SURFACE FINISHES

Characteristics	Lead Free Hot Asir Solder Level (LF-HASL)	Direct Immersion Gold (DIG)	Immersion Silver (AG)	Immersion Tin (SN)	Immersion Silver Immersion Gold (ISIG)	Electroless Nickel Immersion Gold (ENIG)	Electroless Palladium Immersion Gold (EPIG)	Organic Surface Preservation (OSP)	Electroless palladium Autocatalytic Gold (EPAG)
Definition	Lead-Free Hot Air Solder Leveling: A process where the exposed copper traces of a PCB are coated with a lead-free alloy and then leveled using a hot air knife	Direct Immersion Gold: Electroless deposition of gold onto copper without an intermediary nickel layer	Immersion Silver: Electroless deposition of a thin silver layer onto the copper circuitry	Immersion Tin: Electroless deposition of a flat tin layer directly onto the PCB's copper	Immersion Silver Immersion Gold: Dual-layer deposition involving an initial silver layer followed by a thin gold layer	Electroless Nickel Immersion Gold: Electroless nickel plating covered with immersion gold	Electroless Palladium Immersion Gold: Nickel-free alternative with palladium deposition followed by immersion gold	Organic Solderability Preservatives: Chemically applied thin protective layer on copper against oxidation	Electroless Palladium Autocatalytic Gold: Nickel-free process with palladium followed by an autocatalytic gold layer
Solderability	Excellent	Excellent, especially for fine pitch components	Good with multiple solder types	Excellent, uniform soldering surface	Benefits of both silver & gold	Excellent due to gold layer	Highly compatible for soldering & wire bonding	Good for specific soldering processes	Excellent
Surface Quality	Non-uniform, the surface flatness can vary between 1 micron and 40 micron	Flat, ideal for fine-pitch/ BGA	Flat, suitable for fine-pitch	Flat, good for fine-pitch	Benefits of both finishes (SNAU)	Robust protection, suitable for multiple applications	Flat & versatile	Can degrade over time	Superior for diverse applications
Cost	Economical	Expensive, due to the gold	Mid-range	Economical compared to the gold finishes	Expensive, due to dual finishes	Expensive, due to the gold	Expensive and higher that NiAu, due to palladium & gold	Economical	Very expensive due to palladium & gold (can be up to 4 x the price of ENIG)
Protection & Durability	Good for multiple reflows	Long shelf life due to gold	Vulnerable to tarnishing, pre-processing recommended	Whisker growth & oxidation	Benefits from both finishes	Excellent against oxidation/corrosion	Nickel-free, and very durable	Limited shelf life	Robust & durable
Compatibility for Production processes	Standard	Highly compatible	Reasonably good, depending on application	Standard	Combined finishes' benefits	It has a wide window range of processing	Suitable for soldering & wire bonding	Limited to soldering and number of heat cycles	Good for both soldering & wire bonding
Environmental Concerns	Alloy concerns, but acceptable	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal	Eco-friendly	Minimal

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Handling Sensitivity	Standard	Porosity risks	Tarnishing risks	Sensitive to scratches	Potential tarnishing & porosity	Standard	Standard	Can degrade with handling	Standard
RF Properties - Signal Integrity	Adequate for lower frequencies; potential scattering at higher frequencies	Superior; minimal scattering, suitable for GHz frequencies	Stable up to mid-GHz	Adequate; potential scattering at higher frequencies	Good across frequencies	The presence of nickel affects the propgation of RF signals (especially in the GHZ range)	Superior due to smooth layers	Less ideal for high frequencies due to OSP thickness variability	Stable due to palladium & gold
RF Properties - Interference Minimization	Adequate, potential slight interference	Minimal due to continuous gold layer	Minimized but affected by environment	Good but tin whiskers may cause inter-ference	Reduced interference	Excellent shielding	Excellent interference shielding	Good below GHz range; organic layer less robust than metals	Minimal due to continuous gold layer
Availability of Manufacturer	Widely available	Emerging, less common	Fairly common	Commonly available	Less common.	Widely available	Emerging, less common	Widely available	Less common
Corrosion Resistance	Moderate	High due to gold	Moderate; vulnerable to environmental factors	High; unless scratched	High due to both metals	Very high due to gold	High due to both metals	Moderate	Very high due to both metals
Resilience	Moderate; can withstand thermal cycles	High due to stable metal layers	Moderate; sensitive to handling	Moderate; prone to tin whisker growth	High due to combined metal benefits	Very high; stable metal layers	High; stable combination of metals	Moderate; typically limited to single reflow	Very high; stable metal layers
Shelf Life	12 months	12 months	6 months	3 months	12 months	12 months	12 months	4 months	12 months

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