PLUGGING – FILLING – TENTING

Andreas Dreher
technical Projectmanagement

WURTH ELEKTRONIK MORE THAN YOU EXPECT
TOPIC

Plugging – Filling – Tenting

1. Background for Via Opening in Solder Mask
2. Different Options for protection of Via Structures
3. Description of different options according IPC-4761
4. The correct choice for your PCB
Andreas Dreher

Technical Project Management

- HDI-Design
- Signal Integrität & High Speed

Since 2003 at Würth Elektronik CBT

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VIA OPENING IN SOLDER MASK

Background

- Prevention of solder from passing through the via
- Creating a defined State of the Via
- Reliable and producable PCB
VIA OPENING IN SOLDER MASK

Options

**No Clearance**

**With Center Clearance**

Final Diameter +0.25 mm

**Via Land without Solder Mask**

Recomendation

Weitere Details in den [Basic Design Rules](#)
**VIA OPENING IN SOLDER MASK**

Options

- **No Clearance**
  - Undefinierter Zustand

- **With Center Clearance**
  - Final Diameter +0,25 mm
  - Empfehlung

- **Via Land without Solder Mask**
  - Als Testpunkt nutzbar
SOLDER MASK

Design Rules

More Details in the Basic Design Rules
DIFFERENT OPTIONS FOR PROTECTION OF VIA STRUCTURES

- Prevention of solder from passing through the via
- Creating a defined State of the Via
- Reliable and producable PCB
- Coating or Vacuum-Testing?
- Via-in-Pad Design?
- HDI-Designs?
SPECIFIKATION ACCORDING IPC-4761

Design Guide for Protection of Printed Board Via Structures

Typ I
Tented Via

Typ II
Tented & Covered Via

Typ III
Plugged Via

Typ IV
Plugged & Covered Via

Typ V
Filled Via

Typ VI
Filled & Covered Via

Typ VII
Filled & Capped Via

Typ I-a or Typ I-b describe the usage of single sided or double sided technology.
**TYP III PLUGGED VIA**

A Via with material applied allowing partial penetration into the via

**Process**
- silc screen printing

**Material**
- therm. curing ink

**Benefit**
- Vacuum seal for e.g. ICT
- cheap
- Locally selectiv plugging possible

**Concern**
- Bumps up to 70 µm
- Via-in-Pad technology not possible
- Limited in fine line Designs
**TYP III PLUGGED VIA**

**Design Rules**

- The Distance to the next solder pad has to be at least 0,15mm on top and bottom
- Bumps up to 70 µm over solder mask possible
- For German factory’s: double sided plugging is not possible

<table>
<thead>
<tr>
<th>Final Diameter</th>
<th>Size of Plugged Via Mask</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 0,30 mm</td>
<td>0,40 mm</td>
</tr>
<tr>
<td>≤ 0,40 mm</td>
<td>0,50 mm</td>
</tr>
<tr>
<td>0,45 – 0,70 mm</td>
<td>Ø + 0,20 mm</td>
</tr>
<tr>
<td>bis 0,80 mm</td>
<td>Ø + 0,30 mm</td>
</tr>
</tbody>
</table>
TYP III-A PLUGGED VIA - PROCESS

Screen Printing

Curing

Plugged Via
DISTANCE TO SMALL TO SOLDER PAD

- Risk of Ink contamination to the solder pads
- Discoloration of solder pads possible
SPECIFIKATION ACCORDING IPC-4761

Typ I  
Tented Via

Typ II  
Tented & Covered Via

Typ III  
Plugged Via

Typ IV  
Plugged & Covered Via

Typ V  
Filled Via

Typ VI  
Filled & Covered Via

Typ VII  
Filled & Capped Via

Typ I-a or Typ I-b describe the usage of single sided or double sided technology
TYP V FILLED VIA

A via with material applied into the via targeting a full penetration and encapsulation of the hole

Process
Vacuum Filling & sanding

Material
filled nonconductive therm. Curing Epoxyd Resin

Benefit
- Vacuum seal
- Homogenous flat surface through sanding process
- Often used on Inner layers to fill buried via

Concern
- With the filling process all through holes are filled
- Expensive
TYP VI-A FILLED VIA

A via with material applied into the via targeting a full penetration and encapsulation of the hole with solder mask

Process
- Vacuum Filling & sanding & solder mask

Material
- filled nonconductiv therm. Curing Epoxyd Resin

Benefit
- Vacuum seal
- Homogenios flat surface through sanding process
- Often used on Inner layers to fill buried via

Concern
- With the filling process all through holes are filled
- Expensive
FILLED VIA FERTIGUNGSPROZESS

Drilling
Metallization
Vakuüm Filling
Curing
Sanding
Cap metalization

Typ V Filled Via
Typ VII Filled Via
FILLED VIA – MATERIAL COMBINATION

- To avoid a CTE mismatch the resin has to match to the FR-4 Material
- We recommend using filled FR-4 Materials with a $\text{TG} \geq 150^\circ \text{C}$ to achieve highest performance
Surface and Hole Copper Plating Minimum Requirements for Buried Vias > 2 Layers, Through-Holes, and Blind Vias

<table>
<thead>
<tr>
<th>Class 2</th>
<th>Class 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper – average</td>
<td>20 µm [787 µin]</td>
</tr>
<tr>
<td>Thin areas</td>
<td>18 µm [709 µin]</td>
</tr>
<tr>
<td>Wrap</td>
<td>5 µm [197 µin]</td>
</tr>
</tbody>
</table>
Typ I - Tented Via

Typ II - Tented & Covered Via

Typ III - Plugged Via

Typ IV - Plugged & Covered Via

Typ V - Filled Via

Typ VI - Filled & Covered Via

Typ VII - Filled & Capped Via

Typ I-a or Typ I-b describe the usage of single sided or double sided technology.
**TYP VII FILLED & CAPPED VIA**

- A Type V via with a secondary metallized coating covering the via

**Process**
- Vacuum Filling & sanding & cap plating

**Material**
- filled nonconductive therm. Curing Epoxyd Resin

**Benefit**
- Vacuum seal
- Homogenios flat surface through sanding process
- Via-in-Pad compatible

**Concern**
- With the filling process all through holes are filled
- Even more expensive through additional plating
- Reduction of fine line technology possible
TYP VII FILLED & CAPPED VIA

Design Rules

- 0,65 mm - 1,60 mm Board thickness
  - Aspect Ratio 1:10
  - Smallest drill tool Ø 0,25 mm (final Ø 0,15 mm)
  - Pad 500 µm
  - Max final Ø 0,65 mm
  - Layout Clearance >120 µm

- 1,60 mm - 3,20 mm thickness
  - Aspect Ratio 1:8
  - Max final Ø 0,8 mm
  - Layout Clearance >120 µm

Please contact us early in your Design Phase to find optimal Parameters for your needs

Contact via your local WE partner or HDI@we-online.de
FILLED VIA – TECHNOLOGY COMBINATION

design restrictions with fine line technology

Through the need of several metallization processes the copper thickness on the surface will increase

Therefore compromises in combination with fine line Technologies are necessary

<table>
<thead>
<tr>
<th>Copper Thickness</th>
<th>Line</th>
<th>Space</th>
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</thead>
<tbody>
<tr>
<td>~ 30 µm</td>
<td>75 µm</td>
<td>100 µm</td>
</tr>
<tr>
<td>~ 40 µm</td>
<td>100 µm</td>
<td>120 µm</td>
</tr>
<tr>
<td>~ 50 µm</td>
<td>120 µm</td>
<td>180 µm</td>
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</tbody>
</table>
WEITERE ANWENDUNGEN

Micro Via Filling

Material: filled Epoxy Resin or Copper

Benefit:
- Via-in-Pad compatibel
- small Footprint
- Staggered or Stacked is possible

Concern:
- With the filling process all through holes are filled
- Copper-Filling has limited compatibility with Through Hole Via
- Expensive
STACKED MIKROVIA ON TOP OF BURIED VIA

Recomendation by IPC & ZVEI-Arbeitskreis Qualität & from Würth Elektronik:

Also existing Layouts with these technology should by chance

We will assist you!
EXAMPLE & PRATICAL USE

Thermo Vias & Via-in-Pad

Aluminium Heatsink
EXAMPLE & PRACTICAL USE

HDI – Anwendung

Stacked Mikro Via with Copper Filling

125 µm Line

Via Typ V
Impedanz Trace

Via Typ VII
Through Hole

Please contact us early in your Design Phase to find optimal Stack Up for your needs! Contact: HDI@we-online.de
## SUMMARY

<table>
<thead>
<tr>
<th>VIA-TYP</th>
<th>Vacuum Seal</th>
<th>Flat Surface</th>
<th>Possible on inner layer</th>
<th>Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearance in Solder Mask</td>
<td>X</td>
<td>✓</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Typ III a Plugged Via</td>
<td>✓</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Typ V Filled Via</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Typ VII Filled &amp; Ccapped Via</td>
<td>✓</td>
<td>✓</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Micro Via Copper Filling</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
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</tbody>
</table>
THANK YOU FOR YOUR ATTENTION!