



# GRUNDLAGEN DER LEITERPLATTENPRODUKTION IPC – MATERIAL – PRODUKTION

Klaus Schill-Mulack

**WÜRTH ELEKTRONIK** MORE THAN YOU EXPECT

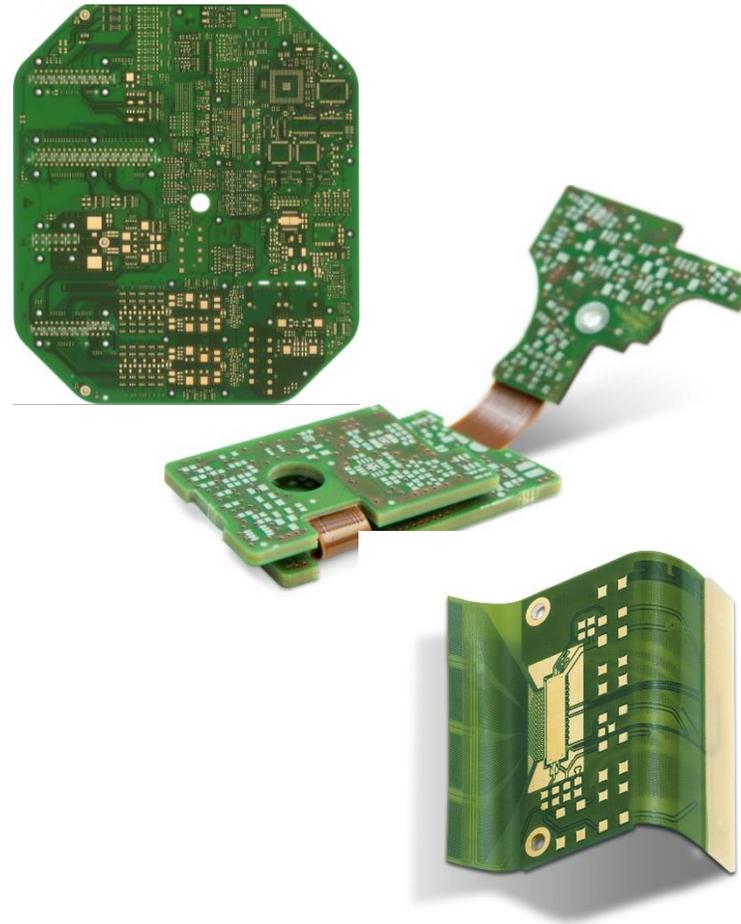
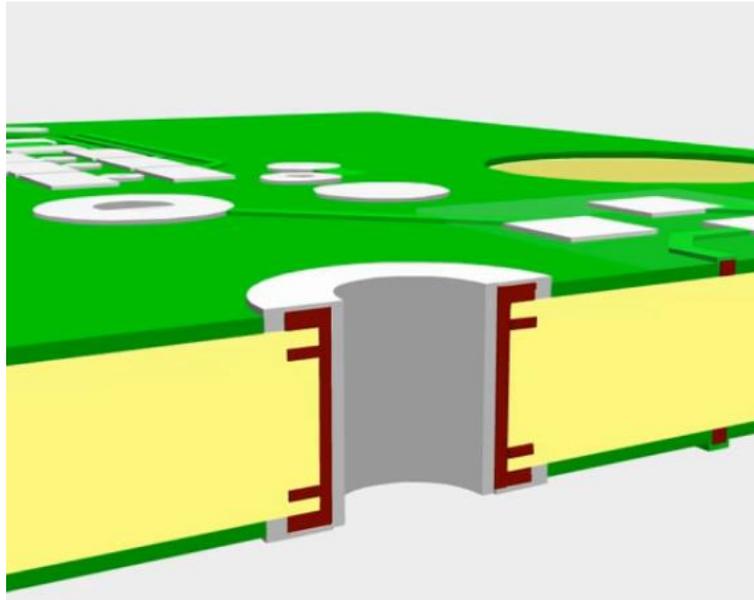
# BASISWISSEN LEITERPLATTE      IPC - MATERIAL - PRODUKTION

1. Allgemeines
2. IPC-Standards
3. Kupferfolien
4. Basismaterial
5. Produktion



**Klaus Schill-Mulack**  
Technisches Projektmanagement

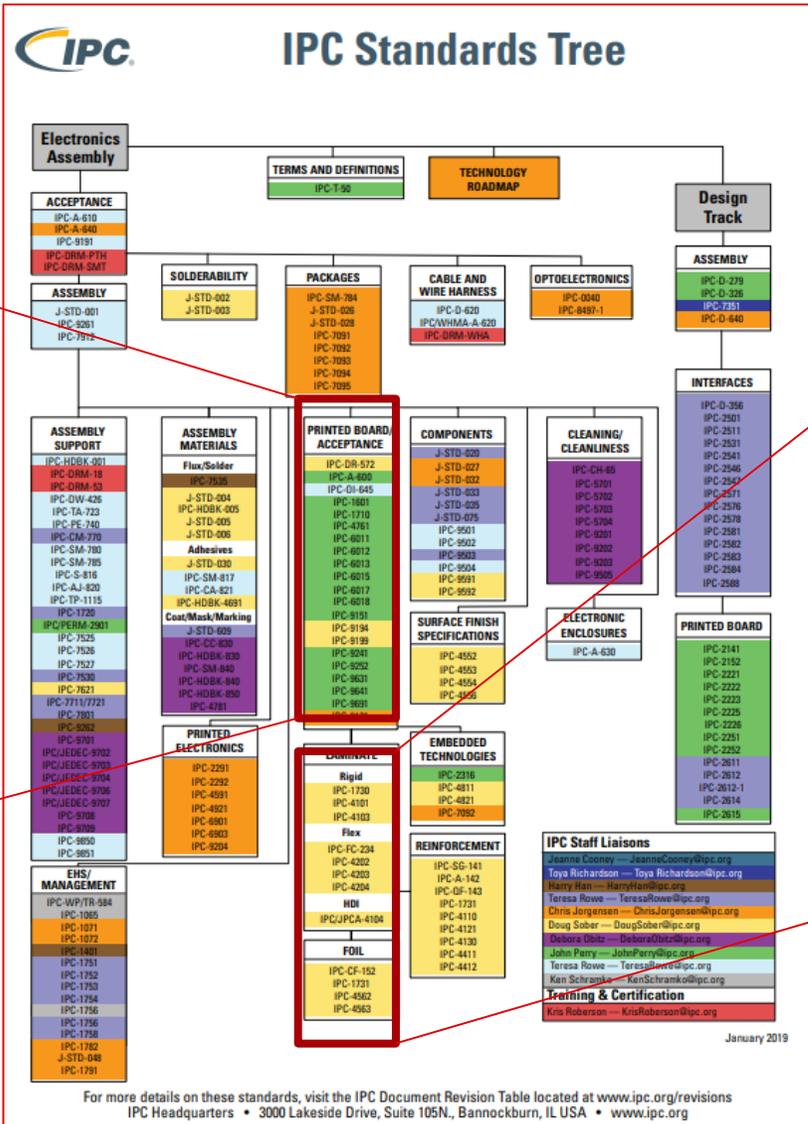
Allgemein



# BASISWISSEN LEITERPLATTE IPC - MATERIAL - PRODUKTION

IPC Richtlinien

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



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

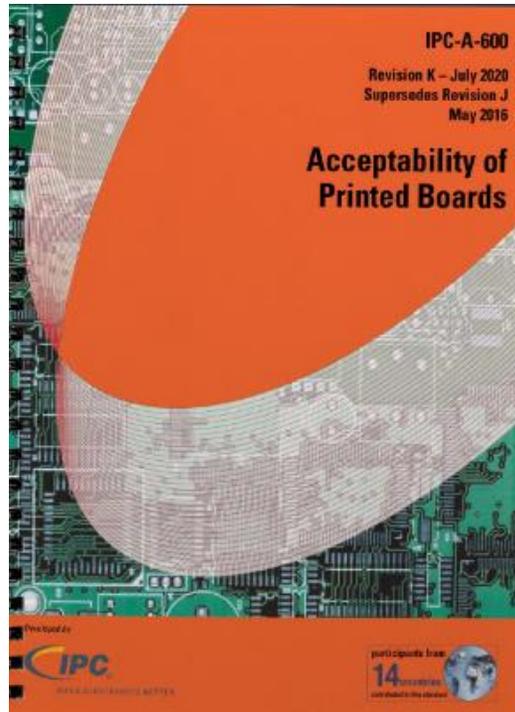
For more details on these standards, visit the IPC Document Revision Table located at [www.ipc.org/revisions](http://www.ipc.org/revisions)  
 IPC Headquarters • 3000 Lakeside Drive, Suite 105N, Bannockburn, IL USA • [www.ipc.org](http://www.ipc.org)



IPC 600 / 601x

- IPC 600 - Abnahmekriterien von Leiterplatten

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



## 2.11 EBENHEIT

### 2.11 Ebenheit (Fortsetzung)

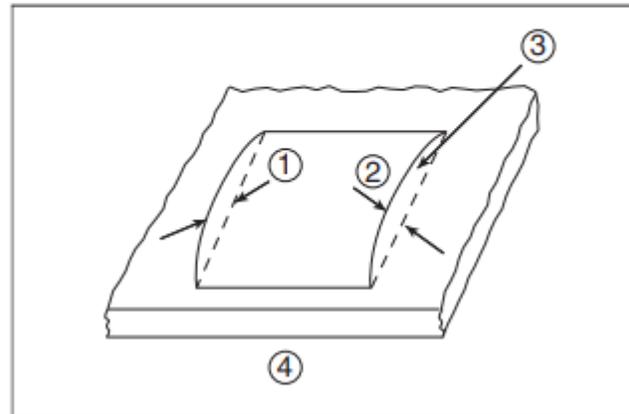


Bild 211a

Zulässig – Klassen 3, 2, 1

- Bei Leiterplatten für SMT-Bauteile **darf** die Wölbung und Verwindung **höchstens** 0,75 Prozent betragen
- Bei allen anderen Leiterplatten **darf** die Wölbung und Verwindung **höchstens** 1,5 Prozent betragen

Fehler – Klassen 3, 2, 1

- Fehler, die obige Kriterien nicht einhalten oder überschreiten

# BASISWISSEN LEITERPLATTE IPC - MATERIAL - PRODUKTION

IPC 600 / 601x

- IPC 601x - Qualifizierung und Leistungsspezifikation von Leiterplatten

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

**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



ASSOCIATION  
CONNECTING  
ELECTRONICS  
INDUSTRIES

Hersteller der  
Deutschen Übersetzung  
**FED**  
FEDERATION EUROPEENNE DES FABRICANTS D'ETIQUETTES

IPC  
Association Connecting Electronics Industries

Allgemeine  
Leistungsspezifikation  
für Leiterplatten

Generic Performance  
Specification for Printed Boards

IPC-6011  
Ausgabe Juli 1996  
Entwick. IPC-6011-276  
Autor der Revision: IPC  
Association Connecting  
Electronics Industries  
Deutsche Übersetzung  
Oktober 2012

Tabelle 3-11 Anforderungen an die Deckflächenmetallisierung bei gefüllten Löchern

	Klasse 1	Klasse 2	Klasse 3
Kupfer-Deckfläche – Mindest-Dicke	AABUS (zw. Anwender und Lieferant zu vereinbaren)	5 µm [197 µin]	12 µm [472 µin]
Deile bei gefüllter Durchverbindung – Maximum <sup>1</sup>	AABUS (zw. Anwender und Lieferant zu vereinbaren)	127 µm [5.000 µin]	76 µm [2.992 µin]
Hügel bei gefüllter Durchverbindung – Maximum <sup>1</sup>	AABUS (zw. Anwender und Lieferant zu vereinbaren)	50 µm [1.970 µin]	50 µm [1.970 µin]

Tabelle 3-15 Dicke von Außenlagen-Leitern nach der Metallisierung

Gewicht <sup>1,4</sup>	Absolut min. Kupferdicke (IPC-4562 minus 10%) (µm) [µin] <sup>5</sup>	Plus mittlere Metallisierung bei Klasse 1 und 2 (20 µm) [787 µin] <sup>2</sup> NUR FÜR REFERENZZWECKE	Plus mittlere Metallisierung bei Klasse 3 (25 µm) [984 µin] <sup>2</sup> NUR FÜR REFERENZZWECKE	Maximal erlaubte Werte der prozessbedingten Dickenreduzierung <sup>3</sup> (µm) [µin] NUR FÜR REFERENZZWECKE	Mindest-Dicke der Außenlagen-Leiter nach der Bearbeitung (µm) [µin]	
					Klassen 1 & 2	Klasse 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]

## 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 #:		IPC-4101/21			
REINFORCEMENT:		1: Woven E-glass		2: NONE	
RESIN SYSTEM:		Primary: Difunctional epoxy		Secondary 1: NONE	
FLAME RETARDANT MECHANISM:		Secondary 1: Multifunctional epoxy		Minimum UL94 Requirement: V-0	
FILLERS:		RoHS Compliant Bromine		RoHS Compliant Bromine: V-0	
ID REFERENCE:		UL/ANSI: FR-4.0/21		MIL-S-13949: /04	
GLASS TRANSITION (T <sub>g</sub> ):		110 °C minimum		- 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 <sup>6</sup>	–	MΩ-cm	2.5.17.1	3.11.1.3
B. After moisture resistance	–	10 <sup>6</sup>			
C. At elevated temperature E-24/125	10 <sup>3</sup>	10 <sup>3</sup>			
3. Surface Resistivity, minimum					
A. 96/35/90	10 <sup>4</sup>	–	MΩ	2.5.17.1	3.11.1.4
B. After moisture resistance	–	10 <sup>4</sup>			
C. At elevated temperature E-24/125	10 <sup>3</sup>	10 <sup>3</sup>			
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 <sup>2</sup> [lb/in <sup>2</sup> ]	2.4.4	3.9.1.3
B. Cross direction	–	345 [50,040]			
9. Flexural Strength at Elevated Temperature, length direction, minimum	–	–	N/mm <sup>2</sup> [lb/in <sup>2</sup> ]	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	–	–			

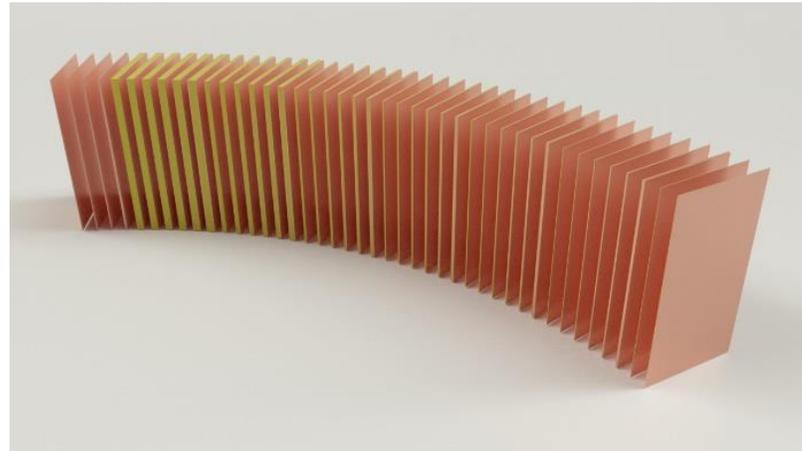
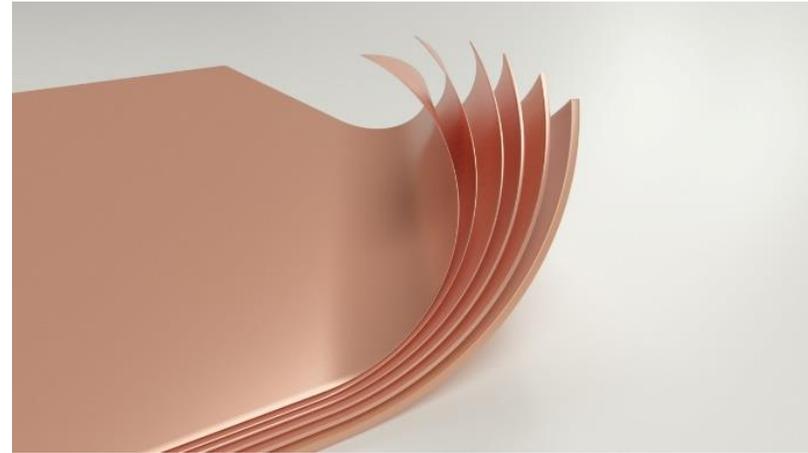
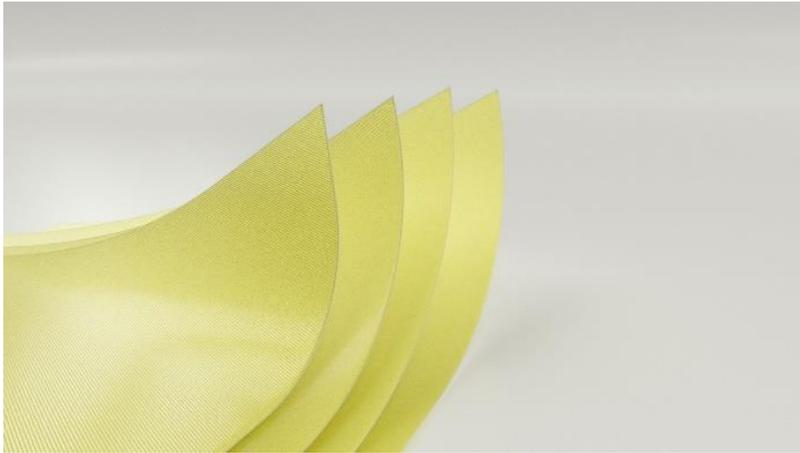
# KURZUMFRAGE

## Multiple-Choice

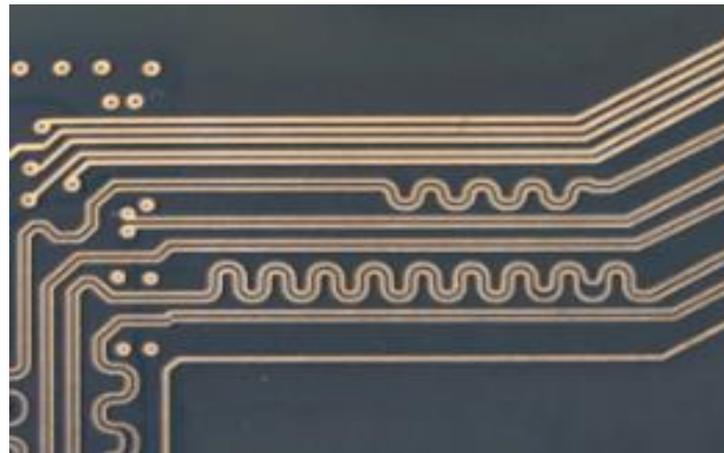
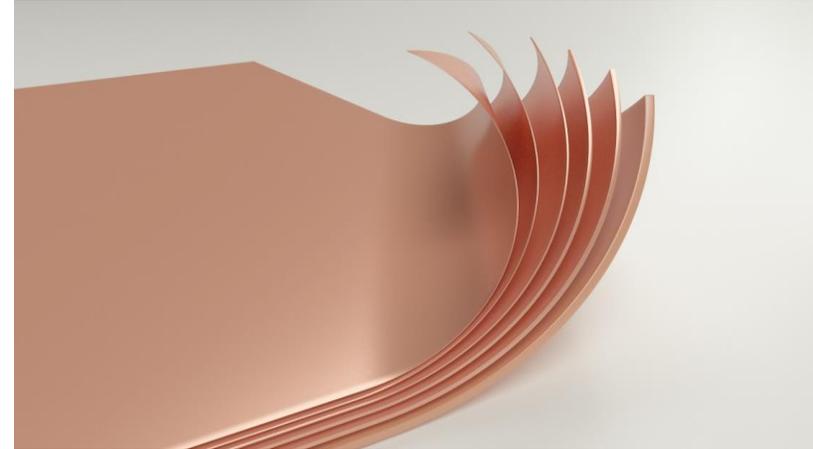
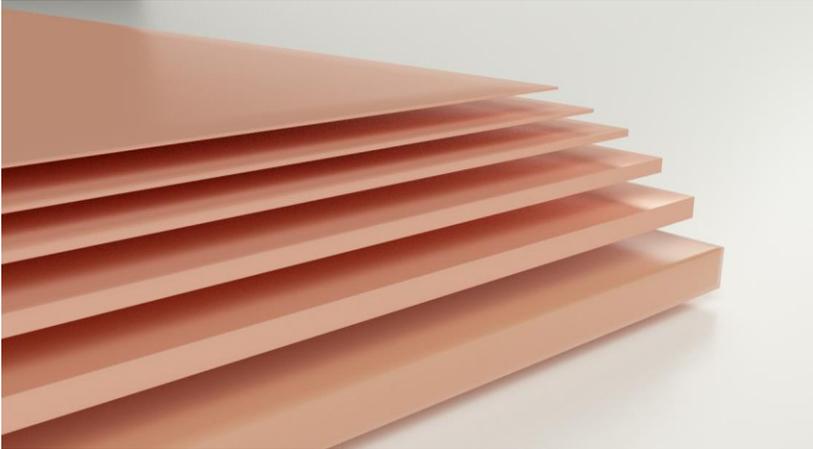
- **Welches ist das am häufigsten verwendete Harzsystem für Leiterplattenmaterial ?**
- Epoxy
- Polyimid
- PTFE - Polytetrafluorethylen
- PPE - Polyphenylenether
- BT - Bismaleimide Triazine



Basismaterial



Kupferfolien



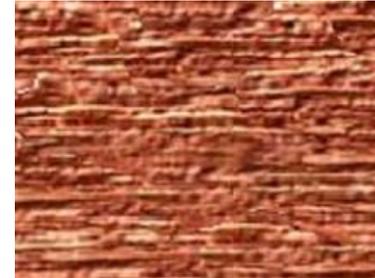
# BASISWISSEN LEITERPLATTE      IPC - MATERIAL - PRODUKTION

## Kupferfolien – IPC-4562

- Folientyp/ -klasse



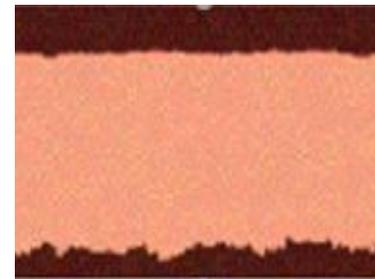
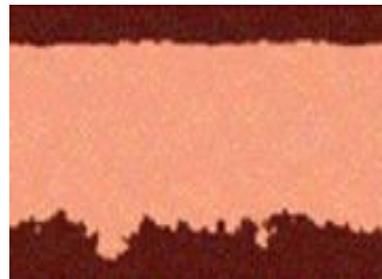
ED = elektrolytisches Kupfer



RA = gewalztes Kupfer

- Foliendicke / gewicht  
– definiert wird eine nominale Dicke in  $\mu\text{m}$  / typ. 18/35/70/105

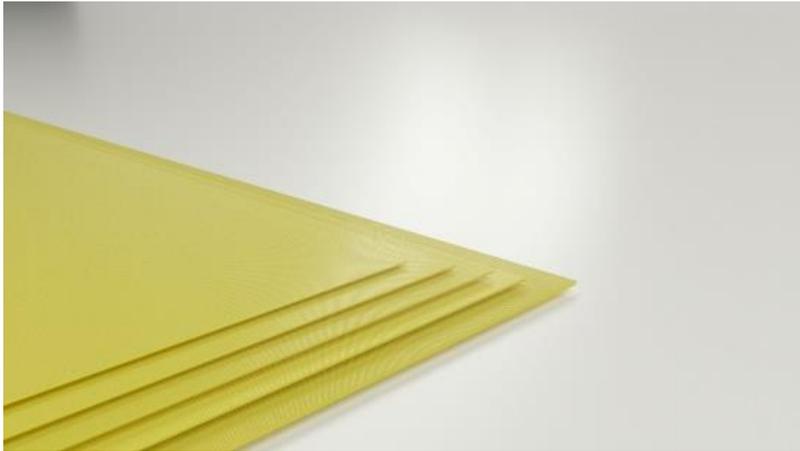
- Folienbehandlung / Haftschrift



	Foil Profile	$\mu\text{m}$
S (Standard)		N/A
L (Low Profile)		10.2
V (Very Low Profile)		5.1
X (No Treatment or Roughness)		N/A

# BASISWISSEN LEITERPLATTE      IPC - MATERIAL - PRODUKTION

Starre Verbund- und Basismaterialien (FR4 - Prepreg)

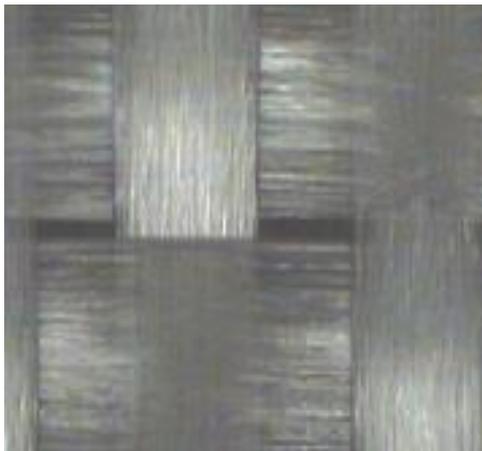


# BASISWISSEN LEITERPLATTE IPC - MATERIAL - PRODUKTION

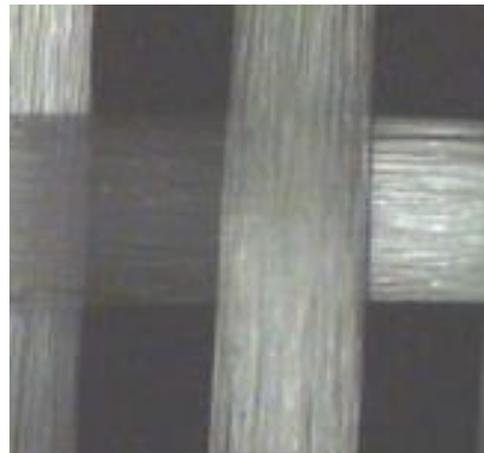
Starre Verbund- und Basismaterialien (FR4 - Prepreg)

Gewebe Typ	Flächengewicht g/m <sup>2</sup>	Kette			Schuß		
		Fadenzahl pro cm	Garntyp EC g/1000 m (tex)	Filamentdicke µm	Fadenzahl pro cm	Garntyp EC g/1000 m (tex)	Filamentdicke 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

Quelle: Isola



Quelle: Isola



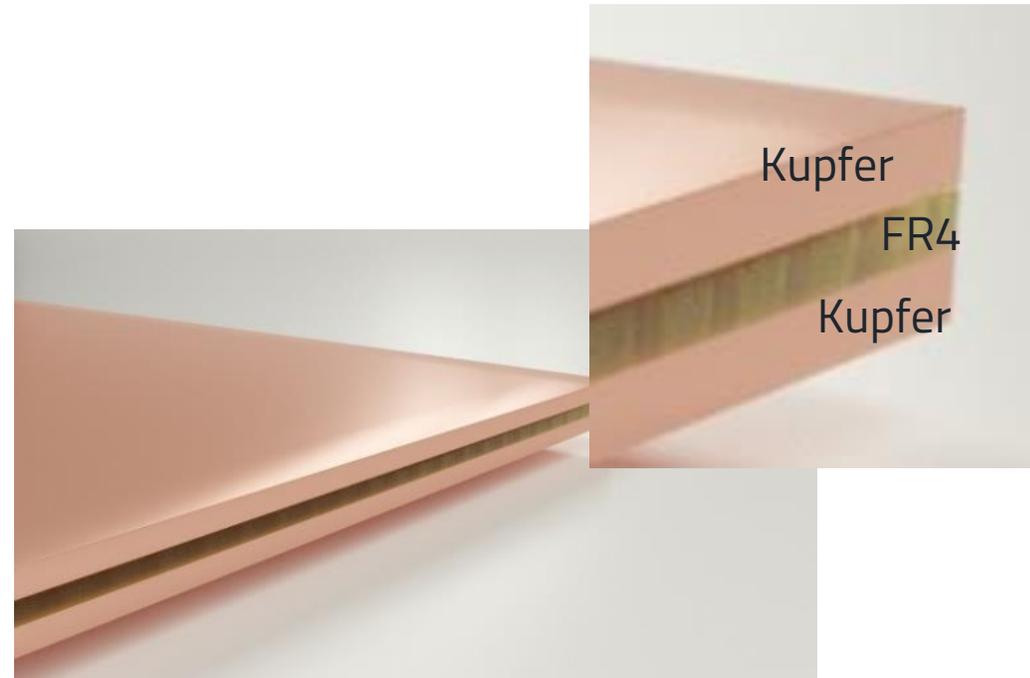
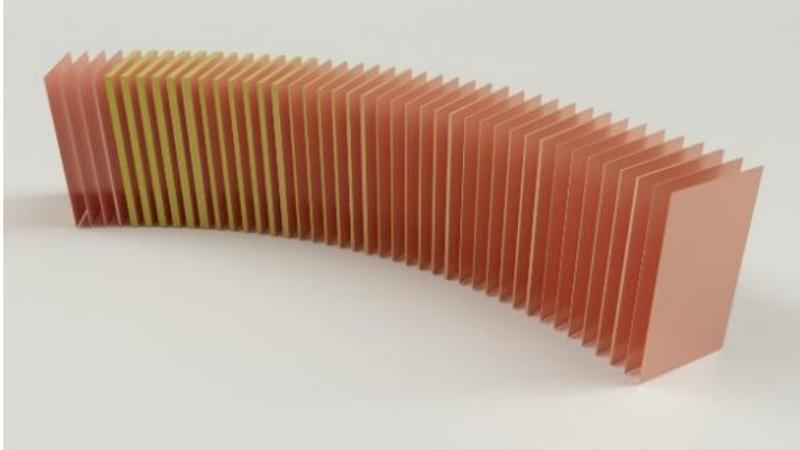
Quelle: Isola



# BASISWISSEN LEITERPLATTE

# IPC - MATERIAL - PRODUKTION

Kupferschichtes Laminat / Kerne (FR4)



# BASISWISSEN LEITERPLATTE      IPC – MATERIAL - PRODUKTION

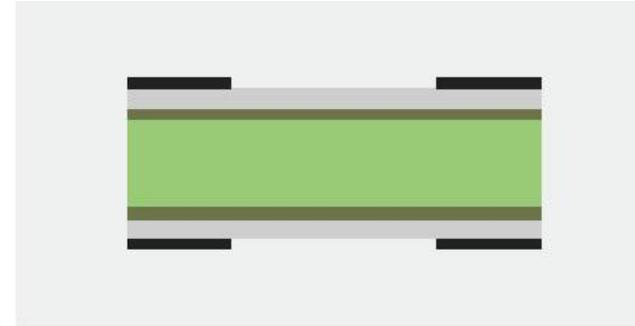
Herstellungsschritte



**Basismaterial**



**Fotoresist**

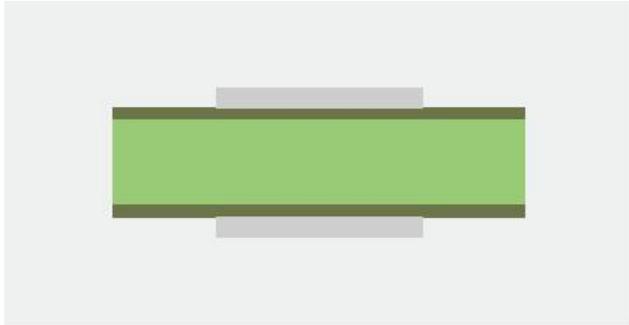


**Belichten**

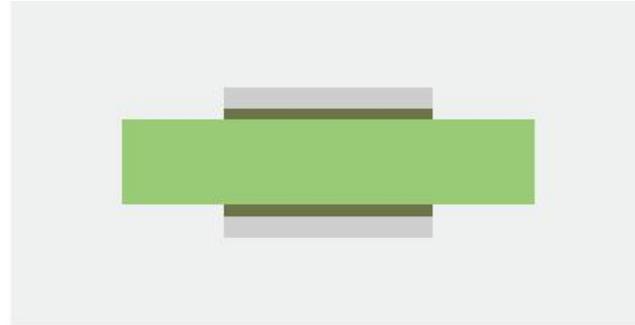


# BASISWISSEN LEITERPLATTE IPC – MATERIAL - PRODUKTION

## Herstellungsschritte



Entwickeln

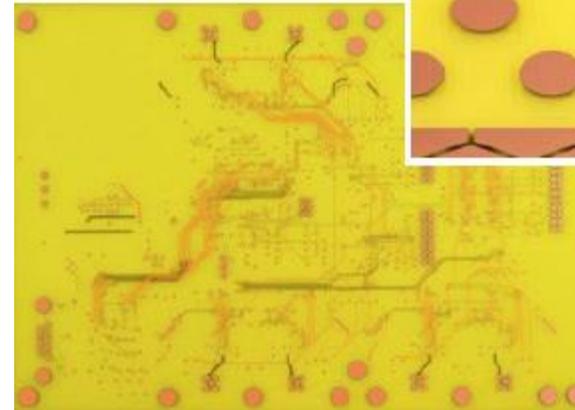
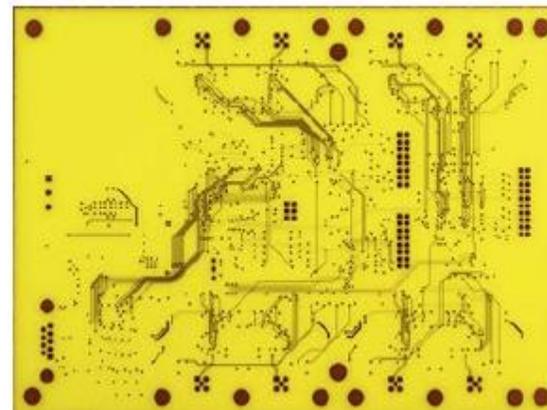


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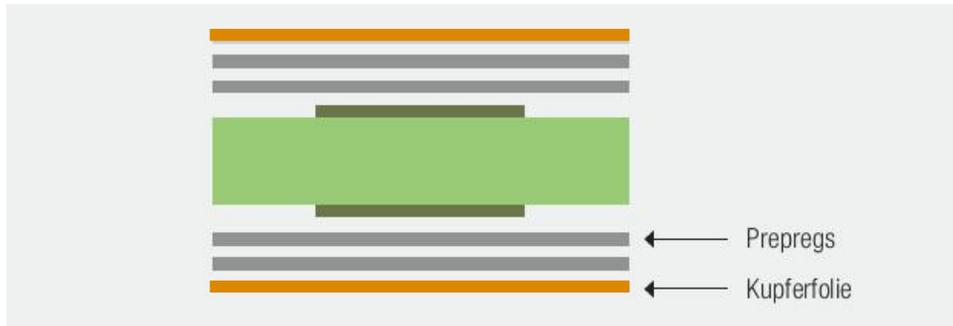


Resiststripfen

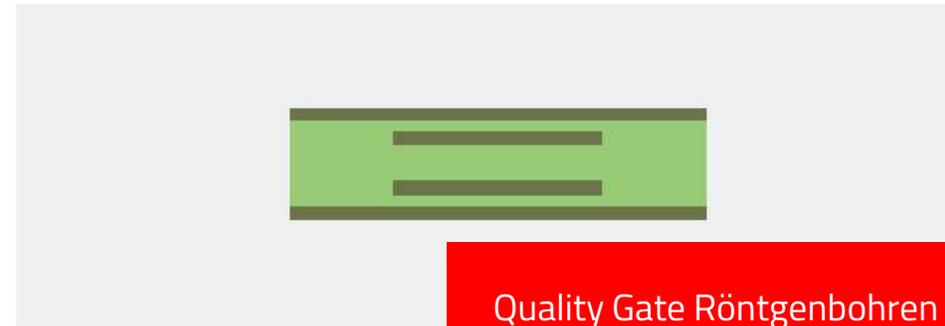
Quality Gate AOI



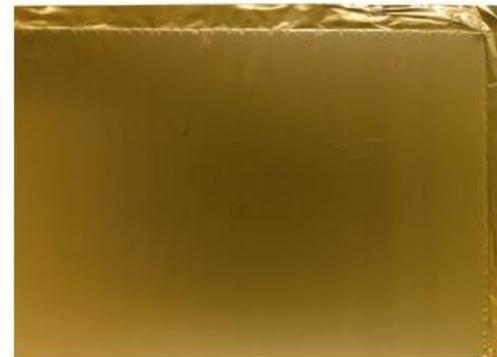
## Herstellungsschritte



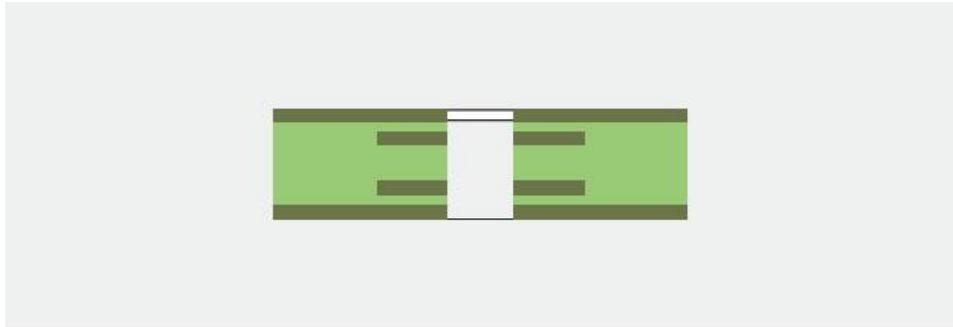
**Verlegen**



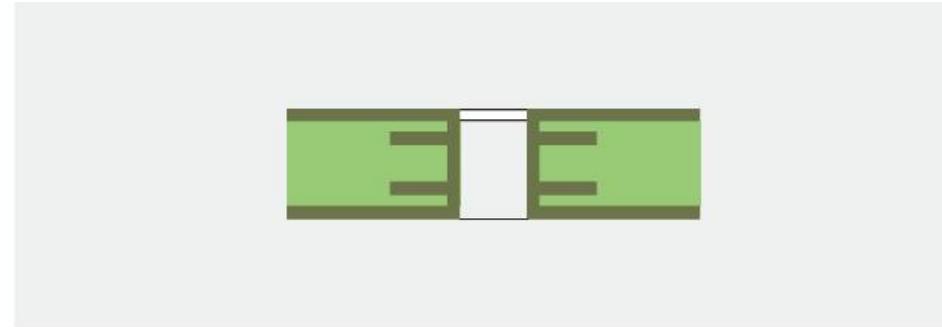
**Verpressen**



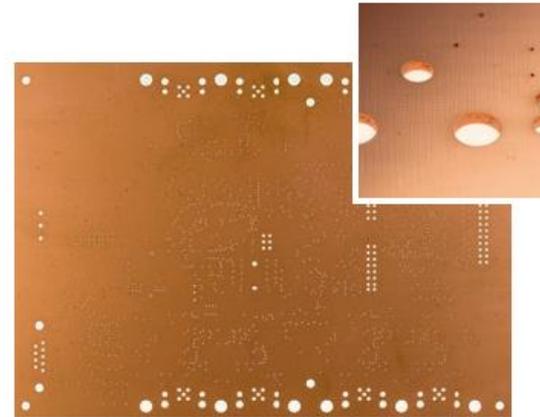
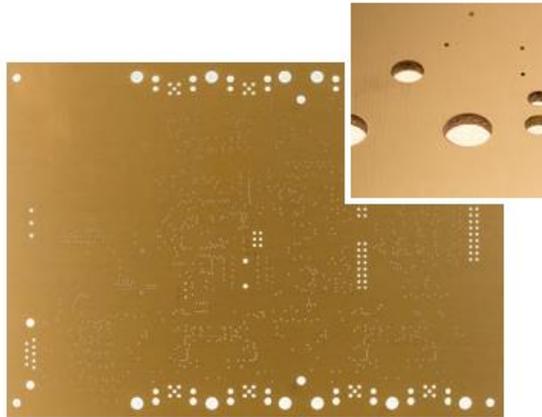
## Herstellungsschritte



**Bohren**

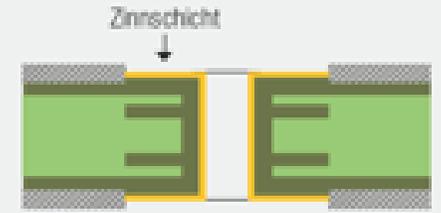
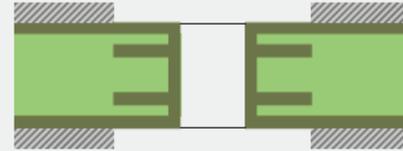
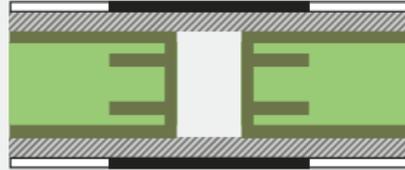
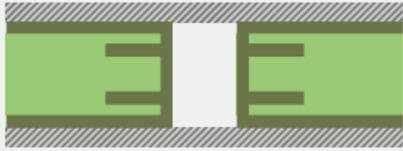


**Durchmetallisierung**



# BASISWISSEN LEITERPLATTE IPC – MATERIAL - PRODUKTION

## Herstellungsschritte

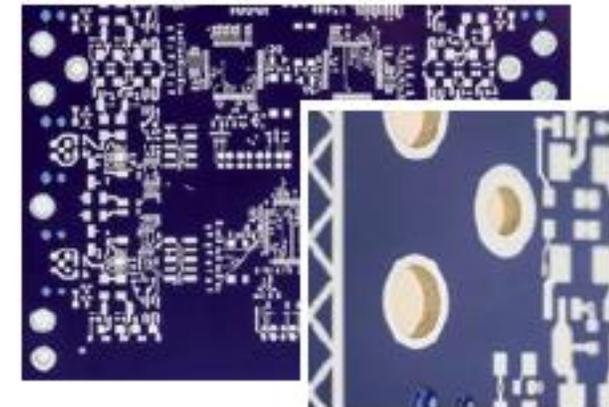
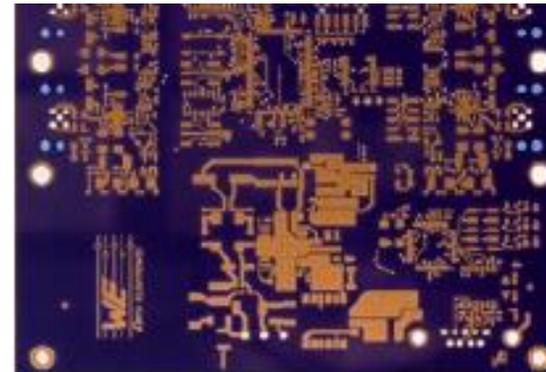


Fotoresist

Belichten

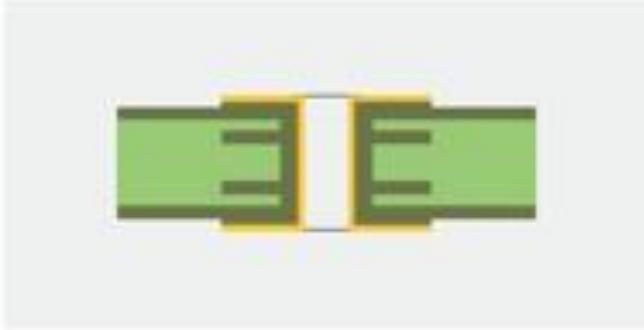
Entwickeln

Leiterbilddaufbau

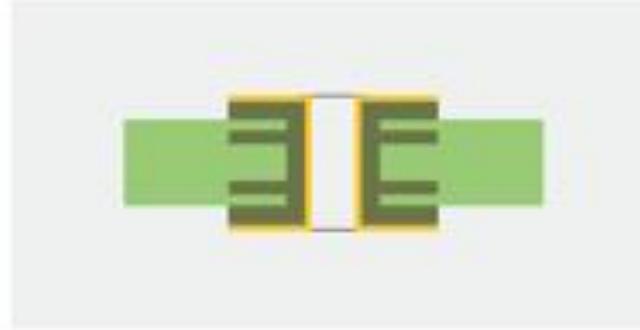


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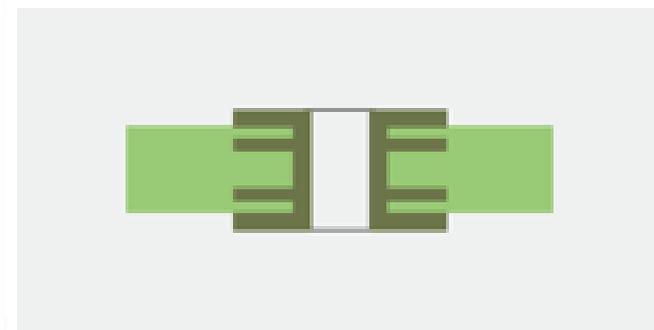
## Herstellungsschritte



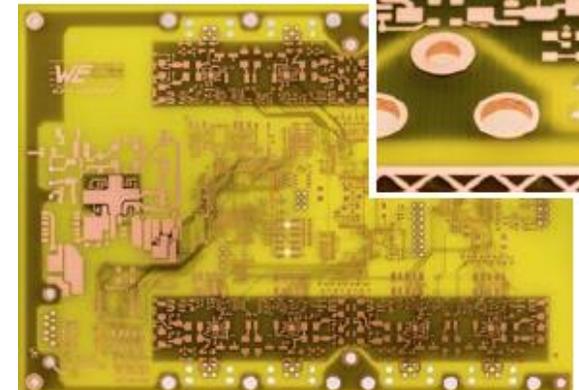
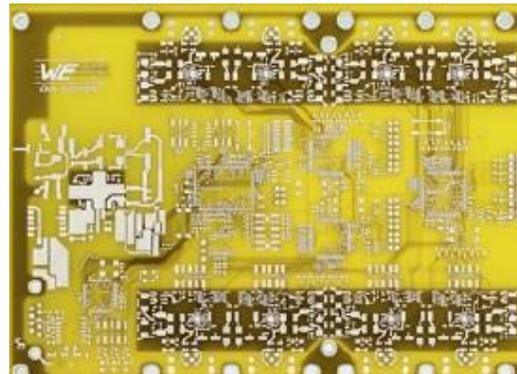
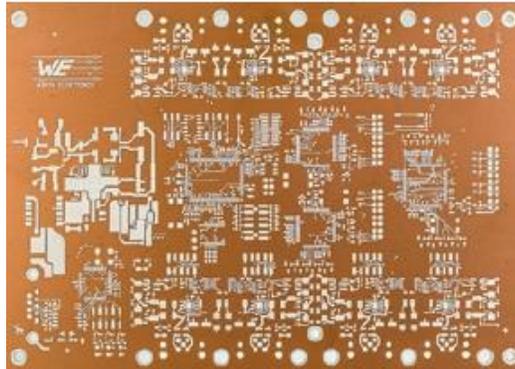
Resiststrippen



Ätzen

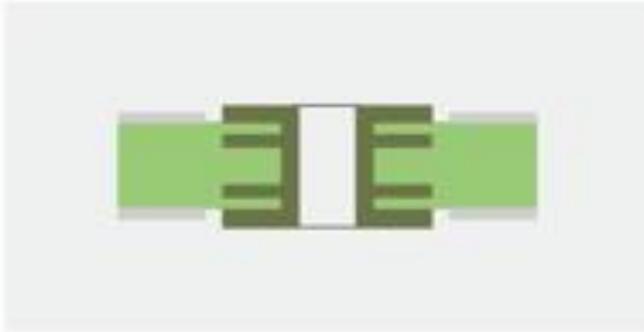


Sn – Strippen

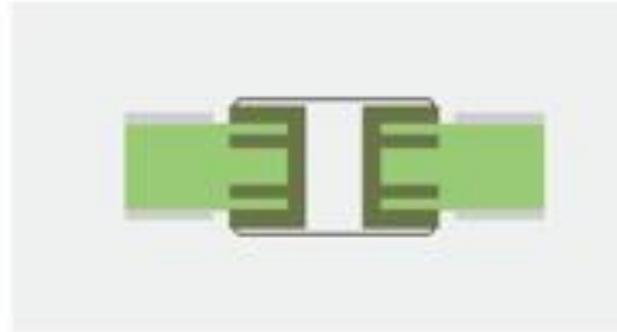


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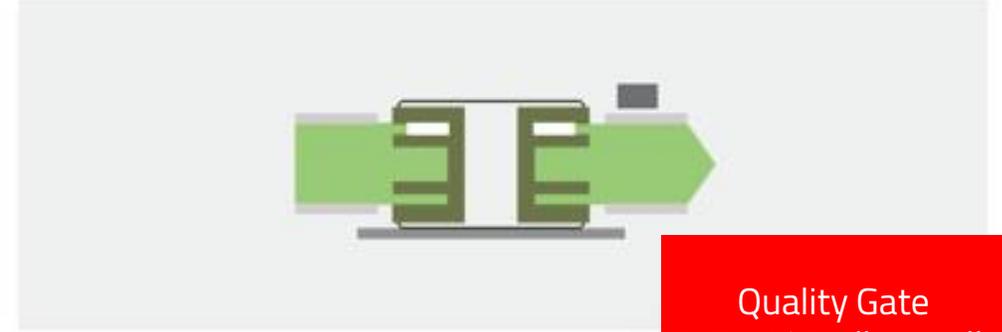
## Herstellungsschritte



Lötstoplack

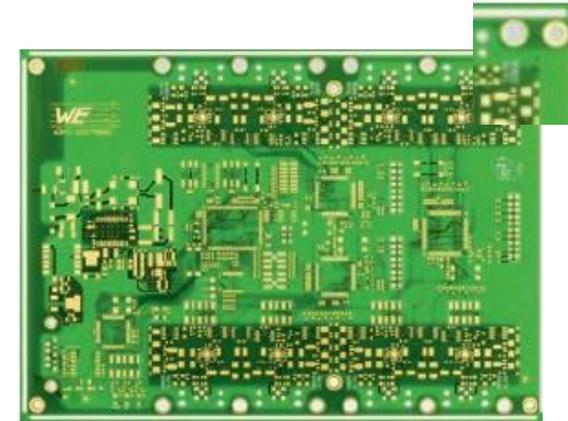
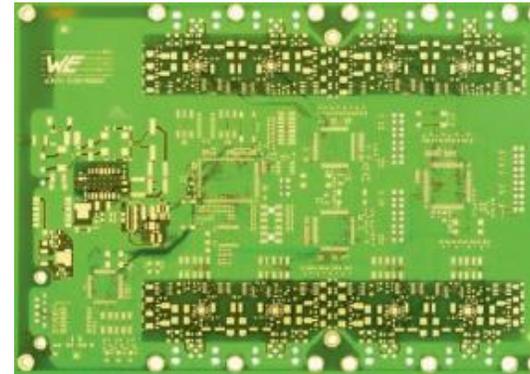
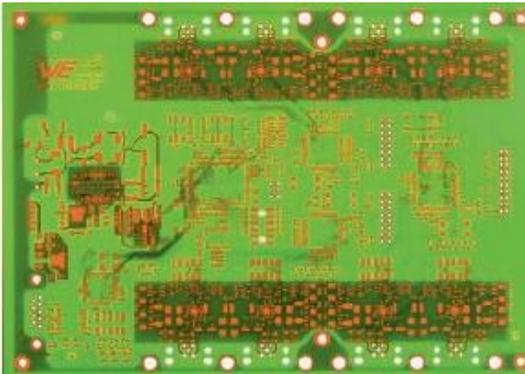


Oberfläche



Endzuschnitt:  
Fräsen oder Kerbfräsen

Quality Gate  
E-Test/ Endkontrolle

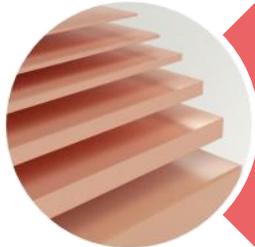


# BASISWISSEN LEITERPLATTE      IPC – MATERIAL - PRODUKTION

Zusammenfassung



IPC – Standards für die Leiterplatte



Basismaterial



Produktion

# VIELEN DANK FÜR IHRE AUFMERKSAMKEIT

Grundlagen der Leiterplattenproduktion  
IPC - Material - Produktion