

Technology Roadmap		Standard Technology	Advanced Technology	Future Technology	Frequency	Notes
Definition		Manufactured with no special handling or involvement from key personnel. High Yields.	Manufactured with minimal special handling or involvement from key personnel. Reduced Yields.	Manufactured only with special handling or involvement from key personnel. Significant impact on Yields.	Designs with stated features are manufactured Daily, Weekly, Monthly, Quarterly, Annually or Never	
Feature	inch (mm)	inch (mm)	inch (mm)			
Minimum Outer Line Width	0.004 (0.102)	0.003 (0.076)	0.0025 (0.064)	1/2 oz copper & +/-20% tolerance		
Minimum Inner Line Width	0.004 (0.102)	0.003 (0.076)	0.0025 (0.064)			
Minimum Outer Space (Trace\Trace & Trace\Pad)	0.005 (0.127)	0.0035 (0.089)	0.003 (0.076)			
Minimum Inner Space (Trace\Trace & Trace\Pad)	0.005 (0.127)	0.0035 (0.089)	0.003 (0.076)	1 oz copper & +/-20% tolerance		
Minimum Outer Line Width	0.005 (0.127)	0.004 (0.102)	0.003 (0.076)			
Minimum Inner Line Width	0.005 (0.127)	0.004 (0.102)	0.003 (0.076)			
Minimum Outer Space (Trace\Trace & Trace\Pad)	0.006 (0.152)	0.004 (0.102)	0.0035 (0.089) <sup>(1)</sup>	2 oz copper & +/-20% tolerance		
Minimum Inner Space (Trace\Trace & Trace\Pad)	0.006 (0.152)	0.004 (0.102)	0.0035 (0.089) <sup>(1)</sup>			
Minimum Outer Line Width	0.010 (0.254)	0.008 (0.203)	0.006 (0.152)	3 oz copper & +/-20% tolerance		
Minimum Inner Line Width	0.010 (0.254)	0.008 (0.203)	0.006 (0.152)			
Minimum Outer Space (Trace\Trace & Trace\Pad)	0.008 (0.203)	0.007 (0.178)	0.006 (0.152) <sup>(1)</sup>			
Minimum Inner Space (Trace\Trace & Trace\Pad)	0.008 (0.203)	0.007 (0.178)	0.006 (0.152) <sup>(1)</sup>	4 oz copper & +/-20% tolerance		
Minimum Outer Line Width	0.014 (0.356)	0.012 (0.305)	0.010 (0.254)			
Minimum Inner Line Width	0.014 (0.356)	0.012 (0.305)	0.010 (0.254)			
Minimum Outer Space (Trace\Trace & Trace\Pad)	0.014 (0.356)	0.012 (0.305)	0.010 (0.254) <sup>(1)</sup>	Assumes 1/2 oz copper		
Minimum Inner Space (Trace\Trace & Trace\Pad)	0.014 (0.356)	0.012 (0.305)	0.010 (0.254) <sup>(1)</sup>			
Minimum Outer Line Width	0.018 (0.457)	0.015 (0.381)	0.012 (0.305)	Assumes 1/2 oz starting copper		
Minimum Inner Line Width	0.018 (0.457)	0.015 (0.381)	0.012 (0.305)			
Minimum Outer Space (Trace\Trace & Trace\Pad)	0.018 (0.457)	0.015 (0.381)	0.012 (0.305) <sup>(1)</sup>			
Minimum Inner Space (Trace\Trace & Trace\Pad)	0.018 (0.457)	0.015 (0.381)	0.012 (0.305) <sup>(1)</sup>	Assumes 0.023 +/- .0015 score depth with 30 deg angle		
Internal Etch tolerance	+/- 20%	+/- 10%	+/- 5%			
External Etch tolerance	+/- 20%	+/- 10%	+/- 5%			
Minimum Space - Conductor to <b>ROUTED</b> PWB Edge	0.010 (0.254)	0.007 (0.178)	0.007 (0.178)			
Minimum Space - Conductor to <b>SCORED</b> PWB Edge	0.020 (0.508)	0.015 (0.381)	0.015 (0.381)			
Layer to Layer Registration - (> 2 layer)	+/- 0.008 (0.203)	+/- 0.006 (0.152)	+/- 0.003 (0.076)			
Layer to Layer Registration - (2 layer)	+/- 0.005 (0.127)	+/- 0.003 (0.076)	+/- 0.002 (0.051)			
Maximum PWB Thickness (inches)	0.150 (3.810)	N/A	N/A			
Minimum Board Thickness Tolerance	+/- 10%	+/- 8%	+/- 5%			
Maximum Number of Layers	16	20	26			
Profile Tolerance (Routed)	+/- 0.005 (0.127)	+/- 0.004 (0.102)	+/- 0.003 (0.076) <sup>(2)</sup>	Tolerance applies to boards before depanelization		
Profile Tolerance (Scored)	+/- 0.010 (0.254)	+/- 0.005 (0.127)	+/- 0.005 (0.127) <sup>(2)</sup>			
Minimum Internal Cut-out Radius	0.046 (1.168)	0.032 (0.813)	0.016 (0.406)			
Smallest BGA footprint pitch - inches (mm)	0.050 (1.270)	0.030 (0.762)	N/A			

<b>Pad and Hole</b>					
Minimum Finished PTH Hole Size	0.008 (0.203)	0.006 (0.152)	0.004 (0.102) <sup>(3)</sup>		
Component Finished PTH Size Tolerance Range	0.006 (0.152)	0.004 (0.102)	N/A		i.e. +/- 0.003 = 0.006 range
Via Finished PTH Size Tolerance Range	0.006 (0.152)	0.004 (0.102)	N/A		Optimum tolerance is +0.003/(hole size)
PTH Locational Tolerance	0.003 (0.076)	N/A	N/A		
Internal Pad Size (Diameter over Drill)	0.012 (0.305)	0.008 (0.203)	N/A		Assumes pad breakout allowed (IPC-6012 Class 2) Add 2 mils for each 1 mil of annular ring required
Internal Anti-pad (Diameter over Drill)	0.016 (0.406)	0.012 (0.305)	0.010 (0.254)		
External Pad Size (Diameter over Drill)	0.010 (0.254)	0.006 (0.152)	N/A		Assumes pad breakout allowed (IPC-6012 Class 2) Add 2 mils for each 1 mil of annular ring required
<b>Drilling</b>					
Smallest Mechanical Drill Size	0.010 (0.254)	0.008 (0.203)	0.006 (0.152)		
Maximum Drill Aspect Ratio (w/ min. drill)	8:1	10:1	14:1		
Maximum Microvia Aspect Ratio (Depth:Diameter)	0.5:1	0.75:1	1.0:1		
Maximum Hole Size (Drilled)	0.250 (6.350)	0.250 (6.350)	0.25 (6.350)		Refers to drill size not finished hole size
Maximum Hole Size (Routed)	Unlimited	N/A	N/A		Minimum tolerance +/- 0.005"
NPTH Size Tolerance Range	0.004 (0.102)	0.003 (0.076)	0.002 (0.051)		i.e. +/- 0.002 = 0.004 range
NPTH Locational Tolerance	0.003 (0.076)	N/A	N/A		Assumes NPTH are drill during the primary drill cycle
Non-Plated Hole to Outer Copper Minimum Spacing	0.008 (0.203)	0.005 (0.127)	N/A		Assumes NPTH are drill during the primary drill cycle
Hole to Inner Copper Minimum Spacing	0.008 (0.203)	0.006 (0.152)	0.005 (0.127)		
Back Drilled Vias (High Speed Transitions)	No	No	Yes	Annual	
Blind/Buried Vias (All Types)	Yes	Yes	Yes	Weekly	
Non-Conductive Epoxy Via Fill <sup>(10)</sup>	No	Yes	Yes	Weekly	Default: San-ei PHP900IR10F
Conductive Via Fill <sup>(10)</sup>	No	Yes	Yes	Quarterly	Default: DuPont CB-100
<b>Solder Mask</b>					
Minimum LPI Soldermask Dam	0.004 (0.102)	0.003 (0.076)	0.003 (0.076)		Black, white, & yellow soldermasks excluded; these require 0.005 min
Soldermask Registration (+/-) or Clearance per side	0.003 (0.076)	0.002 (0.051) <sup>(12)</sup>	0.0015 (0.038) <sup>(12)</sup>		
LPI Soldermask	Yes	Yes	Yes	Daily	Electra EMP110 (80%) Default Finish: Matte (Gloss Available) Taiyo PSR-4000 HFX (20%) Available Finish: Satin Colors:Green,Blue,Red,Black <sup>(4)</sup> , Clear,Orange,Purple,Gray,White <sup>(4)</sup>
Dry Film Soldermask	No	No	No	Never	
Peelable Soldermask	Yes	Yes	Yes	Monthly	Peters SD-2954; Min clearance to exposed feature: 0.040"
Soldermask Via Plug w/LPI	Yes	Yes	Yes	Weekly	Taiyo PSR-4000 (15% min hole fill) Taiyo PIHP 200 (70% min hole fill)
Soldermask Laser Ablation	No	No	No	Never	
Soldermask using Laser Direct Imaging	No	No	No	Never	
<b>Impedance</b>					
Single-ended (+/- %)	10	N/A	N/A	Daily	
Differential/ Edge-coupled (+/- %)	10	N/A	N/A	Daily	
Differential/ Broadside-Coupled (+/- %)	10	N/A	N/A	Quarterly	
In-house Testing/Verification	Yes	Yes	Yes	Daily	Polar CITS500 TDR
<b>Technology</b>					
Etch back	Yes	Yes	Yes	Monthly	Plasma <sup>(10)</sup> , Modified Desmear Cycle <sup>(11)</sup>
Edge Plating	Yes	Yes	Yes	Monthly	
Castellated Holes	No	Yes	Yes	Monthly	
Aluminum Cores	No	No	No	Never	Offshore only
Heat Sinks	No	No	No	Never	
Backplanes	No	No	No	Never	
V-Cut (Scoring)	Yes	Yes	Yes	Daily	Jump scoring; 20°, 30°, 60° blades available
Milling	No	Yes	Yes	Monthly	

<b>Materials</b>					
Available Panel Sizes	18x24, 21x24				18x24 (1 - 26 layers), 21x24 (1 - 12 layers)
Maximum Board Size	17x23 <sup>(5)</sup> 20x23 <sup>(5)</sup> 16.7x22.7 <sup>(6)</sup> 19.7x22.7 <sup>(6)</sup>				
Minimum Dielectric Thickness	0.004 (0.102)	0.003 (0.076)	0.0025 (0.064)		
Minimum Copper Weight - Inner Layers (oz)	0.5	0.25	N/A		
Minimum Starting Copper Weight - Outer Layers (oz)	0.5	0.25	N/A		
Maximum Copper Weight - Inner Layers (oz)	3	4	5		Standard foils stocked: 1/2oz, 1oz, 2oz., 3oz <sup>(7)</sup>
Maximum Starting Copper Weight - Outer Layers (oz)	3	5	6		Standard foils stocked: 1/4oz, 1/2oz, 1oz, 2oz, 3oz <sup>(8)</sup>
Epoxy Glass (140C Tg min)	Yes	Yes	Yes	Daily	In stock Shengyi S1141, Ventek VT-42
Epoxy Glass (170C Tg min)	Yes	Yes	Yes	Daily	In stock Isola 370HR, Shengyi S1170, ITEQ 180A, Ventek VT-47
Polyimide Glass <sup>(9)</sup>	Yes	Yes	Yes	Quarterly	Limited material stocked; 3-5 day LT
Resin Coated Copper (for HDI)	No	No	Yes	Never	Material is NOT stocked
GeTek <sup>(9)</sup>	Yes	Yes	Yes	Annual	Material is NOT stocked; 10 day LT
Nelco 4000-13	Yes	Yes	Yes	Quarterly	Limited material stocked; 5-10 day LT
Rogers <sup>(9)</sup> 4003/4403	No	Yes	Yes	Annual	Material is NOT stocked; 3-5 day LT
Rogers <sup>(9)</sup> 4350B/4450B	No	Yes	Yes	Quarterly	Material is NOT stocked; 3-5 day LT
Teflons <sup>(9)</sup> (Rogers 6002, 6010, 5880)	No	No	Yes	Annual	Material is NOT stocked; SS/DS only; 5-10 day LT
CAF Resistant Epoxies <sup>(9)</sup>	No	No	Yes	Never	Material is NOT stocked; 10 day LT
Halogen Free Epoxies <sup>(9)</sup>	No	No	Yes	Never	Material is NOT stocked; 20 day LT
Buried Capacitance (i.e. BC2000, ZBC)	No	No	No	Never	License required to manufacture
<b>Surface Finishes</b>					
HASL	Yes	Yes	Yes	Daily	C=Chemistry, V=Vendor, S=Specification Range: Coverage and solderable (30 - 1000µin) S: IPC-6012
Lead-free HASL <sup>(10)</sup>	Yes	Yes	Yes	Monthly	Range: Coverage and solderable (30 - 1000µin) C: SN100C V: Unicote S: IPC-6012
Electroless Nickel Immersion Gold (ENIG)	Yes	Yes	Yes	Daily	Def. Range: Ni:118µin min / Au:2-5µin C: DOW S: IPC-4552
Eless Nickel Eless Palladium Imm Gold (ENEPIG) <sup>(10)</sup>	Yes	Yes	Yes	Annual	Default Range: Ni:118µin min / Pd:2-5µin / Au:1-2µin V: Superior Processing S: IPC-4552 (Ni/Au), ASTM-B-679 (Pd)
Hard Gold <sup>(10)</sup>	Yes	Yes	Yes	Monthly	Default Range: Flash gold: 5 - 15µin / Contact pads: 30µin min. V: Superior Processing S: ASTM-B-488
Hard Gold (Tabs)	Yes	Yes	Yes	Weekly	Default Range: Ni:118µin min / Au:30µin min S: ASTM-B-488
Soft Bondable Gold <sup>(10)</sup>	No	Yes	Yes	Annual	Default Range: Ni:118µin min / Au:50µin min V: Superior Processing
Immersion Silver	Yes	Yes	Yes	Weekly	Range: 6 - 18µin C: MacDermid Sterling Silver S: IPC-4553 C: Enthone Entek Plus HT
Organic Solderability Preservative (OSP) <sup>(10)</sup>	No	Yes	Yes	Annual	V: AVT S: IPC-6012
Immersion Tin <sup>(10)</sup>	No	Yes	Yes	Quarterly	Default Range: 30µin min C: MacDermid MacStan HSR V: AVT S: IPC-4554
Carbon Ink	No	Yes	Yes	Quarterly	
Combination Finishes (i.e. ENIG and Soft Gold)	No	Yes	Yes	Monthly	

<b>Lead Time</b>					
24 Hour	Yes	No	No	Quarterly	1 - 2 layer; no outside processes; local delivery only
48 Hour	Yes	No	No	Monthly	1 - 12 layer; no outside processes; data by 8:00am
3 Day	Yes	Yes	Yes	Weekly	Limited to ten 18x24 panels; no outside processes
5 Day	Yes	Yes	Yes	Daily	
10 Day	Yes	Yes	Yes	Daily	
15 Day and Greater	Yes	Yes	Yes	Daily	
<b>Production Capability</b>					
Low - Medium Volume Production	Yes	Yes	Yes	Daily	Domestic
High Volume Production	Yes	Yes	No	Weekly	Domestic & Offshore
<b>Quality</b>					
IPC-6012 Class 1	Yes	Yes	Yes	Never	
IPC-6012 Class 2	Yes	Yes	Yes	Daily	Default
IPC-6012 Class 3 (High Reliability)	Yes	Yes	Yes	Daily	
IPC-6012 Class 3A (Space & Military Avionics)	Yes	Yes	Yes	Quarterly	
<b>Certifications</b>					
ISO 9001:2008	Yes	Yes	Yes		Cert # 09.176.1
AS9100C (Aerospace)	Yes	Yes	Yes		Cert # 10.091.1
MIL-PRF-55110	Yes	Yes	Yes		GF material only
ITAR Registered	Yes	Yes	Yes		
RoHS/Lead-Free	Yes	Yes	Yes		
UL Registered	Yes	Yes	Yes		
IPC Member	Yes	Yes	Yes		

<sup>(1)</sup> Assumes 30% etch tolerance

<sup>(2)</sup> Obtainability will depend on board thickness, geometry, and copper design

<sup>(3)</sup> Obtainability will depend on board thickness and layer count

<sup>(4)</sup> Additional cost

<sup>(5)</sup> 1 to 2 layer only

<sup>(6)</sup> Multilayer only

<sup>(7)</sup> Limited stock

<sup>(8)</sup> Limited stock for double-sided boards

<sup>(9)</sup> Multicircuits not UL certified (UL mark would not appear on finished product).

<sup>(10)</sup> Outsourced

<sup>(11)</sup> Limited to certain material types

<sup>(12)</sup> Value should only be used locally where required and not globally