

***Solutions without Boundaries***



# ***PCB Surface Finishes***

**Todd Henninger, C.I.D.**  
***Sr. Field Applications Engineer***  
***Midwest Region***

# Notice

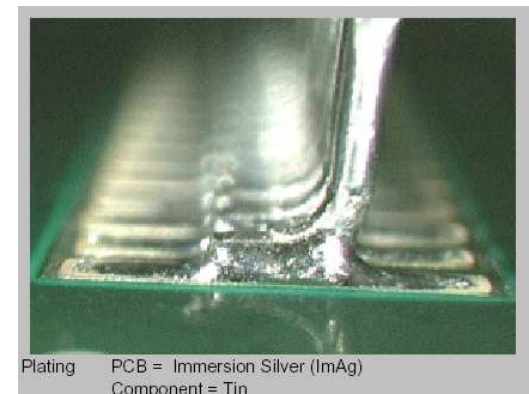
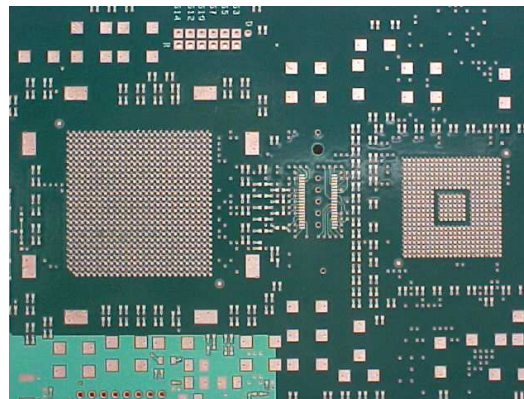


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# Surface Finish Selection



- All about the connectivity between the PCB and component devices.
- Primary function is to either temporarily protect the copper area from oxidation prior to assembly or to form the foundation of the connection to the electronic device.
- Should enhance the assembly process and promote a reliable solder joint for long-term performance.



Plating PCB = Immersion Silver (ImAg)  
Component = Tin

# *Available Finishes*



Sn/Pb Hot Air Solder Level (HASL)

Lead-Free HASL

Organic Solderability Preservative (OSP)

Immersion Silver

Immersion (White) Tin

Electrolytic Nickel/Gold (Hard & Soft Au Wire Bondable)

Electroless Nickel Immersion Gold (ENIG)

Electroless Nickel Electroless Palladium Immersion Gold (ENEPIG)

# Micro Units of Measurement



- **Micro-inch** ( $1 \mu''$ ) = .000001" (one millionth of a inch)
- Micro-meter (**Micron**) ( $1 \mu\text{m}$ ) = one millionth of a meter
- One Micron ( $1 \mu\text{m}$ ) = .00003937" (39  $\mu\text{in}$ )
- 25.4 microns = .001" (1 **mil**)

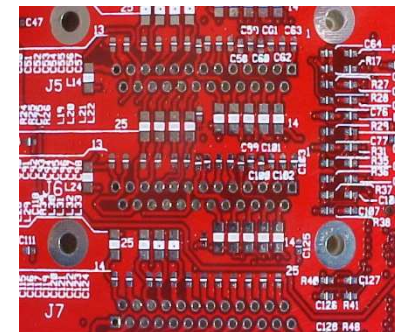
# Sn/Pb Hot Air Solder Level (HASL)



- Most common PCB finish in North America.
- 63% Tin / 37% Lead (“**Eutectic**” composition)
- Molten solder applied to exposed pads in horizontal or vertical panel orientation.
- Excess solder is blown off the circuitry with forced hot air “knife”.
- Typical thickness range of .00003” - .0015” (30-1500  $\mu$ ”).
- Melts at 183 degrees C.
- 12+ month shelf life (considered excellent).

## Issues:

- Surface Planarity for HDI applications (**highly variable topography**)
- Impact of thermal excursion (extreme process temperatures)
- RoHS/WEEE restrictions and environmental issues with the use of lead.



# Lead-Free Solder



- Same application process (HASL) as Sn/Pb Solder.
- Common alloys: Sn/Ag/Cu (SAC), Sn/Cu/Co, Sn/Cu/Ni/Ge.
- Slightly more planar (uniform) coating than can be achieved with tin/lead solders.
- Typical thickness range of .0003”-.001” (300-1000  $\mu$ ”).
- Melts at 228 degrees C.
- Environmentally Friendly (RoHS & WEEE compliant).
- 12 month shelf life.

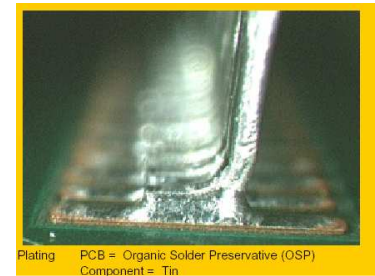
## **Issues:**

- Low demand as PCB finish (outsourced when required).
- Aggressive on copper, depending on the alloy.
- Relatively new compared to Sn/Pb solder (less history).

# Organic Solderability Preservative (OSP)



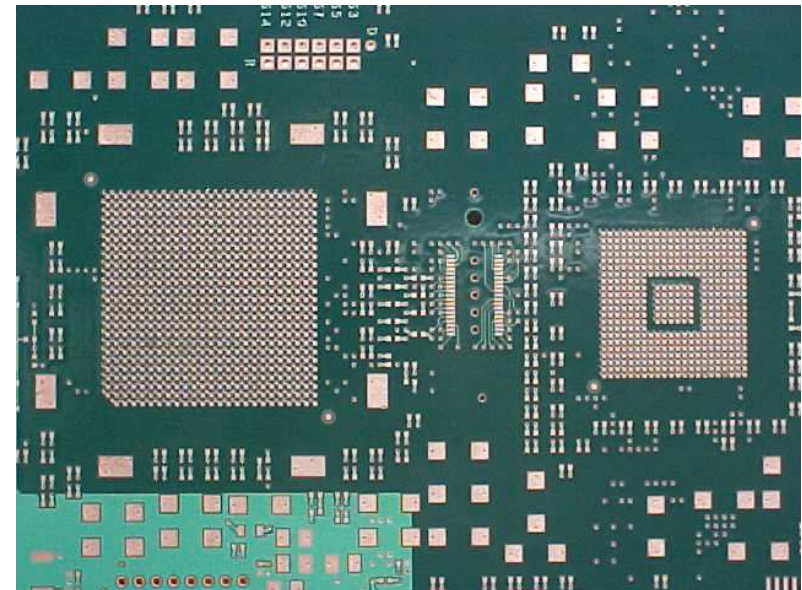
- Preserves copper surface from oxidation until assembly.
- Very thin coating (100-4000 Angstroms).
- Applied in a vertical (dip tank) or conveyORIZED chemical process.
- Flat, planar surface, well suited to tight-pitch pads (BGA, QFP).
- < 6 month shelf life (considered poor).
- Very manufacturable (no concerns).



Plating PCB = Organic Solder Preservative (OSP)  
Component = Tin

## Issues:

- Difficult to inspect (transparent and colorless).
- Sensitive to handling.
  - ✓ *typically applied as final mfg process.*
- Limited shelf life.
- Requires relatively aggressive flux at assembly.

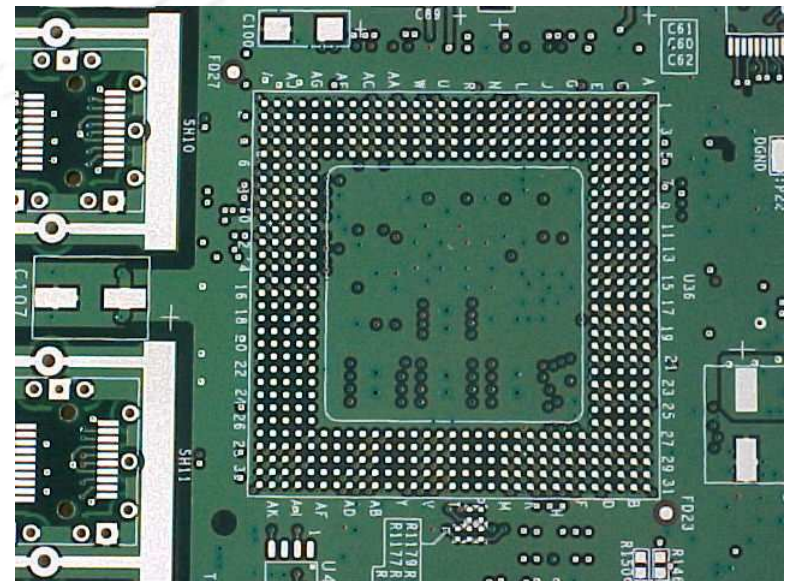




# Immersion Silver

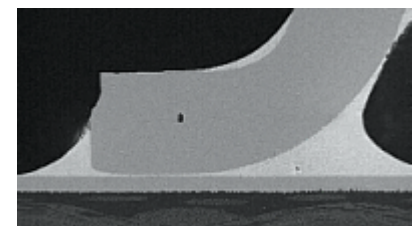


- Metallic solderability preservative.
- 8-15 micro-inches of nearly pure silver.
- Excellent solderability.
- Flat, planar surface.
- Aluminum wire bondable.
- 6-12 month shelf life.



## Issues:

- Sensitive to handling, electrical test, and packaging.



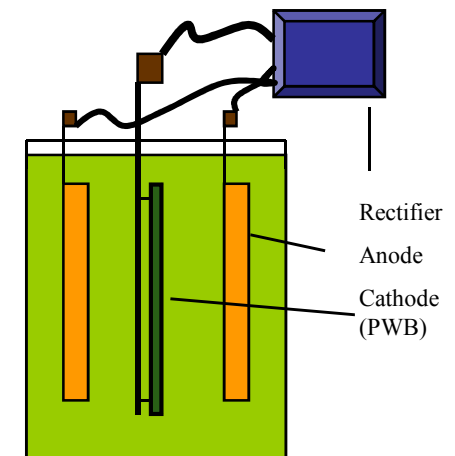


# Electrolytic Ni/Au (Hard/Soft Bondable)

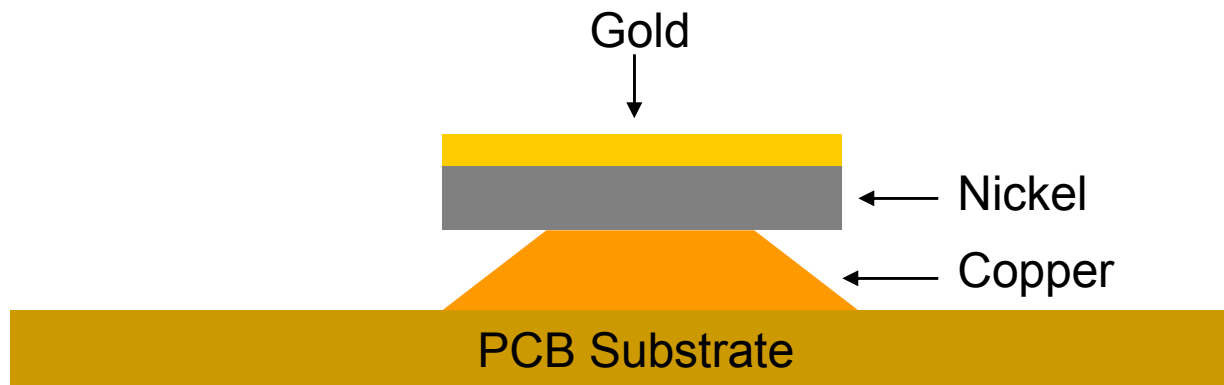
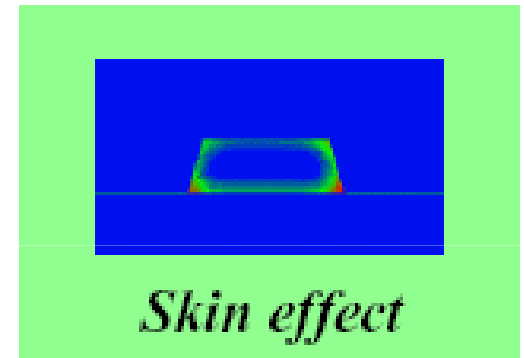


- Au electroplated in varying thicknesses over a base of electroplated Ni.
- Au hardness controlled for application (50-90 knoop = soft / 130-200 knoop = hard).
- Hard Au = 99.6% purity (*Type 2, Grade C*)
- Soft Au = 99.9% purity (*Type 3, Grade A*)
- 12+ month shelf life.

<u>Type</u>	<u>Thickness</u>	<u>Comments</u>
Gold Flash	5 – 15 $\mu$ inches	Solderable
Full Body Gold	30 – 60 $\mu$ inches	Trace undercut/skin effect issues
Selective Gold	30 – 50 $\mu$ inches	Contact switches and gold “fingers”
Bondable Gold	30 – 80 $\mu$ inches	Wire Bonding (soft Au)



# Electrolytic Ni/Au Issues/Concerns



Full-Body Gold "Undercut"  
(when bussing isn't possible)  
aka "Gold as Etch Resist"

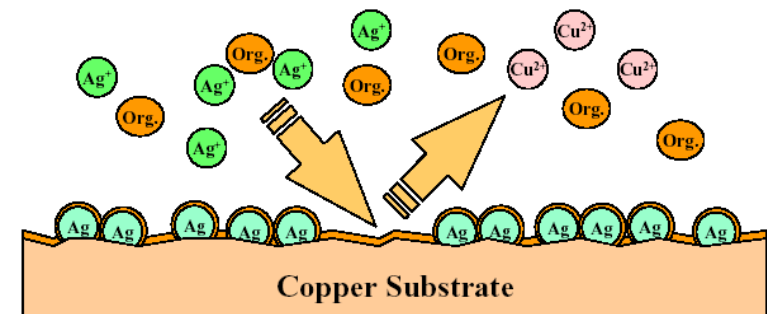
# Electroless Nickel Immersion Gold (ENIG)



- Two-layer metallic coating over catalyzed copper (ion exchange).
- Ni is a diffusion barrier to the Cu and is the surface to which the soldering occurs.
- Au protects the nickel from oxidation during storage.
- Au also provides low contact resistance, excellent shelf-life, and good wetting.
- Flat, planar surface excellent for fine-pitch pads (BGA, QFP).
- 2-8  $\mu$ " Au over 120-240  $\mu$ " Ni.
- Good Contact Resistance (1 million + cycles).
- 12 month shelf life.

## Issues:

- Electroless nickel/phosphorous can have undesirable magnetic properties.
- Aluminum wire bondable, but not gold wire.



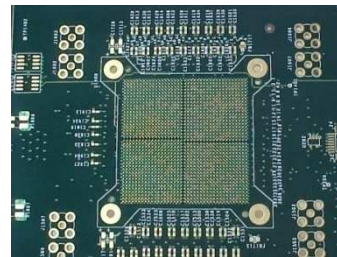
# ***Electroless Ni / Electroless Pd / Immersion Au (ENEPIG)***



- Electroless Ni layer of 120 – 240  $\mu$ " deposited on the copper surface.
- Coated with an electroless palladium layer (4 to 20  $\mu$ " )
- Topped with immersion gold (2 to 8  $\mu$ " ).
- Forms a superior solder joint with SAC solders.
- Palladium layer eliminates corrosion potential from immersion reaction.
- Creates an ideal gold wire bondable surface.
- Allows thinner gold than electrolytic soft bondable gold, therefore less expensive.
- Fastest growing surface finish.
- 12 month shelf life.

## **Issues:**

- Palladium does not form a strong intermetallic bond with lead in Sn/Pb solders.



# Surface Finish Characteristics/Cost



Type	Planarity	Solderability	Al Wire Bondable	Au Wire Bondable	Contact Surface	Relative Cost Adder *
HASL	POOR	GOOD	NO	NO	NO	1.0
LFHASL	FAIR	GOOD	NO	NO	NO	1.0
OSP	GOOD	GOOD	NO	NO	NO	1.0
IMM Ag	GOOD	GOOD	YES	NO	NO	1.1
IMM Sn	GOOD	GOOD	NO	NO	NO	1.1
ENIG	GOOD	GOOD	YES	NO	YES	1.1
ENEPIG	GOOD	GOOD	YES	YES	YES	2.5
Elec Au	GOOD	GOOD	YES	(soft only)	YES	3.5

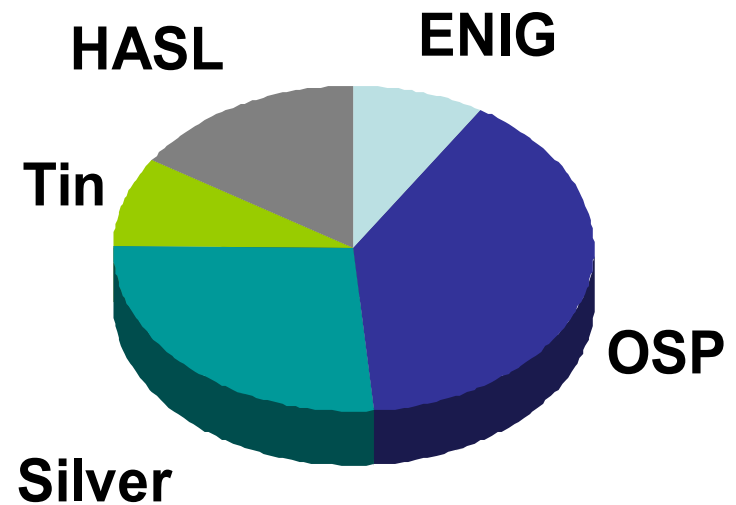
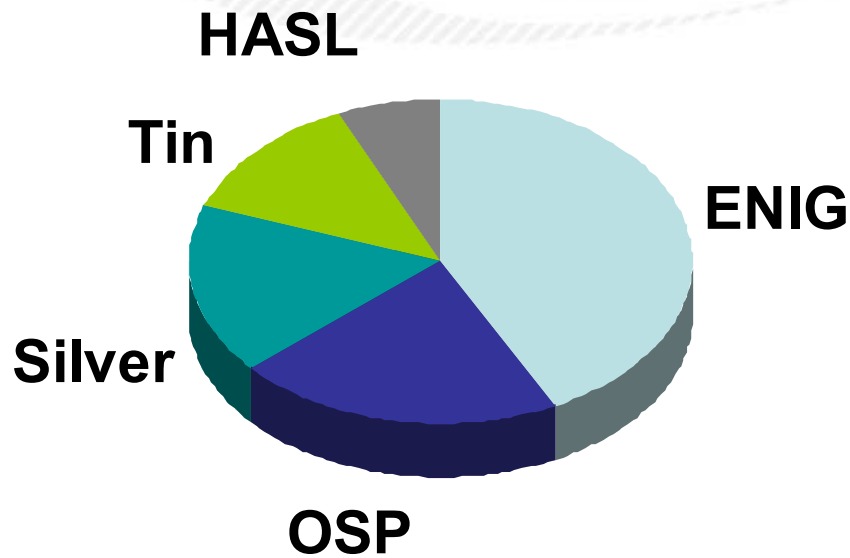
\* Finish cost factor only, all other features being equal.

# Worldwide Usage by Surface Finish



by Revenue of Consumable Materials

by Area of PCBs Manufactured



Source: Printed Circuits Handbook, 6<sup>th</sup> Edition (Coombs) 2006



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