Flex-rigid: Base materials and their characteristics

Webinar February, 7th 2017
Speaker: Andreas Schilpp
Introduction: Integration of Module Interconnects Benefits through Flex-Rigid Technology

- Reliability
- Signal integrity
- Miniaturisation
- Dynamic bending
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
- 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

- 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
  - Polyimide flex area
  - Depth milled contact areas for ZIF/FPC connectors

- Bottom
  - B2B connector with semiflex area
  - Laser cut
  - ZIF/FPC contact with flex arm
  - Solder contacts due to edge plating

- **samples you will get [here](#)**!
Ingredients for a Flex-Rigid PCB

**Flex-rigid xRi-2F-xRi**

Top

- Signal layer
- ZIF/FPC contact with vias on outer layer

Bottom

- Ground/reference layer with Copper removal
- Key and slot construction

samples you will get [here](#)!

- flexible foil Polyimide, copper 2 sides
- rigid FR4, FR4 prepreg
- copper resp. ENIG surface
- Polyimide coverlay
- standard soldermask
Ingredients for a Flex-Rigid PCB

**Flex-rigid 2F-xRi**

- Top
  - Signal layer
  - B2B connector

- 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
- 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

(see IPC-42xy)
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
  - Acrylic 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
  - warp and weft direction
  - spread glass constructions
  - specification: IPC-4412
Ingredients for a Flex-Rigid PCB
Copper foils

- Thickness derived from surface weight oz/ft²
  - 1 oz/ft² = 305g/m² = 35µm Dickie

- Copper quality acc. IPC-4562
  - electro plated (ED)
  - rolled copper RA-Quality
  - new: rolled copper HA-Quality

- rough treatment side facing the base material
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

Source: Isola
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
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 \( \geq 150^\circ\text{C} \), halogen free, filled- standard thicknesses
  - flex: Polyimide Tg >> 200\(^\circ\text{C}\), adhesiveless– typical 25µm / 50µm thick(...up to 150µm)
  - standard solder mask, flexible solder mask, Polyimide overlay

- **Stack-up plans**
  - example:
    - \( \mu \text{Via capable} \)
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
Material characteristics and their effect on applications

- **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

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

### Table: Copper Treatment Characteristics

<table>
<thead>
<tr>
<th>Dicke (µm)</th>
<th>Treatmentseite (R_s) HTE (µm)</th>
<th>Treatmentseite (R_s) VLP (µm)</th>
<th>Shiny-Seite (R_s) HTE und VLP (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>6,5 - 8,5</td>
<td>3,5 - 4,5</td>
<td>0,2 - 0,35</td>
</tr>
<tr>
<td>35</td>
<td>7,0 - 9,0</td>
<td>3,5 - 5,0</td>
<td>0,2 - 0,35</td>
</tr>
<tr>
<td>70</td>
<td>8,0 - 10,5</td>
<td>3,5 - 5,0</td>
<td>0,2 - 0,35</td>
</tr>
</tbody>
</table>

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