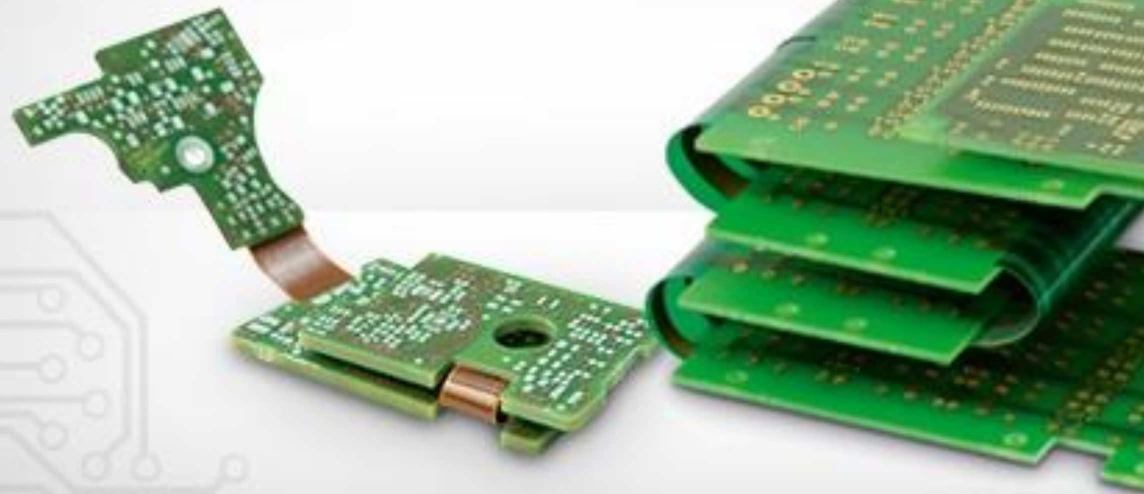
WÜRTH ELEKTRONIK

MINIATURISATION TO THE POWER OF TWO – PART II

Combine the advantages of RIGID.flex and HDI on your printed circuit board!



Niedernhall

13.07.2021

AGENDA

1 Summary part 1

2 Stack-up options: How can HDI and Rigidflex be combined?

3 What are the possibilities for optimisation?

4 How can the costs be reduced?

5 Summary

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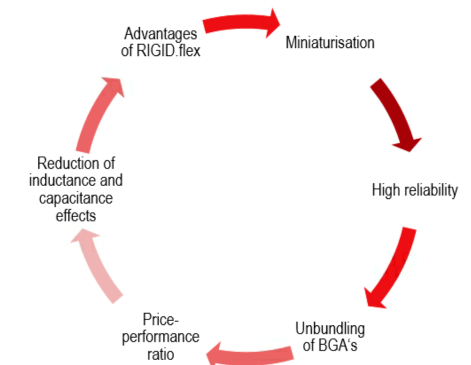
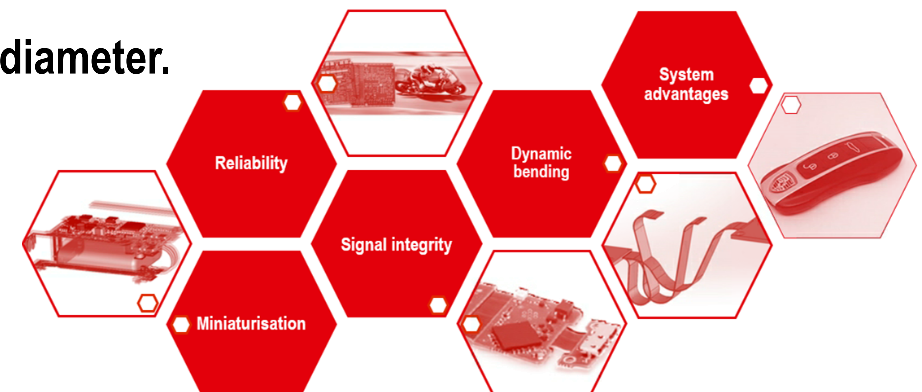
Technisches Projektmanagement

SUMMARY

Part 1

- **The combination of HDI and rigid-flex makes optimal use of the advantages of both technologies.**
- **The technology HDI uses Micro and Buried Vias to**
  - Gain space in the layout or
  - Reduce the size of the overall system.
- **The technology Rigidflex creates additional space in the system by**
  - The elimination of connectors, connector footprints and Cable harnesses or
  - The three-dimensional use of the housing space.
- **The Aspect Ratio plays an important role in the selection of the via pad diameter.**
- **The different Filling types require the observance of the applicable design rules in the Layout.**
  - Min. distances copper to copper





HDI-RIGID.FLEX

Stack-up variants

RIGID.**flex 1F-xRi**

- **Standard stack-up: 1 x MV**
- **Special stack-up: BV & MV completely**
- **Thin total thickness possible**
  - Min. 0.50mm +/-0.05mm
- **MV-Pad-Ø: min. 350µm**
- **BV-Pad-Ø: min. 450µm**

Legend:
MV: Micro Via **PTH**: Plated Through Hole
BV: Buried Via

Rigidflex 1F-5Ri + HDI 2 - 2(4b) - 2

PCB Thickness : 1,03 mm +/- 10% Flex Thickness: 0,13 mm +/-0,05mm

Flex area Thickness	Rigid area Thickness	Material description		Flex area Structure	Viatypes
40					
	15				
40	40	* Incl. Plating	Top-Layer		
50	50	Polyimide			
	45	FR4 TG 150° HF			
	30				
	65	FR4 TG 150° HF			
	17				
	510	FR4 TG 150° HF			
	17				
	65	FR4 TG 150° HF			
	30				
	90	FR4 TG 150° HF			
	40	* Incl. Plating	Bottom-Layer		
	15				

1 2

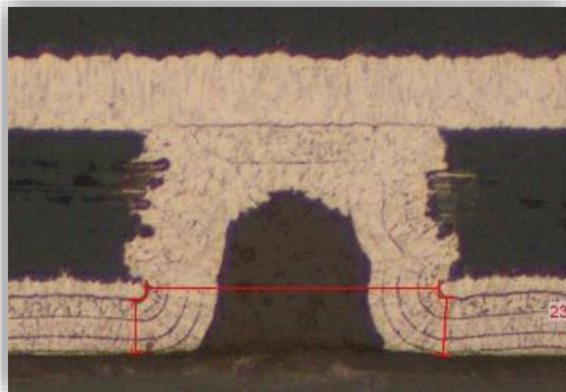
HDI-RIGID.FLEX

Stack-up variants

RIGID.**flex 1F-xRi**

Design tip:

- **Thinner prepreg on bottom side**
  - MV-Pad-Ø: min. 250µm



e.g. 1 x 1080

Rigidflex 1F-5Ri + HDI 2 - 2(4b) - 2

PCB Thickness : 1,03 mm +/- 10% **Flex Thickness:** 0,13 mm +/-0,05mm

Flex area Thickness	Rigid area Thickness	Material description	Flex area Structure	Viatypes
40				
	15			
40	40	* Incl. Plating	Top-Layer	
50	50	Polyimide		
	45	FR4 TG 150° HF		
	30			
	65	FR4 TG 150° HF		
	17			
	510	FR4 TG 150° HF		
	17			
	65	FR4 TG 150° HF		
	30			
	60	FR4 TG 150° HF		
	40	* Incl. Plating	Bottom-Layer	
	15			

HDI-RIGID.FLEX

Stack-up variants

RIGID.**flex 2F-xRi**

- **Standard stack-ups: 1 x MV**
- **No additional MV and BV possible**
- **MV-Pad-Ø: min. 300µm**

No connection between L2 and L5 possible!

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

PCB Thickness : 1,01 mm +/- 10% **Flex Thickness:** 0,19 mm +/-0,05mm

Flex area Thickness	Rigid area Thickness	Material description		Flex area Structure	Viatypes
40					
	15				
40	40	incl. plating	Top-Layer		
50	50	Polyimide adhesiveless			
17	17				
40		Coverlay			
	90	FR4 TG150 HF			
	250	FR4 TG150 HF			
	17				
	125	FR4 TG150 HF			
	17				
	250	FR4 TG150 HF			
	17				
	65	FR4 TG150 HF			
	40	incl. plating	Bottom-Layer		
	15				

HDI-RIGID.FLEX

Stack-up variants

RIGID.**flex 2F-xRi**

- **Design tip:**
  - ➢ Special stack-up 1F+1F-xRi
  - ➢ Top side MV-Pad-Ø: min. 350µm
  - ➢ Bottom side MV-Pad-Ø: min. 250µm
  - ➢ BV-Pad-Ø: min. 450µm

Rigidflex 1F+1F-4Ri + HDI 2-2(4b)-2

10% Flex Thickness: 0,26 mm +/-0,05mm

Flex area Structure

Viatypes

50	FR4 TG 150° HF
17	
510	FR4 TG 150° HF
17	
65	FR4 TG 150° HF
17	
65	FR4 TG 150° HF
40	* Incl. Plating
15	

Bottom-Layer

HDI-RIGID.FLEX

Stack-up variants

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

- **MV possible from six layers (2Ri-2F-2Ri)**
- **MV through nearly all layers**
- **BV through flex plus adjacent rigid layers**
- **Thin total thickness possible**
- **MV-Pad-Ø: min. 250µm**
- **BV-Pad-Ø: min. 450µm**

Caution:

MV between flex layers and adjacent layers not possible!

Rigidflex 3Ri-2F-3Ri + HDI 2-4b-2

PCB Thickness : 1,59 mm +/- 10% **Flex Thickness:** 0,16 mm +/- 0,05mm

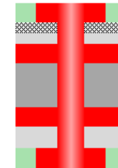
Flex area Thickness	Rigid area Thickness	Material description		Flex area Structure	Viatypes
	15				
	40		Top-Layer		
	60	FR4 Tg150 HF			
	30				
	60	FR4 Tg150 HF			
	30				
	70	FR4 Tg150 HF			
	250	FR4 Tg150 HF			
	200	FR4 Tg150 HF			
40		Coverlay			
17	17				
50	50	Polyimide			
17	17				
40	200	Coverlay			
		FR4 Tg150 HF			
	250	FR4 Tg150 HF			
	70	FR4 Tg150 HF			
	30				
	60	FR4 Tg150 HF			
	30				
	60	FR4 Tg150 HF			
	40		Bottom-Layer		
	15				

X

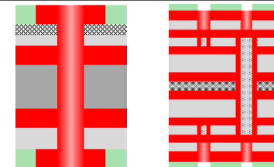
SURVEY

- **Which via types do you use to unbundle BGAs?**

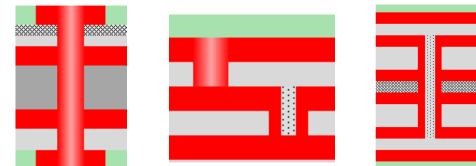
- Only PTH



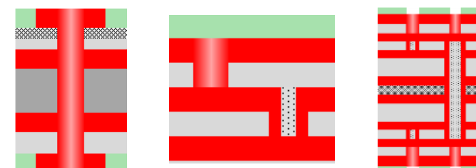
- PTH in combination with stacked MV und BV



- PTH in combination with staggered MV and BV



- PTH, MV and BV both stacked and staggered

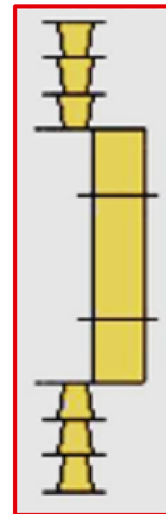


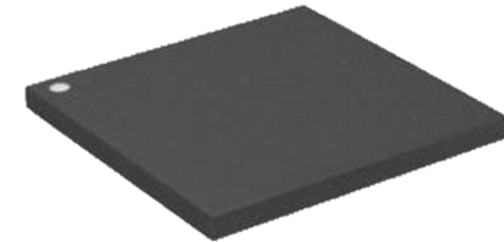
HDI-RIGID.FLEX: STRONG COMBINATIONS WITH HDI

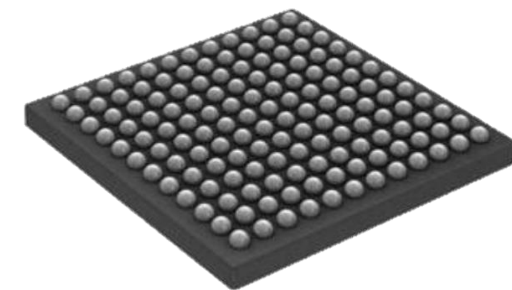
Reference design UFBGA 7X7X0.6 169L P 0,5mm

Initial situation and challenge:

- **Customer request: µBGA full array, 13x13 on a highly complex Rigidflex PCB**
- **Stack-up idea: 4Ri-2F-4Ri + HDI 3+4b+3**
  - Idea customer: stacked Microvias
  - Buried Via shifted to Microvias
  - Objection WE: requires 2x copper filling:
Limits the layout spacing on L2/L3 and L8/L9
- **Design parameter customer:**
  - Microvia Pad 275µm
  - Microvia-in-µBGA-Pad on top layer
  - Width / space: 75µm / 75µm
  - Impedance control not necessary



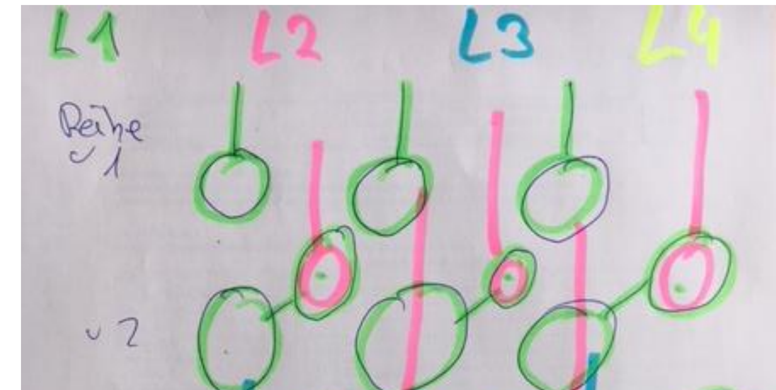


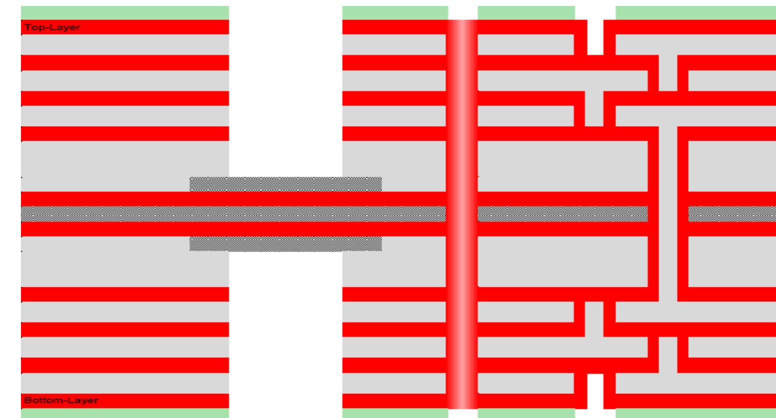


HDI-RIGID.FLEX: STRONG COMBINATIONS WITH HDI

Reference design UFBGA 7X7X0.6 169L P 0,5mm

- **Solution approach WE CBT Technichal project management:**
- **Stack-up HDI-RIGID.flex 4Ri-2F-4Ri + HDI 3+4b+3**
  - Staggered instead of stacked Microvias
  - No copper filling of Microvias necessary:
    Finer layout spacing becomes possible
  - Buried Via shifted to Microvias
- **Special design rules only in the µBGA-area**
  - Microvia Pad smaller: 250µm
  - µBGA-Pad smaller: 240µm
  - Solder mask clearances 50µm
  - Microvia-in-pad
  - Width / space: 70µm / 90µm (Layers with plating!)





HDI-RIGID.FLEX: STRONG COMBINATIONS WITH HDI

Reference design UFBGA 7X7X0.6 169L P 0,5mm

TOP
Layer 2
Layer 3
Layer 4

HDI-RIGID.FLEX: STRONG COMBINATIONS WITH HDI

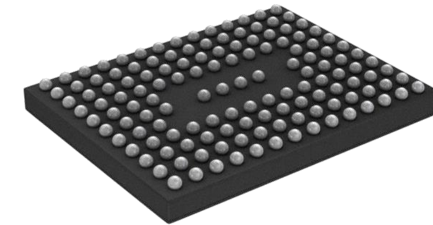
Reference design UFBGA 7X7X0.6 169L P 0,5mm

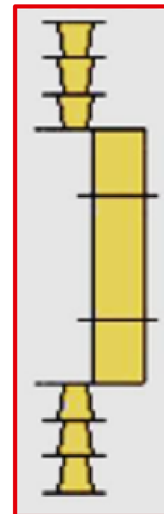
HDI-RIGID.FLEX: STRONG COMBINATIONS WITH HDI

Reference design W-CSP138 5.9X4.6 P 0,4mm

Initial situation and challenge:

- **Customer request: W-CSP, no Full Array 138 pins on a highly complex Rigidflex PCB**
- **Stack-up idea: 4Ri-2F-4Ri + HDI 3+4b+3**
  - Idea customer: stacked Microvias
  - Buried Via shifted to Microvias
  - Requires 2x copper filling:
    limits the layout spacing on L2/L3 and L8/L9
- **Design parameter customer:**
  - Microvia Pad 275µm
  - Microvia-in-µBGA-Pad on top layer
  - Width / Space: 75µm / 75µm
  - Impedance control not necessary





HDI-RIGID.FLEX: STRONG COMBINATIONS WITH HDI

Reference design W-CSP138 5.9X4.6 P 0,4mm

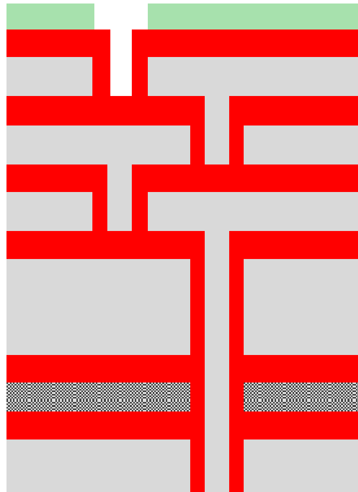
TOP

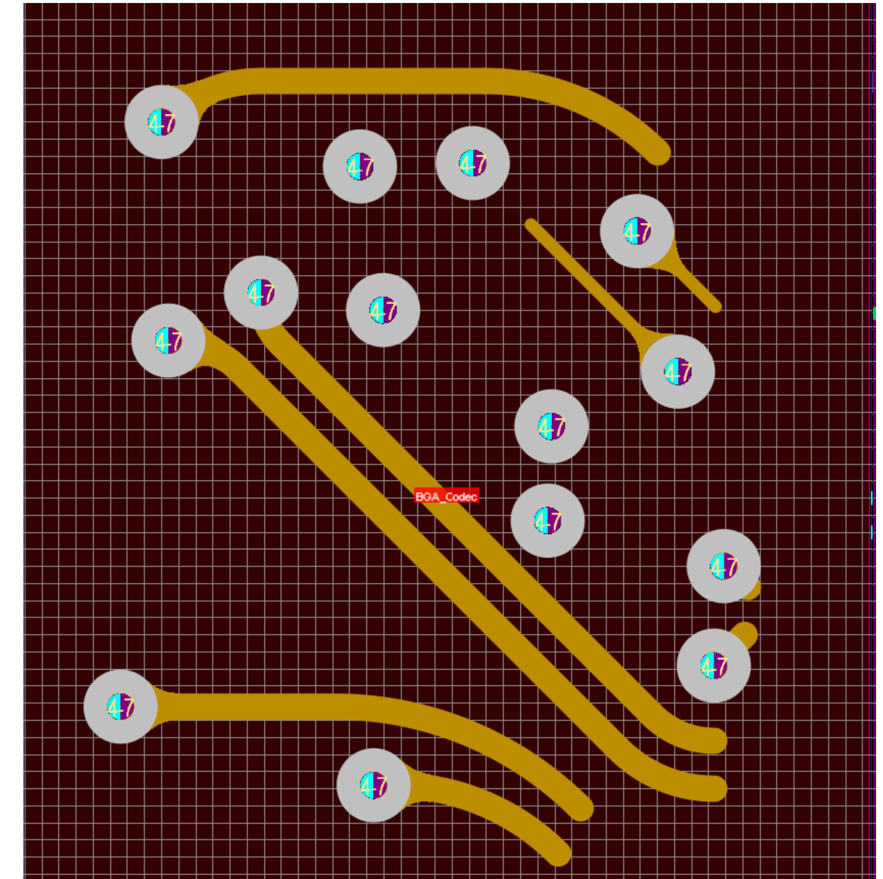
Layer 2

Layer 3

Layer 4

Layer 5





HDI-RIGID.FLEX: STRONG COMBINATIONS WITH HDI

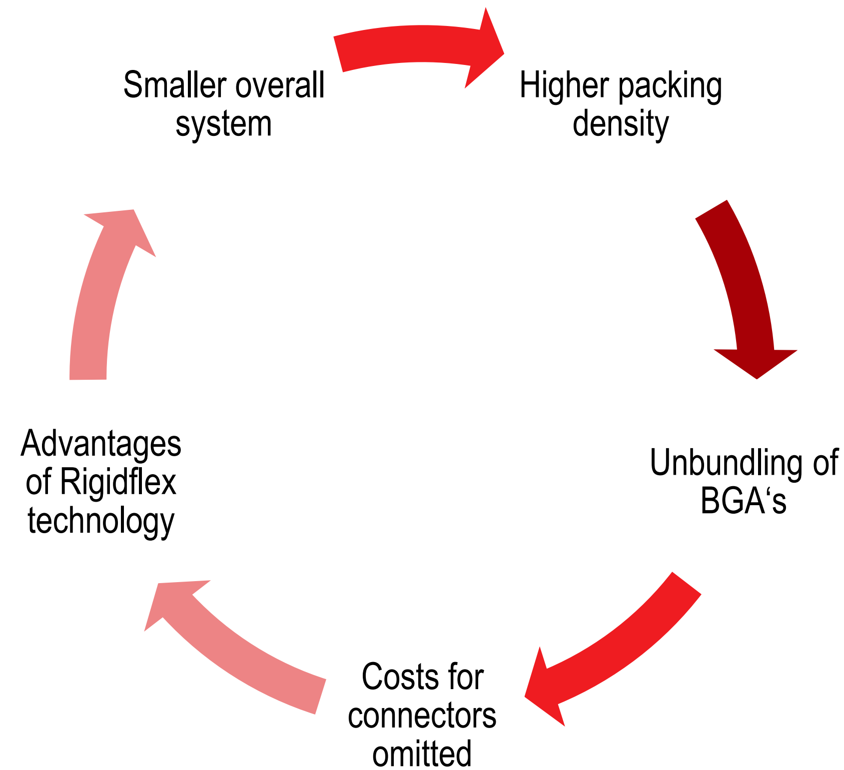
Reference design W-CSP138 5.9X4.6 P 0,4mm

SURVEY

- **For what reasons have you refrained from combining Starrflex with HDI so far?**
  - Costs
  - Complexity – no experienve
  - HDI was not necessary
  - Other

COST CONSIDERATION

Comparison



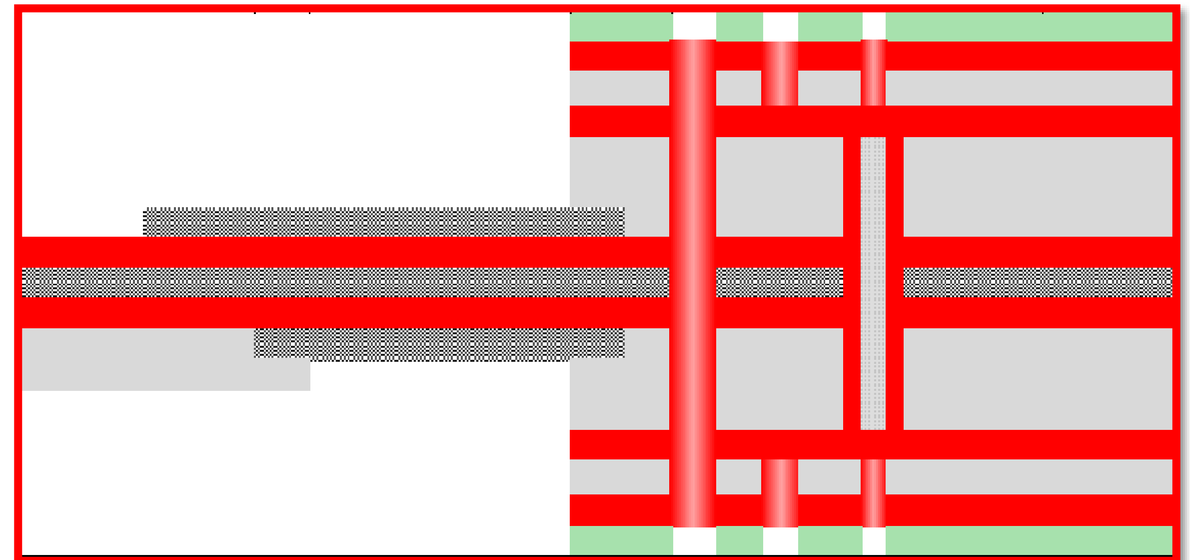
COST CONSIDERATION

Application example

Customer requirement

- Rigidflex with six Layers, of which two flex
- Connection between L1 and L3
- Total thickness: 0.60mm
- ZIF-connector

➢ **Re-Design necessary! Unfavourable are:**
  - ➢ Flex layers on inner layers
  - ➢ Stacked MV and BV
  - ➢ ZIF on inner layers
  - ➢ Total thickness 0.90mm

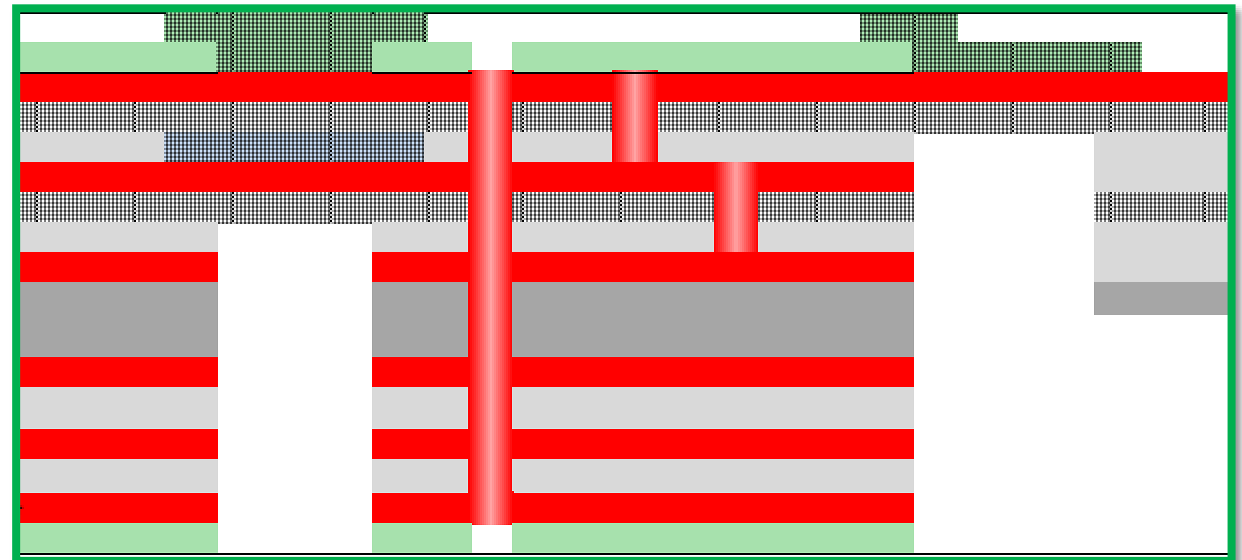


COST CONSIDERATION

Application example

Solution approach WE CBT technical project management:

1. **Stack-up:**
   - 1F+1F-4Ri + HDI 2-2-2
   - Connection by MV and PTH
2. **MV staggered**
   - No copper filling necessary
   - Fine spacing possible
   - Reduce PTH
3. **ZIF-contacts on layer 1**



COST CONSIDERATION

RIGID.flex and HDI: Via typs

Single pressing

Double pressing

Triple pressing

200 %

100 %

Costs

1 - 6 - 1

1

2 - 4 - 2

1 2

Staggered Microvias

2 - 4 - 2

1 2

Stacked Microvias

1 - 6b - 1

1 2

Mech. drilled Buried Vias and Microvias (staggered)

2 - 4(6b) - 2

1 2

Staggered Microvias and mech. Buried Vias

2 - 4(6b) - 2

1 2

Mech. drilled Buried Vias and Microvias (stacked)

2 - 4b - 2

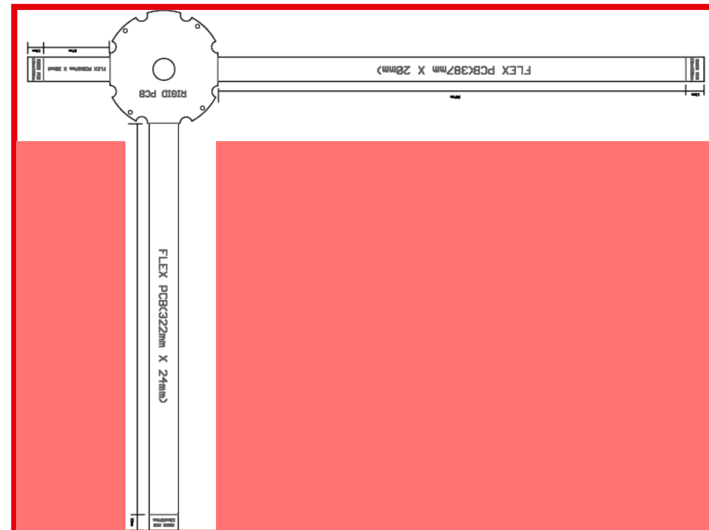
1 2 3

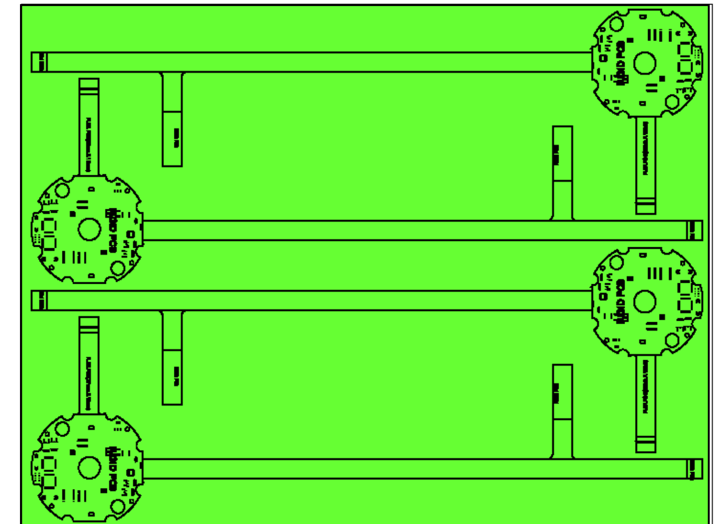
Staggered Microvias and mech. Buried Vias

Complexity

COST CONSIDERATION
Application example

4. Delivery panel
- Possibility for folding
- Optimisation of required area
- Nested orientation





SUMMARY

- **The combination of HDI and RIGID.flex opens up numerous possibilities for connections between the copper layers.**
- **Seemingly impossible connections can be realised with the appropriate design tips.**
- **Complex layouts can be simplified by the right choice of via types. This saves unnecessary filling processes and allows for smaller layout structures if necessary.**
- **Costs can be optimised by choosing the right layout, via types and panel design.**

THANK YOU FOR YOUR ATTENTION