

BASICS OF PRINTED CIRCUIT BOARD PRODUCTION

IPC – MATERIAL – PRODUCTION

Klaus Schill-Mulack

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

1. General
2. IPC-Standards
3. Copper Foil
4. Laminate
5. Production

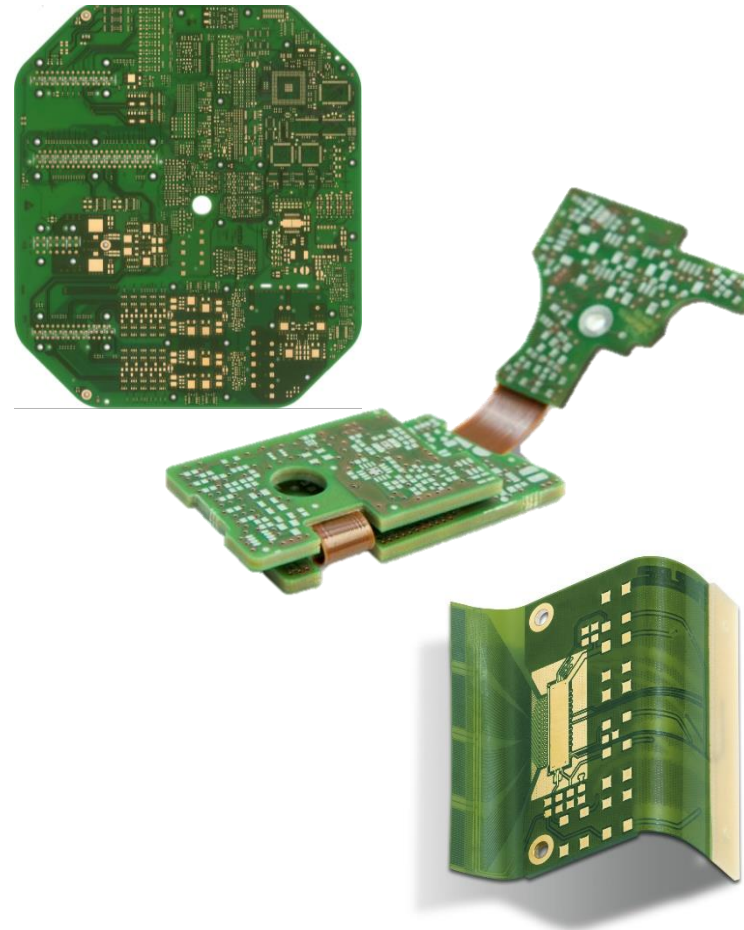
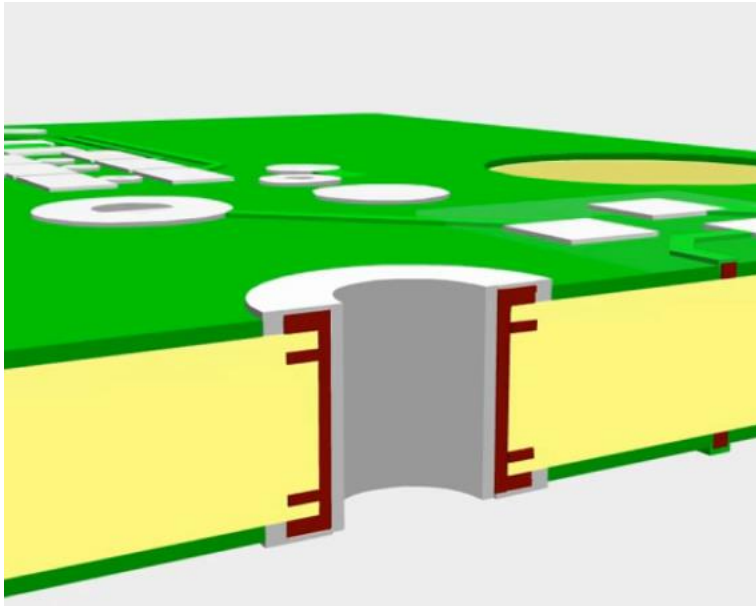


Klaus Schill-Mulack
Technical Project Management

BASICS OF PRINTED CIRCUIT BOARD

IPC - MATERIAL - PRODUCTION

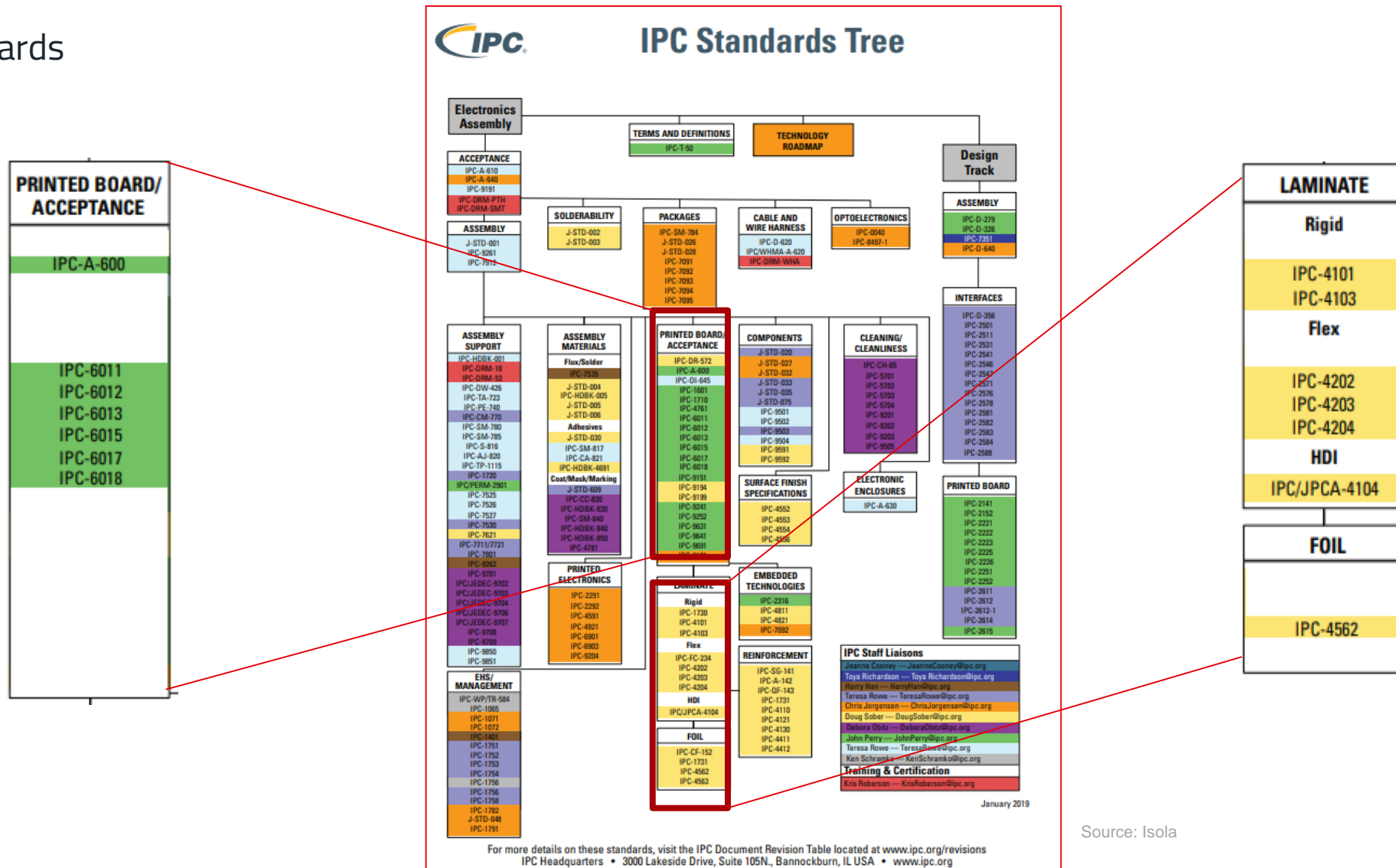
General



BASICS OF PRINTED CIRCUIT BOARD

IPC - MATERIAL - PRODUCTION

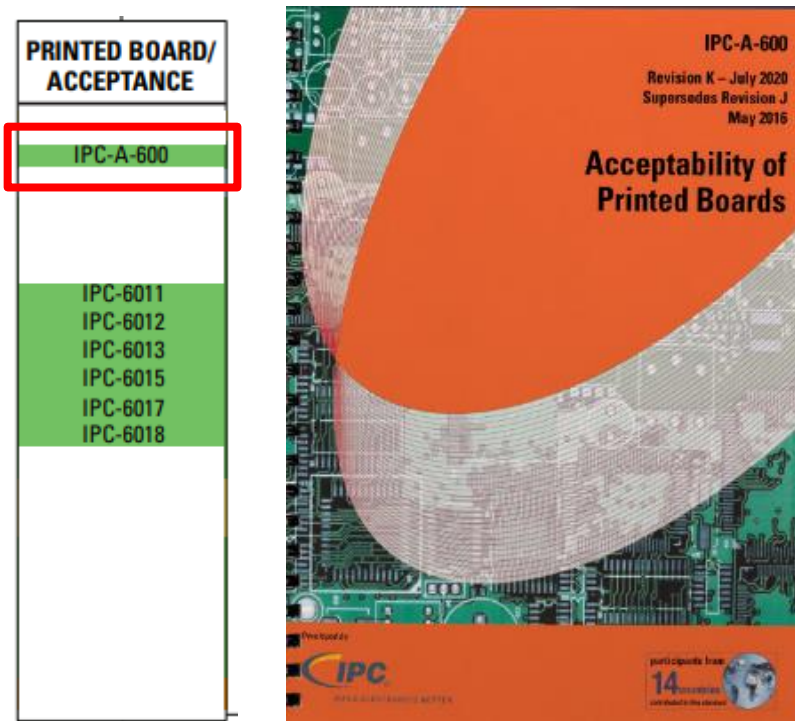
IPC Standards



Source: Isola

IPC 600 / 601x

- IPC 600 - Acceptance criteria of Printed Circuit Boards



2.11 Flatness

2.11 Flatness (cont.)

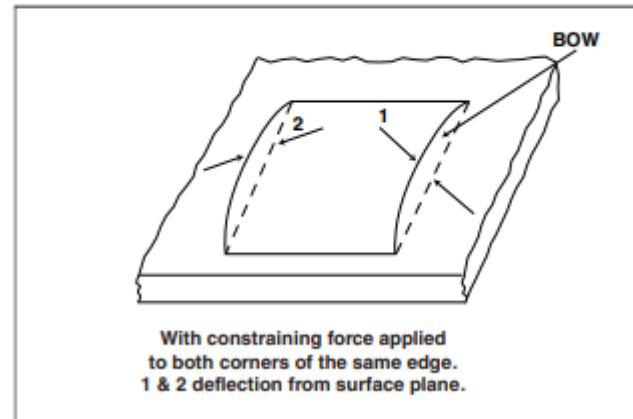


Figure 211a

Acceptable - Class 1, 2, 3

- For printed boards using surface mount components, the bow and twist **shall** be 0.75% or less.
- For all other printed boards, bow and twist **shall** be 1.50% or less.

Nonconforming - Class 1, 2, 3

- Defects either do not meet or exceed above criteria.

Source: Isola

BASICS OF PRINTED CIRCUIT BOARD

IPC - MATERIAL - PRODUCTION

IPC 600 / 601x

- IPC 601x - Qualification and performance specification of Printed Circuit Boards

PRINTED BOARD/ ACCEPTANCE
IPC-A-600
IPC-6011 IPC-6012 IPC-6013 IPC-6015 IPC-6017 IPC-6018



IPC-6011

Generic Perform
Specification for
Printed Boards

IPC-6012E
2020 - March
Qualification and Performance
Specification for Rigid
Printed Boards
Supersedes IPC-6012D
September 2015
An international standard developed by IPC

IPC-6013E
2021 - September
Qualification and Performance Specification for
Flexible/Rigid-Flexible Printed Boards
Supersedes IPC-6013D Amendment 1
April 2018
An international standard developed by IPC



Table 3-11 Cap Plating Requirements for Filled Holes

	Class 1	Class 2	Class 3
Copper Cap – Minimum Thickness	AABUS	5 µm [197 µin]	12 µm [472 µin]
Filled via Depression (Dimple) – Maximum ¹	AABUS	127 µm [5,000 µin]	76 µm [2,992 µin]
Filled Via Protrusion (Bump) – Maximum ¹	AABUS	50 µm [1,970 µin]	50 µm [1,970 µin]

Table 3-14 External Conductor Thickness after Plating

Weight ^{1,4}	Absolute Cu Min. (IPC-4562 less 10% reduction) (µm) [µin] ⁵	Plus average plating for Class 1 and 2 (20 µm) [787 µin] ² FOR REFERENCE PURPOSES ONLY	Plus average plating for Class 3 (25 µm) [984 µin] ² FOR REFERENCE PURPOSES ONLY	Maximum Variable Processing Allowance Reduction ³ (µm) [µin] FOR REFERENCE PURPOSES ONLY	Minimum Surface Conductor Thickness after Processing (µm) [µin]	
					Class 1 & 2	Class 3
1/8 oz.	4.60 [181]	24.60 [967]	29.60 [1,165]	1.50 [59]	23.1 [909]	28.1 [1,106]
1/4 oz.	7.70 [303]	27.70 [1,091]	32.70 [1,287]	1.50 [59]	26.2 [1,031]	31.2 [1,228]
3/8 oz.	10.80 [425]	30.80 [1,213]	35.80 [1,409]	1.50 [59]	29.3 [1,154]	34.3 [1,350]
1/2 oz.	15.40 [606]	35.40 [1,394]	40.40 [1,591]	2.00 [79]	33.4 [1,315]	38.4 [1,512]
1 oz.	30.90 [1,217]	50.90 [2,004]	55.90 [2,201]	3.00 [118]	47.9 [1,886]	52.9 [2,083]
2 oz.	61.70 [2,429]	81.70 [3,217]	86.70 [3,413]	3.00 [118]	78.7 [3,098]	83.7 [3,295]
3 oz.	92.60 [3,646]	112.60 [4,433]	117.60 [4,630]	4.00 [157]	108.6 [4,276]	113.6 [4,472]
4 oz.	123.50 [4,862]	143.50 [5,650]	148.50 [5,846]	4.00 [157]	139.5 [5,492]	144.5 [5,689]

Source: Isola

BASICS OF PRINTED CIRCUIT BOARD

IPC - MATERIAL - PRODUCTION

IPC 410x – Specification Sheet

LAMINATE
Rigid
IPC-4101 IPC-4103
Flex
IPC-4202 IPC-4203 IPC-4204
HDI
IPC/JPCA-4104
FOIL
IPC-4562

SPECIFICATION SHEET

SPECIFICATION SHEET #:

REINFORCEMENT:

RESIN SYSTEM:

FLAME RETARDANT MECHANISM:

FILLERS:

ID REFERENCE:

GLASS TRANSITION (T_g):

IPC-4101/21

1: Woven E-glass

Primary: Difunctional epoxy

Secondary 1: Multifunctional epoxy

RoHS Compliant Bromine

<5%

UL/ANSI: FR-4.0/21

110 °C minimum

2: NONE

Secondary 2: NONE

Minimum UL94 Requirement: V-0

MIL-S-13949: /04

- GF, GFN, GFK, GFP, GFM

LAMINATE REQUIREMENTS

Laminate Requirement	Specification <0.50 mm [0.0197 in]	Specification ≥0.50 mm [0.0197 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum					3.9.1.1
A. Low profile copper foil and very low profile copper foil – all copper foil >17 μm [0.669 mil].	0.70 [4.00]	0.70 [4.00]	N/mm [lb/in]	2.4.8	3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
B. Standard profile copper foil				2.4.8.2	
1. After thermal stress	0.80 [4.57]	1.05 [6.00]		2.4.8.3	
2. At 125 °C [257 °F]	0.70 [4.00]	0.70 [4.00]			
3. After process solutions	0.55 [3.14]	0.80 [4.57]			
C. All other foil – composite	AABUS	AABUS			
2. Volume Resistivity, minimum					
A. 96/35/90	10 ⁶	–	MΩ-cm	2.5.17.1	3.11.1.3
B. After moisture resistance	–	10 ⁶			
C. At elevated temperature E-24/125	10 ³	10 ³			
3. Surface Resistivity, minimum					
A. 96/35/90	10 ⁴	–	MΩ	2.5.17.1	3.11.1.4
B. After moisture resistance	–	10 ⁴			
C. At elevated temperature E-24/125	10 ³	10 ³			
4. Moisture Absorption, maximum	–	0.80	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	–	40	kV	2.5.6	3.11.1.6
6. Permittivity at 1 MHz, maximum (Laminate & laminated prepreg)*	5.4	5.4	–	2.5.5.2 2.5.5.3 2.5.5.9	3.11.1.1 3.11.2.1
7. Loss Tangent at 1 MHz, maximum (Laminate & laminated prepreg)*	0.035	0.035	–	2.5.5.2 2.5.5.3 2.5.5.9	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum					
A. Length direction	–	415 [60,190]	N/mm ² [lb/in ²]	2.4.4	3.9.1.3
B. Cross direction	–	345 [50,040]			
9. Flexural Strength at Elevated Temperature, length direction, minimum	–	–	N/mm ² [lb/in ²]	2.4.4.1	3.9.1.4
10. Arc Resistance, minimum	60	60	s	2.5.1	3.11.1.5
11. Thermal Stress 10 s at 288 °C [550.4 °F], minimum					
A. Unetched	Pass Visual	Pass Visual	rating	2.4.13.1	3.10.1.2
B. Etched	Pass Visual	Pass Visual			
12. Electric Strength, minimum (Laminate & laminated prepreg)	30	–	kV/mm	2.5.6.2	3.11.1.7 3.11.2.3
13. Flammability, minimum (Laminate & laminated prepreg)	V-0	V-0	rating	UL94	3.10.2.1 3.10.1.1
14. Glass Transition Temperature, minimum	–	110	°C	2.4.24 2.4.25	3.10.1.6
15. Other	–	–			

Source: Isola

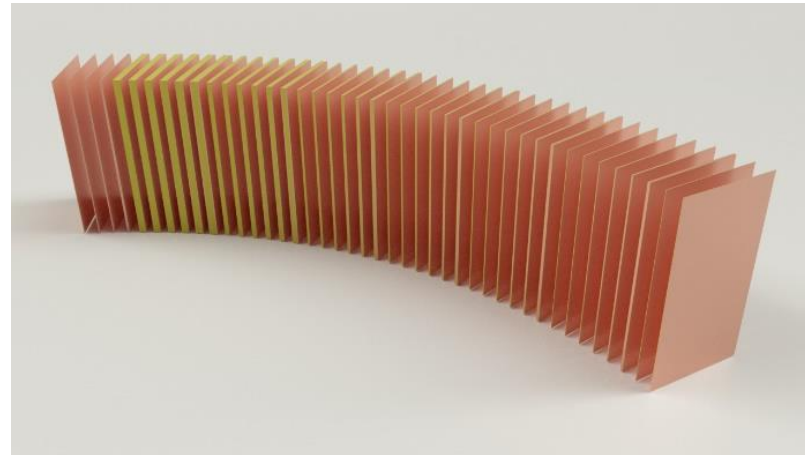
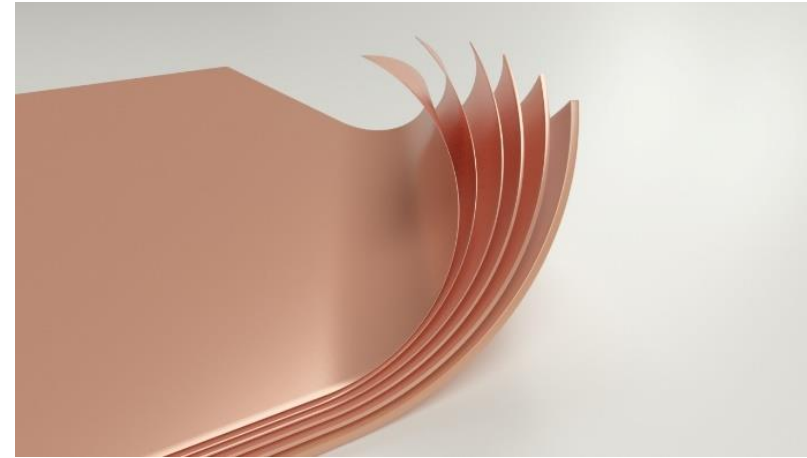
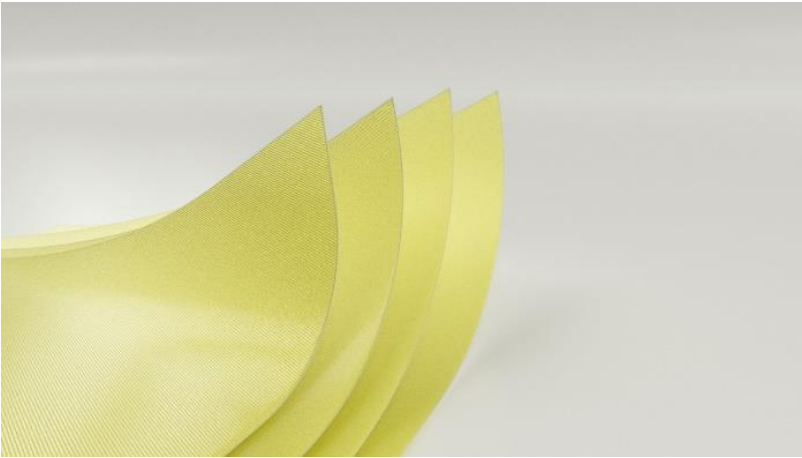
SURVEY

Multiple-Choice

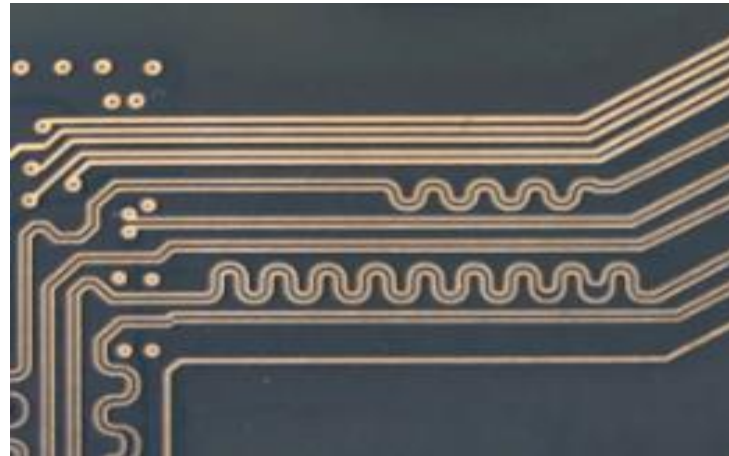
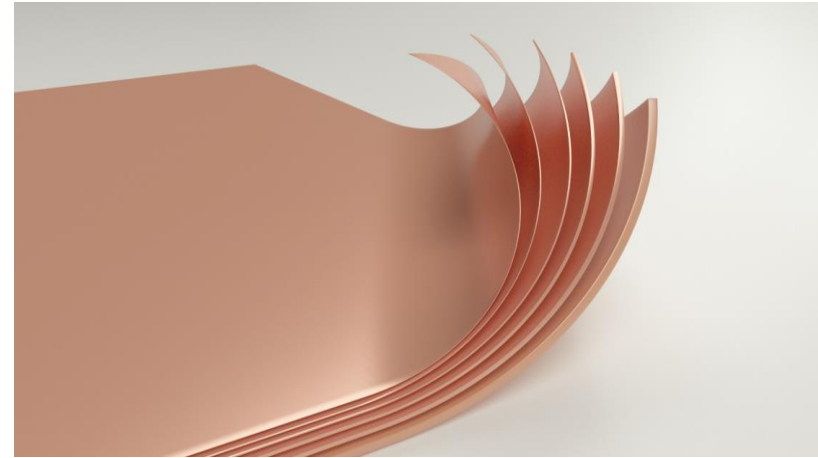
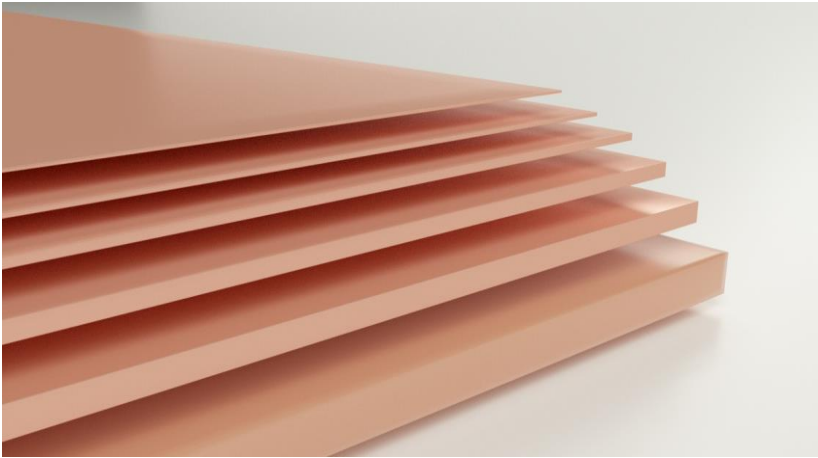
- **What is the most commonly used resin system for printed circuit board m?**
- Epoxy
- Polyimid
- PTFE - Polytetrafluorethylen
- PPE - Polyphenylenether
- BT - Bismaleimide Triazine



Laminate



Copper Foils

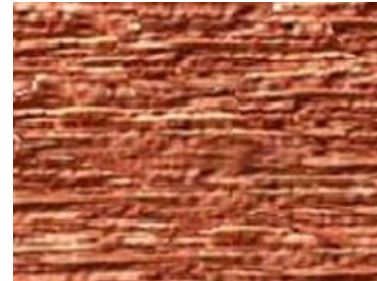


Copper Foils – IPC-4562

- Foil type/ -class



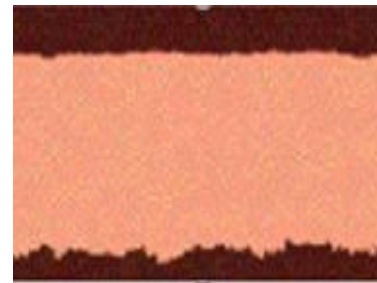
ED = Electrodeposited Copper



RA= Rolled (Annealed) Copper

- Foil thickness / weight
 - Definition of nominal thickness in μm / typ. 18/35/70/105

- Foil treatment



Foil Profile	μm
S (Standard)	N/A
L (Low Profile)	10.2
V (Very Low Profile)	5.1
X (No Treatment or Roughness)	N/A

FR4 - Prepreg



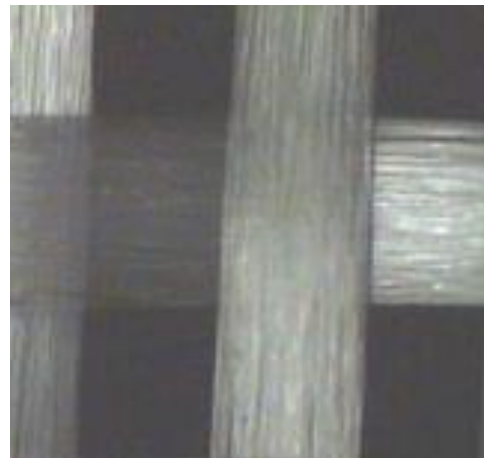
FR4 - Prepreg

Gewebe Typ	Flächen- gewicht g/m ²	Kette			Schuß		
		Faden- zahl pro cm	Garntyp EC g/1000 m (tex)	Filament- dicke µm	Faden- zahl pro cm	Garntyp EC g/1000 m (tex)	Filament- dicke µm
106	25	22	5,5	5	22	5,5	5
1080	47	24	11	5	19	11	5
2113	78	24	22	7	22	11	5
2116	107	24	22	7	23	22	7
7628	203	17	68	9	12	68	9

Source: Isola



Source: Isola



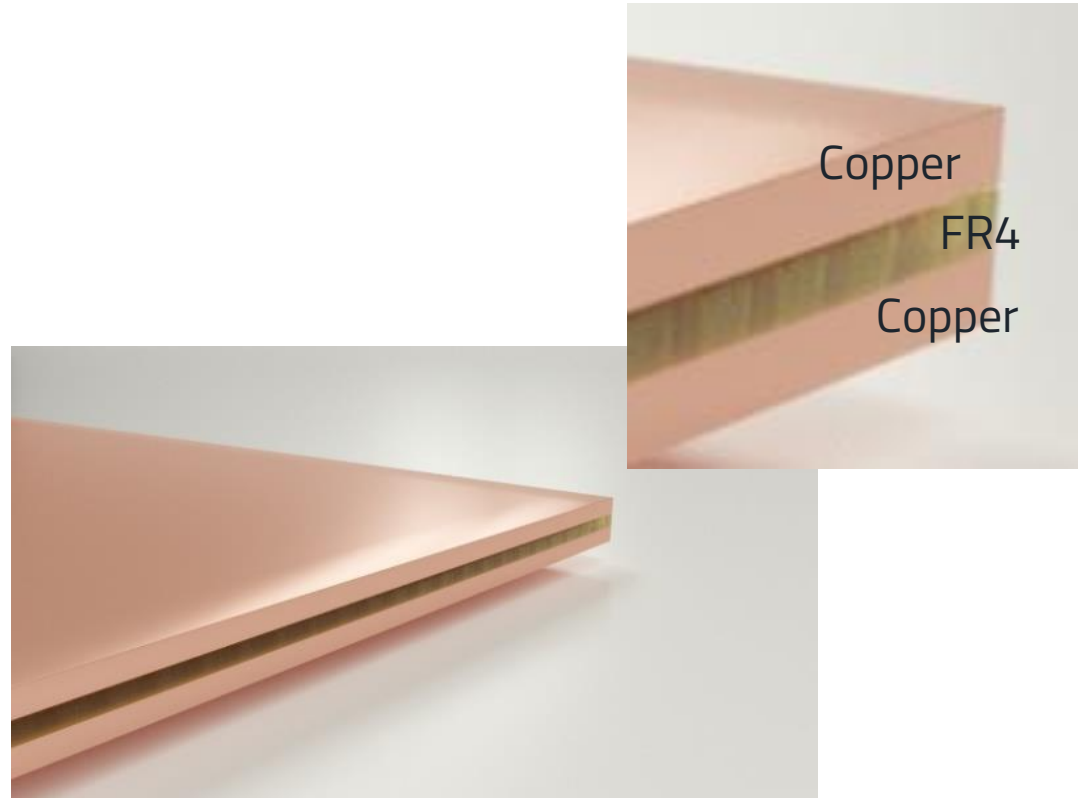
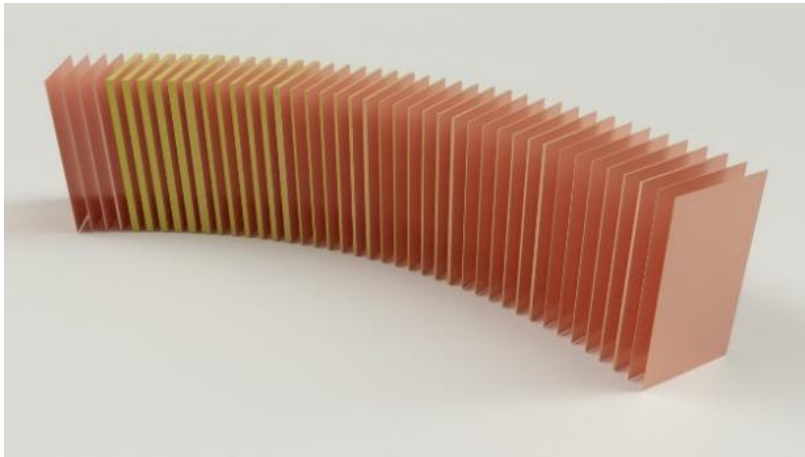
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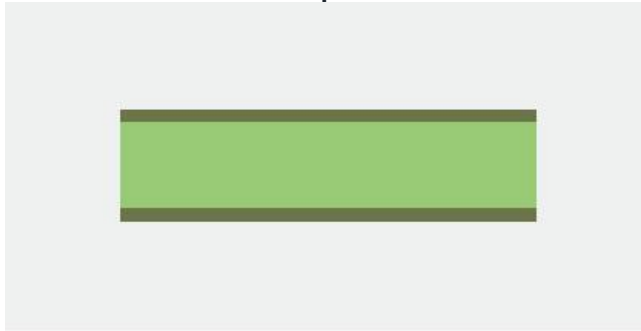
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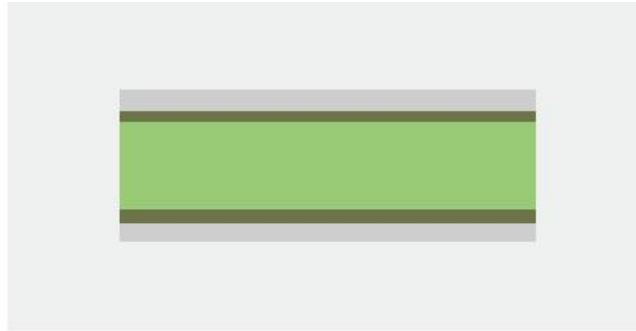
Copper clad laminate / core



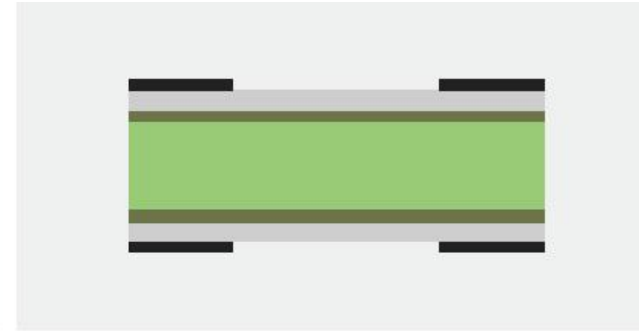
Production steps



Base material



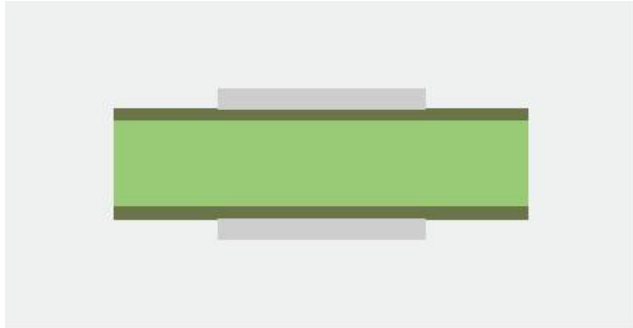
Film resist



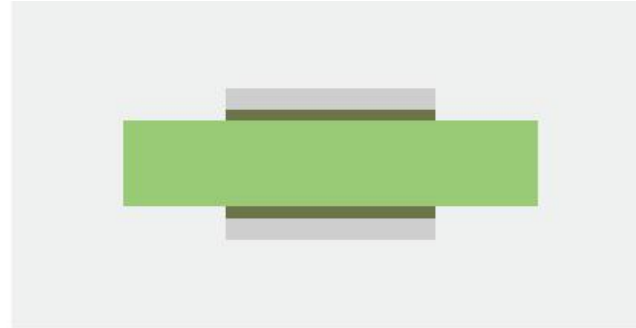
Imaging



Production steps



Developing

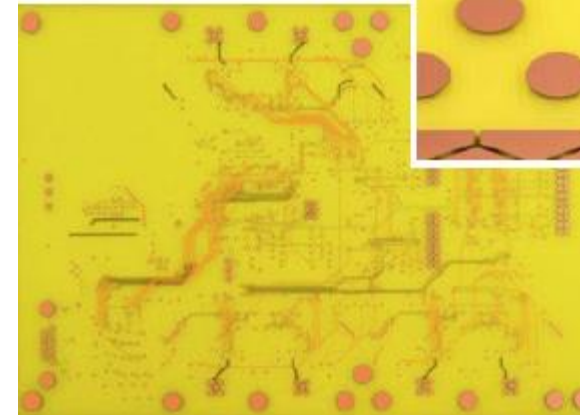
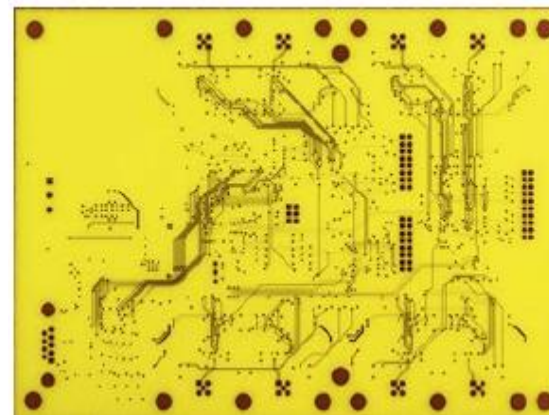


Etching

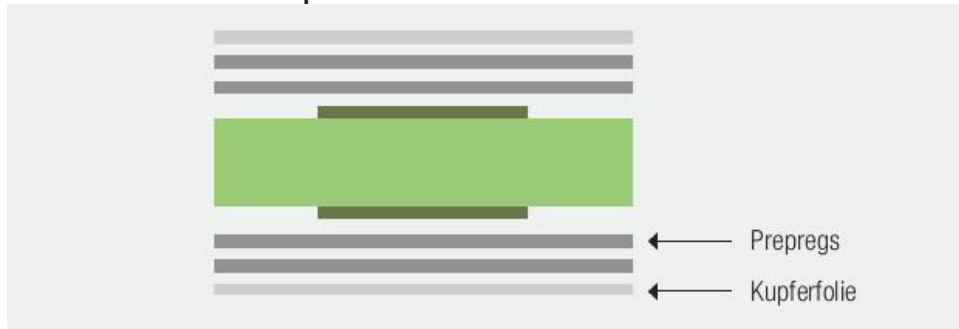


Stripping

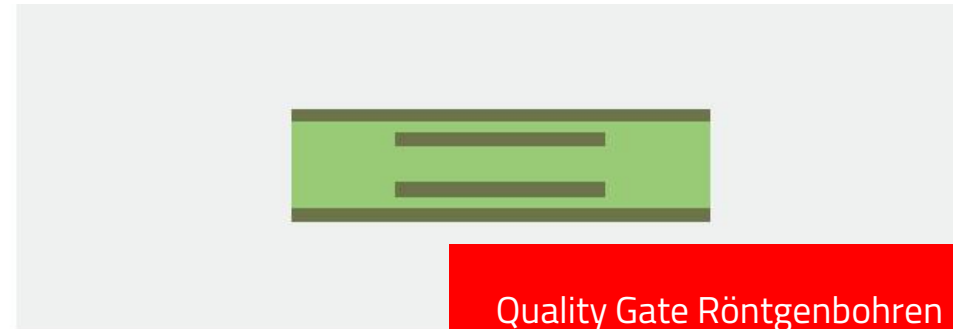
Quality Gate AOI



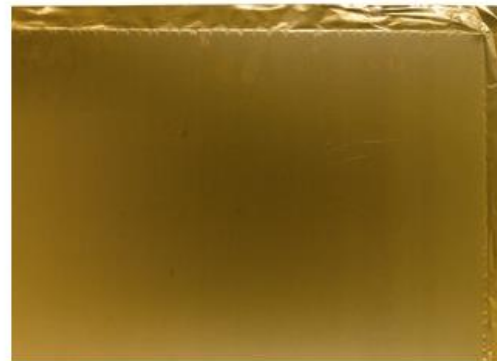
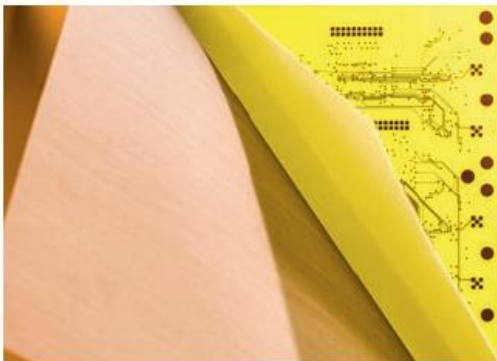
Production steps



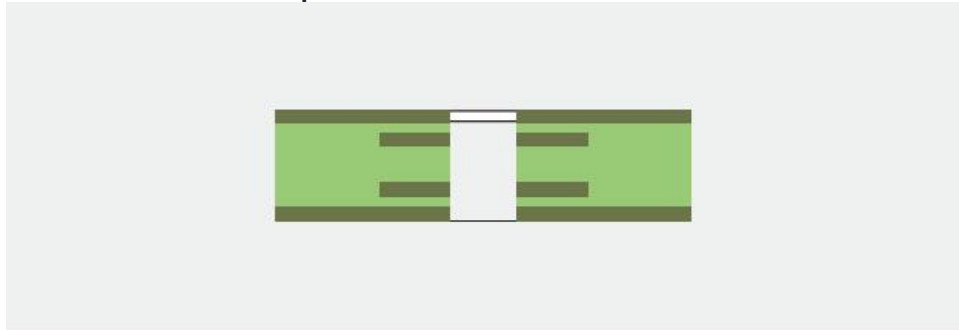
Multilayer Lay-up



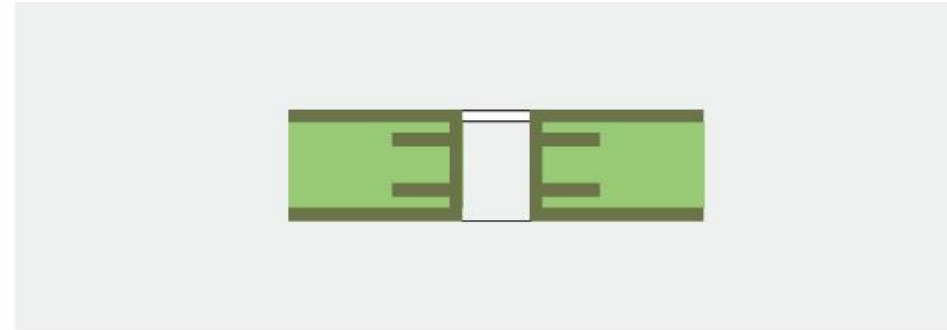
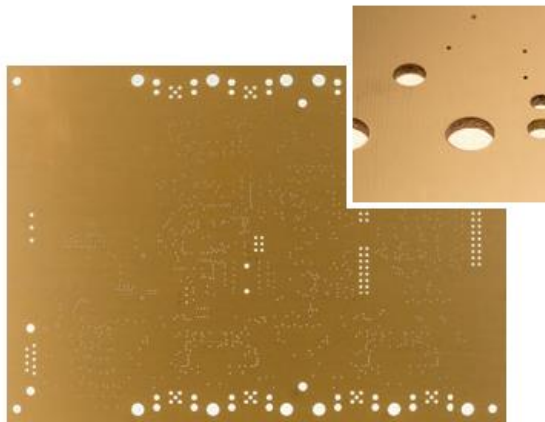
Lamination



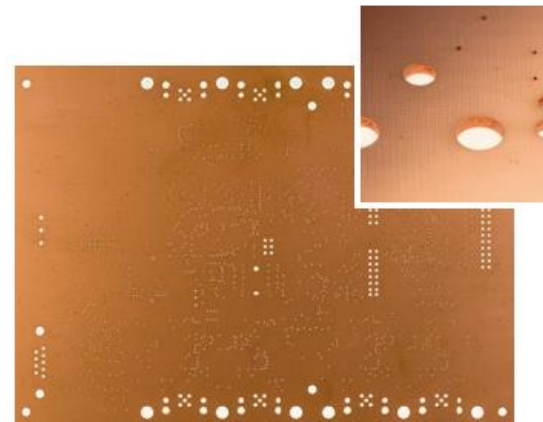
Production steps



Drilling



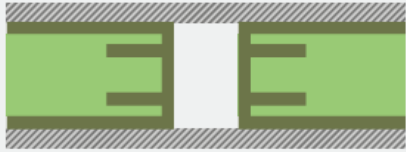
Desmear / Panel Plating



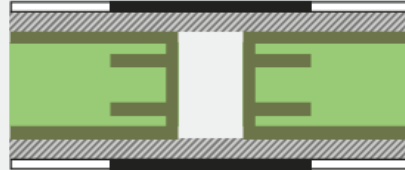
BASICS OF PRINTED CIRCUIT BOARD

IPC - MATERIAL - PRODUCTION

Production steps



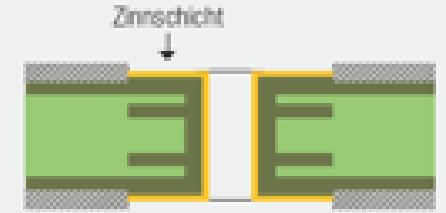
Photoresist



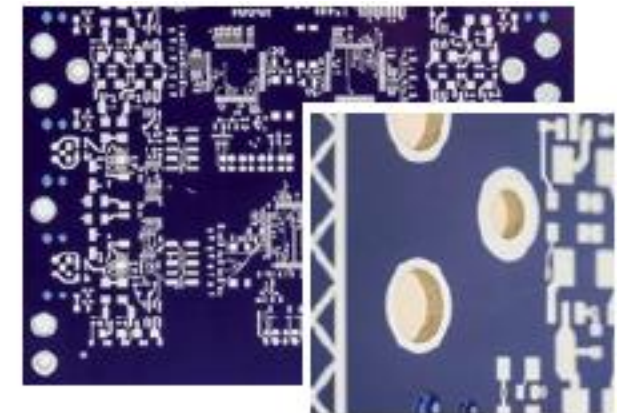
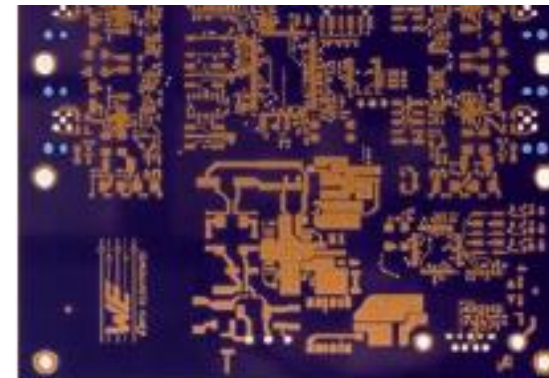
Imaging



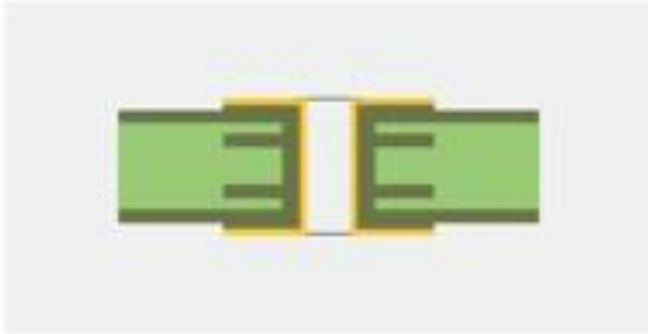
Developing



Plating



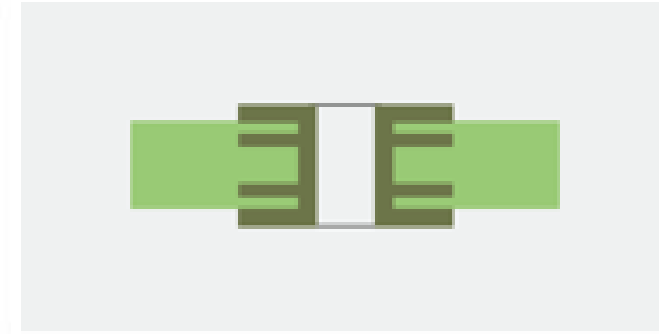
Production steps



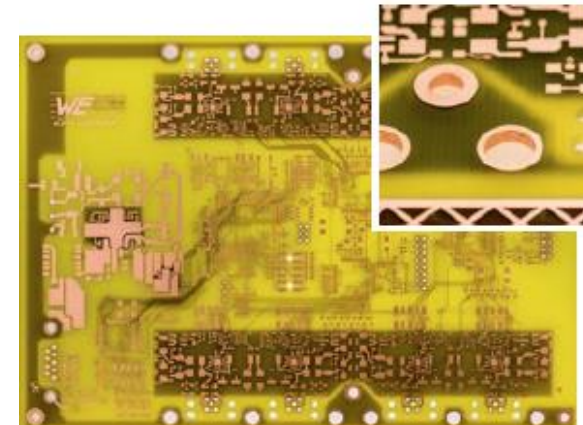
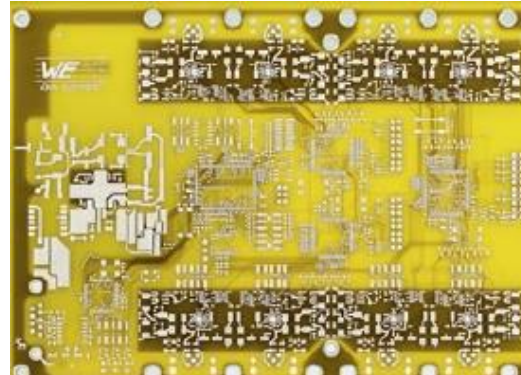
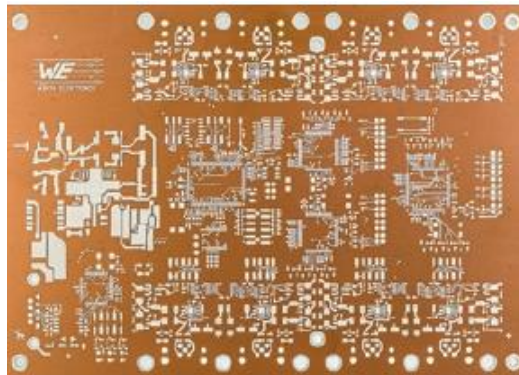
Resist Stripping



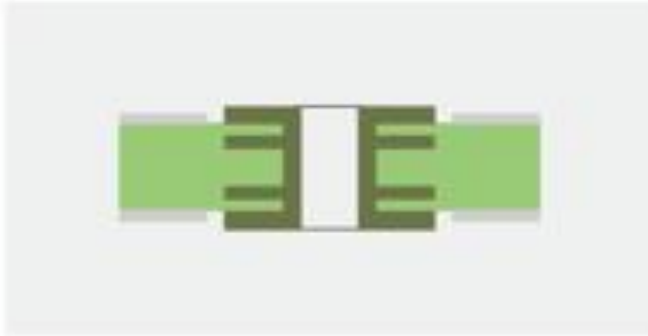
Etching



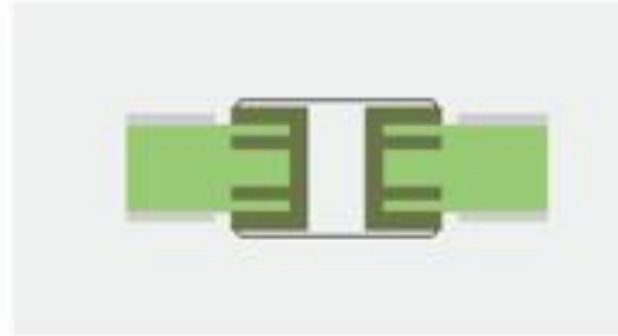
Tin Stripping



Production steps



Soldermask

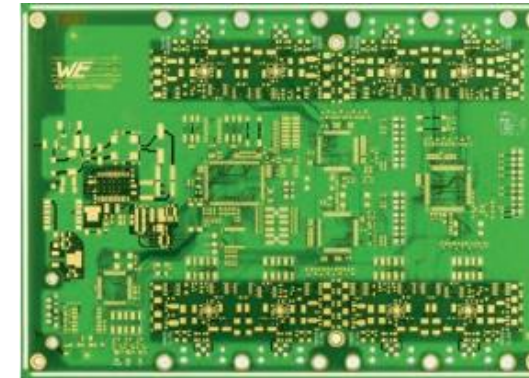
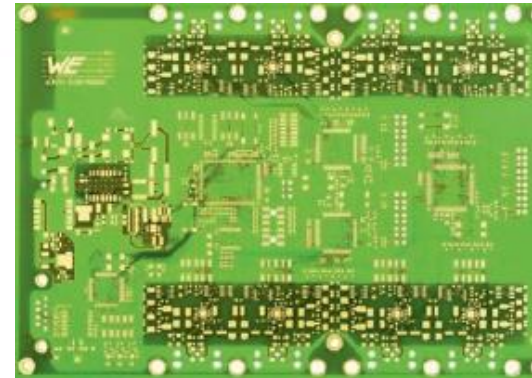
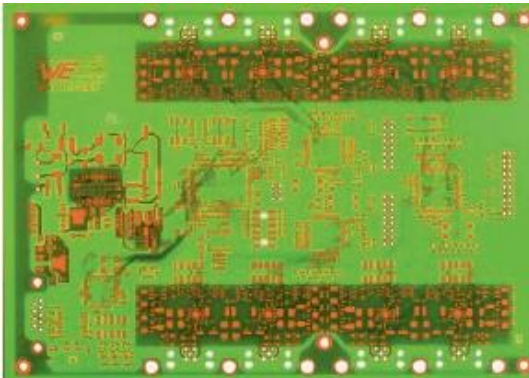


Surface (e.g. ENIG)



Depaneling / Routing

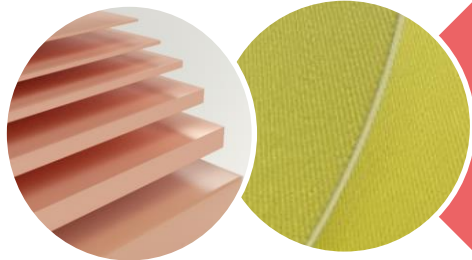
Quality Gate
E-Test/ Final Control



Summary



IPC – Standards for Circuit Boards



Base Materials



Production

THANK YOU FOR YOUR ATTENTION

Basics of printed circuit board production
IPC - Material - Production