PCB DESIGN GUIDE 04

SELECTING THE CORRECT SURFACE FINISH

FUNCTION FIRST • NOT FINISH FIRST ///

LEAD PRINCIPLE: Select the finish from the functional requirements of the board and assembly process.

START WITH THE FUNCTION



EXPOSED COPPER PAD

SOLDER JOINT



Requires excellent solderability and wetting for reliable solder joints.

Examples:
HASL, Lead Free HASL, ENIG, ENEPIG, OSP

REPEATED CONTACT



Requires wear resistance and low contact resistance over many mating cycles.

Example:
SELECTIVE HARD GOLD

WIRE BOND



Requires a bondable, clean and stable surface for reliable wire bonds.

Examples:
ENIG, ENEPIG, Soft Gold

PRESS-FIT



Requires controlled plating for mechanical retention and reliability.

Examples:
ENIG (barrel and pad), Hard Gold (select uses)

RF CONDUCTOR



Evaluate the complete RF structure and finish metallurgy for performance, loss and reliability.

Examples:
Depends on structure and materials used

WHY A FINISH IS NEEDED

Protects exposed copper from oxidation
Prevents tarnish and surface degradation before assembly and during storage.

Creates a controlled interface
Provides a defined surface for soldering, bonding, pressing or mating.

Influences key performance factors
Affects solderability, planarity, storage life, reliability and overall cost.

Enables reliable, repeatable assembly
Supports consistent yields across volume manufacture and field life.

QUESTIONS BEFORE SELECTION

1. Is the design fine pitch or high density?
2. Will the board see multiple reflows?
3. What is the required storage duration?
4. Will the board be exposed to sulfur or humidity?
5. Are there RF or controlled impedance requirements?
6. Are edge fingers or repeated mating contacts used?
7. Is there a mandated customer or industry specification?
8. What inspection and acceptance evidence is required?

THERE IS NO UNIVERSALLY BEST FINISH.
Match the finish to the function, environment and process to ensure performance, reliability and cost effectiveness.

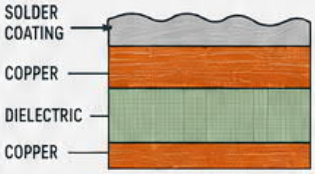
SELECTING THE CORRECT SURFACE FINISH

FINISH FAMILIES • STRUCTURE • TRADE-OFFS

1 LF-HASL

Hot Air Solder Leveling (Lead-Free)



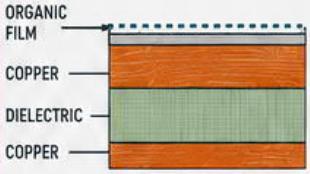


- Solder coating
- Economical and robust
- Fair planarity
- Verify for very fine pitch

2 OSP

Organic Solderability Preservative



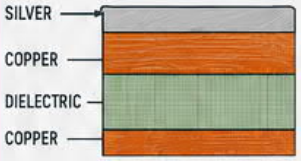


- Organic film on copper
- Excellent planarity and low cost
- Handling, storage and repeated heat require control

3 IMMERSION SILVER

Immersion Silver



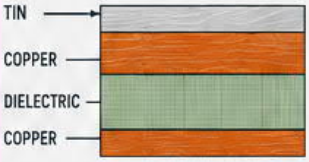


- Thin silver on copper
- Flat and nickel-free
- Sulfur/tarnish and packaging require control

4 IMMERSION TIN

Immersion Tin



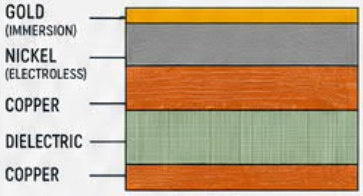


- Thin tin on copper
- Flat and solderable
- Time, temperature and storage affect the interface

5 ENIG

Electroless Nickel Immersion Gold



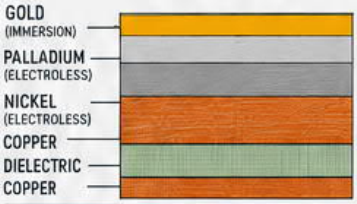


- Electroless nickel + immersion gold
- Planar and multifunctional
- Process control and nickel effects matter

6 ENEPIG

Electroless Nickel Electroless Palladium Immersion Gold





- Nickel + palladium + immersion gold
- Mixed assembly and bonding capability
- Higher cost and tighter thickness control

7 HARD GOLD

Electroplated Nickel/Gold





- Electroplated nickel/gold
- Repeated-contact wear resistance
- Not the default solderable finish

ENIG LOOKS GOLD — IT IS NOT HARD GOLD.

ENIG gold is an immersion deposit that is thin and porous. Hard gold is an electroplated deposit that is thicker and much harder. They serve different functions.

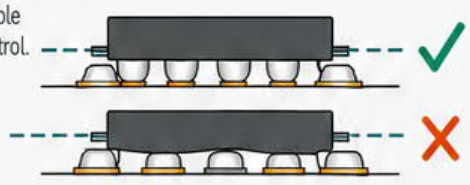
SELECTING THE CORRECT SURFACE FINISH

ASSEMBLY • CONTACT • BONDING • RF • PRESS-FIT

FUNCTION	POSSIBLE DIRECTION	VERIFY
GENERAL, COST-SENSITIVE	LF-HASL or OSP	geometry, process, storage
FINE-PITCH / HIGH PLANARITY	ENIG, ENEPIG, OSP, Imm Ag or Imm Sn	assembly and environment
REPEATED CONTACT WEAR	Selective hard gold	nickel/gold thickness and contact life
WIRE BONDING	Process-specific ENEPIG, ENIG or soft-gold solution	wire material, ball/wedge method, qualified process
NICKEL-SENSITIVE RF	Evaluate nickel-free options	frequency, geometry, loss and environment
PRESS-FIT	Dedicated plated-hole requirement	connector finished-hole and plating specification

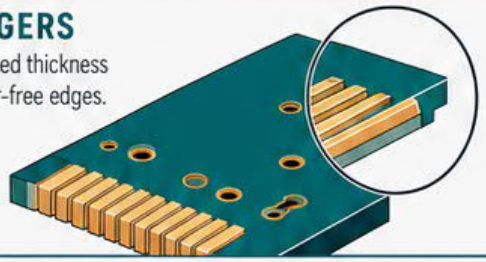
QFN / BGA PLANARITY

Flat, coplanar pads for reliable solder wetting and void control.



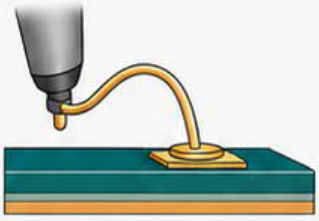
EDGE FINGERS

Uniform, controlled thickness and smooth, burr-free edges.



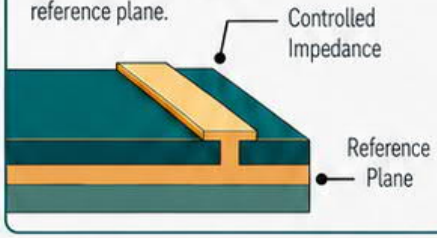
WIRE BOND

Consistent bond pad metallurgy for reliable wire loop formation.



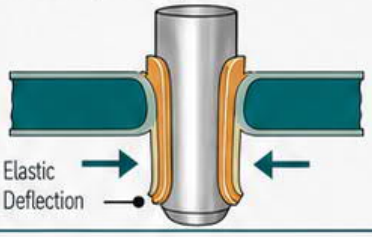
RF TRACE

Controlled impedance, smooth transitions and continuous reference plane.



COMPLIANT PIN (PRESS-FIT)

Plated-through hole engineered for elastic, reliable press-fit.



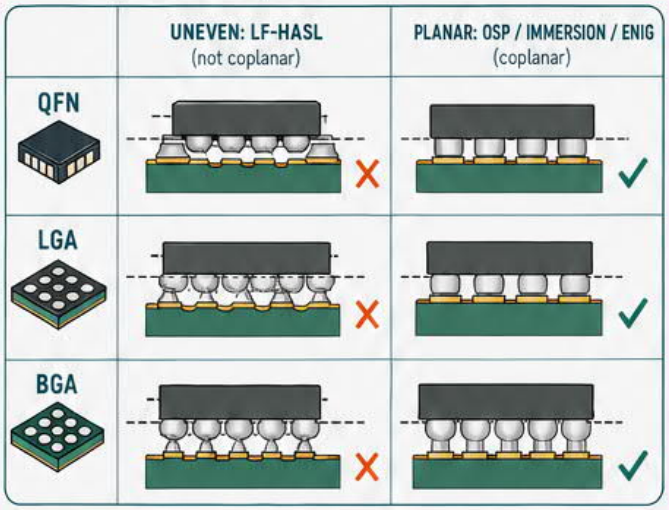
A BOARD MAY LEGITIMATELY USE MORE THAN ONE SELECTIVE FINISH.

RELIABILITY IS A PROCESS

PLANARITY • STORAGE • HEAT • ENVIRONMENT

1 PLANARITY & FINE PITCH

Flat, coplanar pads support consistent solder volume and reliable joints.



Planarity is also driven by stencil design, paste volume, pad geometry, solder mask and reflow profile.

2 SHELF LIFE, PACKAGING & HANDLING

Protect finishes from moisture, contamination and uncontrolled environments.



MOISTURE-BARRIER PACKAGE
Keep boards sealed until use.
Store flat in original packaging.



CLEAN HANDLING
Use gloves. Avoid touching pads and features. Minimise particulates and oils.



FABRICATION LOT & DATE
Track lot and date code for traceability and process consistency.



CONTROL ENVIRONMENT
Manage temperature and humidity.
Avoid condensation and rapid changes.

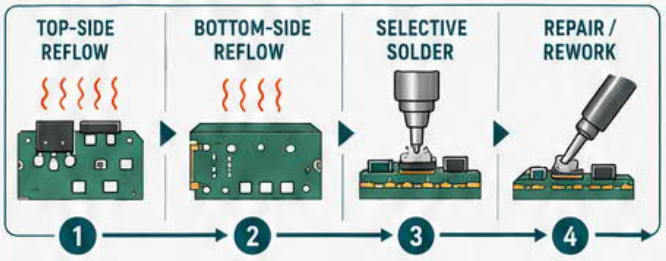


MINIMISE CONTAMINANTS
Protect from ionic contamination, chemicals and airborne residues.

Use supplier-qualified shelf-life data.

3 MULTIPLE REFLOW & REWORK

Each heat cycle adds risk. Plan the sequence and manage delays between operations.



ASK THESE QUESTIONS

- How many heat cycles will the board experience?
- What is the maximum temperature at each step?
- How long is the delay between operations?
- Are finishes and components qualified for this?

Follow the most temperature-sensitive component.

4 CORROSION & ENVIRONMENT

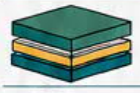
Finishes and environments interact. Control the risks through design, process and protection.



SULFUR RISK FOR SILVER
Silver can tarnish in sulfur-bearing environments (e.g., H_2S, SO_2).



HUMIDITY & IONIC CONTAMINATION
Moisture and ions drive electrochemical reactions and leakage currents.



SOUND BARRIER LAYERS
Use appropriate finishes and barrier layers for the environment.



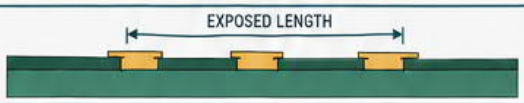
CLEANLINESS MATTERS
Remove flux and residues when required.
Specify and verify cleanliness.



COATING & ENCLOSURE
Use conformal coating and/or enclosure as part of the protection strategy.

CONFORMAL COATING DOES NOT CORRECT A DEFECTIVE OR CONTAMINATED FINISH.

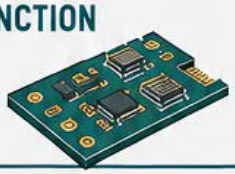
RF NOTE
Nickel effects depend on frequency, geometry, exposed length and loss budget.
Evaluate insertion loss, surface roughness and plating thickness in context.



SELECTING THE CORRECT SURFACE FINISH

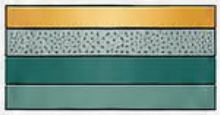
SPECIFICATION • MEASUREMENT • VERIFICATION

1 FUNCTION



Define electrical, mechanical and environmental requirements; application and reliability targets.

2 FINISH SYSTEM



Select the finish system and selective finish requirements by function and assembly method.

3 APPLICABLE SPECIFICATION



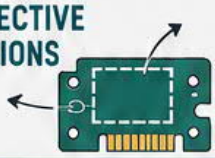
Identify the controlling IPC specification that defines the requirements and verification.

4 THICKNESS / CLASS



Specify required thickness range or class where applicable. Stated in micrometres (µm).

5 SELECTIVE REGIONS



Define location and extent of selective finishes precisely. Use drawings and callouts.

6 TEST / CERTIFICATE



Specify verification methods and required certification or inspection records.

7 APPROVED CHANGE CONTROL

Any change to finish, thickness, process or verification requires approved engineering change.

RELEVANT DOCUMENTS

- ENIG — IPC-4552B
- ENEPIG — IPC-4556
- OSP — IPC-4555
- Solderability verification — IPC J-STD-003D

Confirm the current contractual revision and procurement hierarchy.

FABRICATION NOTE PATTERNS

- SURFACE FINISH: ENIG PER IPC-4552B.
- SELECTIVE HARD GOLD ON EDGE CONNECTOR FINGERS ONLY.
- DO NOT SUBSTITUTE WITHOUT WRITTEN ENGINEERING APPROVAL.
- PROVIDE FINISH THICKNESS / PROCESS CERTIFICATION WHEN REQUIRED.

VERIFY WITH THE MANUFACTURER

- In-house process?
- Certifiable revisions?
- Thickness measurement?
- Packaging and warranted shelf life?
- Selective plating rules?
- Press-fit and wire-bond qualification?
- Lot reports?

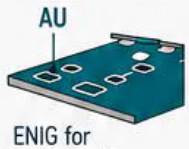
A FINISH NAME ALONE MAY BE INSUFFICIENT FOR HIGH-RELIABILITY WORK.

SELECTING THE CORRECT SURFACE FINISH

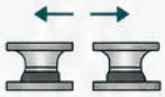
DECISION MATRIX • COMMON MISTAKES • FINAL REVIEW

FINISH	PLANARITY	PRIMARY STRENGTH	WATCH-OUT:
LF-HASL	FAIR	economical solder coating	fine-pitch topography
OSP	EXCELLENT	flat and economical	handling, storage, repeated heat
Ag IMMERSION SILVER	EXCELLENT	flat, nickel-free	sulfur and packaging
Sn IMMERSION TIN	EXCELLENT	flat solderable interface	ageing and storage
Ni Au ENIG	EXCELLENT	planar, multifunctional	process control, nickel, not wear gold
Ni Pd Au ENEPIG	EXCELLENT	mixed assembly and bonding	cost and thickness control
Au HARD GOLD	EXCELLENT	repeated contact wear	selective use, not default SMT

COMMON MISTAKES



ENIG for every board



HASL on fine pads without review



immersion gold used as wear gold



vague "gold finish"



assumed wire-bond compatibility



ignored RF nickel



selection on unit price only



unapproved substitution

FINAL REVIEW CHECKLIST

- **exposed-feature function understood** — electrical, mechanical, RF or environmental requirements defined.
- **planarity reviewed** — guided by pad geometry, pitch and assembly environment.
- **alloy/profile and heat cycles known** — soldering, rework and bonding temperature limits considered.
- **storage/environment controlled** — shelf conditions and expiry risks addressed.
- **RF, press-fit, contacts and bonding separately defined** — distinct requirements captured and matched to finish.
- **specification and documentation set** — finish callout, thickness, areas, notes and test requirements.
- **selective areas shown** — clear definition of where each finish is required.
- **fabricator and assembler reviewed** — feasibility confirmed and expectations aligned.

CHOOSE THE LOWEST TOTAL MANUFACTURING RISK AND LIFECYCLE COST — NOT SIMPLY THE LOWEST BOARD PRICE.