



**OUR FLEX SOLUTIONS**  
How much flexibility do you need?



# AGENDA

- 1** The full package of Flex solutions
- 2** Flexibility or bendability: How do the different options perform?
- 3** Digital available stackups for your EDA software
- 4** Project based optimisation
- 5** Flexibility and costs in relationship



**Klaus Schill-Mulack**  
Project management



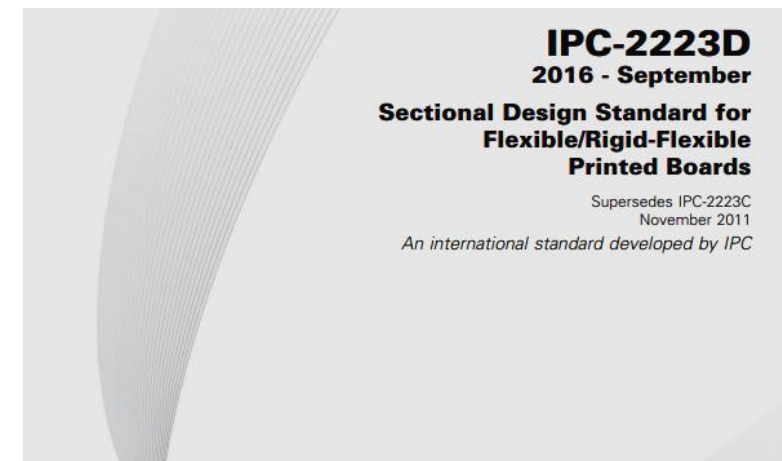
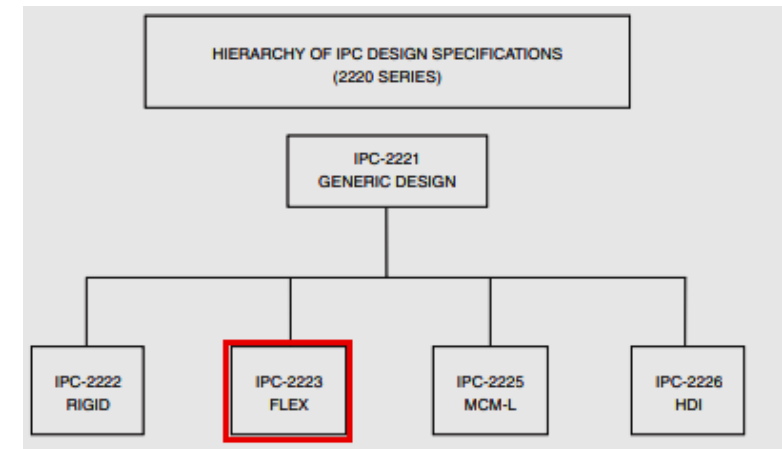
# SPECTRUM OF WE FLEX SOLUTIONS

## IPC Standards



### IPC-2223 (D) – Design for flexible and rigid-flexible printed circuit boards

- Dielectric flexible films like polyimide or polyester
- Copper foils like ED or RA copper
- Completely flexible or a combination of rigid and flexible Printed Circuit Board
- Application A: Flex-to-install / static
- Application B: permanent, specified bending load / dynamic
  
- Bending = tension and compression

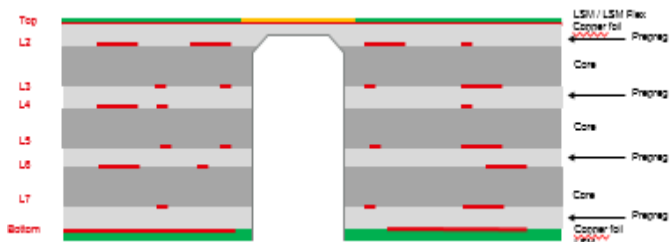


# SPECTRUM OF WE FLEX-SOLUTIONS

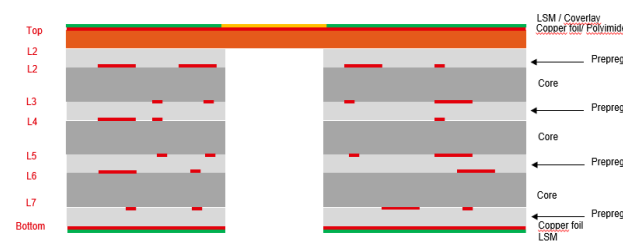
## Typical Stackups



### SEMI.flex / BEND.flex



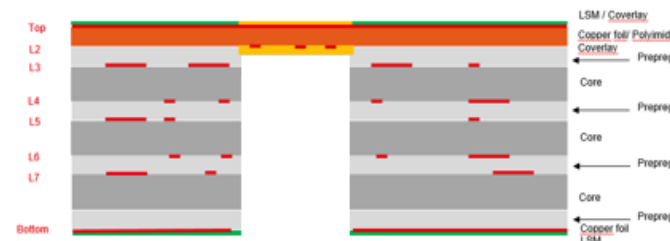
### RIGID.flex 1F-7Ri



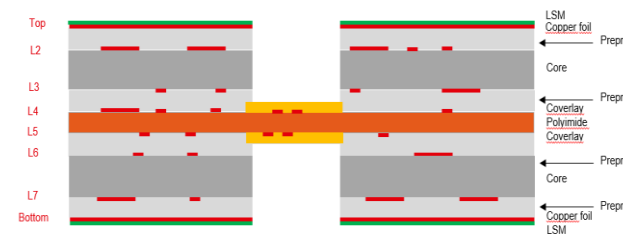
### PURE.flex 2F



### RIGID.flex 2F-6Ri



### RIGID.flex 3Ri-2F-3Ri



### SLIM.flex 6F



# SPECTRUM OF WE FLEX-SOLUTIONS

## SEMI.flex / BEND.flex



### SEMI.flex



- Rigid Material, only Tg 135
- ED-Cu + plated Copper
- Flexible solder mask in the flex area
- Z-axis controlled depth milling tool 45°Phase
- Milling in the glass/resin matrix
- Copper on outer radius only

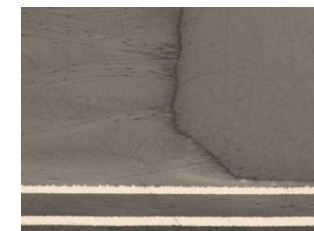
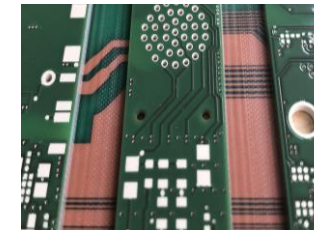
### BEND.flex



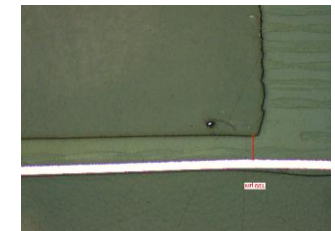
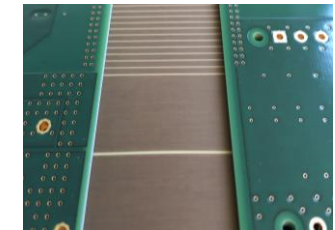
- Rigid material, Tg135 - Tg170
- ED-Cu + plated copper
- Coverlay or flexible solder mask in the flex area
- Use of spacer, FR4-cores, Lowflow-Prepreg
- Copper on inner and outer radius possible

### Direct comparison:

#### SEMI.flex



#### BEND.flex



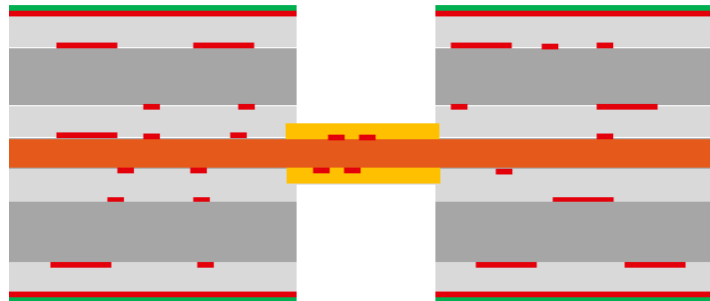
# SPECTRUM OF WE FLEX-SOLUTIONS

## RIGID.flex

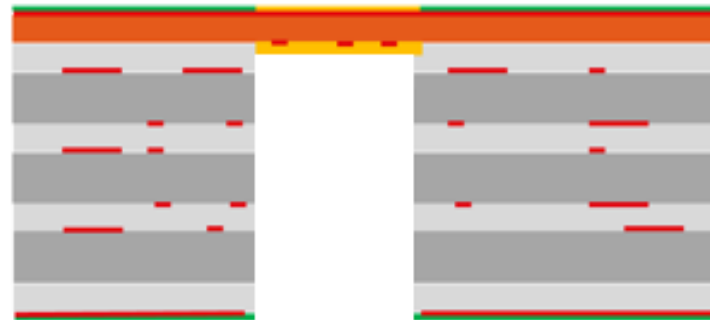


- Multilayer Stack-up with Polyimide
- Z-axis controlled depth milling
- Use of spacer, FR4-cores, Lowflow-Prepreg
- Rigid Material Tg 130-220
- Polyimide adhesiveless
- Coverlay in Flex area
- RA or ED-Copper

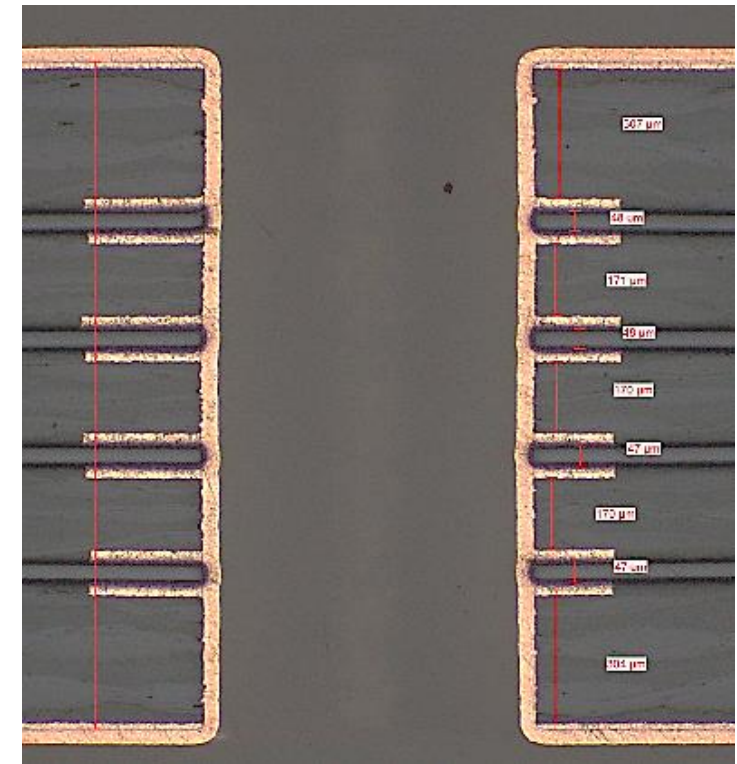
### ▪ Stack-up xRi-2F-xRi



### ▪ Stack-up 2F-xRi



### ▪ Microsection 1Ri-8F-1Ri



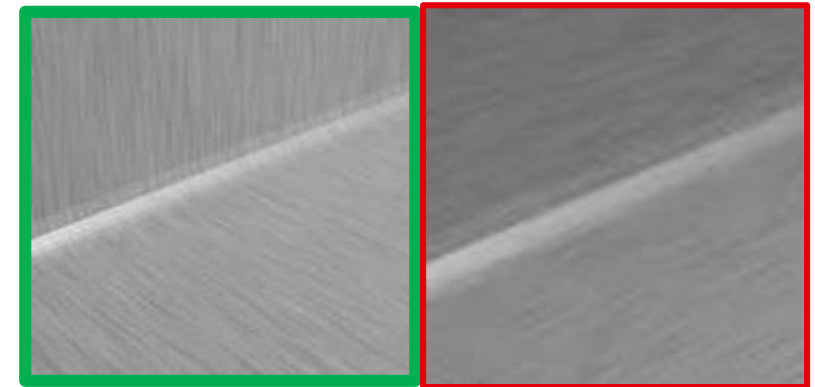
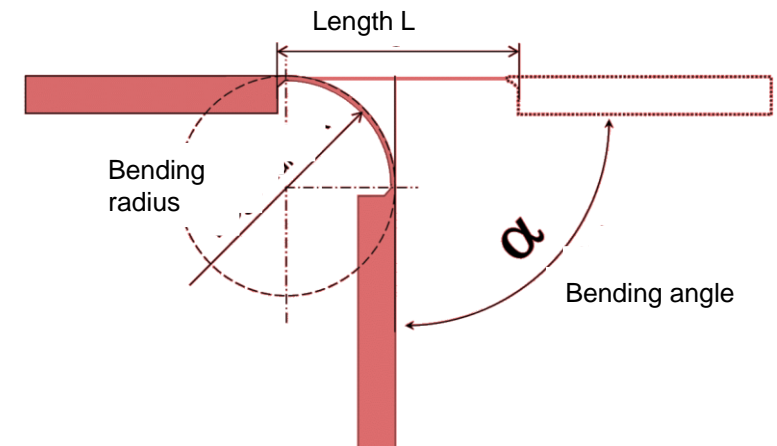
# FLEXIBILITY OR BENDABILITY

## Definitions



Any PCB material is flexible if it is thin enough

- Stiffness describes the resistance of a body to elastic deformation
- Flexibility describes the ability to adapt to changing circumstances. ability to bend or compress easily
- Bendability describes the forming process. Bending stresses act in the forming zone
- Bending radius describes the radius with which the material can be bent without cracking. The material is bent as closely as possible for 180°. The radius is determined on the inside of the material
- Rolling direction describes the stretching of the copper by rolling. A fiber-like material structure is created. The elongation of the fibres is always in the rolling direction



# FLEXIBILITY OR BENDABILITY

## Static Application



- Keep the bending radii as large as possible
- Build up of flexible layers with polyimide or FR4
- The minimum bending radius should be ten times the thickness of the finished flexible printed circuit board.
- Flex PCBs should preferably be able to follow their natural curve in the bend
- For FR4-Semiflex printed circuit boards, the use of a bending support / preforming can be useful
- FR material  $>250\mu\text{m}$  and polyimide with  $>4$  Cu layers in the flex area can be described as more or less stiff

- Guidelines for everyday practice

Cu layer 35u	D app. ( $\mu\text{m}$ )	R (mm)
Flex 1-layer	120	$>1,2$
Flex 2-layer	200	$>2$
Flex 4-layer	300	$>6$
FR4 1-layer	200	$>5$
FR4 2-layer	300	$>8$



# FLEXIBILITY OR BENDABILITY

## Dynamic Application



- Construction of flexible layers only with polyimide/acrylic adhesive
- The neutral axis should be in the middle of the flex layer. Use identical materials on both sides of the tracks
- Use of RA copper and orientation of the rolling direction parallel to the bending direction
- No plated-through holes in the bending area (plated copper)

### DuPont™ Pyralux® AP

All-Polyimide Double-Sided Copper-Clad Laminate  
Flexible Circuit Materials

Property	AP9121 Typical Value	Test Method
Flexural Endurance, cycles	6,000	IPC-TM-650 2.4.3

- Guidelines for everyday practice

Cu layer 35u	D app. (µm)	R (mm)
Flex 1-layer	120	>12
Flex 2-layer	200	>30
Flex 4-layer	Not recommended	

- Conductor tracks in two-sided printed circuit boards shall not be arranged directly on top of each other

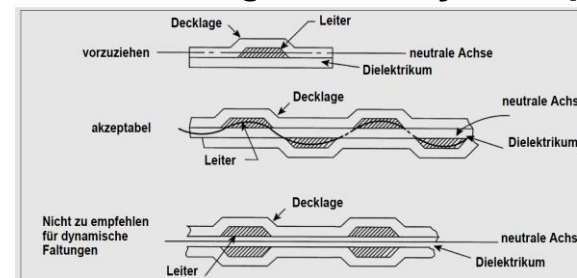


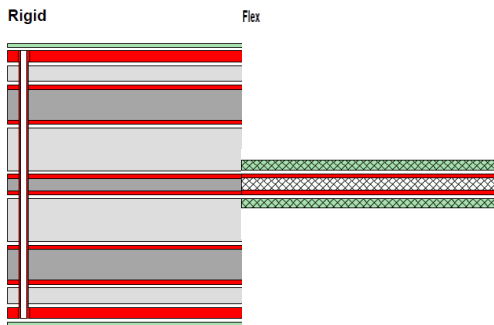
Bild 5-8 Neutrale Zonen bei Biege-/ Faltbereichen

Quelle: IPC-2223

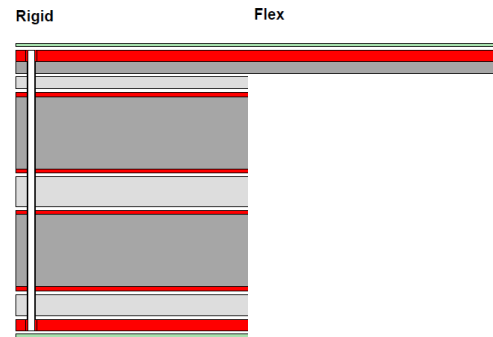
# DIGITAL STACKUPS



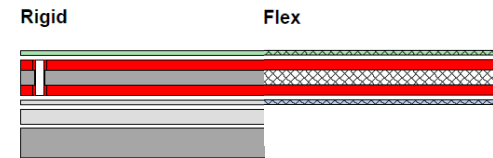
- Flex-Rigid, Flex inner layer



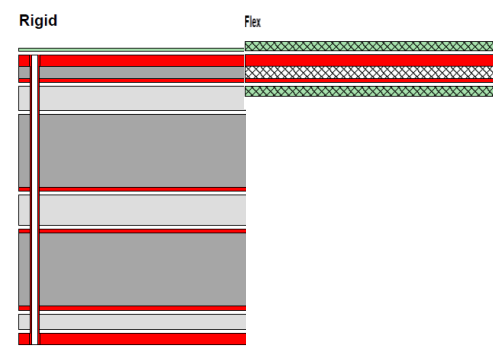
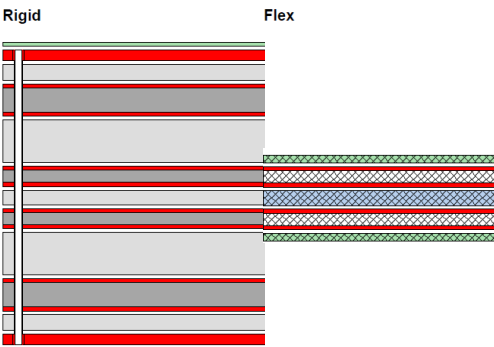
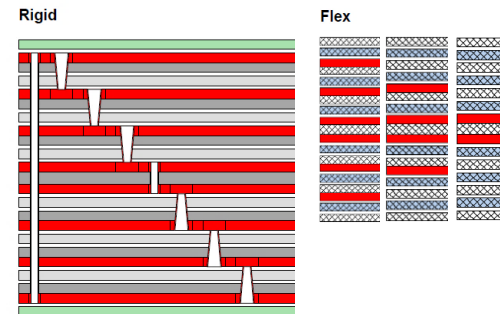
- Flex-Rigid, Flex outer layer



- Flex with Stiffener



- SLIM.flex



## EDA Tools:

- Cadence OrCAD / Allegro
- Altium AD20
- IPC-2581
- further tools in progress

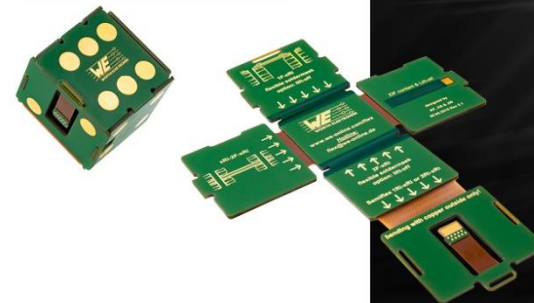
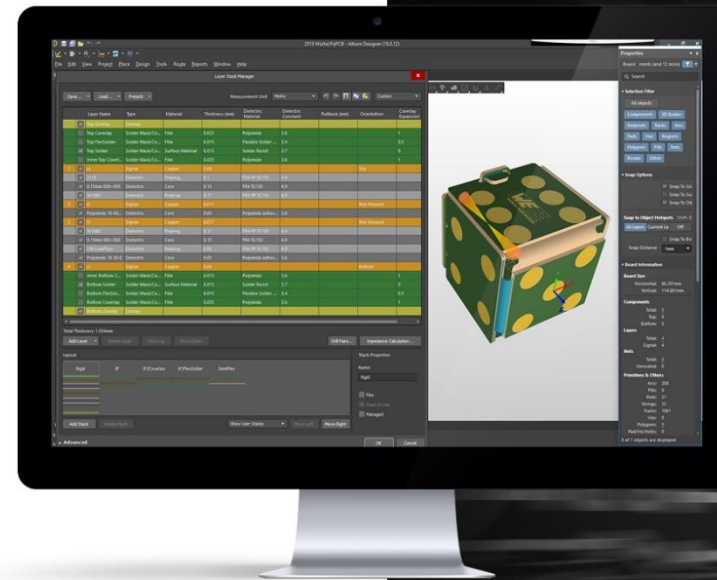
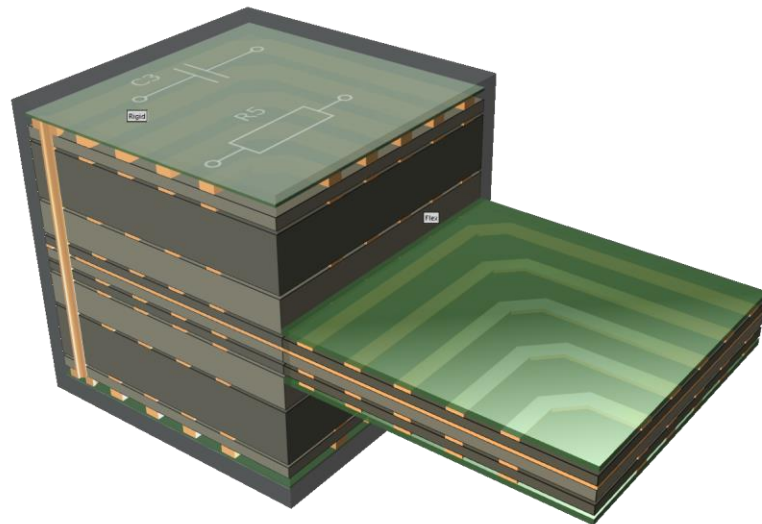
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# DIGITAL STANDARD STACKUPS

Start your layout faster



- Avoiding errors
- Increase productivity
- Designing reliability
- Achieving safety



# PROJECT BASED OPTIMISATION

## Key factors

- Material in bending area  
Polyimide from 25-125 $\mu\text{m}$ , >10 different coverlay types
- LP thickness in the bending range >130 $\mu\text{m}$
- Copper type (ED / RA...maschine direction of rolling process)
- Design - conductor routing, grid/hatching
- Array design
- Processing guidelines

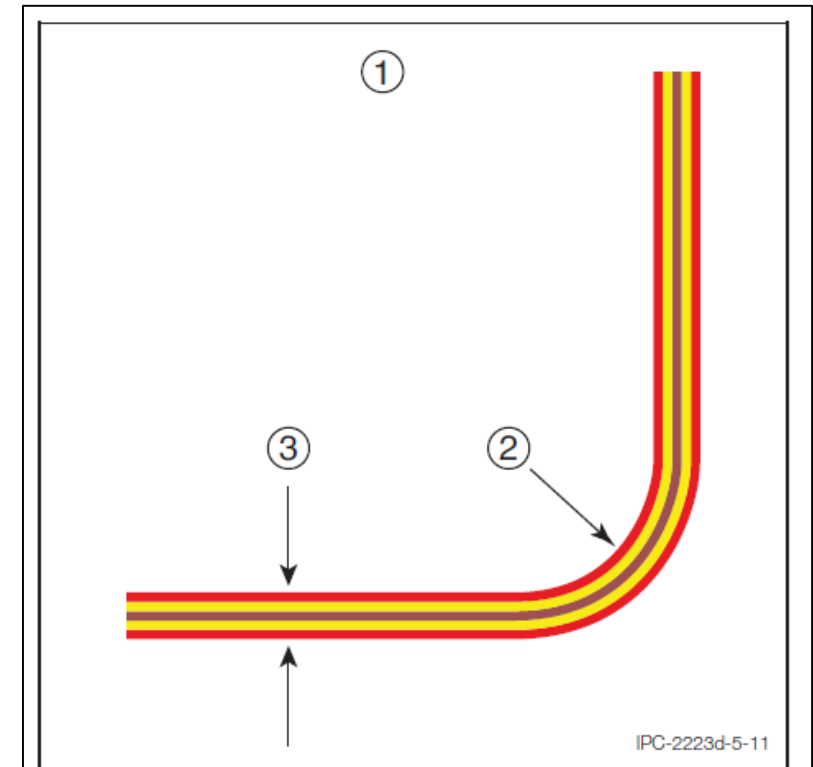


Figure 5-11 Definition of Bend Ratio

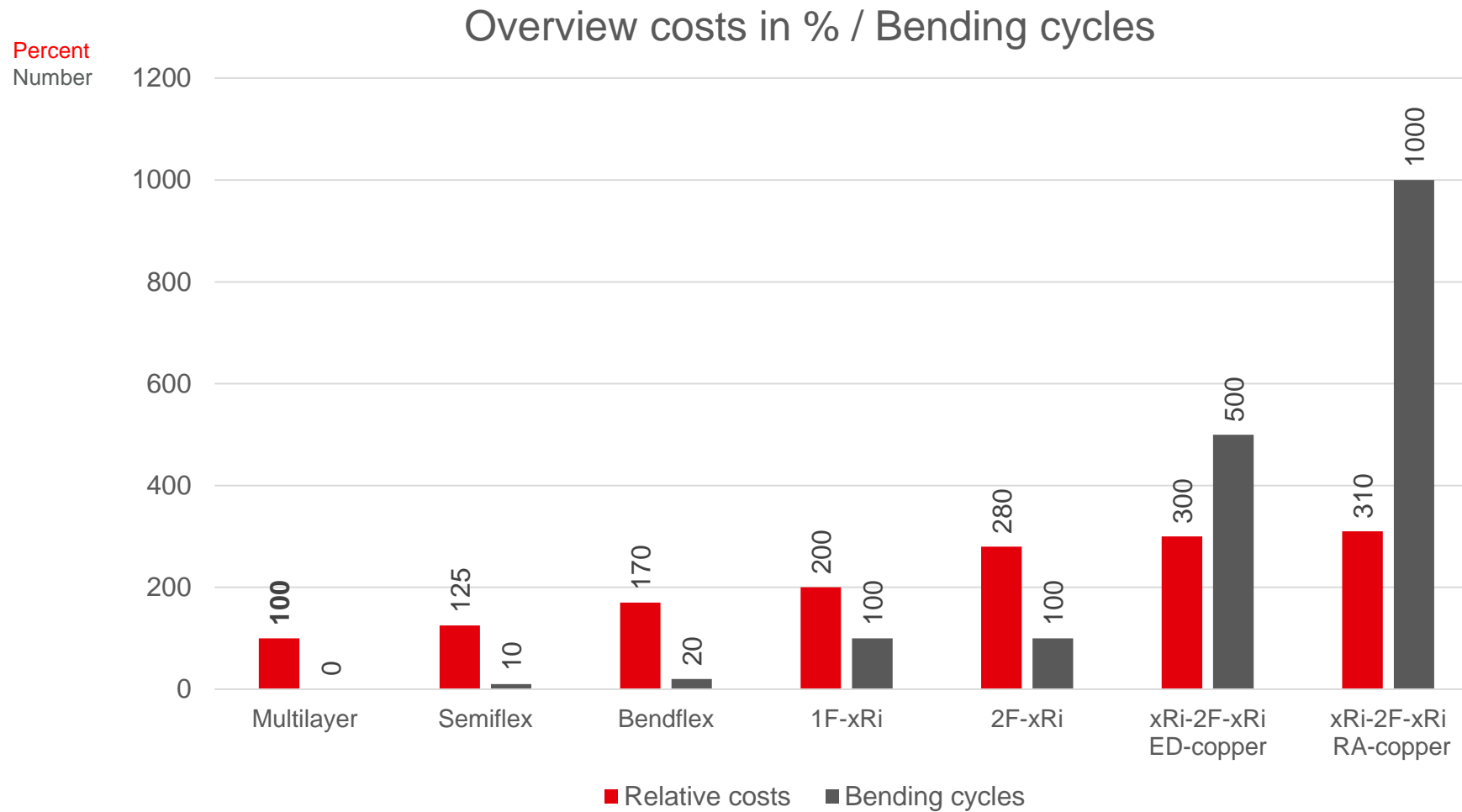
Note 1: Bend ratio = Bend radius / Circuit Thickness.

Note 2: Bend radius.

Note 3: Circuit thickness.

# FLEXIBILITY AND COSTS

An estimation





**THANK YOU FOR YOUR ATTENTION!**

**What kind of  
application  
do you have?**

**HOW can WE  
support you?**

**Contact:  
[flex@we-online.com](mailto:flex@we-online.com)**