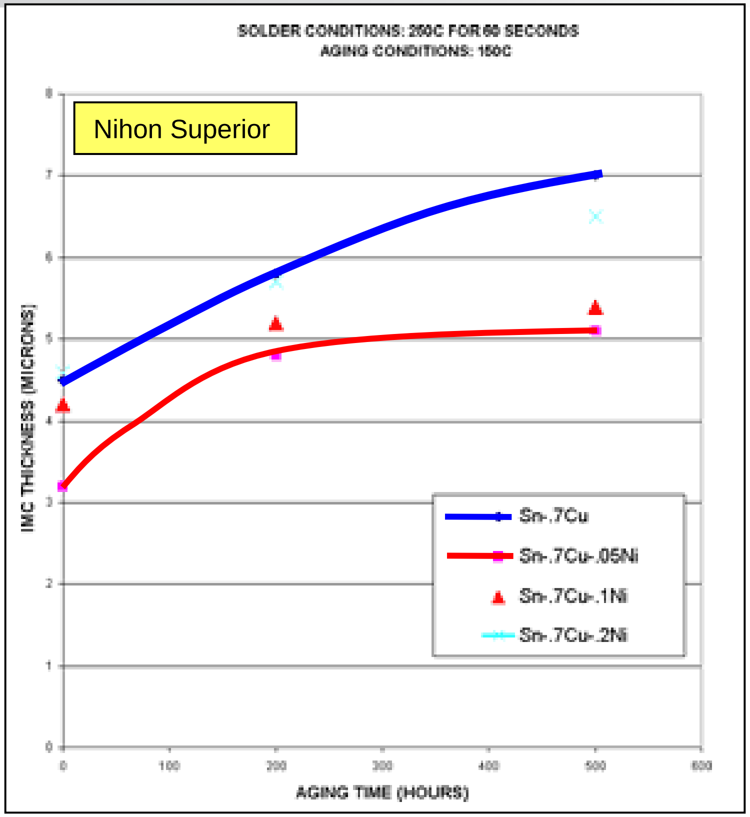
Pb-Free HASL: Planarity (cont.)

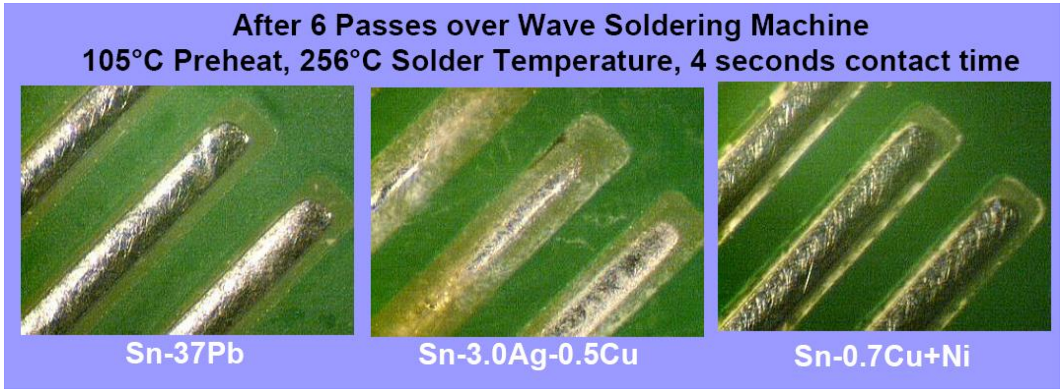


- Air knives
  - Pb-free HASL requires lower air pressure to blow off excess solder
- Pot Temperatures
  - SnPb: 240C to 260C
  - SN100CL: 255C to 270C (air knife temp of 280C)
- Ni content
  - Variation can influence fluidity
    - Minimum levels critical for planarity
  - Some miscommunication as to critical concentrations

Pb-Free HASL: Copper Dissolution

- Presence of nickel is believed to slow the copper dissolution process
  - SAC HASL removes ~5 um
  - SNC HASL removes ~1 um





www.p-m-services.co.uk/rohs2007.htm

www.pb-free.org/02_G.Sikorcin.pdf

www.evertiq.com/news/read.do?news=3013&cat=8 (Conny Thomasson, Candor Sweden AB)

Pb-Free HASL: Additional Concerns

- Risk of thermal damage, including warpage and influence on long term reliability (PTH fatigue, CAF robustness)
  - No incidents of cracking / delamination / excessive warpage reported to DfR to date
  - Short exposure time (3 to 5 seconds) and minimal temp. differential (+5°C above SnPb) may limit this effect
- Compatibility with thick (>0.135”) boards
  - Limited experimental data (these products are not currently Pb-free)
- Mixing of SNC with SAC
  - Initial testing indicates no long-term reliability issues (JGPP)

LF HASL – Critical Parameters

Pre-Clean:

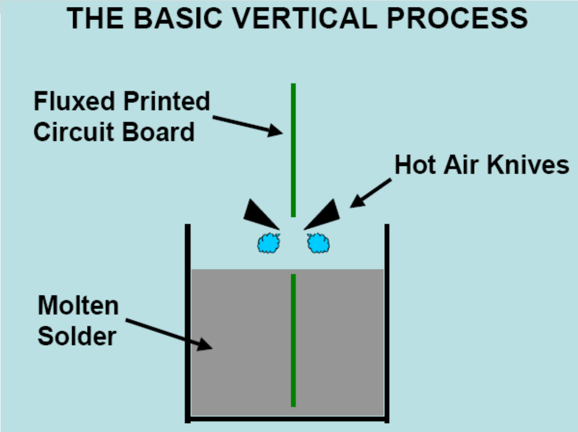
- Micro-etching rate
- Flux

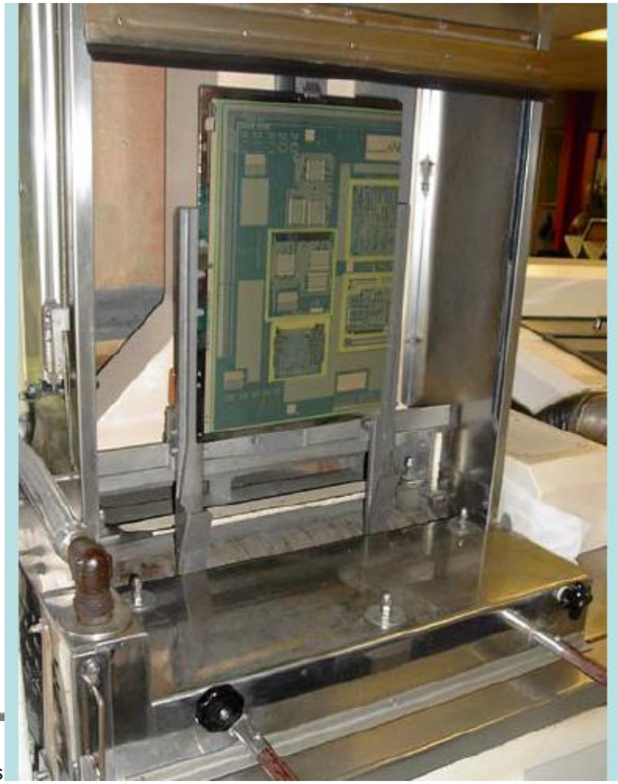
HASL:

- LF Alloy
- Pot temperature (~265C)
- Front & Back air knife pressure
- Front & Back air knife angle
- Distance between air knife & PCB
- Lifting speed
- Dwell time (~ 2-4 sec)

Post-Clean:

- Final flux clean and rinsing





Newer Finishes to the Market

Product Attributes

Cost Sensitive Product

Lower cost than ENIG

High Volume Required

Cosmetics of Finish is Important

High Yield ICT Required

EPd

Pb-Free Wave Solder (PCB > 62mil)

Pb-Free Shock/Drop is a Concern

Fine Pitch Components Used

Corrosion Failure is Possible

Needs verification

Wire bonding to Finish is Required

Capable

Not Capable

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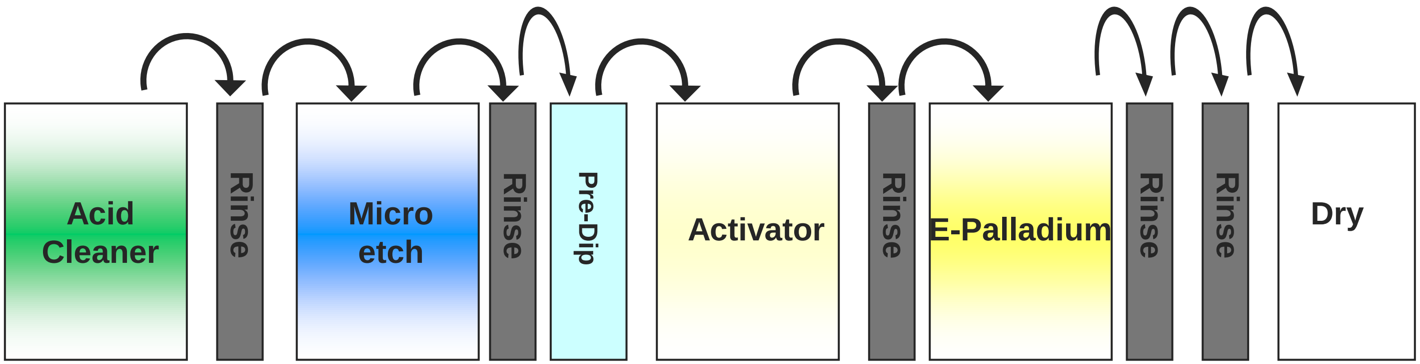
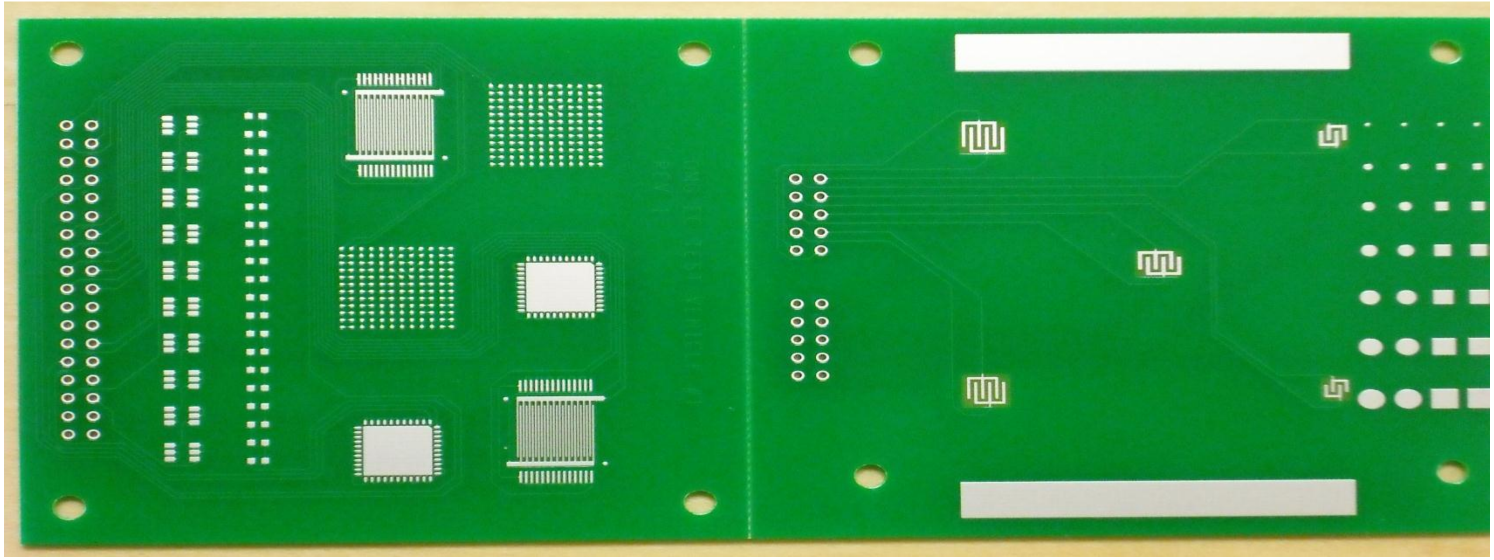
Electroless Pd

Process Sequence





Courtesy of OMGI

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Newer Finishes to the Market

Product Attributes

Cost Sensitive Product

High Volume Required

These will become more favorable with time.

Cosmetics of Finish is Important

High Yield ICT Required

Nanofinish & Plasma

Pb-Free Wave Solder (PCB > 62mil)

Pb-Free Shock/Drop is a Concern

Fine Pitch Components Used

Corrosion Failure is Possible

Wire bonding to Finish is Required

Capable

Not Capable

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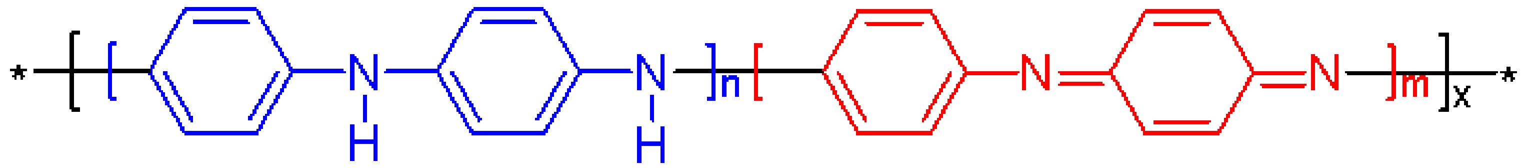
What is Nanofinish?

- Nanofinish was released by Ormecon in 2007 (purchased by Enthone in 2008)
  - After 5 to 10 years of research
  - Currently used in structural applications (e.g., iron)
- Nanofinish is described as an organic nanometal
  - Consists of a conductive polymer (polyaniline) complexed with nanoparticles of silver
  - Total thickness is 50 nm; silver particles are nominally 4 nm



Chemical structure of polyaniline (PNI or PANI)

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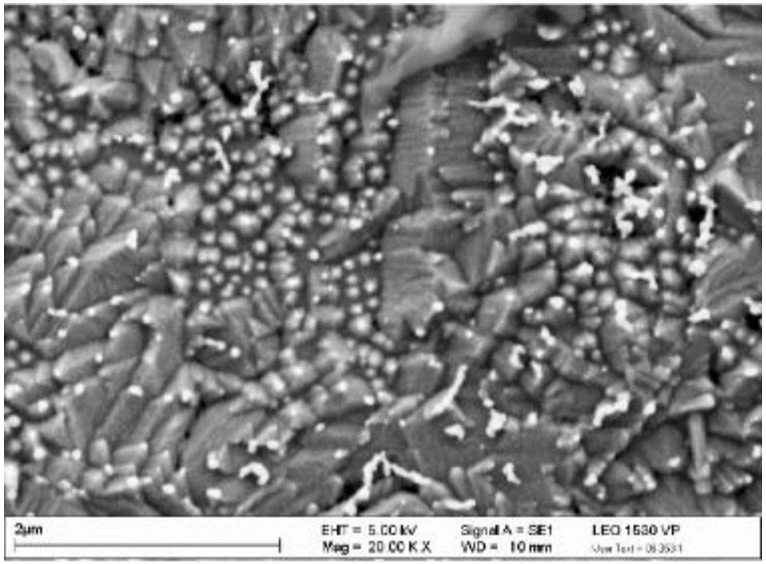
How does Nanofinish work?

- The process of passivation is different from other surface finishes
  - Finish is preferentially deposited on the grain boundaries



- Grain boundaries are high energy area most prone to oxidation
  - Conduction helps passivate copper by lowering the energy levels

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Why Nanofinish?

- Similar advantages to OSP
  - Bonding is to copper (stronger than bonding to nickel)
  - Few number of process steps
- Some advantages over OSP
  - Conductivity is better for in-circuit testing
  - Supposedly superior performance in regards to number of reflows (>10) and long-term aging

ACL 7002 Cleaner (2 min)
MET 7002 Etch (2 min)
DI-Rinse
CND 7200 Predip (60 s)
OMN 7200 Nanofinish (90 s)
DI-Rinse Drying

Market for Nanofinish

- Lots of interest; still limited penetration
- Largest users or most receptive were in Asia (Korea, China) and some in Germany
- Market strategy was directed at OEMs

Assessment of Nanofinish

- Must consider material set
  - Conductive polymers are known to be sensitive to moisture
  - Silver is known to be reactive with sulfur

- Test coupon must be similar to board design
  - Through holes
  - Solder mask
  - Similar feature sizes

- Testing should go beyond steam aging and mixed flowing gas (MFG)

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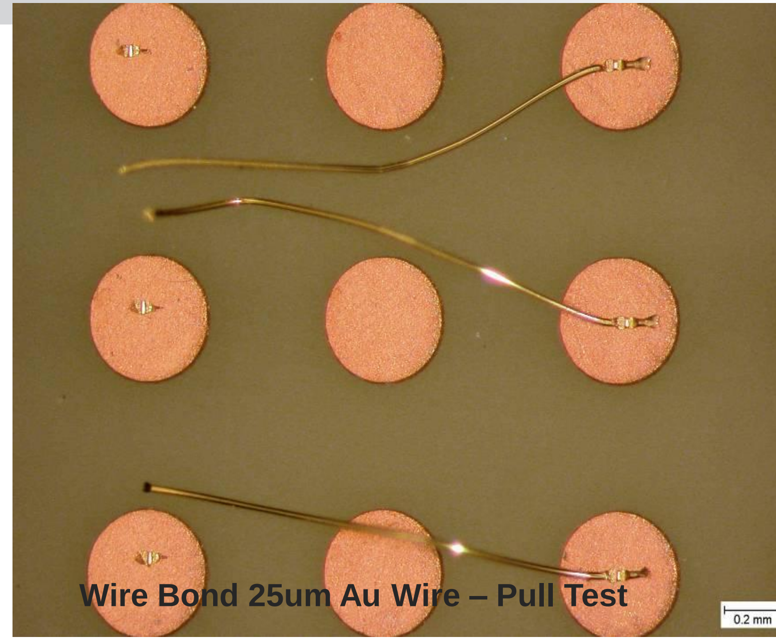
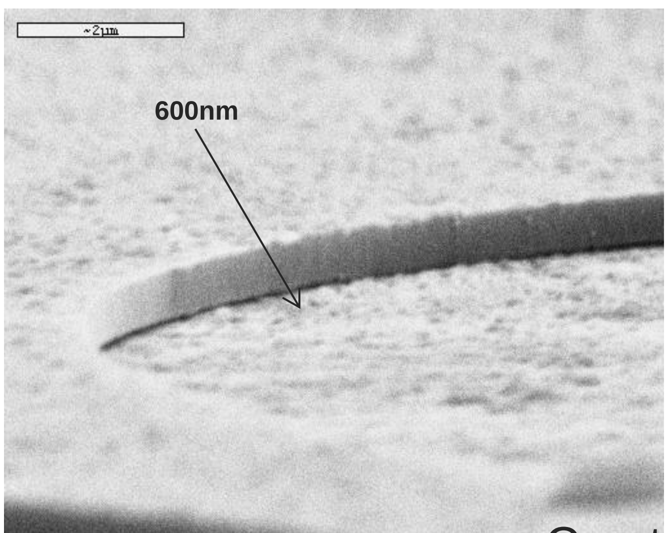
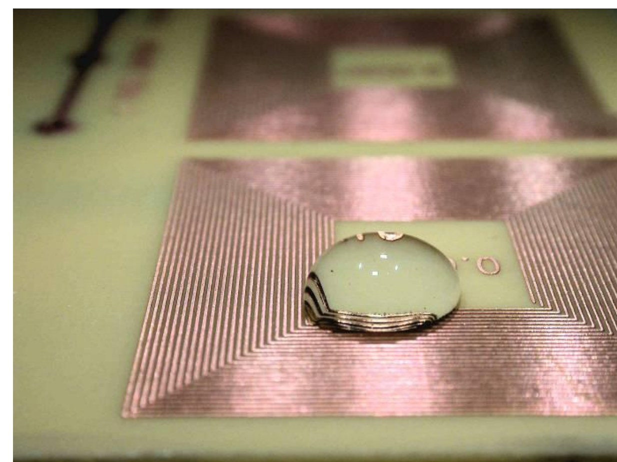
Plasma Coated Finish

- Coated in plasma chamber.
- Many panels coated simultaneously.
- Film is 60 nm thick.
- Flux breaks through film at elevated temperature.
- Hydrophobic and acid resistant







Courtesy of Semblant

DfR Solutions

Semblant

- Utilizes plasma polymerization to deposit an ultrathin protective coating on the surface of a PCB
  - Extremely hydrophobic

- Extended PCB shelf life
  - Long term protection against oxidation
  - Corrosion resistance
- Acceptable solderability
  - Compatible with SnPb and Pb-free reflow processes

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Plasma Polymerization

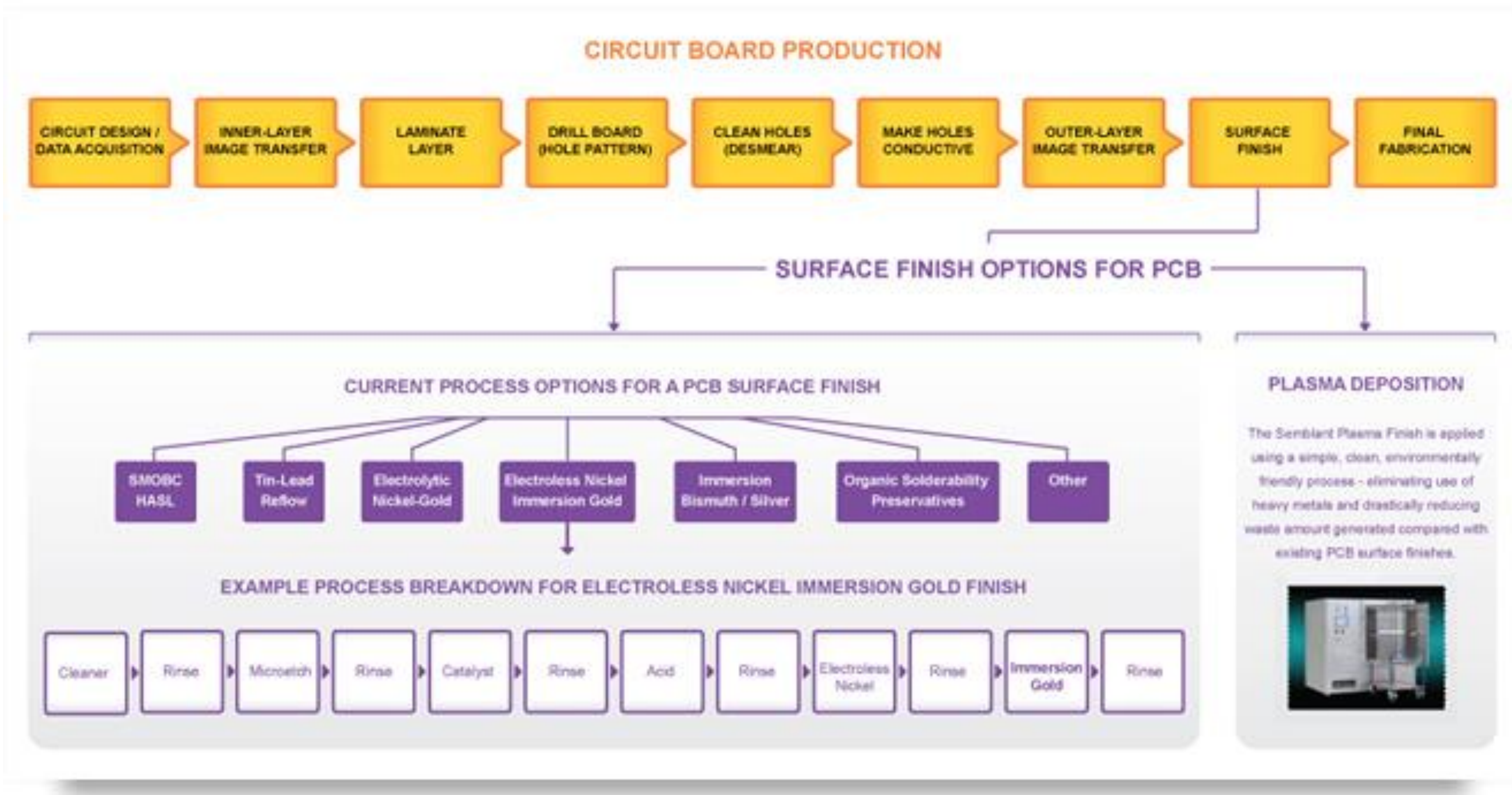
- Deposited using a plasma polymerization process in a vacuum chamber.
  - Ionizing a precursor gas in a low pressure, low temperature plasma
  - The process creates a dense, highly crosslinked polymer coating

- Because the coating is deposited uniformly wherever the process gas contacts the substrate, the process can deposit continuous film at coating thicknesses as low as 15nm.
  - Types of polymers that can be deposited using plasma polymerization includes a range of functional materials
  - Properties of the coatings can be tuned by selection of the precursor gas and control of the operating parameters of the process

Plasma Polymerization Process

- Precursor gas is introduced to the vacuum chamber containing the printed circuit board panels.
- RF generator sparks the plasma which ionizes and fragments the gas molecules in a glow discharge.
- Active molecular fragments can then recombine on the surface of the circuit board panels to create a thin film.
- The polymer structures that can be created in a plasma polymerization are unique to this process

Plating vs. Plasma Process



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Semblant Plasma Finish

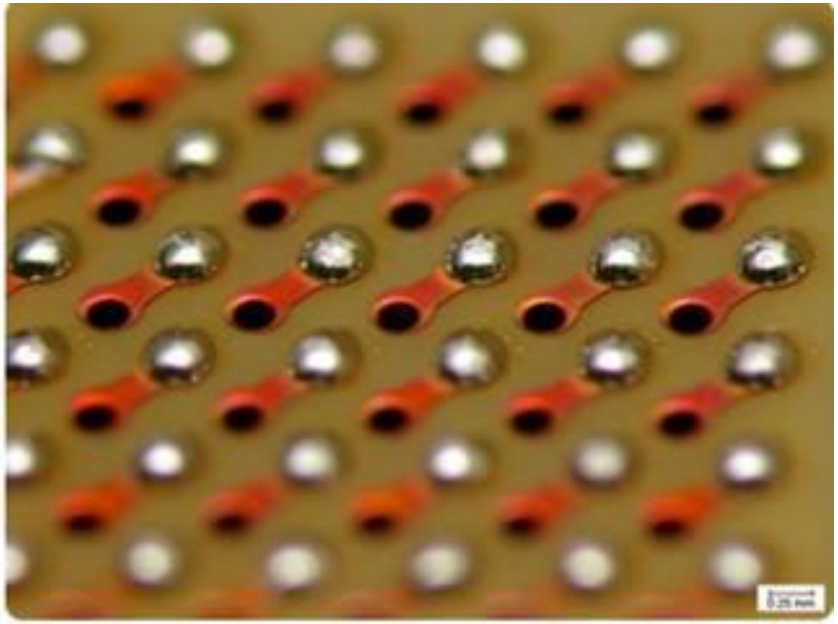
- Uses a fluoropolymer coating in a room temperature process.
  - The plasma deposition is combined with a pre-cleaning step
- Creates a continuous film that is 10's of nanometers thick everywhere the active gas plasma comes into contact with the surface – including through vias.
- The SPF fluoropolymer has stable chemical properties
  - Resistant to heat (up to 40 minutes at 260C)
  - Resistant to chemicals (non-reactive to flux at room temp)

Semblant Finish (cont.)

- The Semblant fluoropolymer is removed by the combined action of the acidic flux and the high temperatures used during reflow, resulting in a direct Cu/Sn solder joint.
  - The unoxidized copper beneath the SPF coating ensures wettability of the solder.
  - The surrounding fluoropolymer film prevents the solder from spreading beyond the printed area, reducing bridging and enabling ultra-fine pitch assembly.

Plasma Finish - Advantages

- Solder mask and solderability plating in one



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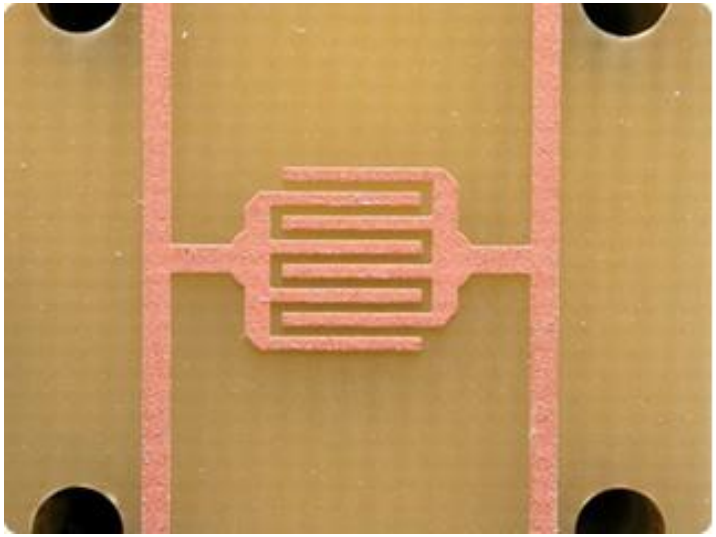
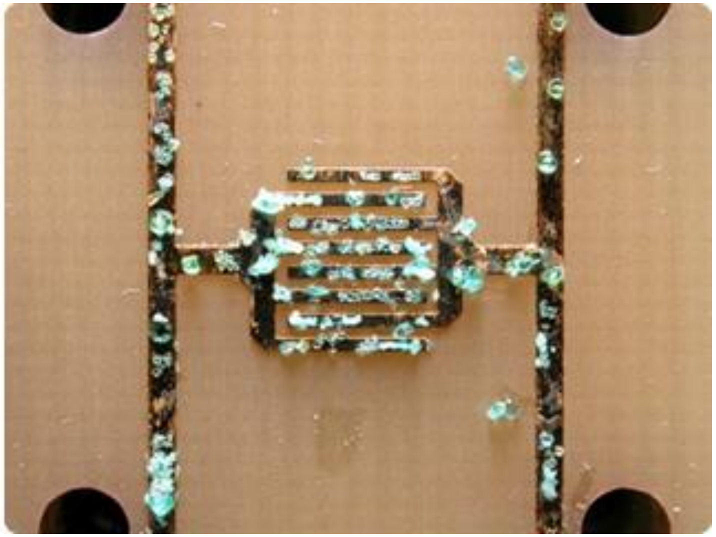
Advantages (cont.)

- Protection against corrosive gases
  - Actively repelling water and preventing corrosive gasses from coming into contact with the copper surface.





Plasma coating vs. ENIG (elevated sulfur gas testing

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Challenges

- Will require redesign of stencils and optimization of some manufacturing processes
  - No flux? No wetting
  - Can not rely on solder alone

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Examples of Best Application Fits

- OSP (but must address ICT issues)
  - Hand held electronics
  - Notebook computers
  - Basic desktop computers
  - Basic consumer electronics & power supplies
  - Simple Pb-free Medical or aerospace (thin PCBs)
- ENIG or ENEPIG
  - SnPb medical and aerospace
  - Pb-free that is not susceptible to shock

Examples of Best Fits

- ImAg
  - Fully enclosed hand held electronics
  - Basic consumer electronics – low power and airflow
- ImSn
  - Simple consumer electronics (not fully enclosed)
  - Simple medical or aerospace applications (1 side)
  - Low to moderate volume peripheral components
- LF HASL
  - Thick LF PCBs going into business environments (servers, telecom equipment)
  - Complex Pb-Free medical or aerospace?

What to do if there is no SF fit?

- If no SF fits your specific requirements, design modifications may be required and tradeoffs made.
- For example, I need low cost, high volume, corrosion resistant, with good ICT capability.
  - One solution might be to use ImAg but plug the vias with soldermask to protect from corrosion (but some cost is sacrificed).
  - Another is to use OSP but implement cleaning to remove flux residue for probing (cost is again sacrificed).

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Example #2

- Another example might be the desire to use ENIG for a Pb-free product where shock is a concern.
  - One solution might be to underfill critical components sensitive to shock (cost adder).
  - Another might be to dampen the shock by better design of the enclosure (possible cost adder).

Summary

- The surface finish you select will have a large influence on quality, reliability and cost.
- It is a complex decision that impacts many areas of the business.
- Select a finish that optimal for the business (and not just one function).
- Know that there are engineering tricks to improve on weak areas of each finish.
- Stay current in this field because new developments continue to be made.

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Contact Information

- Questions?
  - Contact Cheryl Tulkoff, ctulkoff@dfrsolutions.com, 512-913-8624
  - www.dfrsolutions.com

- Connect with me in LinkedIn as well!

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Speaker Biography

- Cheryl Tulkoff has over 22 years of experience in electronics manufacturing with an emphasis on failure analysis and reliability. She has worked throughout the electronics manufacturing life cycle beginning with semiconductor fabrication processes, into printed circuit board fabrication and assembly, through functional and reliability testing, and culminating in the analysis and evaluation of field returns. She has also managed no clean and RoHS-compliant conversion programs and has developed and managed comprehensive reliability programs.

- Cheryl earned her Bachelor of Mechanical Engineering degree from Georgia Tech. She is a published author, experienced public speaker and trainer and a Senior member of both ASQ and IEEE. She has held leadership positions in the IEEE Central Texas Chapter, IEEE WIE (Women In Engineering), and IEEE ASTR (Accelerated Stress Testing and Reliability) sections. She chaired the annual IEEE ASTR workshop for four years, is an ASQ Certified Reliability Engineer and a member of SMTA and iMAPS.

- She has a strong passion for pre-college STEM (Science, Technology, Engineering, and Math) outreach and volunteers with several organizations that specialize in encouraging pre-college students to pursue careers in these fields.

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Best Regards,

Dr. Craig Hillman, CEO

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