BASICS FLEXIBLE AND RIGIDFLEXIBLE PRINTED CIRCUIT BOARDS

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Technical project management

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

AGENDA

- A short introduction
- Features of flexible and rigidflexible PCB‘s
  - Flexible (FPC) PCB‘s
  - Rigidflexible (RFPC) PCB‘s
  - Advantages of flexible (FPC) and rigidflexible (RFPC) summarized.
- Standard base materials
  - Flexible base materials with copper
  - Flexible composite and protective materials
  - Rigid Composite and protective materials (FR4 and Prepreg)
  - Standard stackups FPC
  - Standard stackups RFPC
  - Summary
- Production process of a rigidflex 1F – 7Ri
  - Design-Rules
- The next Webinar

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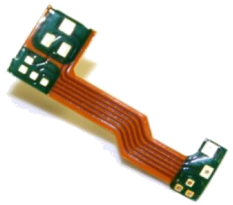
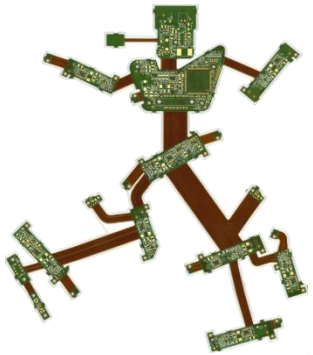
FLEXIBLE AND RIGIDFLEXIBLE PCB‘S

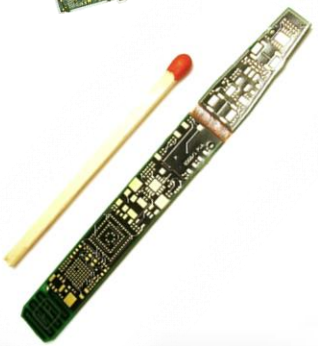
A short introduction

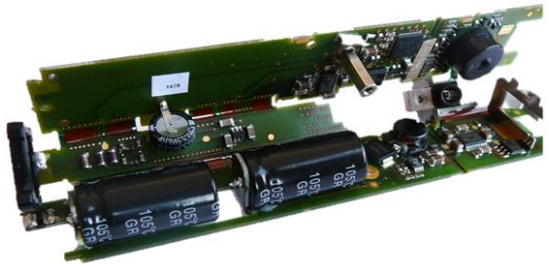




Flexible and rigidflexible PCB‘s can be used in variety of ways

- 3D installation for optimal utilization of the limited installation volume available
- The flexible area can be bend with very small bending radii
- High integration density and miniaturization
- Very robust and high reliability, because a lot soldering points and plug connections can be omitted
- The total connection of an application can be realised by one single (rigid-) flexible PCB
- Small weight and space requirement
- Uniform reproducible electrical properties, e.g. impedance, crosstalk, signal integrity etc.

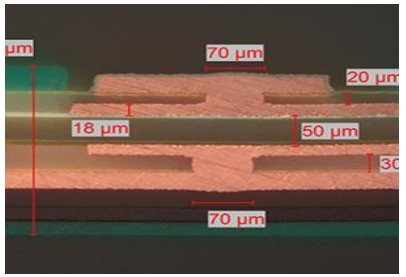


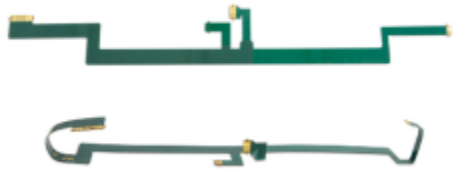


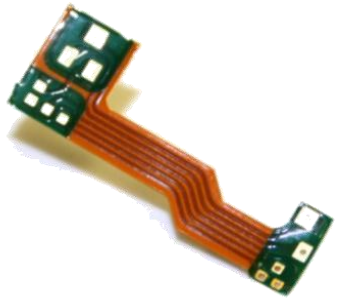
FLEXIBLE (FPC) PCB'S

Features

- Flexible PCB's are essentially made of flexible base materials
- One-layered-designs up to high-layered flex multilayers with buried- and blind vias are possible (SLIM.flex)
- High integration density and miniaturisation
- Partial stiffeners at different areas with different thicknesses on top and bottom side are possible
- The partial stiffeners are **not electrical** connected to the flex layers. (No through plating).
- Small weight and space requirement
- Uniform reproducible electrical properties



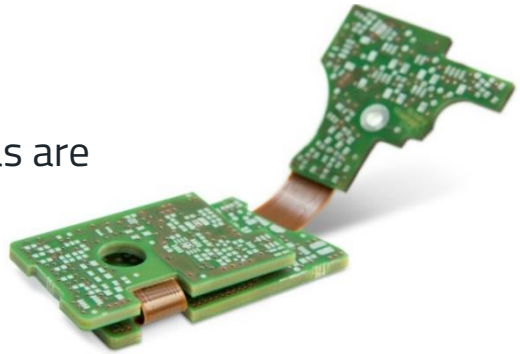


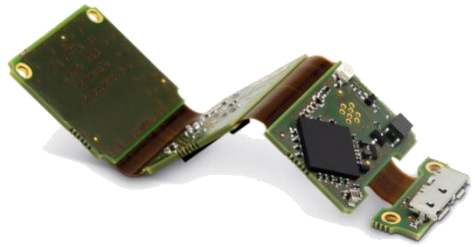


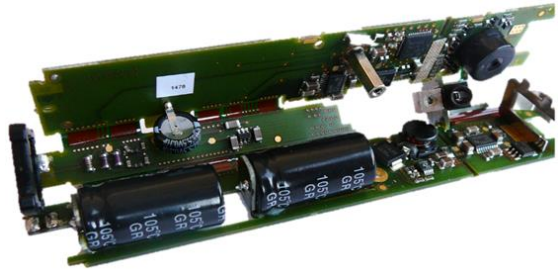
RIGIDFLEXIBLE (RFPC) PCB'S

Features

- Rigidflexible PCB's consists of rigid and flexible areas. The rigid, multilayered areas are connected by flexible base material and include through-plated connections
- Rigidflexible PCB's are made of **at least two** copper layers
- 3D installation for optimal utilization of the limited installation volume available
- The flexible area can be bend with very small bending radii
- High integration density and miniaturization
- The total connection of a product can be realised by one single (rigid-) flexible PCB
- Small weight and space requirement
- Uniform reproducible electrical properties, e.g. impedance, crosstalk, signal integrity etc.



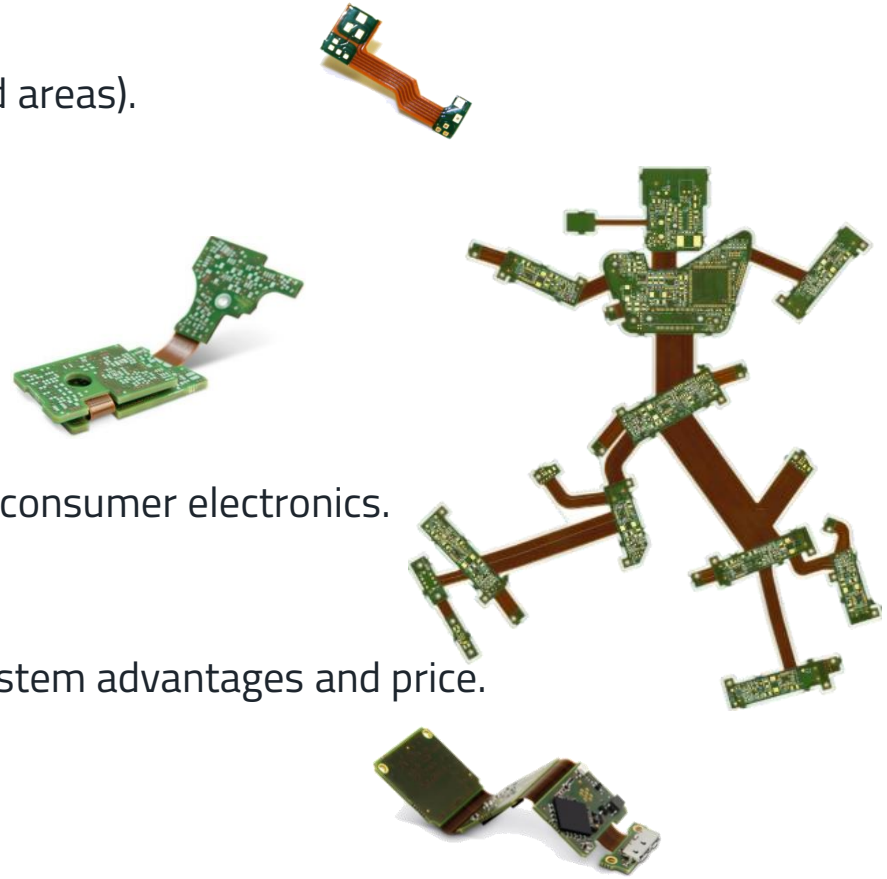




FLEXIBLE AND RIGIDFLEXIBLE PCB‘S

Summary

- Flexible PCBs FPC have no electrical connections with partial stiffeners (rigid areas).
- Rigid-flex PCBs RFPC consist of rigid and flexible areas and include vias
- Rigid-flex PCBs have at least two copper layers
- Flex and flex-rigid technologies are used in all markets.
  Industry, medicine, aerospace, telecommunications, automotive and also in consumer electronics.
- The motivation for using flex and rigidflex technology are:
  Miniaturisation, dynamic movement, reliability, signal integrity as well as system advantages and price.



FLEXIBLE AND RIGIDFLEXIBLE PCB‘S

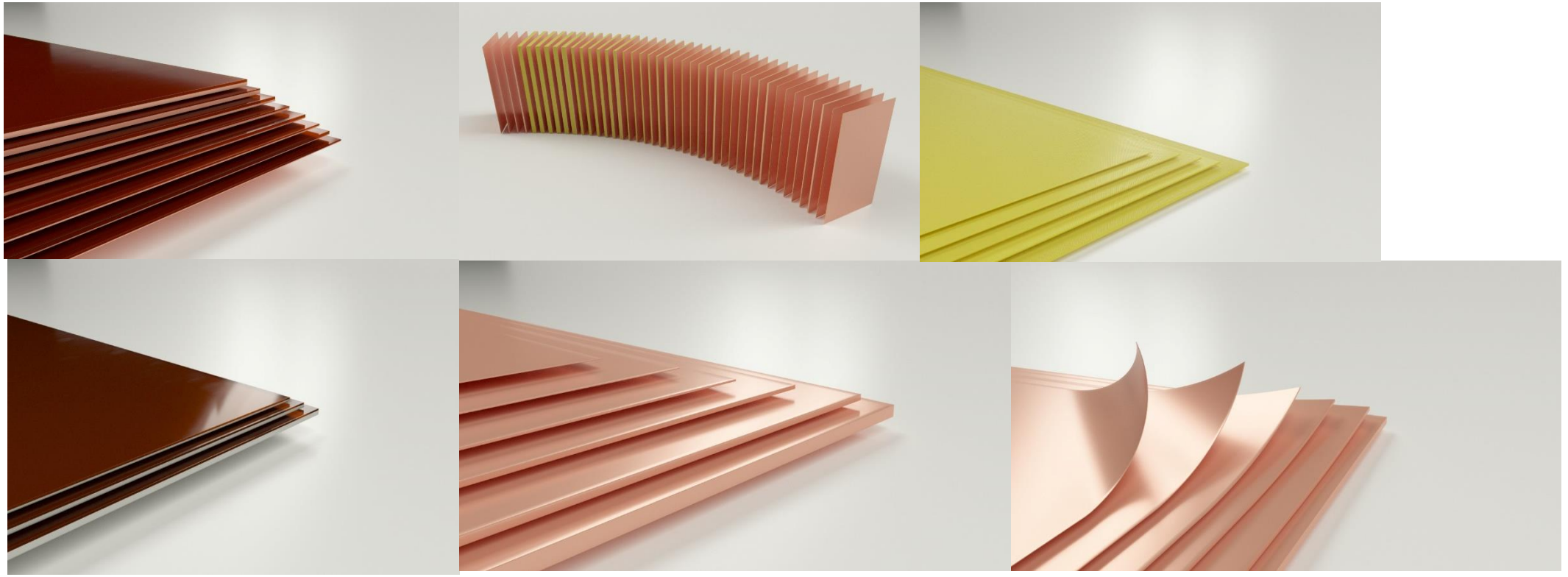
POLL: Multiple-Choice with one correct answer

What is the main difference between flexible and rigid-flexible PCBs?

- They are made of different materials
- The rigid materials are electrically connected to the flexible materials
- Flexible printed circuit boards have no rigid areas
- Flexible printed circuit boards have a maximum of two copper layers
- Rigid printed circuit boards are only available with flexible solder mask

STANDARD BASE MATERIALS

Standard Base Materials



STANDARD BASE MATERIALS

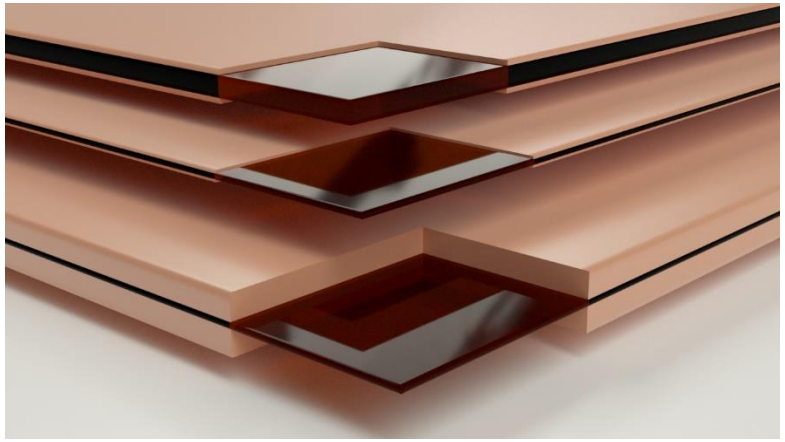
Flexible base materials with copper.

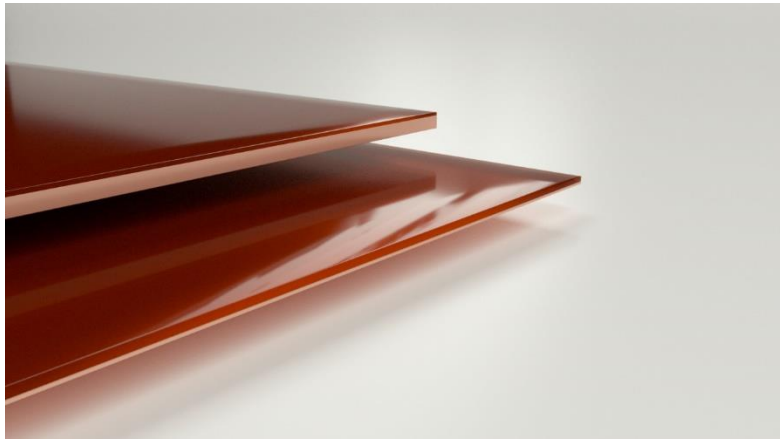
- Flexible base materials are available in some variations.
  Only the standard materials are shown here. These materials are used in 98% of WE CBT.

- Copper thickness in **18µm, 35µm** and 70µm. One and double sided.
- Core thickness in 25µm, **50µm**, 75µm, 100µm and 150µm
- Glue and adhesiveless base materials. WE CBT uses only adhesiveless materials.

  WE CBT standard suppliers are:
- **Panasonic Industrial Devices Materials Europe GmbH**
- **DuPont de Nemours (Deutschland) GmbH**

- DuPont™ Pyralux® AP, Panasonic R770, Panasonic R775





STANDARD BASE MATERIALS

Flexible composite and protective materials

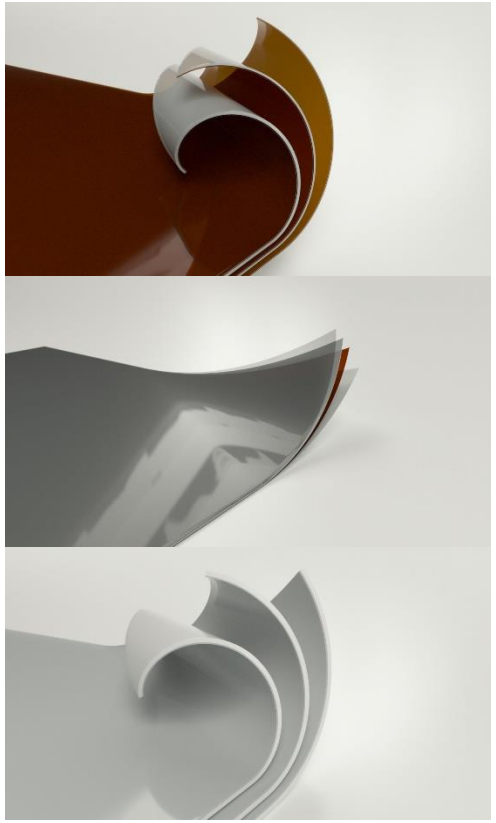
- In the flex and rigid-flex technologies a variety of so-called composite materials is used:

- **Coverlayer / Cover foil**
  Hereby the copper areas and signals are protected. These materials will be applied by the thermal process pressing.

- **BondPly / Composite foil**
  With this material the flexible and rigid materials are glued together. Here, too, the thermal process of pressing is used.

- **Adhesive / Glue**
  With this material the flex and rigid materials are glued together. Here, too, the thermal process of pressing is used.

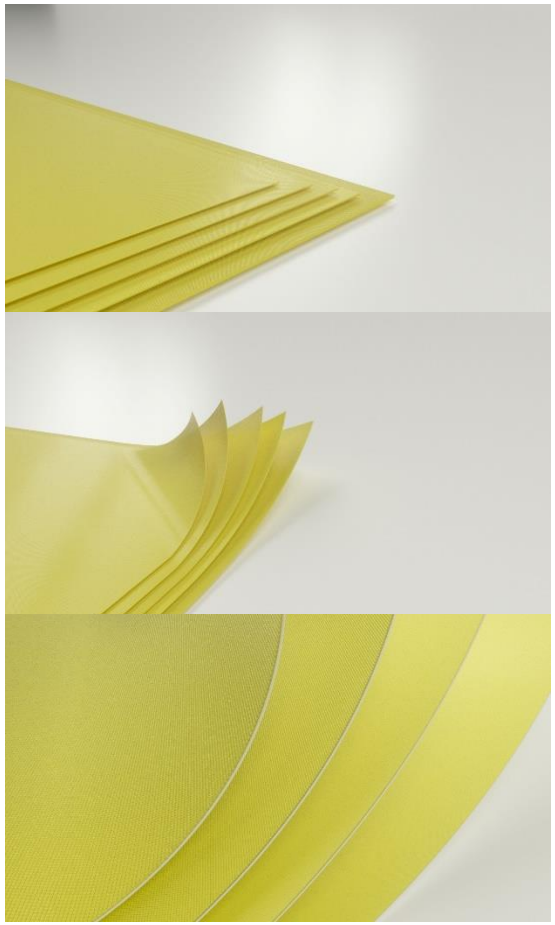
  WE CBT standard suppliers are:
- **DuPont de Nemours (Deutschland) GmbH**



STANDARD BASE MATERIALS

Rigid composite and base materials (FR4 and Prepreg)

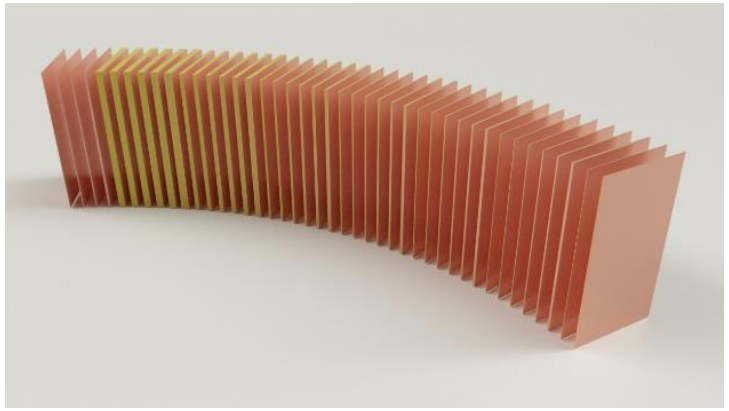
- These base and composite materials are the **classic** materials for **all technologies** in the PCB industry.
- **Prepreg (Standard)**
  The so-called prepreg is the adhesive medium of all common PCB technologies. With prepreg the single rigid and flexible cores (inner layers and copper foils) will be glued/bonded. This bonding is done only by the thermal process pressing.
  The prepreg consists of a glass fabric (textile) which is pre-impregnated with resin and Hardeners. Common thicknesses are: 106, 1080, 2116, 7628
  TG-values area: **TG135°**, **TG150°** and **TG170°**
- **Prepreg Low Flow**
  This so-called LowFlow prepreg consists of a glass fabric (textile) which is pre-impregnated with resin and Hardeners. The difference to “normal” Prepreg lies in the recipe of resin and hardeners. Common Thicknesses are: 106 and 1080
  TG-values are: **TG135°** and **TG150°**

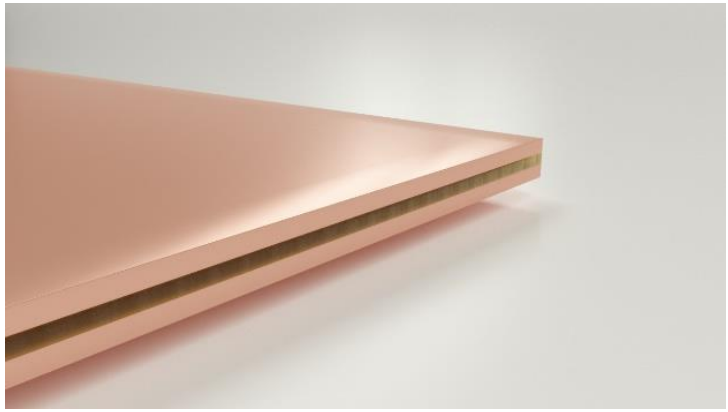


STANDARD BASE MATERIALS

Rigid composite and base materials (FR4 and Prepreg)

- FR4 or also FR-4 describes a class of flame retardant composite materials. The composite material FR4 has been used in PCB-Technology since ca. 1968 and is the Standard.
- Copper thicknesses: **18µm**, **35µm** and 70µm. One and double sided. Single sided laminates aren't used at WE CBT.
- Core thicknesses: 50µm, 60µm, 100µm and 125µm, 150µm, 200µm, 250µm, 300µm, 360µm, 410µm……., 1,20mm
- TG-values from **135°**, **150°** and **170°** are used as standard at WE. The TG value is slightly confusingly referred to as the "glass transition temperature". At the specified temperatures, of course, the material is not converted into glass, but the epoxy resin structure becomes soft and elastic.

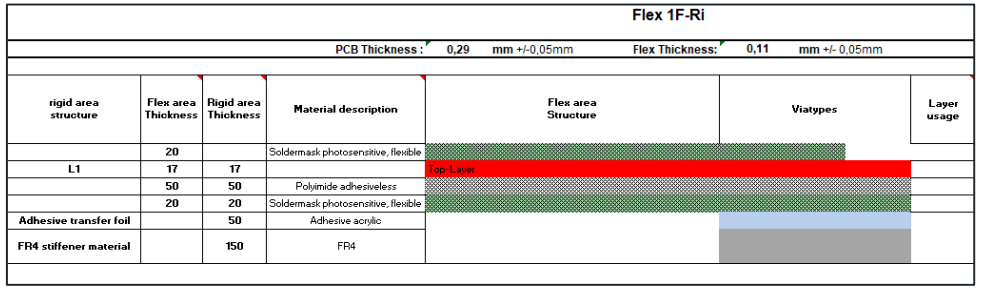




STANDARD STACKUPS FOR FLEX PCB'S

WE CBT Standard flex stackups

Standard 1F-Ri PURE.flex

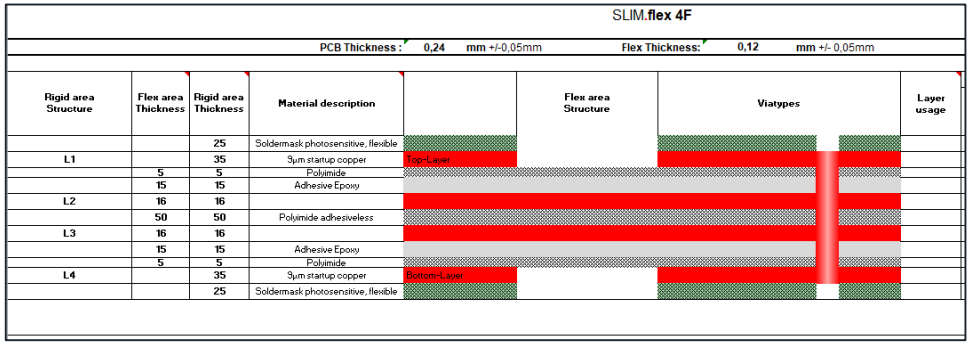


Flex 1F-Ri

PCB Thickness : 0,29 mm +/-0,05mm Flex Thickness: 0,11 mm +/- 0,05mm

rigid area structure	Flex area Thickness	Rigid area Thickness	Material description	Flex area Structure	Viatypes	Layer usage
	20		Soldermask photosensitive, flexible			
L1	17	17	Top-Layer			
	50	50	Polyimide adhesiveless			
	20	20	Soldermask photosensitive, flexible			
Adhesive transfer foil		50	Adhesive acrylic			
FR4 stiffener material		150	FR4			

Standard 4F SLIM.flex

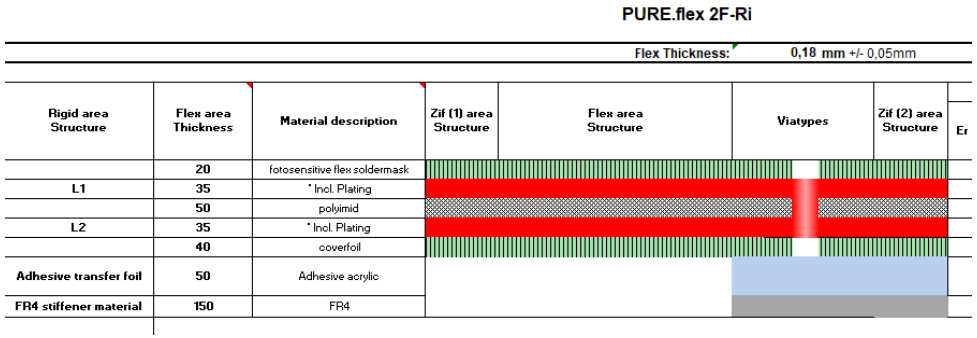


SLIM.flex 4F

PCB Thickness : 0,24 mm +/-0,05mm Flex Thickness: 0,12 mm +/- 0,05mm

Rigid area Structure	Flex area Thickness	Rigid area Thickness	Material description	Flex area Structure	Viatypes	Layer usage
		25	Soldermask photosensitive, flexible			
L1		35	9µm startup copper	Top-Layer		
	5	5	Polyimide			
	15	15	Adhesive Epoxy			
L2	16	16				
	50	50	Polyimide adhesiveless			
L3	16	16				
	15	15	Adhesive Epoxy			
	5	5	Polyimide			
L4		35	9µm startup copper	Bottom-Layer		
		25	Soldermask photosensitive, flexible			

Standard 2F-Ri PURE.flex

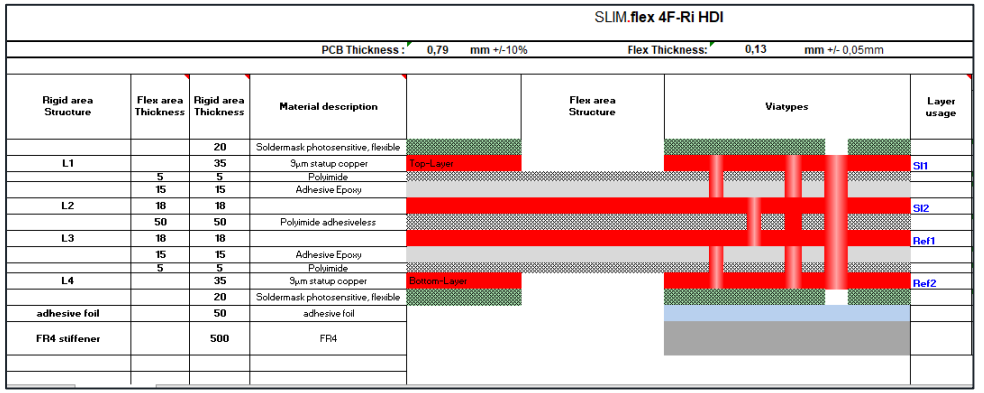


PURE.flex 2F-Ri

Flex Thickness: 0,18 mm +/- 0,05mm

Rigid area Structure	Flex area Thickness	Material description	Zif (1) area Structure	Flex area Structure	Viatypes	Zif (2) area Structure	Er
	20	fotosensitive flex soldermask					
L1	35	* Incl. Plating					
	50	polyimid					
L2	35	* Incl. Plating					
	40	coverfoil					
Adhesive transfer foil	50	Adhesive acrylic					
FR4 stiffener material	150	FR4					

Standard 4F-Ri SLIM.flex HDI



SLIM.flex 4F-Ri HDI

PCB Thickness : 0,79 mm +/-10% Flex Thickness: 0,13 mm +/- 0,05mm

Rigid area Structure	Flex area Thickness	Rigid area Thickness	Material description	Flex area Structure	Viatypes	Layer usage
		20	Soldermask photosensitive, flexible			
L1		35	9µm startup copper	Top-Layer		St1
	5	5	Polyimide			
	15	15	Adhesive Epoxy			
L2	18	18				St2
	50	50	Polyimide adhesiveless			
L3	18	18				Ref1
	15	15	Adhesive Epoxy			
	5	5	Polyimide			
L4		35	9µm startup copper	Bottom-Layer		Ref2
		20	Soldermask photosensitive, flexible			
adhesive foil		50	adhesive foil			
FR4 stiffener		500	FR4			

https://www.we-online.com/web/en/leiterplatten/produkte_/slim_flex/slim_flex_uebersicht_1.php

STANDARD STACKUPS FOR RIGID-FLEX PCB'S

WE CBT Standards rigid-flex stackups

Standard 1F-xRi

Rigidflex 1F-3Ri

PCB Thickness: 1,50 mm +/- 10% Flex Thickness: 0,13 mm +/-0,05mm

Rigid area Thickness	Material description	Flex area Structure	Viatypes	Layer usage
15				
40	* Incl. Plating	Top-Layer		
50	Polyimide			
50	FR4 TG 150° HF			
17				
1164	FR4 TG 150° HF			
17				
90	FR4 TG 150° HF			
40	* Incl. Plating	Bottom-Layer		
15				

Standard 1F-xRi HDI

Rigidflex 1F-5Ri + HDI 1 - 4b - 1

PCB Thickness: 0,93 mm +/- 10% Flex Thickness: 0,14 mm +/-0,05mm

Rigid area Structure	Flex area Thickness	Rigid area Thickness	Material description	Flex area Structure	Viatypes	Layer usage
Flex Soldermask	40					
Soldermask		15				
L1	45	45	* Incl. Plating	Top-Layer		
	50	50	Polyimide			
		50	FR4 TG 150° HF			
L2		17				
		65	FR4 TG 150° HF			
L3		17				
		410	FR4 TG 150° HF			
L4		17				
		65	FR4 TG 150° HF			
L5		17				
		100	FR4 TG 150° HF			
L6		45	* Incl. Plating	Bottom-Layer		
Soldermask		15				

Standard 2F-xRi

Rigidflex 2F-2Ri

PCB Thickness: 1,52 mm +/- 10% Flex Thickness: 0,19 mm +/-0,05mm

Rigid area Structure	Flex area Thickness	Rigid area Thickness	Material description	Flex area Structure	Viatypes	Layer usage
Flex Soldermask	40					
Soldermask		15				
L1	45	45	incl. plating	Top-Layer		
	50	50	Polyimide adhesiveless			
L2	17	17				
	40		Coverlay			
		90	FR4 TG150 HF			
		1164	FR4 TG150 HF			
L3		17				
		65	FR4 TG150 HF			
L4		45	incl. plating	Bottom-Layer		
Soldermask		15				

Standard 2F-xRi with Micro-Vias

Rigidflex 2F-2Ri

PCB Thickness: 1,52 mm +/- 10% Flex Thickness: 0,19 mm +/-0,05mm

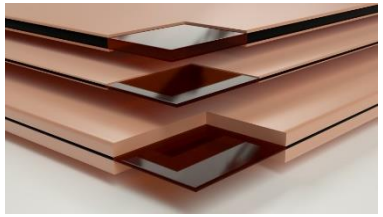
Rigid area Structure	Flex area Thickness	Rigid area Thickness	Material description	Flex area Structure	Viatypes	Layer usage
Flex Soldermask	40					
Soldermask		15				
L1	45	45	incl. plating	Top-Layer		
	50	50	Polyimide adhesiveless			
L2	17	17				
	40		Coverlay			
		90	FR4 TG150 HF			
		1164	FR4 TG150 HF			
L3		17				
		65	FR4 TG150 HF			
L4		45	incl. plating	Bottom-Layer		
Soldermask		15				

FLEXIBLE AND RIGIDFLEXIBLE PCB‘S

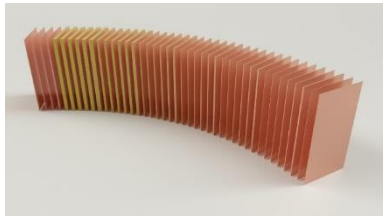
Summary base material and stackups

- All common flexible base materials can be used here. But at WE CBT we are using the materials of **DuPont** and **Panasonic**.

- All common rigid base materials can be used here. But at WE CBT we are using the materials of **ISOLA, Technolam NanYa**, **Panasonic** and **Schowa Denko** Hitachi.



- TG-values from **135°**, **150°** and **170°** are used as standard at WE CBT.

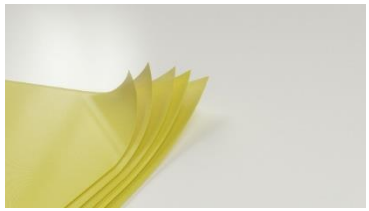


Important Information:

- Stackups of flex and rigidflex are always a mix of different base and composite materials and therefore **Hybrides**.

Standard 2F-xRi

Standard 1F-Ri



FLEXIBLE AND RIGIDFLEXIBLE PCB‘S

Manufacturing process of a rigid-flex pcb

- Stackup 1F-7Ri

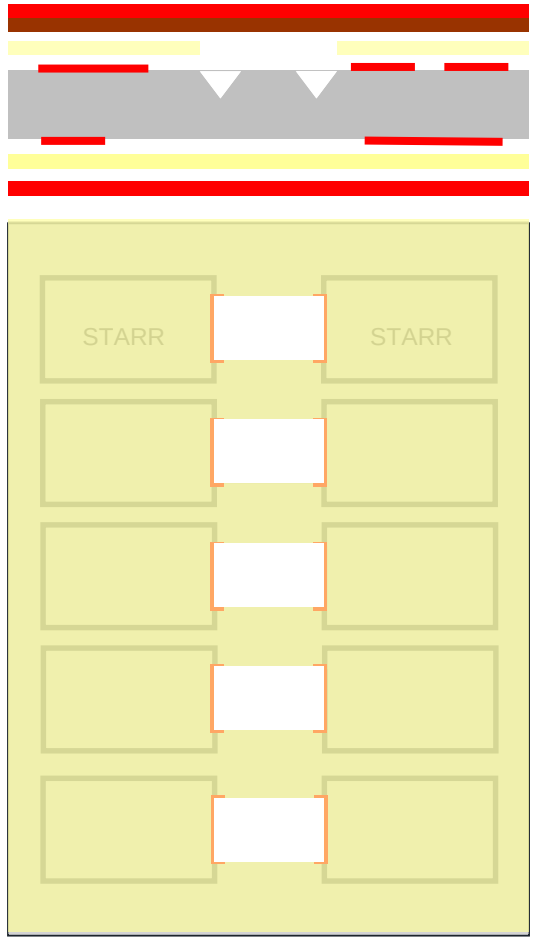
Polyimide + Copper

LowFlow Prepreg

Core

Prepreg

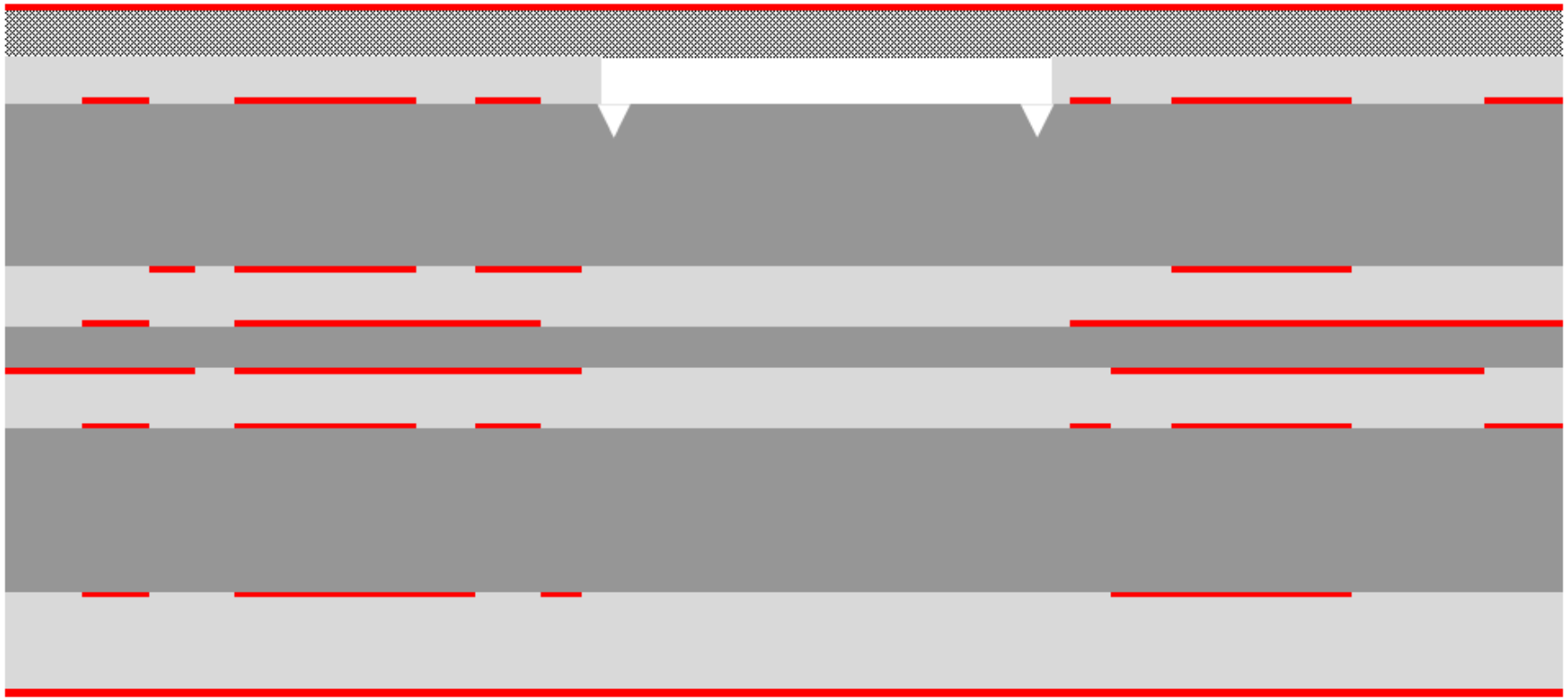
Copper



FLEXIBLE AND RIGIDFLEXIBLE PCB‘S

Manufacturing process of a rigid-flex pcb

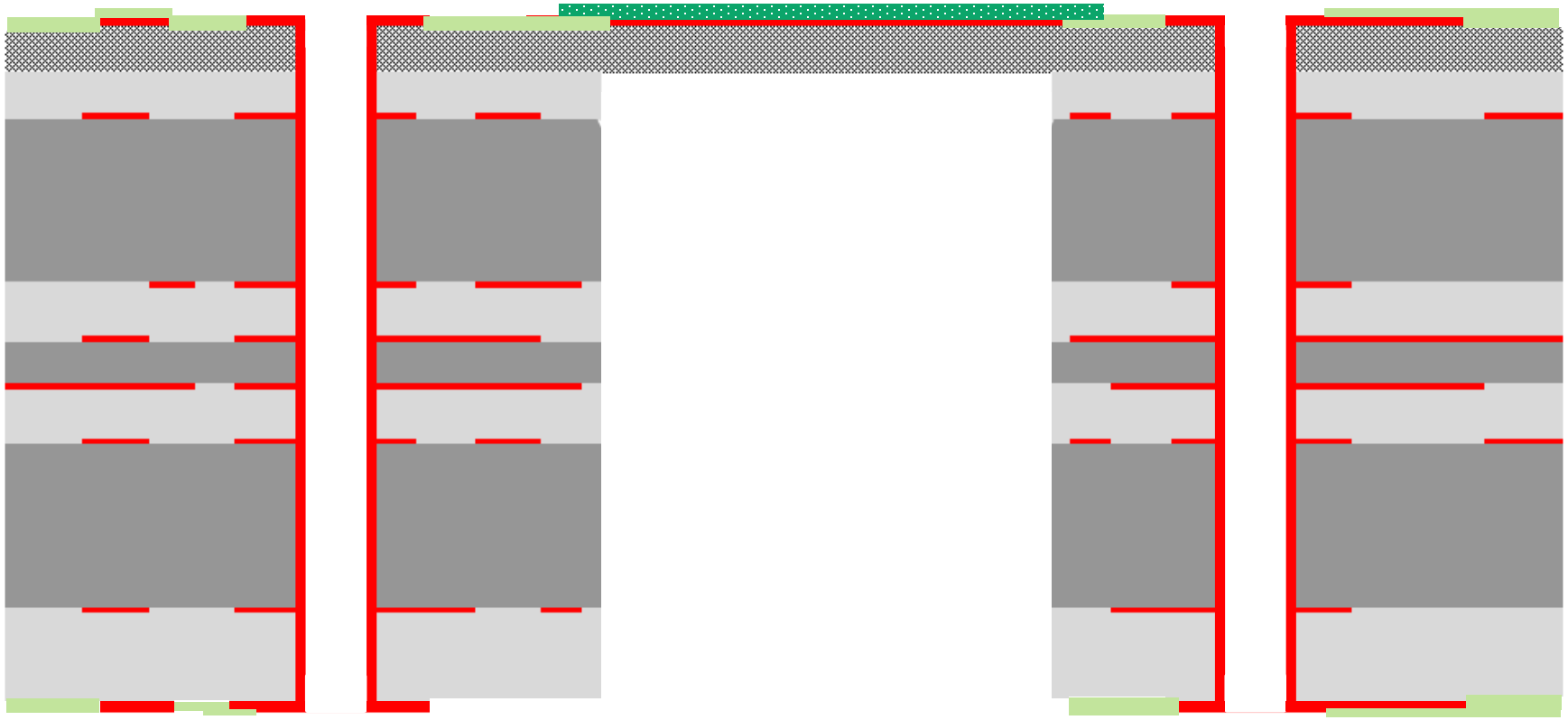
- Stackup 1F-7Ri



FLEXIBLE AND RIGIDFLEXIBLE PCB‘S

Manufacturing process of a rigid-flex pcb

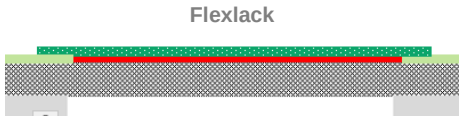
- Stackup 1F-7Ri



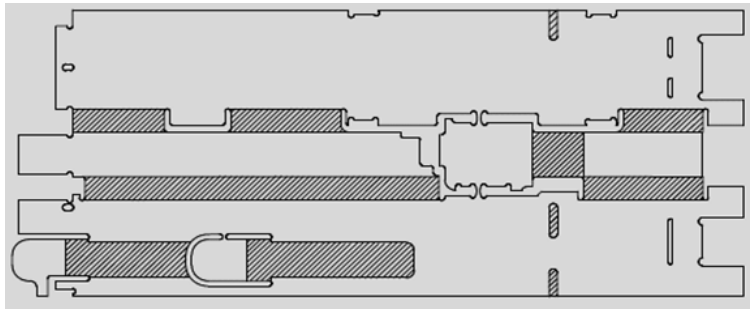
FLEXIBLE AND RIGIDFLEXIBLE PCB‘S

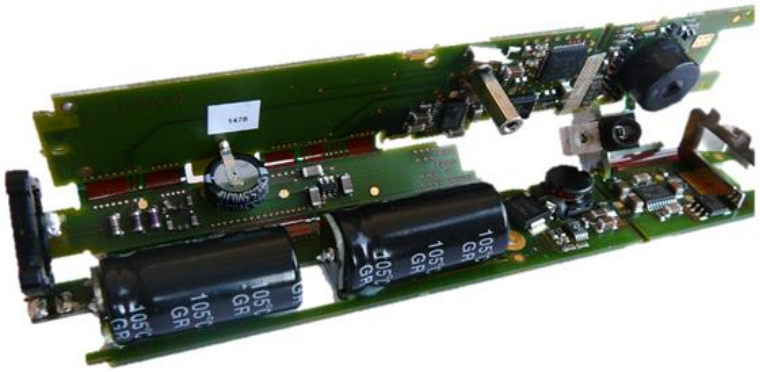
Example of application of a flex-rigid pcb. Stackup 1F – xRi

- Stackup 1F-3Ri, 50µm Polyimid, FR4 TG150°, **flex solder mask** in the flex area
- Integration of electronics, display, keyboard and energy storage
- Rigid flex with mechanical functions



- Miniaturisation
- Reliability
- System advantages





FLEXIBLE AND RIGIDFLEXIBLE PCB'S

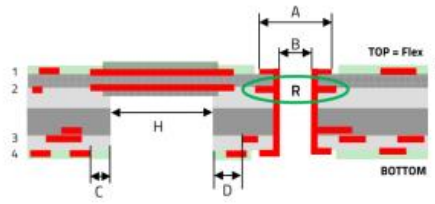
Design-Rule für 1F-xRi und 2F-xRi

Important Design-Rule **D** und **G**

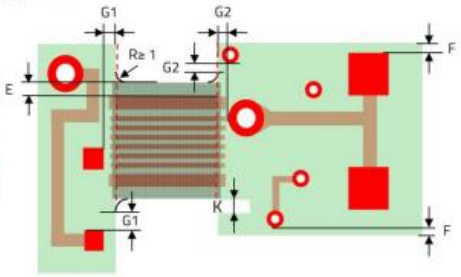
- Design Rules STARR.flex 1F (we-online.com)
- Design Rules STARR.flex 2F (we-online.com)

RIGID.**flex** 2F-xRi

Stackup 1F-3Ri



Top view

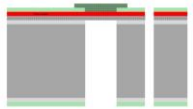


Design Rules
RIGID.**flex** 1F-xRi

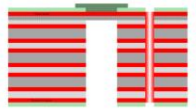
WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

These design rules apply to:
RIGID.flex PCBs with one copper layer on flexible polyimide material, externally located.
Application in accordance with IPC 2223 Use A: Flex-to-install, UL marking according UL94 and UL796F possible.

Examples:



1F-0Ri: 1 copper layer



1F-7Ri: 8 copper layers with PTH

Nomenclature: Ri = Rigid, F = Flex

Basic instructions

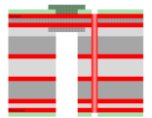
- Please comply with general standards, such as IPC or IEC
- Please refer to the valuable hints and tips in our RIGID.flex Design Guide at www.we-online.com/flex .
- Please refer to our BASIC Design Rules for rules on conductor widths, spacings, via and pad sizes as well as solder mask at www.we-online.com/basic.
- Filling of PTHs (plated through holes):
  Do not use open holes in solder pads! Keep at least 400µm distance from solder pads to holes to be plugged on both sides (Via plugging, IPC-4761 type III). For vias according to IPC-4761 type VII (filled and capped) please consult us for allowed design rules (conductor spacing)!
- Lift-off areas - attention: NO copper layout below the flex and NO vias permitted in these areas!
- Flexible and rigid-flexible circuit boards must be dried before they are assembled. Further information about this is available at www.we-online.com/dryingprocess.
- Copper removal is required in ground or reference layers for drying.
  - Recommendation: Copper openings 0.3mm per 1mm length of copper.
- Flex-to-install bending radius: Installation Use A in accordance with IPC-2223 up to 90° bending angle:
  - 1 copper layer: 10 x total thickness (IPC-2223 section 5.2.3.3)
  - For use in more demanding conditions, please contact us.
- We will be happy to create the optimal delivery panel for you (best price!).

Design Rules
RIGID.**flex** 2F-xRi

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

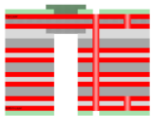
These design rules apply to:
RIGID.flex PCBs with two copper layers on flexible polyimide material, externally located.
Application in accordance with IPC 2223 Use A: Flex-to-install, UL marking according UL94 and UL796F possible.

Examples:



2F-4Ri: 6-layers

2F-1Ri: 3-layers



2F-6Ri + HDI 1-6-1: 8-layers

Nomenclature: Ri = Rigid, F = Flex

Basic instructions

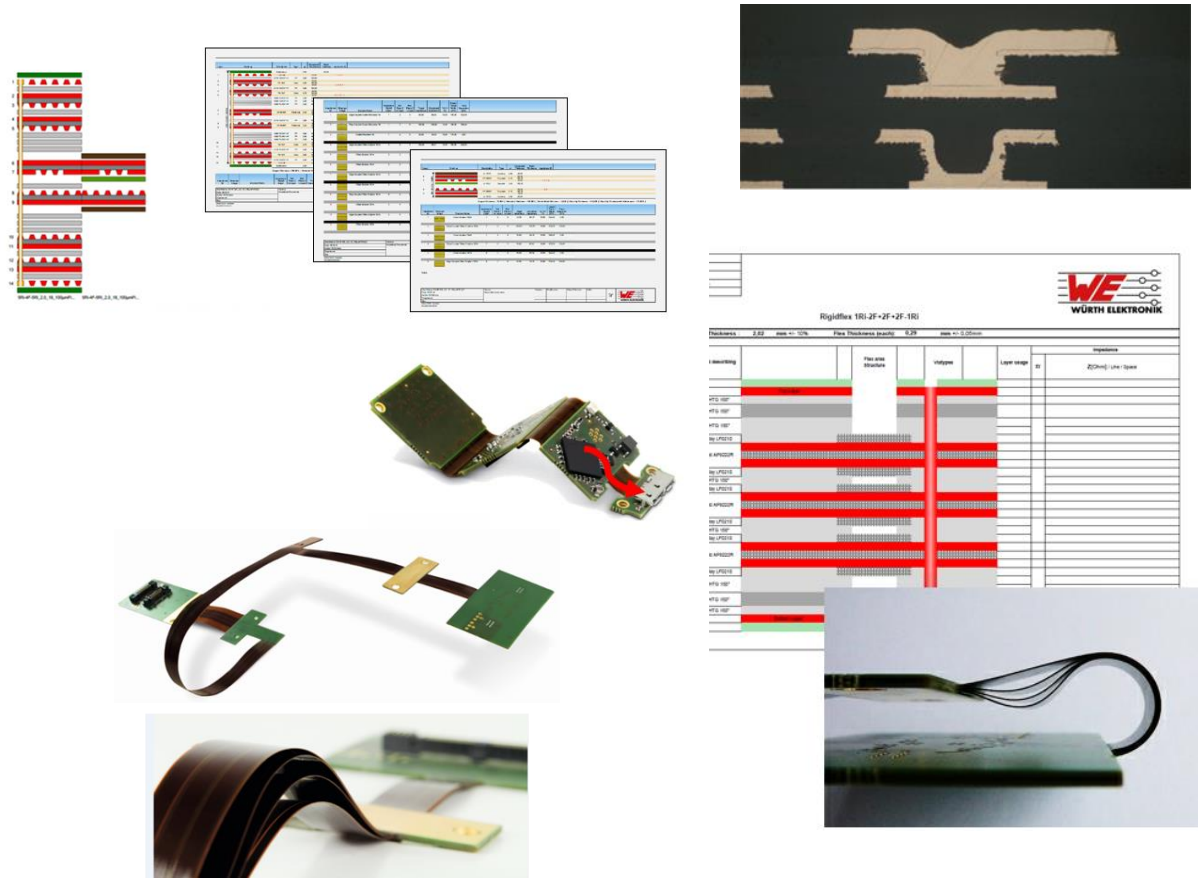
- Please comply with general standards, such as IPC or IEC
- Please refer to the valuable hints and tips in our RIGID.flex Design Guide at www.we-online.com/flex .
- Please refer to our BASIC Design Rules for rules on conductor widths, spacings, via and pad sizes as well as solder mask at www.we-online.com/basic.
- Filling of PTHs (plated through holes):
  Do not use open holes in solder pads! Keep at least 400µm distance from solder pads to holes to be plugged on both sides (Via plugging, IPC-4761 type III). For vias according to IPC-4761 type VII (filled and capped) please consult us for allowed design rules (conductor spacing)!
- Lift-off areas - attention: NO copper layout below the flex and NO vias permitted in these areas!
- Flexible and rigid-flexible circuit boards must be dried before they are assembled. Further information about this is available at www.we-online.com/dryingprocess.
- Copper removal is required in ground or reference layers for drying.
  - Recommendation: Copper openings 0.3mm per 1mm length of copper.
- Flex-to-install bending radius: Installation Use A in accordance with IPC-2223 up to 90° bending angle:
  - 2 copper layers: 10 x total thickness (IPC-2223 section 5.2.3.3)
  - For use in more demanding conditions, please contact us.
- We will be happy to create the optimal delivery panel for you (best price!).

FLEXIBLE AND RIGIDFLEXIBLE PCB‘S

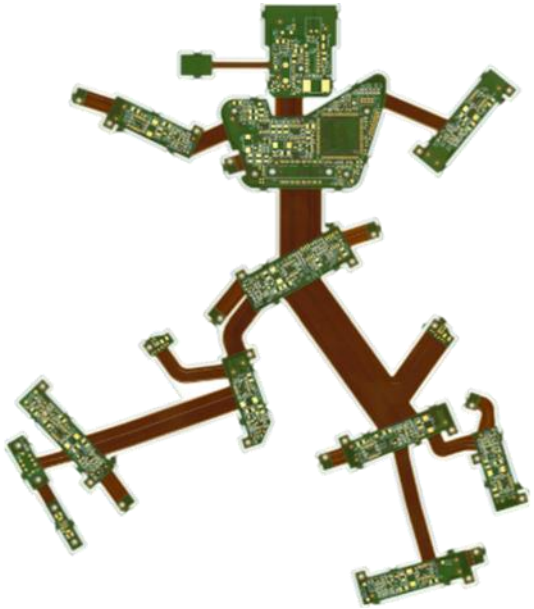
Information about the next webinar on flexible and rigid-flex PCBs

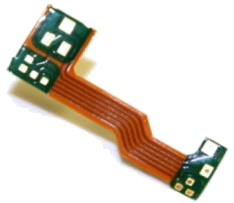
The following topics will be presented.

- Standard stackup xRi-2F-xRi
- Standard stackup xRi-4F-xRi
- NON Standard stackup
- Production process of a rigidflex 3Ri-2F-3Ri
- Design-Rules



FLEXIBLE AND RIGIDFLEXIBLE PCB‘S





Thank You