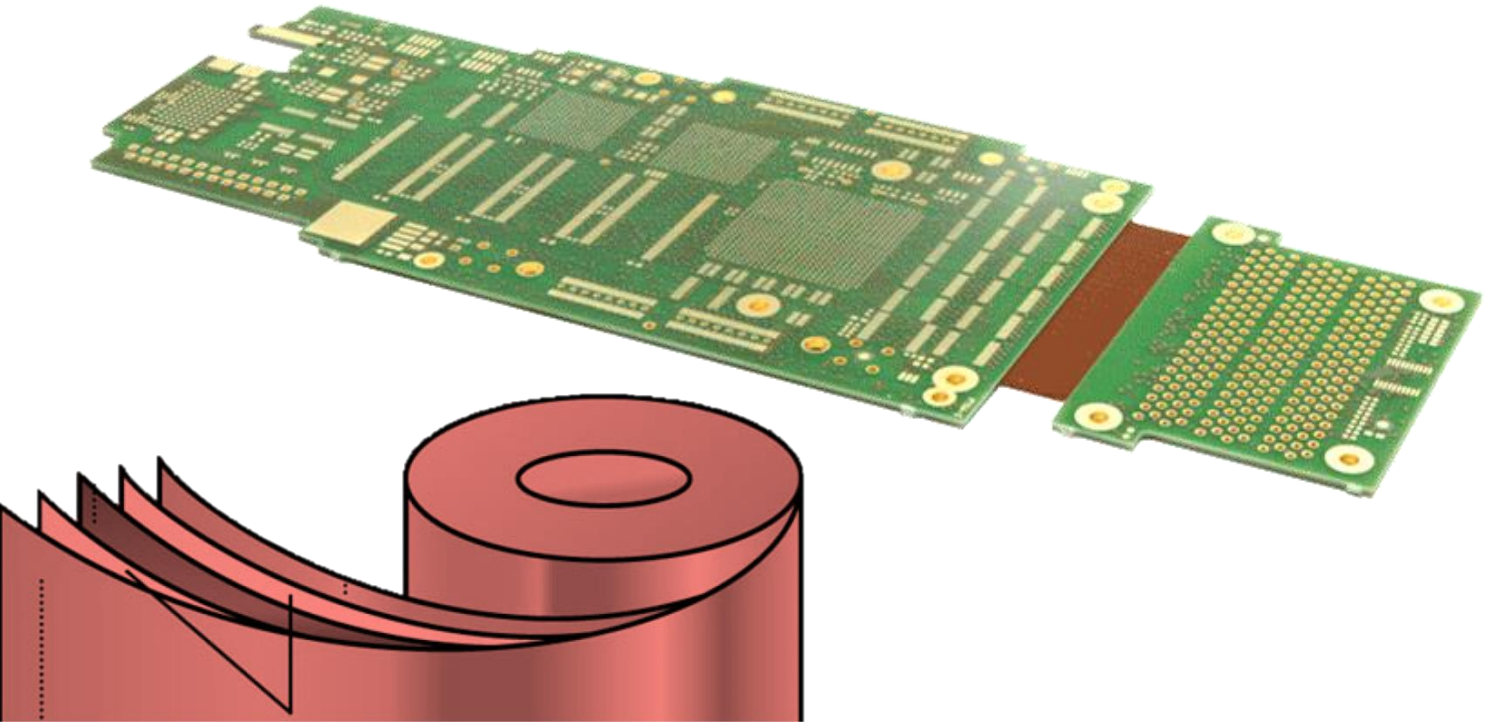
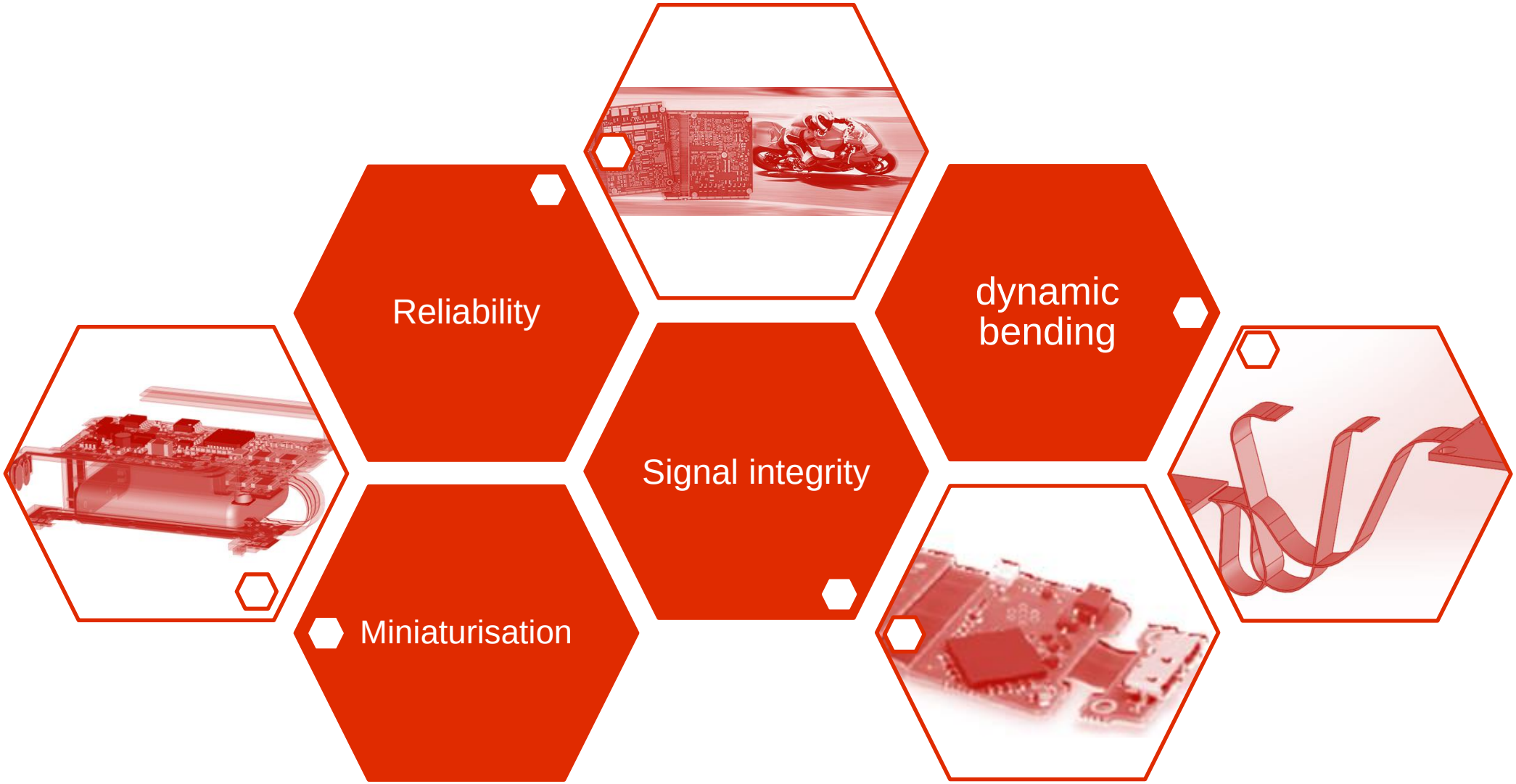
Flex-rigid: Base materials and their characteristics



Webinar February, 7th 2017

Speaker: Andreas Schilpp

Introduction: Integration of Module Interconnects
Benefits through Flex-Rigid Technology



agenda

1. • Ingredients for a Flex-Rigid PCB
2. • Standard Flex-rigid Stack-ups
3. • Material characteristics and their effect on applications

Terms and Abbreviations

- **Bondply**
- **B2B: Board-to-Board**
- **CAF: Conductive Anodic Filament**
- **Cu: Copper**
- **CL: Coverlay**
- **FPC: Flexible Prited Circuit**
- **IPC: Organisation "Association Connecting Electronics Industries„ www.ipc.org**
- **PI: Polyimide**
- **TPI: Thermoplastic PI (Adhesive)**
- **ZIF: Zero Insertion Force**

Ingredients for a Flex-Rigid PCB

Flex/TWINflex® xF-Ri

Top

Flex PCB

ENIG surface finish

ZIF/FPC contact on flex tail

B2B connector on flex tail

Flex with solder carrier

Flex/TWINflex® xF-Ri

Bottom

FR4 solder carrier for flex PCB

FR4 rigidiser for ZIF/FPC contact

FR4 rigidiser for B2B connector

- flexible foil Polyimide, copper 2 sides
- copper resp. ENIG surface
- flexible soldermask
- rigid FR4 (stiffener)
- 3M transfer adhesive

*samples you will get **here** !*

Ingredients for a Flex-Rigid PCB

Flex-rigid 1F-xRi + FR4 Semiflex

Top

Semiflex area

B2B connector with semiflex area

Polyimide flex area

Depth milled contact areas for ZIF/FPC connectors

*samples you will get **here** !*

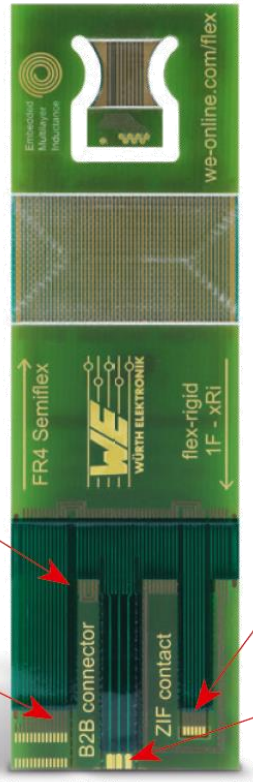
- flexible foil Polyimide, copper 1 side
- rigid FR4, FR4 prepreg
- copper resp. ENIG surface
- flexible soldermask
- standard soldermask

Flex-rigid 1F-xRi + FR4 Semiflex

Bottom

Laser cut

B2B connector with flex arm



ZIF/FPC contact with flex arm

Solder contacts due to edge plating

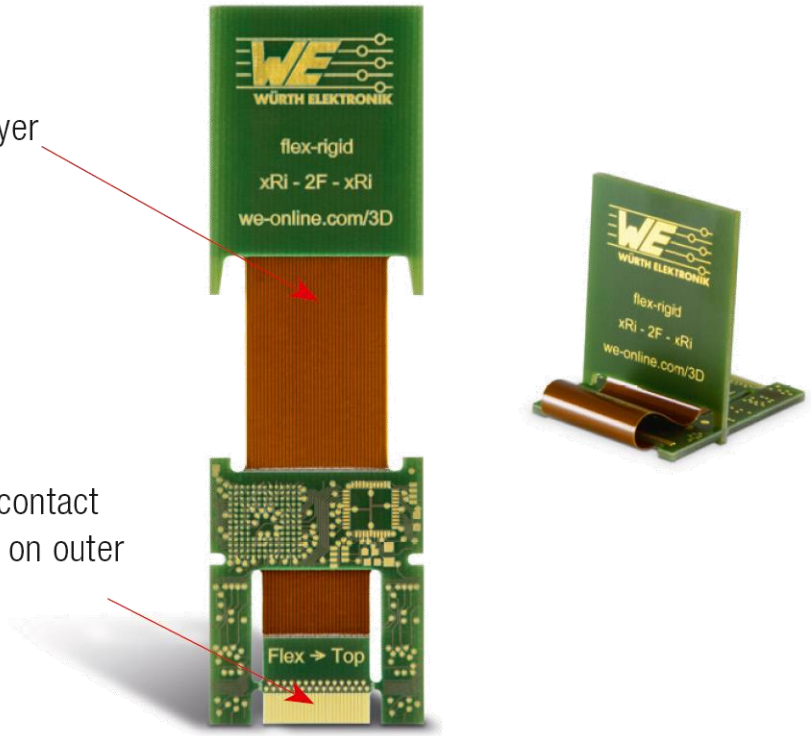
Ingredients for a Flex-Rigid PCB

Flex-rigid xRi-2F-xRi

Top

Signal layer

ZIF/FPC contact with vias on outer layer

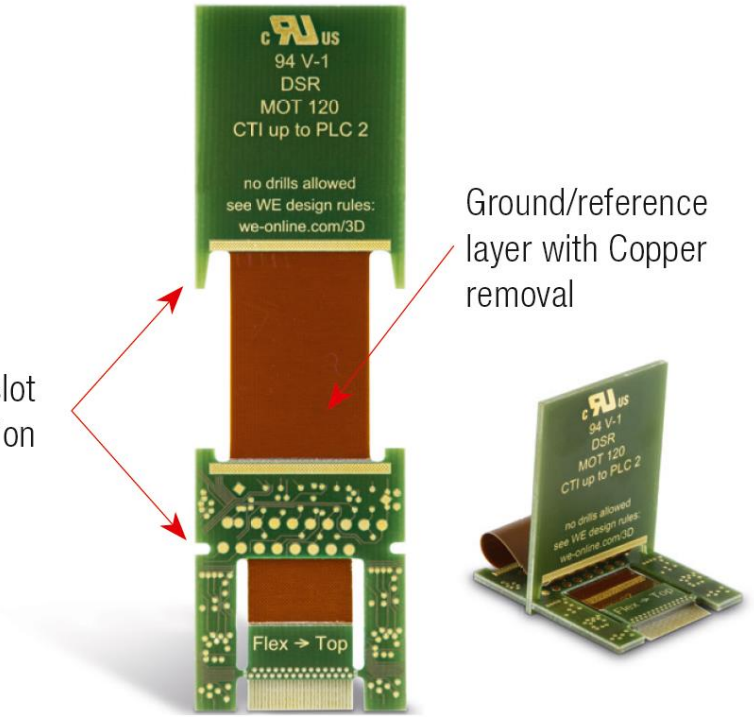


Flex-rigid xRi-2F-xRi

Bottom

Key and slot construction

Ground/reference layer with Copper removal



- flexible foil Polyimide, copper 2 sides
- rigid FR4, FR4 prepreg
- copper resp. ENIG surface
- Polyimide coverlay
- standard soldermask

*samples you will get **here** !*

Ingredients for a Flex-Rigid PCB

Flex-rigid 2F-xRi

Top

Signal layer

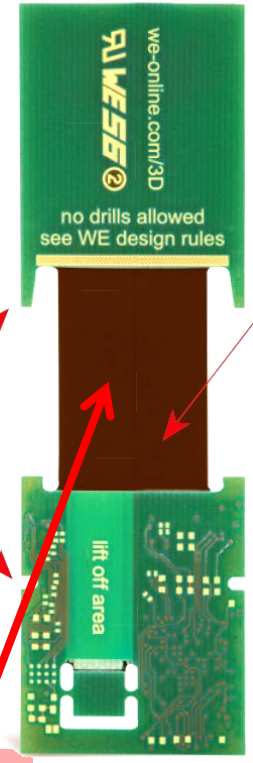
B2B connector

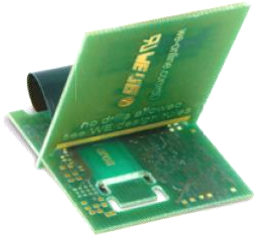
Flex-rigid 2F-xRi

Bottom

Ground/reference layer with Copper removal

Key and slot construction





- flexible foil Polyimide, copper 2 sides
- rigid FR4, FR4 prepreg
- copper resp. ENIG surface
- flexible soldermask / Polyimide coverlay
- standard soldermask

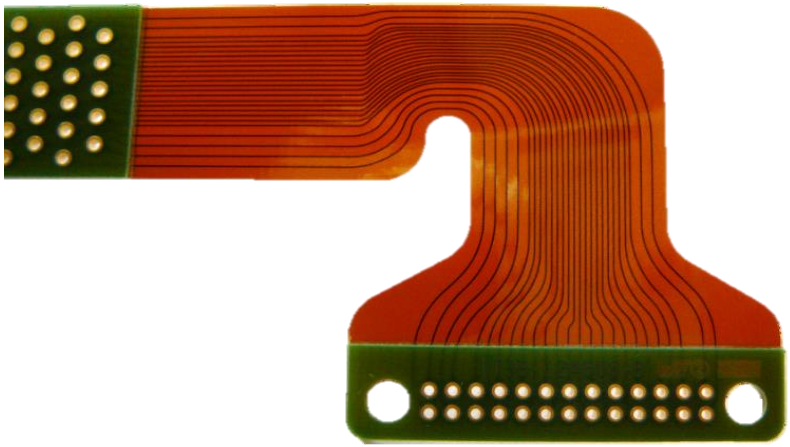
*samples you will get **here** !*

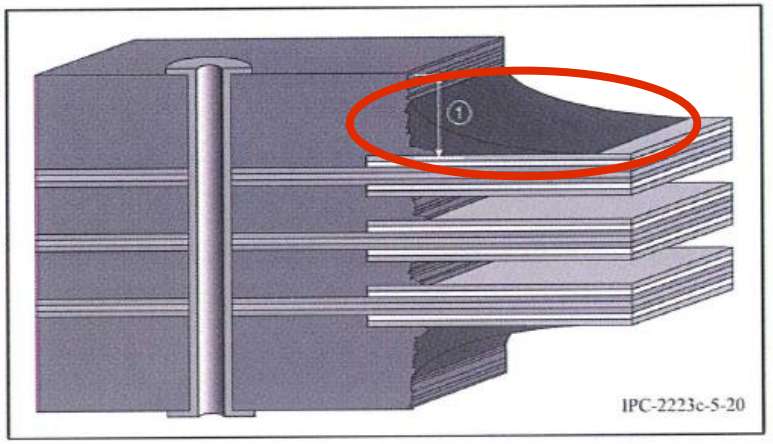
Ingredients for a Flex-Rigid PCB

- flexible foils, copper-clad
- flexible foils with adhesive
- flexible adhesive foils

(see IPC-42xy)

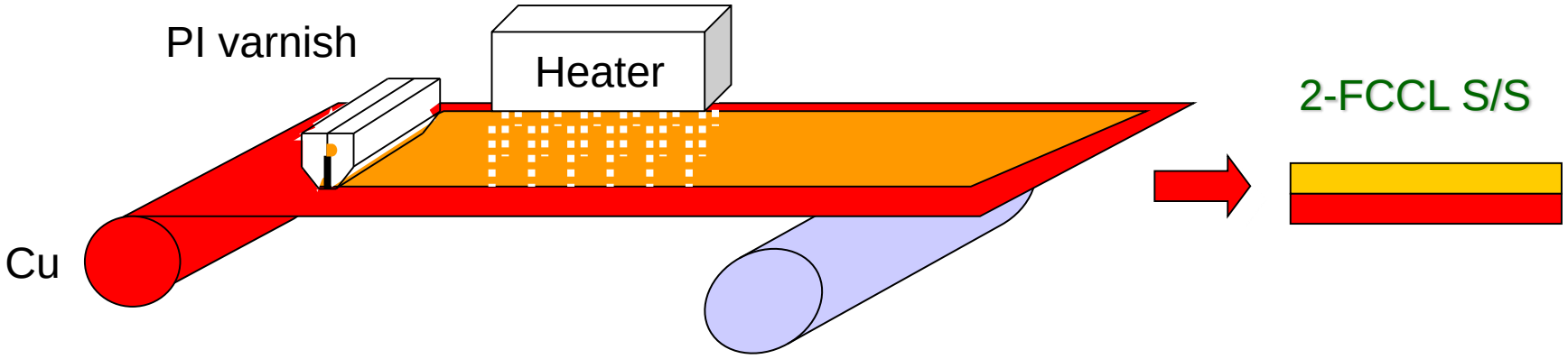
- rigid cores, copper-clad
- rigid prepregs (adhesive compound)
  - specialty: LowFlow prepreg
- copper foils
- copper plating (barrels and plated layers)
- solder surface (on copper)
- soldermask
  - Standard (almost green)
  - flexibel
- ink for legend
- strain relief out of elastomer





Ingredients for a Flex-Rigid PCB
Production of flexible base materials (1)

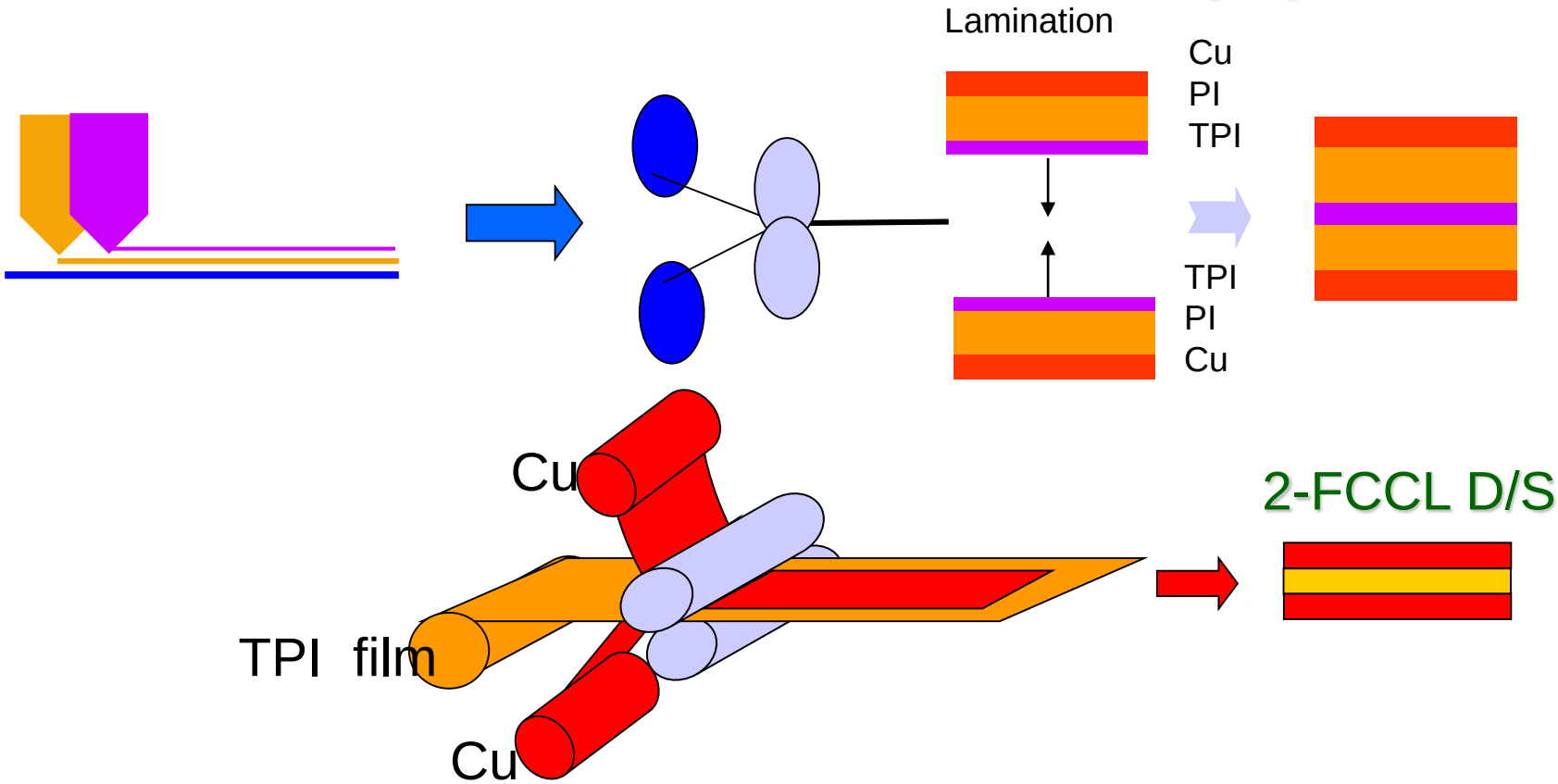
- Polyimide, single sided copper clad base material **adhesiveless**, „Casting“



- Polyimide foil thickness: (12,5µm) / 25µm / 50µm Standard / 75µm / 100µm / (….)
- Copper foil thickness: (5µm / 7µm / 9µm) / 12µm / 18µm / 35µm / 70µm

Ingredients for a Flex-Rigid PCB
Production of flexible base materials (2)

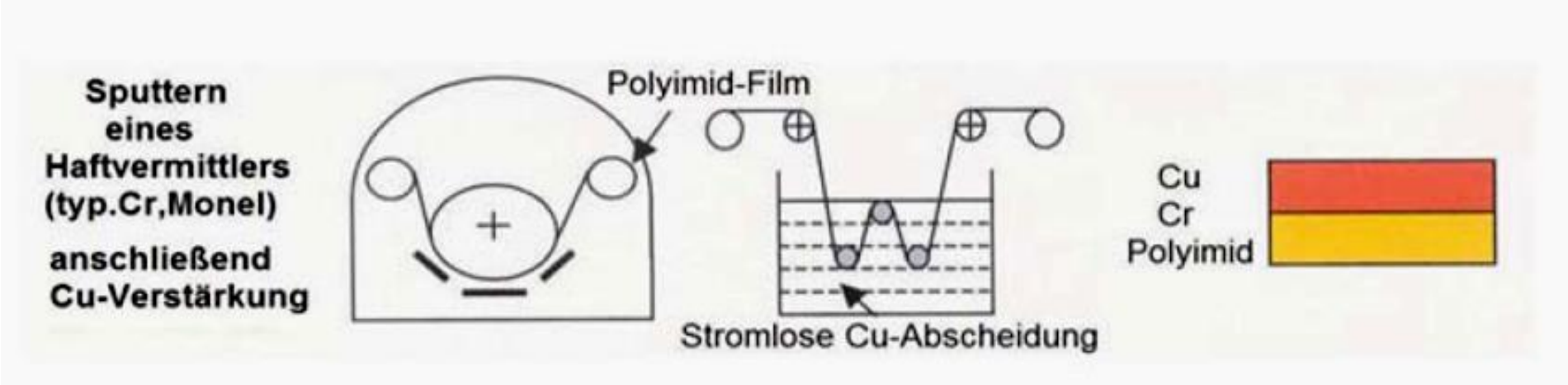
- Polyimide, double sided copper clad base material **adhesiveless (TPI)**



- Polyimide foil thickness: (12,5µm) / 25µm / 50µm Standard / 75µm / 100µm / (….)
- Copper foil thickness: (5µm / 7µm / 9µm) / 12µm / 18µm / 35µm / 70µm

Ingredients for a Flex-Rigid PCB
Production of flexible base materials (3)

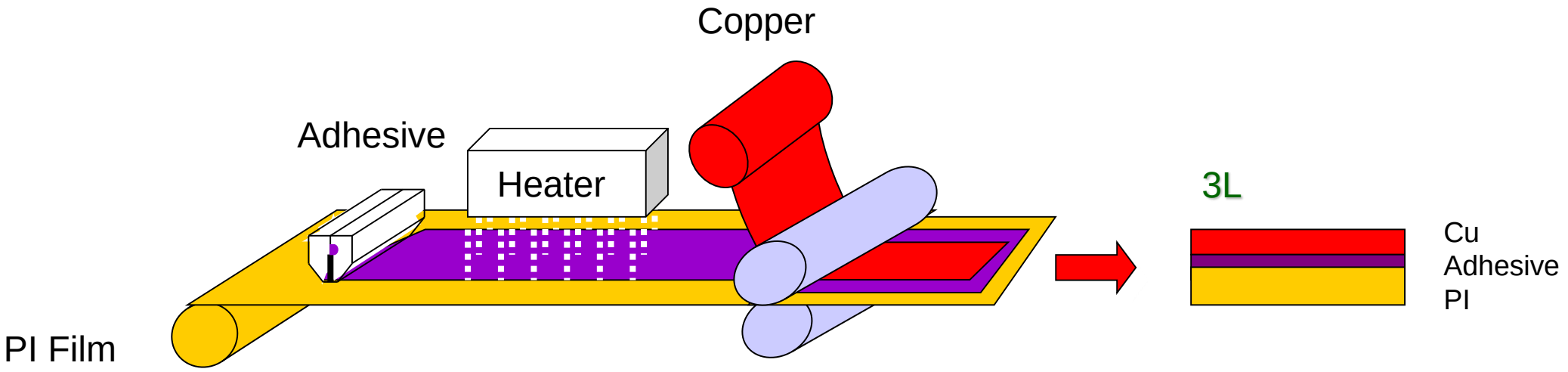
- Polyimide, double sided copper clad base material **adhesiveless: Sputter methode**
- (we do not use this kind of material)



- Polyimide foil thickness: (12,5µm) / 25µm / 50µm Standard / 75µm / 100µm / (….)
- Primer
- Copper foil thickness: (5µm / 7µm / 9µm) / 12µm / 18µm

Ingredients for a Flex-Rigid PCB
Production of flexible base materials (4)

- Polyimide, single sided copper clad base material **with adhesive**

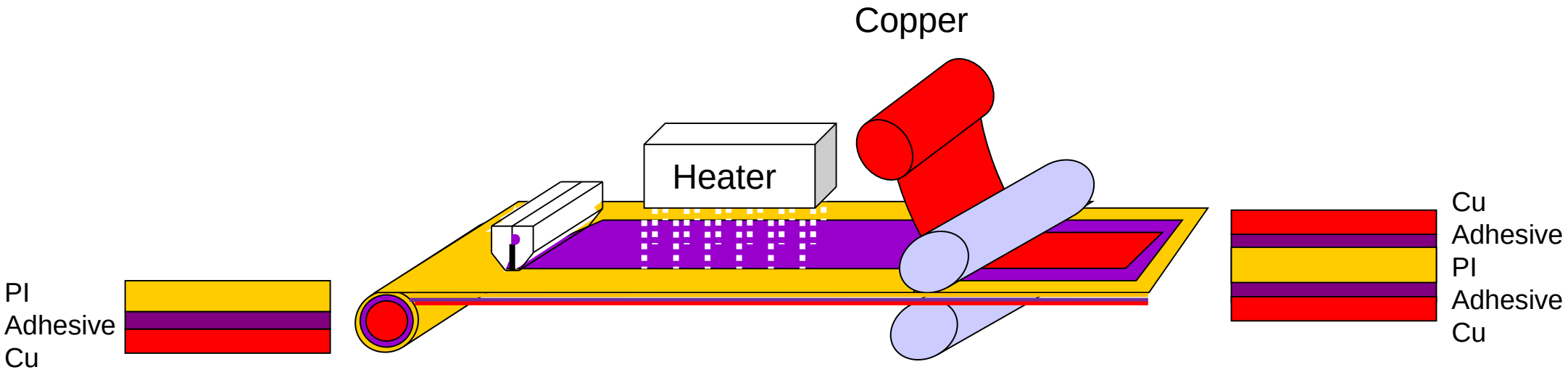


- Polyimide foil thickness: (12,5µm) / 25µm / 50µm Standard / 75µm / 100µm / (….)
- Adhesive thickness: typical 13µm / 20µm / 25µm
  - Acrylc glue (since 1970´s) or Epoxy
- Copper foil thickness: (5µm / 7µm / 9µm) / 12µm / 18µm / 35µm / 70µm

- Paper instead of copper foil ➔ Coverlay (Polyimide + adhesive on one side)
- Paper instead of copper foil and Polyimide ➔ pure adhesive foil (i.e. LF0100)

Ingredients for a Flex-Rigid PCB
Production of flexible base materials (5)

- Polyimide, double sided copper clad base material **with adhesive**



- Polyimide foil thickness: (12,5µm) / 25µm / 50µm Standard / 75µm / 100µm / (….)
- Adhesive thickness: typical 13µm / 20µm / 25µm
  - Acrylc glue (since 1970´s) or Epoxy
- Copper foil thickness: (5µm / 7µm / 9µm) / 12µm / 18µm / 35µm / 70µm

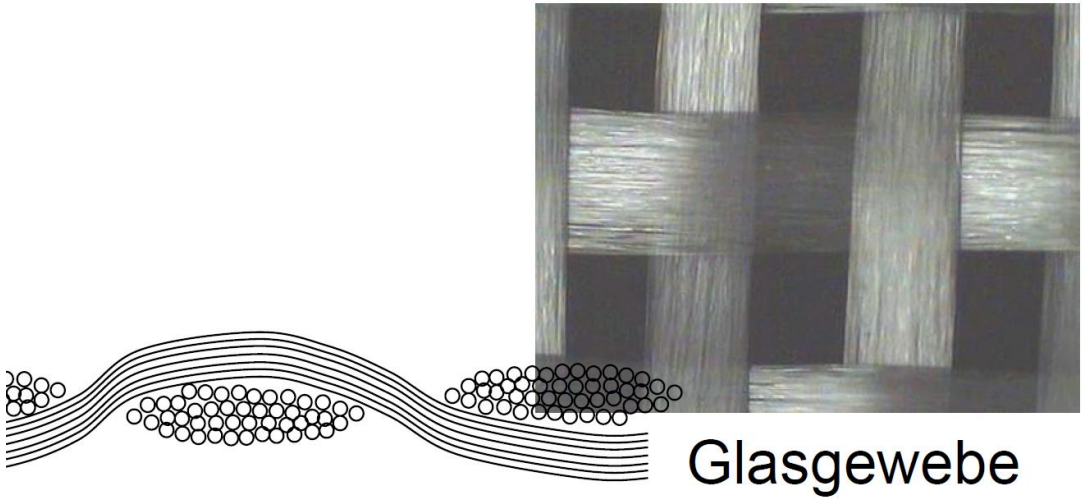
- Paper instead of copper foil ➔ Bondply (Polyimide with adhesive on both sides)

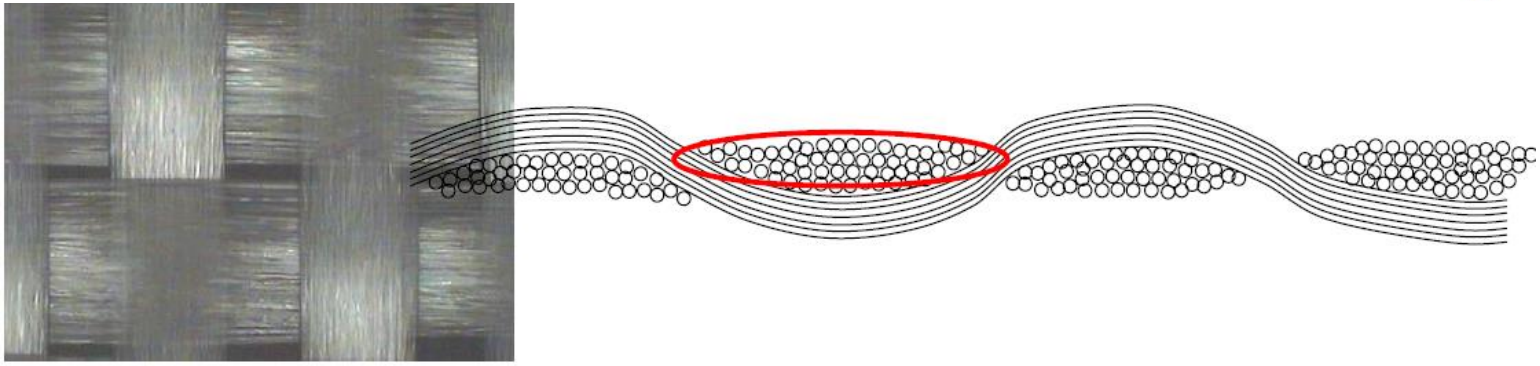
Ingredients for a Flex-Rigid PCB
Rigid Base material (1)

- **Spezification according IPC-4101**
- **Ingredients:**
  - **resin: Epoxy, Polyimid, …**
  - **hardener**
  - **fillers**
  - **carrier: paper or glas**
  - **copper foil**

Ingredients for a Flex-Rigid PCB
Rigid Base material (2)

- **woven glass as carrier**
  - **worp and weft direction**
  - **spread glass constructions**
  - **specification: IPC-4412**





Quellen:
NanYa

Ingredients for a Flex-Rigid PCB

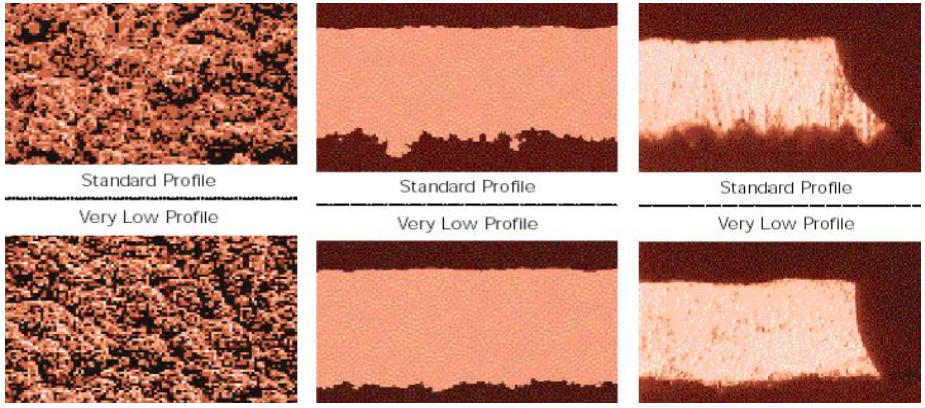
Copper foils

- **Thickness derived from surface weight oz/ft²**
  - **1 oz/ft² = 305g/m² = 35µm Dicke**
- **Copper quality acc. IPC-4562**
  - **electro plated (ED)**
  - **rolled copper RA-Quality**
  - **new: rolled copper HA-Quality**
- **rough treatment side facing the base meterial**

Table A1 Application Guide for Copper Foil

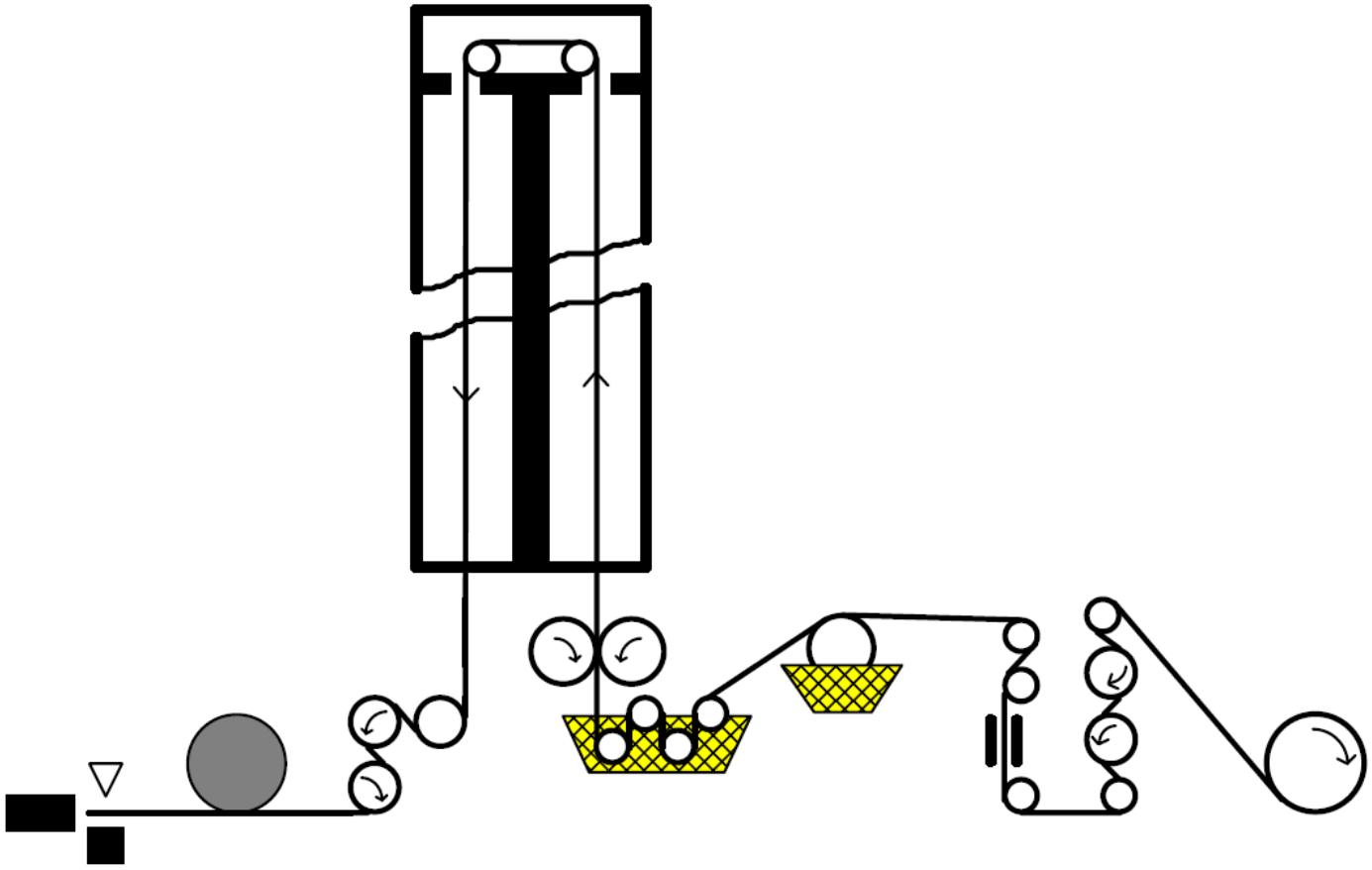
TYPE	GRADE	CLASS	Handling	Maximum Strain Range (%) / Minimum Bend Diameter (µm [mil]) Accommodated by 1 oz. (CIT) Foil[1]					
				Flex to Install		Continuous Flexing	Flex to Install		Continuous Flexing
				Single Bend	Low Cycle Fatigue[2]	High Cycle Fatigue[2]	Single Bend	Low Cycle Fatigue[2]	High Cycle Fatigue[2]
				At Room Temperature			At Elevated Temperature (180°C [356°F])[3]		
E	1	All	Good	Not recommended for applications requiring foil flexing or bending					
E	2	All	Good	30/84 [3.31]	7.1/965 [37.99]	0.19/37,338 [1470]	Not applicable		
E	3	All	Good	20/142 [5.59]	5.3/1320 [51.968]	0.18/39,624 [1560]	15/201 [7.913]	4.2/1600 [62.992]	0.17/40,894 [1610]
E	4	All	Caution[8]	50/36 [1.41]	10.3/660 [25.98]	0.28/25,400 [1000]	41/51 [2.01]	7.7/889 [35]	0.21/33,655 [1325]
W	5[4]	All	Good	30/84 [3.31]	7.5/914 [35.98]	0.32/22,098 [870]	15/201 [7.913]	4.2/1600 [62.992]	0.17/40,894 [1610]
W	5[5]	All	Good	65/20 [0.787]	13.1/508 [20]	0.32/22,098 [870]	TBD	TBD	TBD
W	6[6]	All							
W	7	All	Caution[8]	65/20 [0.787]	12.5/533 [20.98]	0.32/22,098 [870]	45/43 [1.69]	9.5/711 [27.99]	0.20/34,798 [1370]
E	8[7]	All	Good	25/102 [4.0157]	6.2/1118 [44.0157]	0.15/48,006 [1890]	TBD	TBD	TBD
E	9	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
E	10	All	Good	41/51 [2.0079]	8.9/762 [30]	0.31/22,860 [900]	32/76 [2.99]	6.8/1016 [40]	0.22/33,020 [1300]
E	11	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

1. Larger maximum strain range and smaller minimum bend diameter values indicate superior performance for a given strain mode.
2. Low cycle fatigue <500 cycles-to-failure. High cycle fatigue > 10^4 cycles-to-failure. The values given here have been calculated for 20 and 10^5 fatigue cycles for low- and high-cycle fatigue, respectively. For the calculations the minimum mechanical properties for 34 µm [1.34 mil] copper foil given in the respective slash sheets have been used. Typical property values can be considerably higher. (See IPC-TR-484.)
3. The values for elevated temperature applications should primarily be used for qualitative purposes, since unproven assumptions were nec-



Ingredients for a Flex-Rigid PCB
Rigid Base material (3)

- **vertical impregnation system**

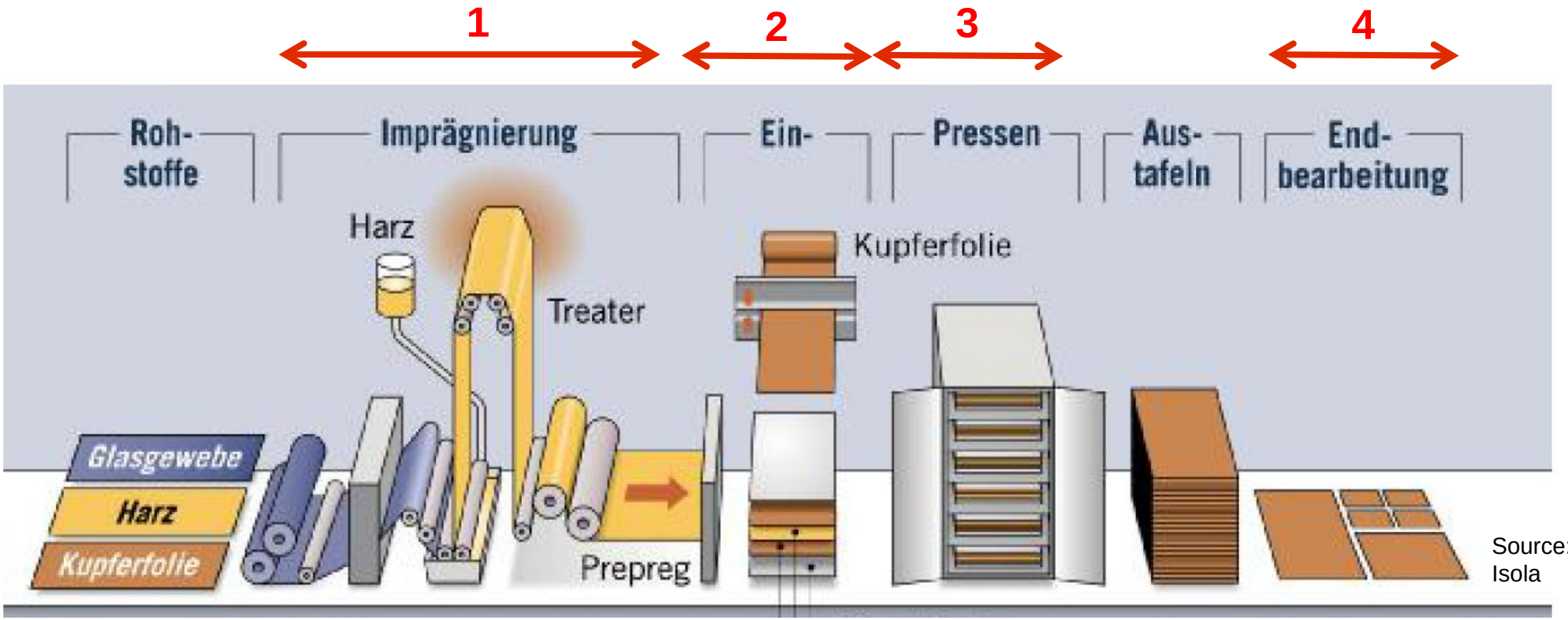


Source:
VDE/BDI3711, Blatt 2

Ingredients for a Flex-Rigid PCB

Rigid Base material (4)

1. impregnation
2. prepreg cutting, copper foil lay-up
3. copper lamination
4. final cutting

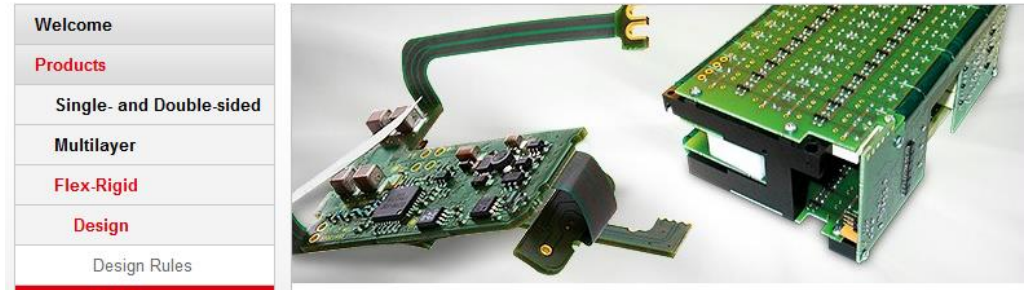


agenda

1. • Ingredients for a Flex-Rigid PCB
2. • **Standard Flex-rigid Stack-ups**
3. • Material characteristics and their effect on applications

Standard stack-ups Flex-rigid

- **Modifications:**
  - **flex inside / outside**
  - **thickness of flexible material Polyimide**
  - **adhesiveless / with adhesive**
  - **quality rigid base material**
  - **copper quality and thickness**
  - **flexible soldermask or coverlay**
  - **coverlay partially / full size**
  - **total thickness of pcb**
  - **solder surface**



Welcome
Products
Single- and Double-sided
Multilayer
Flex-Rigid
Design
Design Rules
Buildups
Design-to-cost
UL Identification
FAQs
Drying
Production Technique
Cost Considerations
Solderable Surfaces
Publications
Microvia HDI
Signal Integrity
Thermal Management
Wire Bonding
ECT
High Current Wirelaid®
Printed Polymer
SMD Stencils

Flex- and flex-rigid buildups

How many layers do you need?

Flex-rigid buildups are first and foremost characterised by the number of layers at the flexible regions and in particular by arrangement of these layers. The sum of copper-layers on the rigid and flexible materials defines the total number of layers.

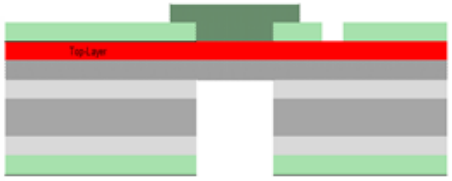
The standard flex-rigid buildups are summarised and immediately available for free download:

Select the desired buildup and the necessary number of layers. After this, please select between the different forms of buildups those with various total thicknesses, if available.

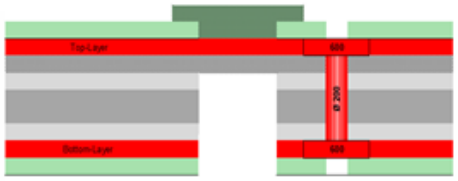
Buildup	1F-xRi (flex-rigid)	xRi-2F-xRi (flex-rigid)
xF (Flex) as TWINflex®, but without stiffener	› 1 layer › 2 layers › 4 layers › 6 layers › 8 layers	› 4 layers › 6 layers › 8 layers
xF-Ri (TWINflex®)		
› 1 layer › 2 layers › 4 layers 6 layers(on request)		2F-xRi (flex-rigid) › 3 layers › 4 layers › 6 layers

Standard stack-ups Flex-rigid (2)

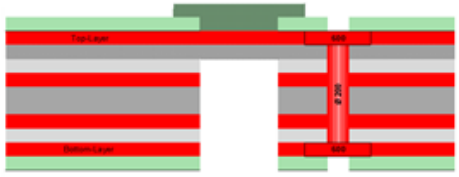
1F-xRi – for all stack-ups ≥ 4 layers microvias 1-x-1 could be added



1F-0Ri

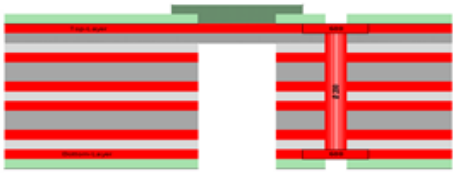


1F-1Ri

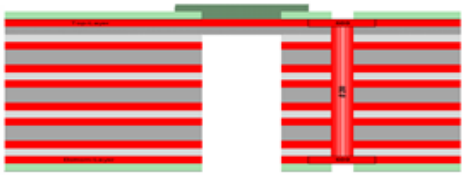


1F-3Ri

1F-3Ri + HDI 1-2-1

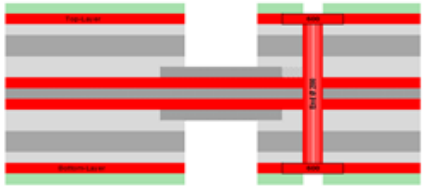


1F-5Ri

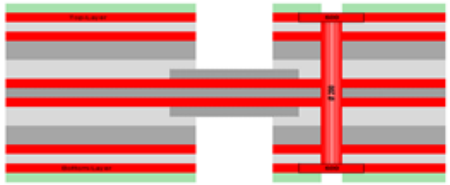


1F-7Ri

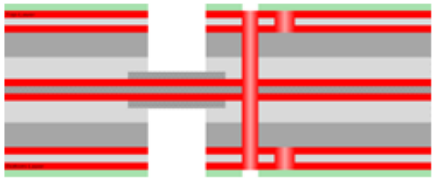
xRi–2F–xRi – for all stack-ups ≥ 6 layers microvias 1-x-1 could be added



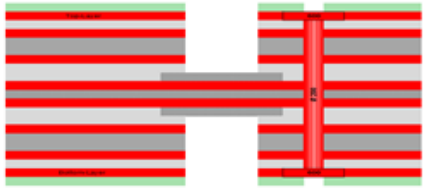
1Ri-2F-1Ri



2Ri-2F-2Ri part. CL “Bikini”



2Ri-2F-2Ri + HDI 1-4-1



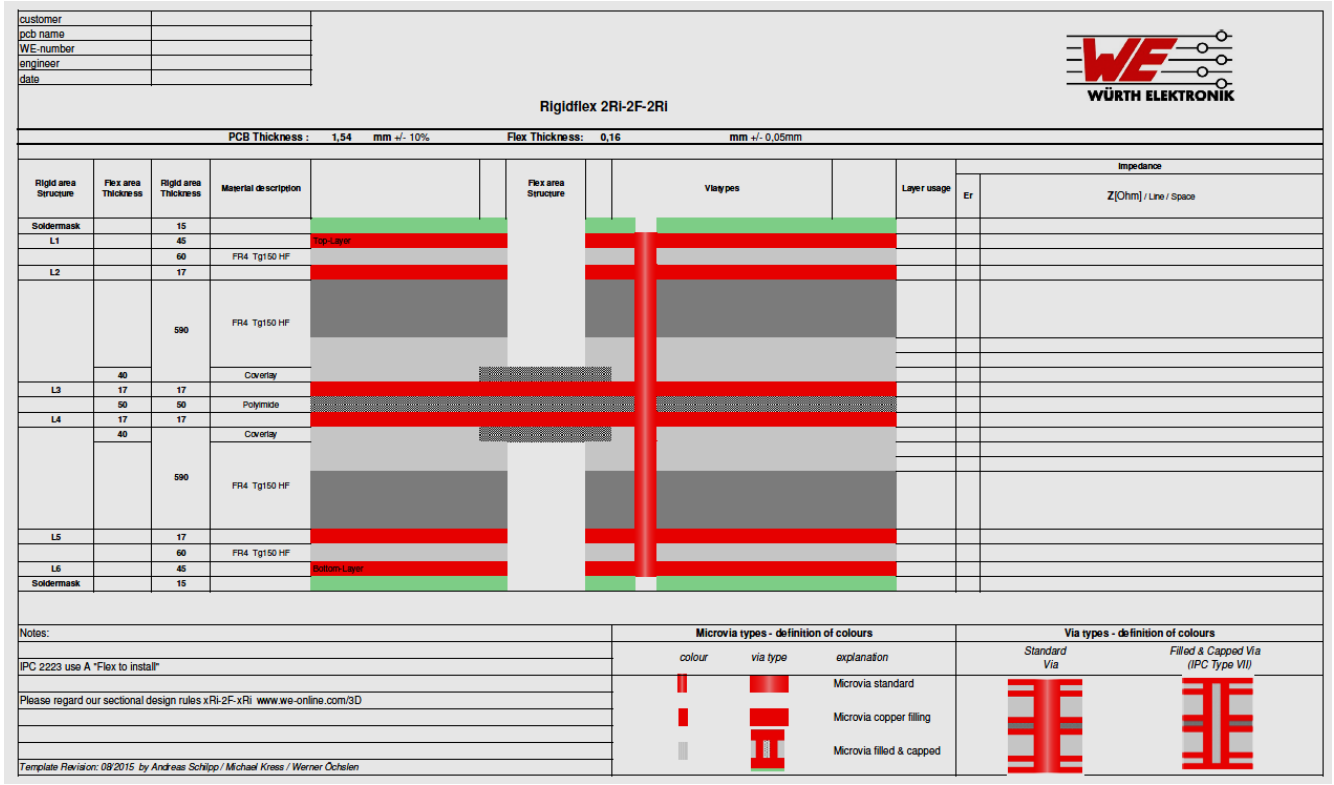
3Ri-2F-3Ri

Standard stack-ups Flex-rigid (3)

- Base materials
  - rigid: FR4 Tg ≥150°C, halogen free, filled- standard thicknesses
  - flex: Polyimide Tg >> 200°C, adhesiveless– typical 25µm / 50µm thick(…up to 150µm)
  - standard solder mask, flexible solder mask, Polyimide coverlay

- Stack-up plans
  - example:

    µVia capable

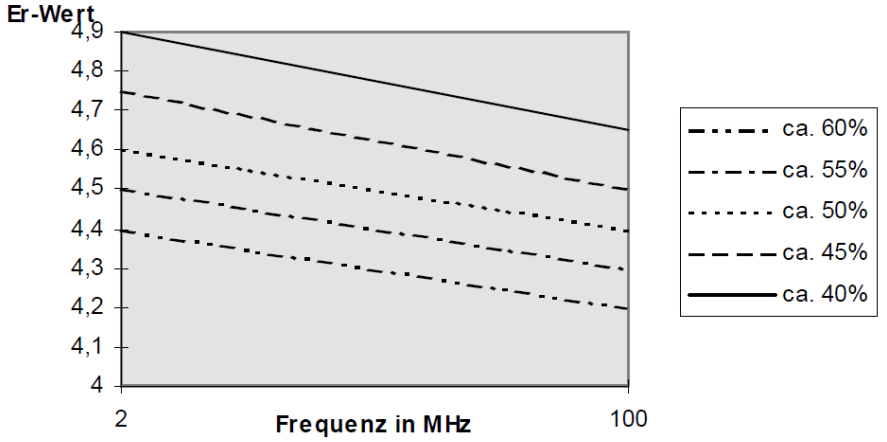


agenda

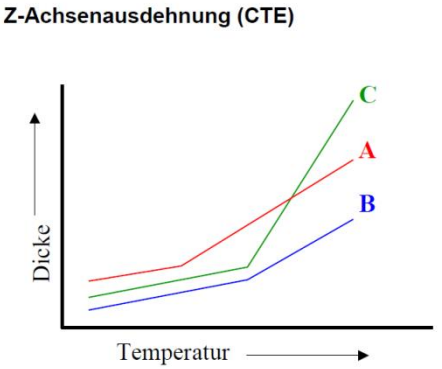
1. • Ingredients for a Flex-Rigid PCB
2. • Standard Flex-rigid Stack-ups
3. • **Material characteristics and their effect on applications**

Material characteristics and their effect on applications (1)

- resin system
  - dielectric properties
- ration resin : carrier
  - dielectric properties
- resin + hardener + fillers:
  - temperature stability (➔ PI)
    - soldering
    - performance, application
  - thermal expansion behavior CTE
  - thermal conductivity



ZVEI:



A - Mittel Tg mit Füllstoff
B - Hoch-Tg mit Füllstoff
C - Hoch- Tg

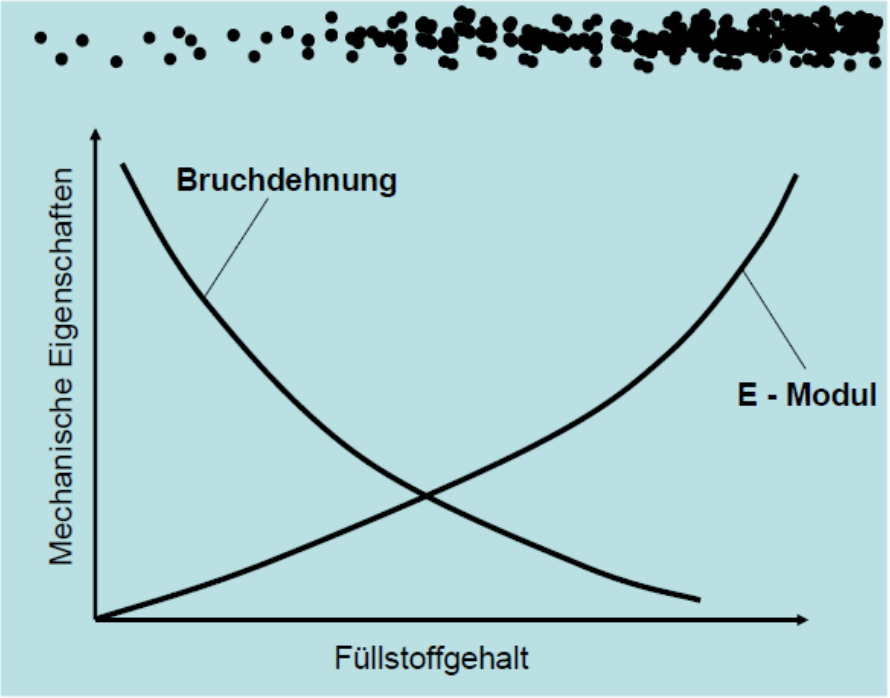
CTE über Tg ist größer als CTE unter Tg

ZVEI, GMM

Material characteristics and their effect on applications(2)

- adhesive
  - general weak point in a compound
  - thermal expansion in z-axis
  - capability for UL listing
  - impact on tracking index CTI
- solder mask – Coverlay
  - dielectric strength
  - abrasion resistance
  - buckling resistance

Eigenschaftsmodifikation durch Zugabe von Füll- und Verstärkungsstoffen

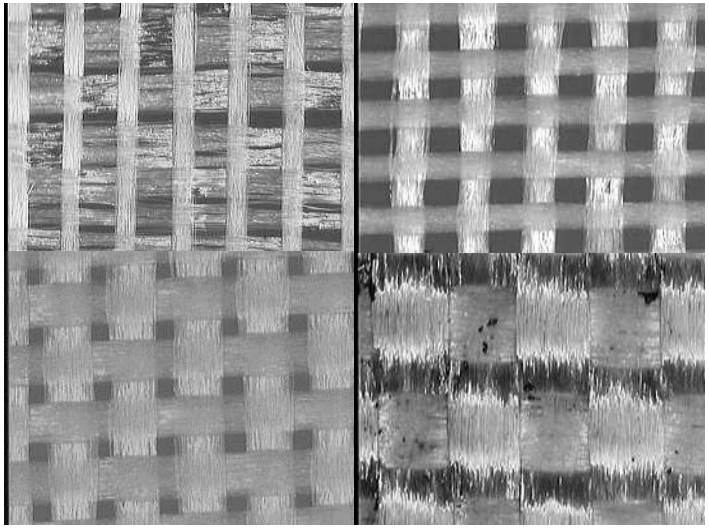


Source:
Dr. Seidel, Siemens

Material characteristics and their effect on applications (3)

- copper treatment
  - adhesion on base material
  - fine line capability
  - suitable for high frequencies
- copper quality
  - robustness in dynamical bending and buckling
- carrier
  - dimensional stability ➔ registration ➔ annular ring
  - glass matrix: HR characteristics, CAF

Dicke	Treatmentseite (R_z)		Shiny-Seite (R_z)
µm	HTE (µm)	VLP (µm)	HTE und VLP (µm)
18	6,5 - 8,5	3,5 - 4,5	0,2 - 0,35
35	7,0 - 9,0	3,5 - 5,0	0,2 - 0,35
70	8,0 - 10,5	3,5 - 5,0	0,2 - 0,35



Source: Isola

Summary

- there is an incredible variety in materials used for flex and flex-rigid technology and in their combinations
- standardisation is important to meet quality and cost targets
- knowledge about material characteristics and processes is mandatory
- specification of materials and stack-ups has to be fixed in an early phase of a project
- based on the specification of the entire project („mission profile“)
- ***Please contact us as soon as possible!***

Thank you for your attention

The webinar was presented by