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LaserJob

BRNO SMT – info 10/11

Improved Printing Results with PatchWork® Stencils (Step Stencils) and NanoWork Stencils (Nanocoated Stencils)

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2. **PatchWork® Stencil**
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   - Production Steps
   - Example from Practice
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   - Design rules

LaserJob GmbH

Established: 1 April 1992

By: Georg Kleemann and Robert Englmaier

Production area :2100m²

Number of employees: 30

Lasersystems: 6+2

Our Qualtity:

- LaserJob own developed Laser Cutting Systems with innovative Fiberlasertechnology
- Stencil with highest and most reproducable precision
- cutting only when the foil is fixed in a frame or in a tensioning system
  - no distortion of the layout
  - high precision of the layout in the stencil +/- 0,1mm
- Outstanding paste release
- Production of stencils in airconditioned Rooms 22° C +/- 0,5° C
- Inhouse lasersystem maintenance
- cold rolled high precision foils thickness tolerance +/-3µm
- No electropolishing for burr removal (no padsize enlargement)
  - only brushing of stencil

  → Reduction of foilsize max: 1-2 µm

  → Padsize is not effected

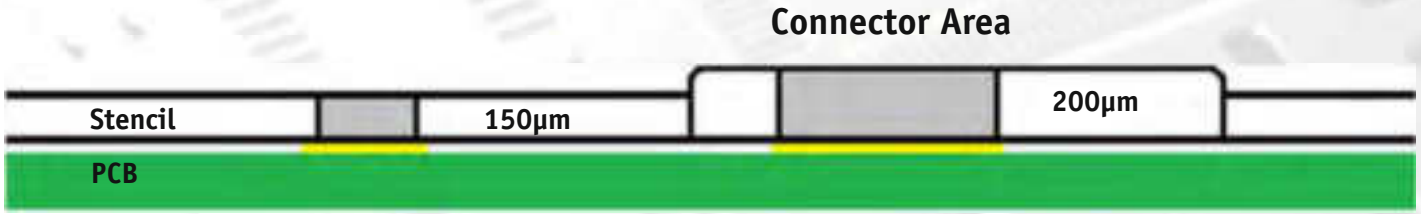
PatchWork® Stencils (Step Stencils)

Why PatchWork ®

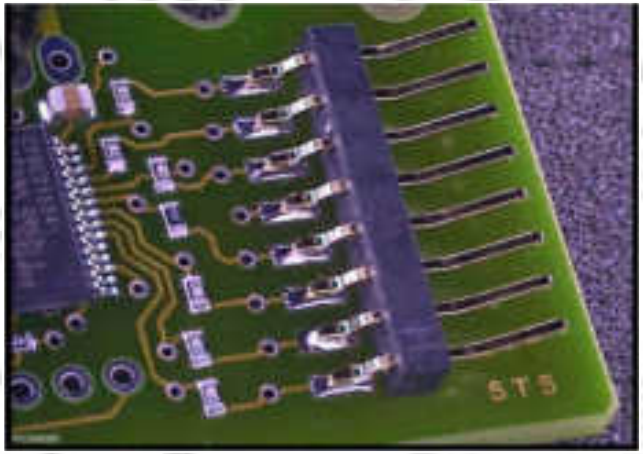
Step-Up Stencil

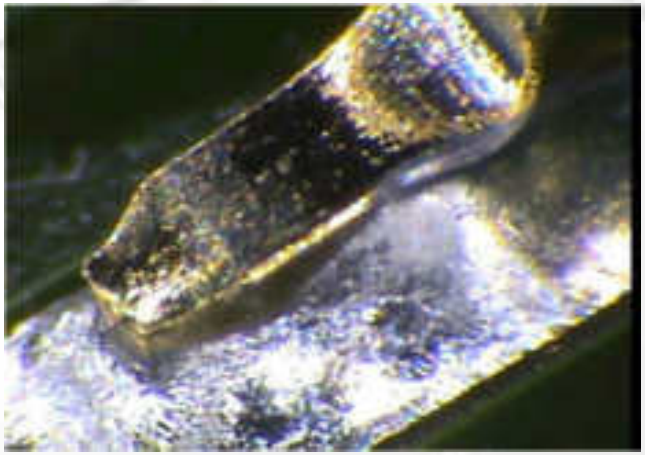
Application: (IPC 7525A)

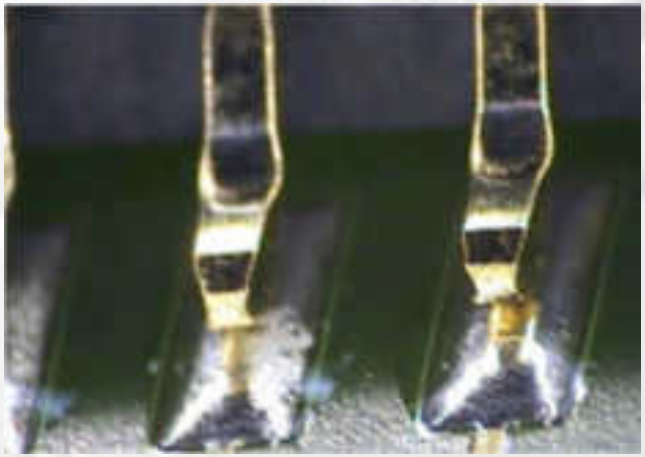
- This type of stencil is useful when it is desirable to print thicker solder paste in a small portion of the stencil.
- e.g.: a Connector where it is necessary to get 0,2mm paste height because of bad pin coplanarity, but 0,15mm height on all other surface-mount component pads.



Connector with insufficent solderpaste depot because of bad coplanarity of pins







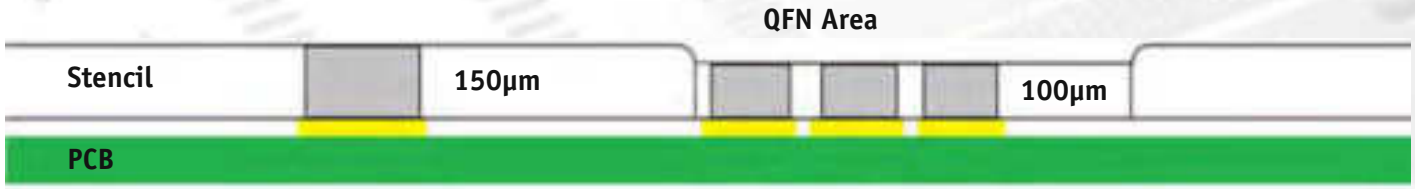
Why PatchWork ®

Step-Down Stencil

Application: (IPC 7525A)

- This type of stencil is useful when it is desirable to print fine-pitch devices using a thinner stencil foil but print other devices using thicker stencil foils.

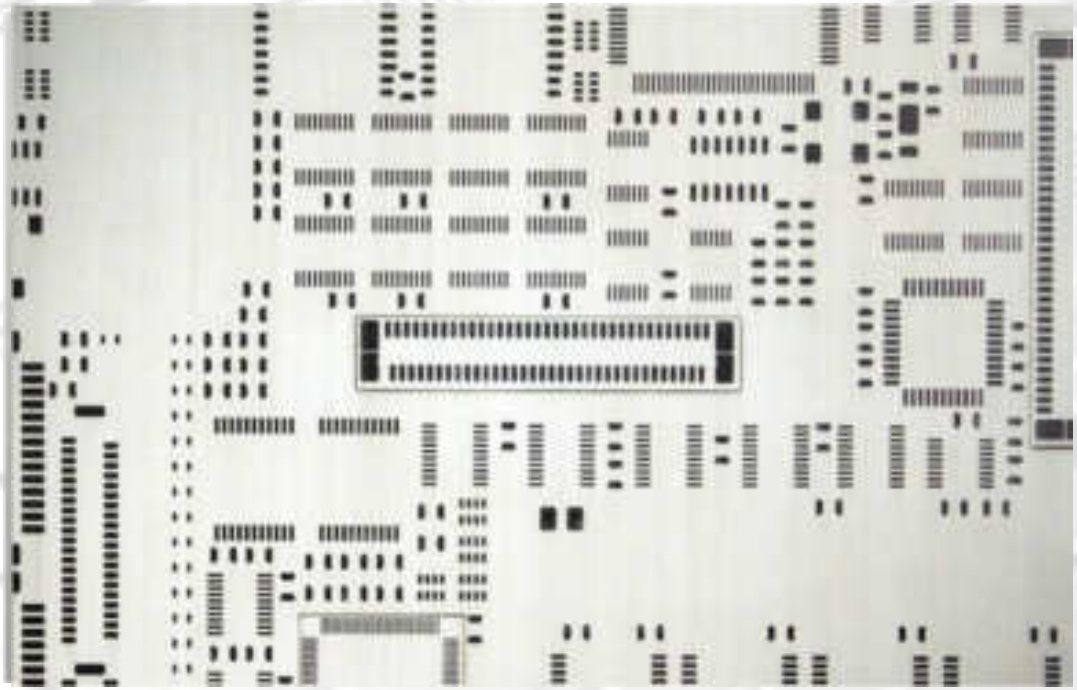
- e.g.: fine pitch QFN ≤ 0,5mm (20mil) pitch that requires a stencil thickness of 0,1mm to achieve an area ration >0,66. At the same time there are devices on the same board that need a thickness of 0,150mm.



PatchWork® - Technology

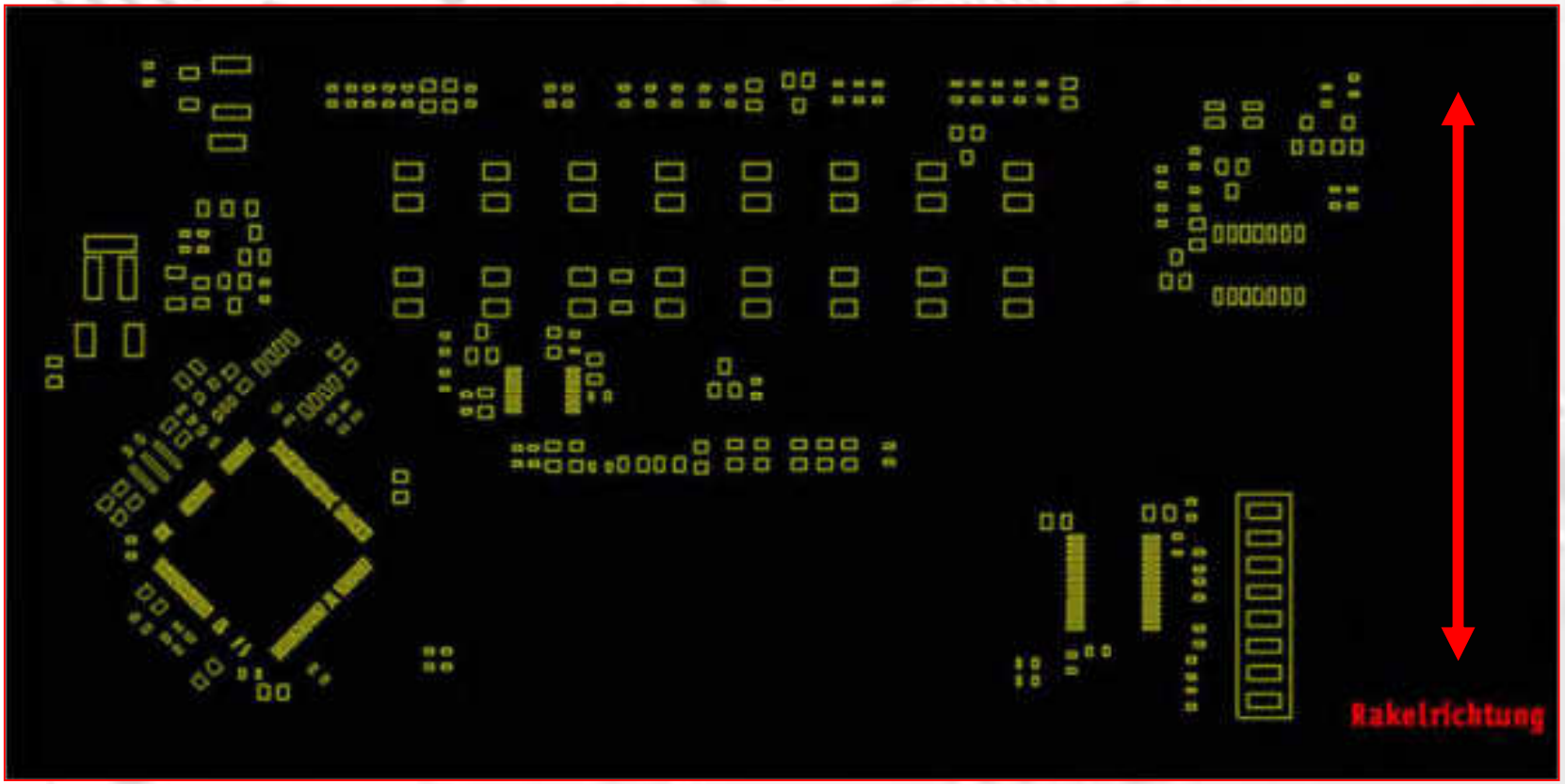
Production Steps

Accurate fitting and laser welding of patch



Example from Practice

Layout:



Example from Practice

Problem:
Touchfoil-Connector on EPZ730 EGB.
Connector Materialsl: NiAu, solderable to IPC/ Jedec J-STD-020C, RoHS conform.

Stencil:
Standard Foil Thicknes 150 µm with 210µm PatchWork®- Foíl Thickness
No Reduction at Aperture of Touchfoil Connector

Solder Paste Typ:
Class 3.

Amount of PCB: 700 pc

Problem:
Connector was difficult to solder , because of to big tolerances of the Pick & Place Cap

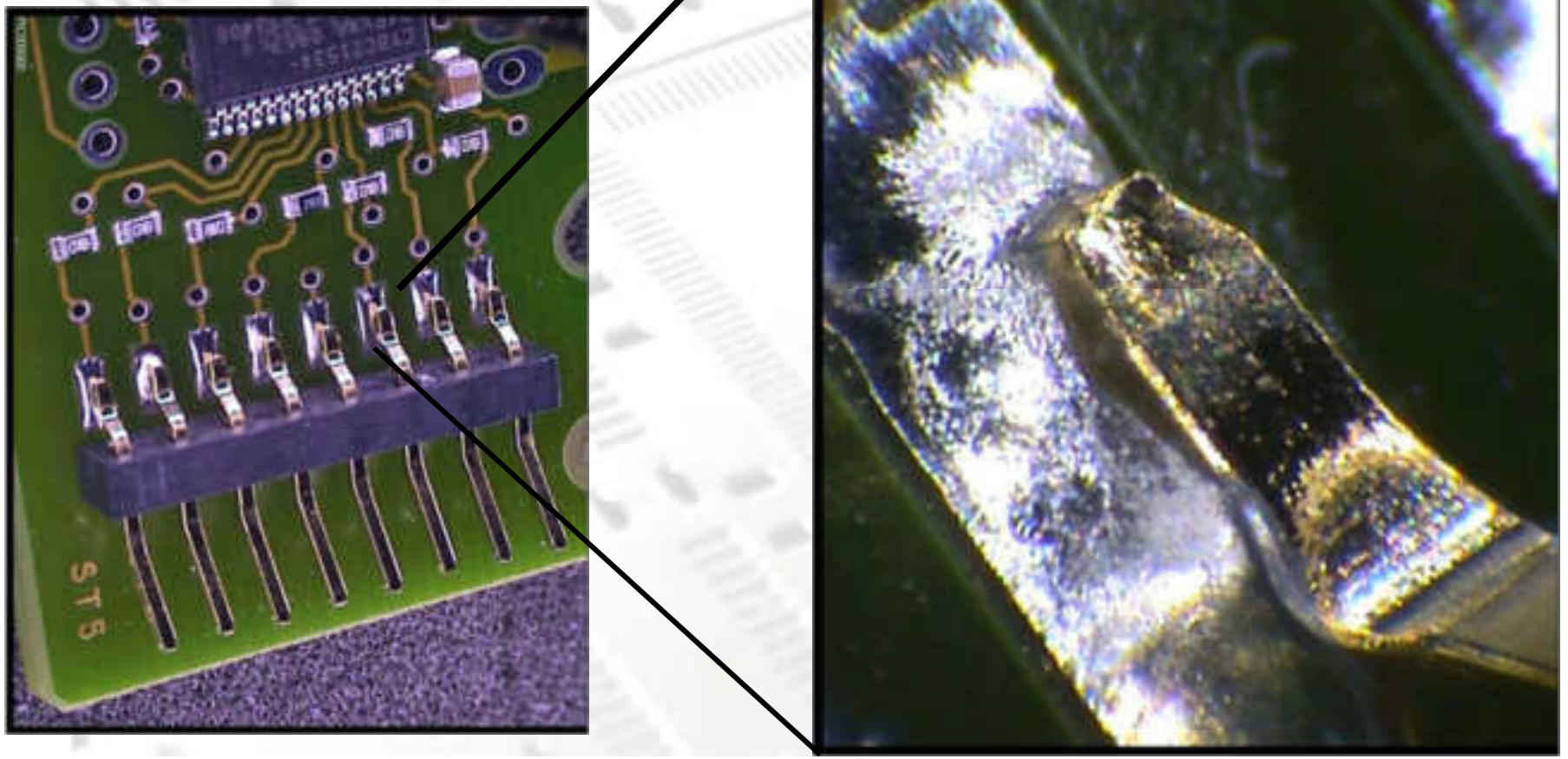
Failure Rate at the connector with Standard Stencil: 35-40%

With PatchWork®Stencil the failure rate is less then 1 %.

Example from Practice:

Failure:

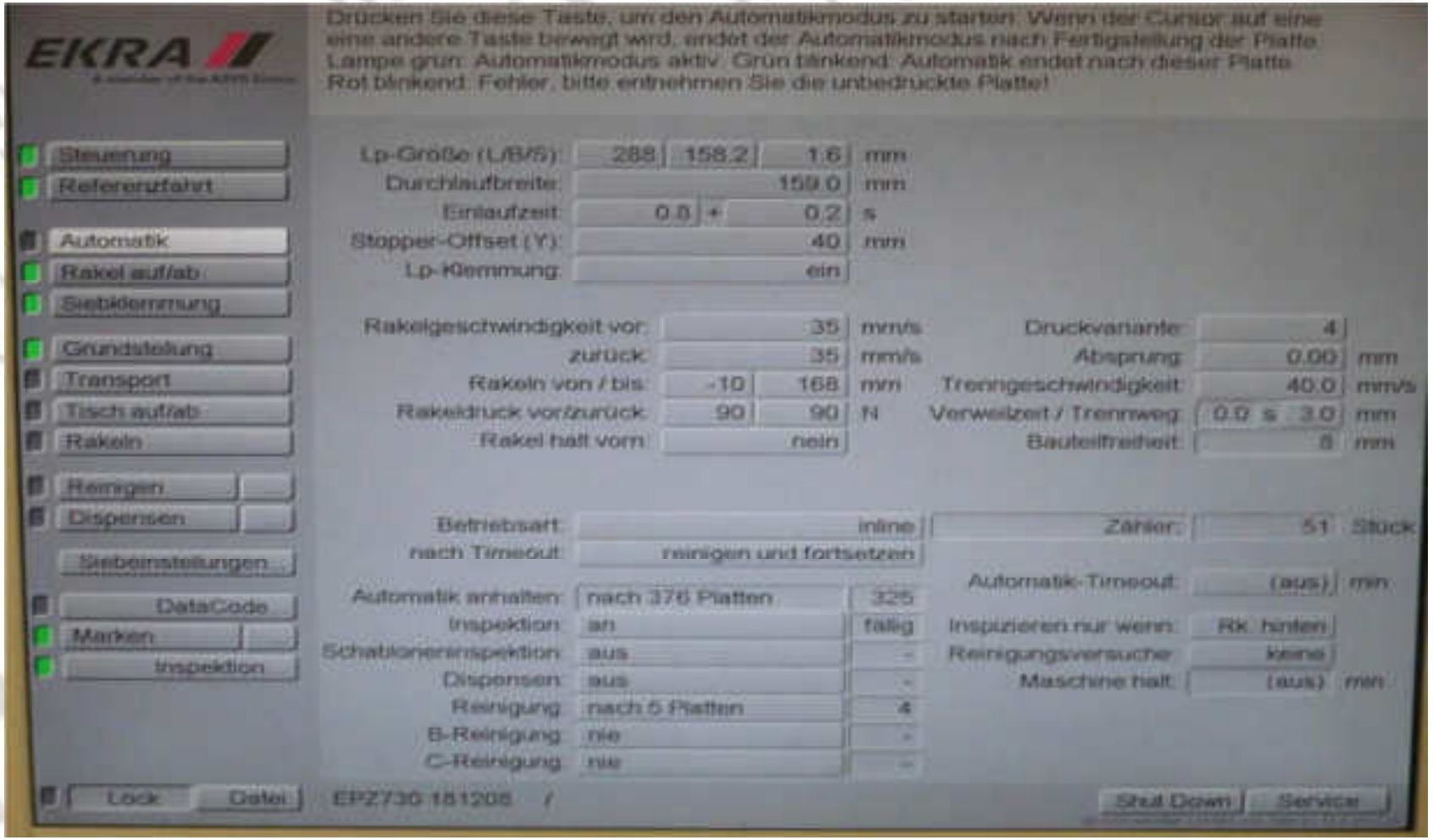
insufficent welded Connector Pins



LaserJob

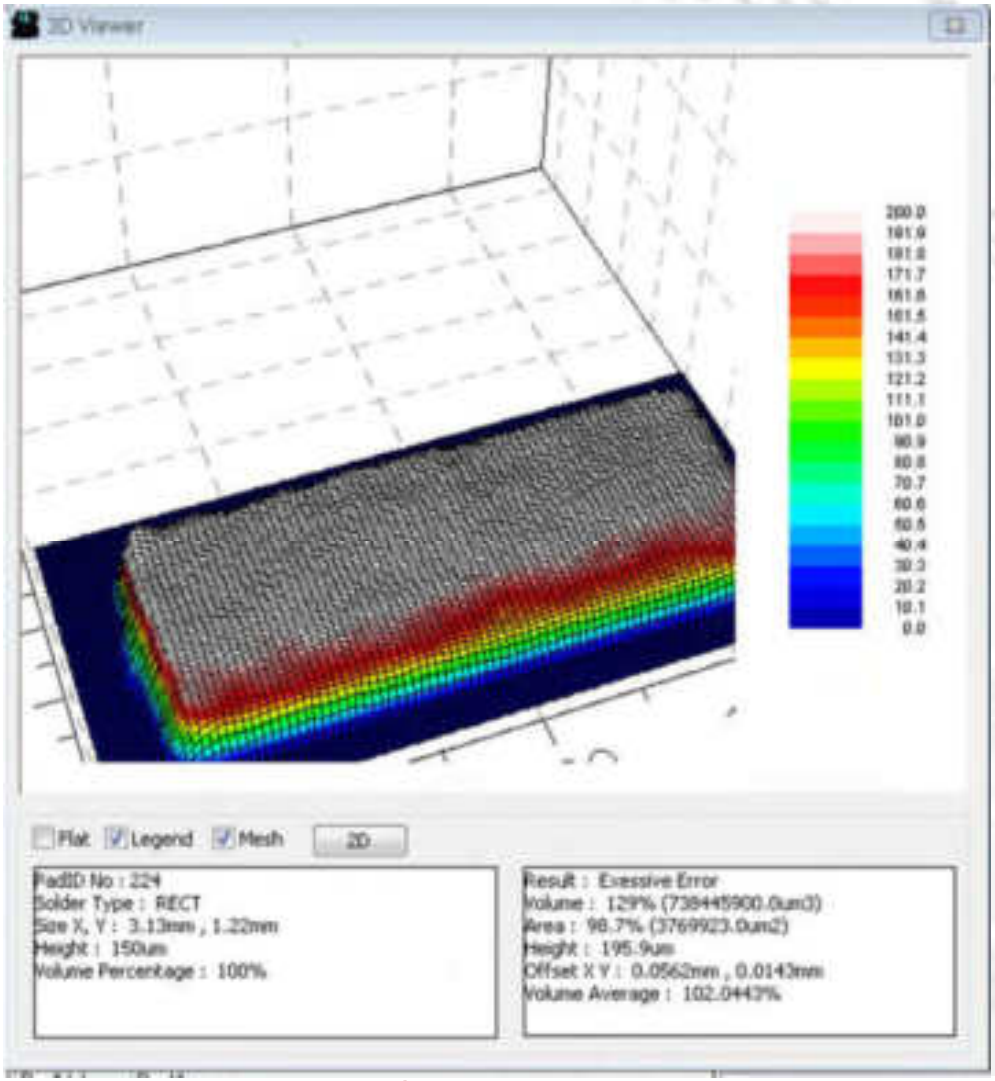
Example from Practice

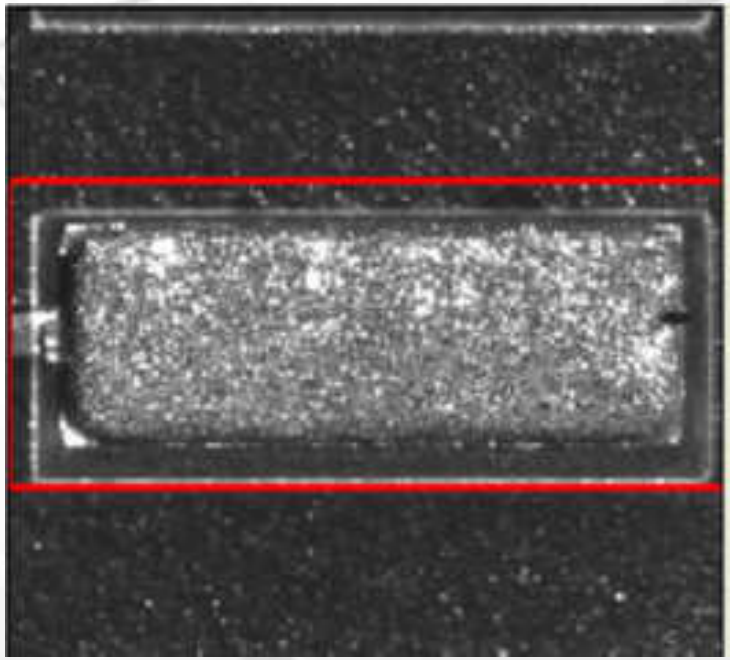
Printersettings:



Example from Practice

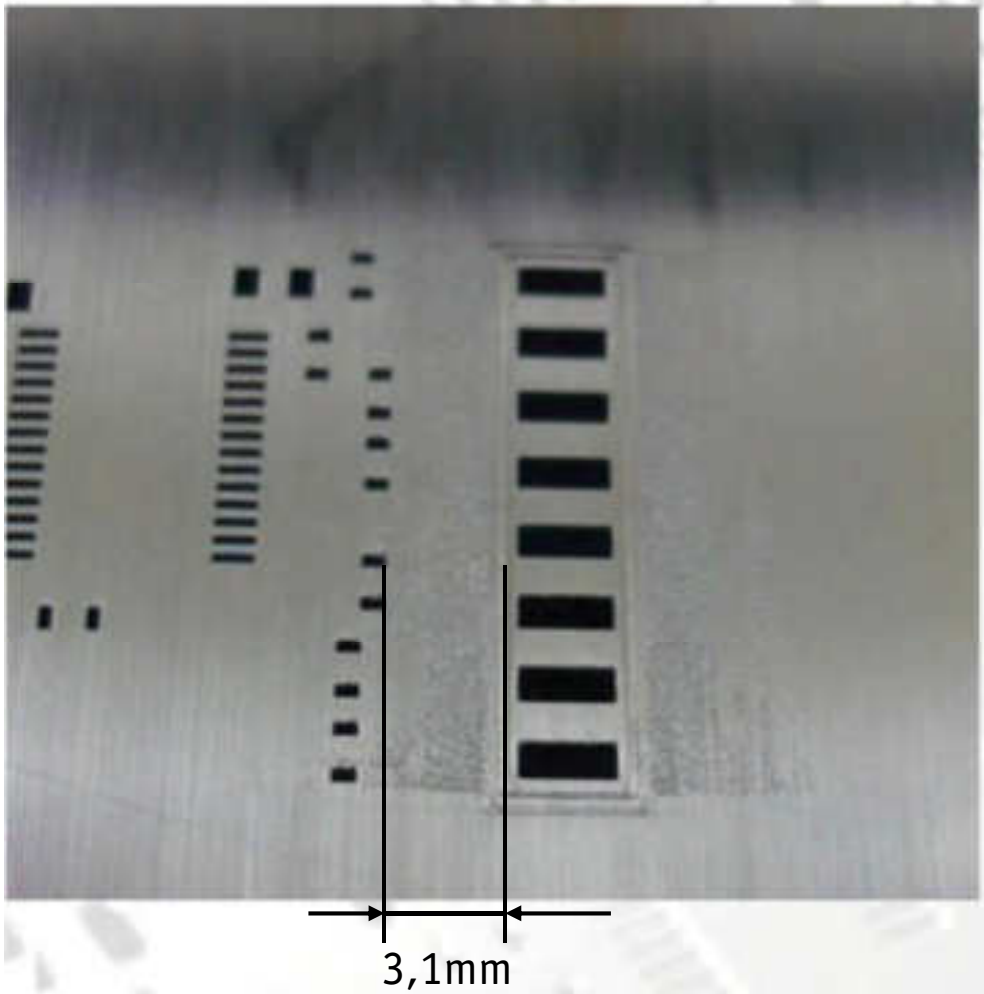
Solderdepot Hight at PatchWork®Area: 195,9µm





Example from Practice

Abziehverhalten auf der Schablone:



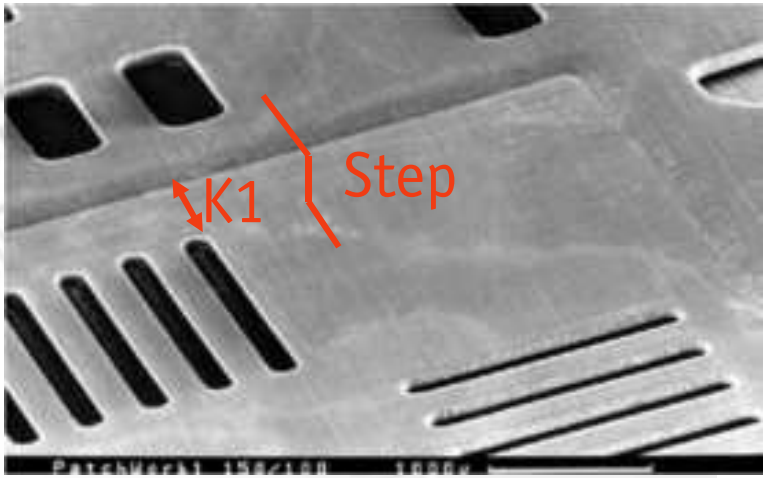
Distance from Patchedge to Aperture at thinner Foil: 3,1mm

Stepdifference: 60µm

IPC 7525 stencil guidelines: Design for step stencils

K1 is the distance from the step edge to the nearest aperture in the step-down area.

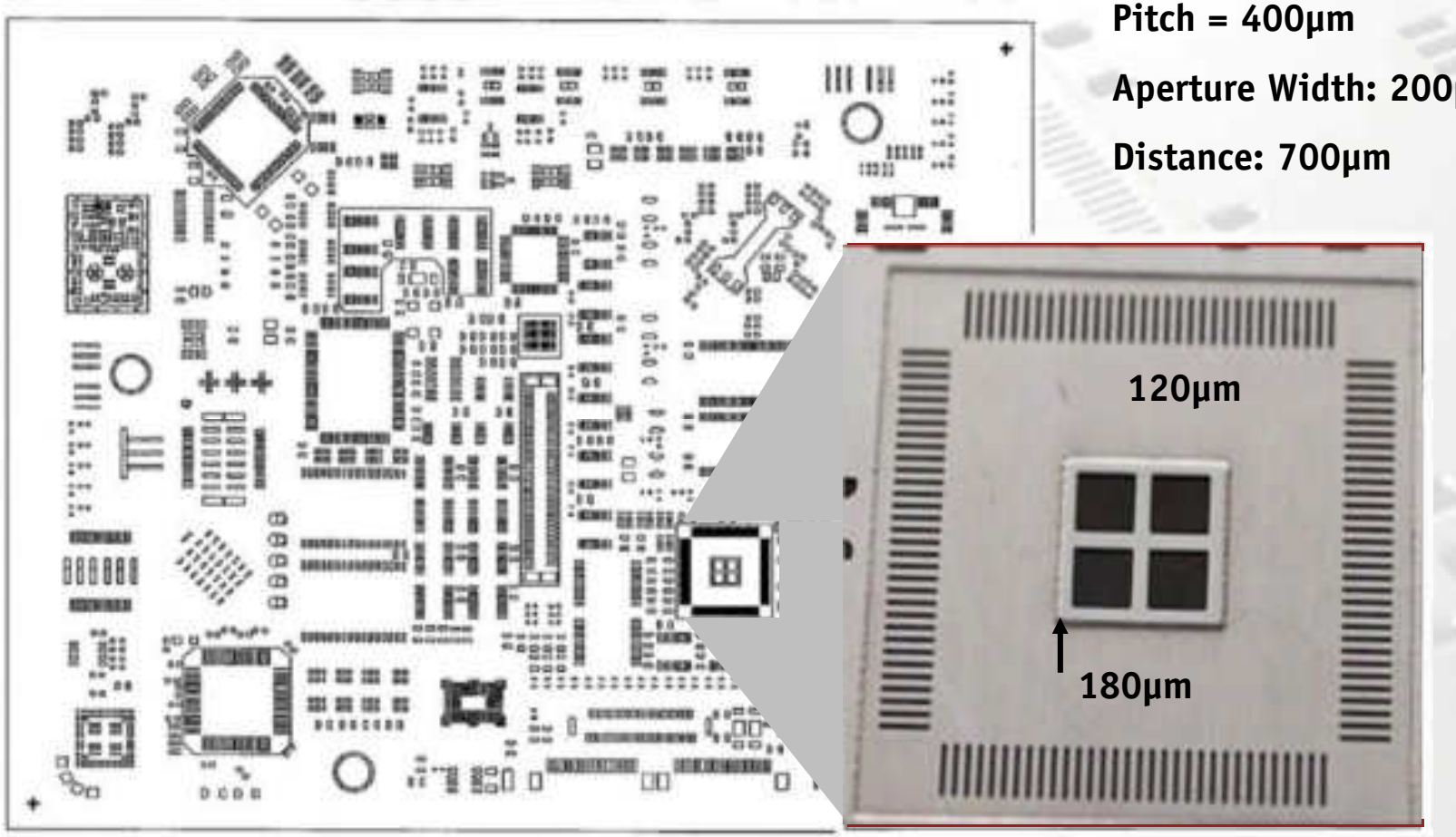
As a general design guide K1 should be 0,9mm [35,4mil] for every 0,025mm[0,98mil] of step- down thickness.



Step in mm	K1 is distance form the step edge to the nearest aperture in step –down area
0,010 [0,397mil]	0,36mm [14,1mil]
0,020 [0,787mil]	0,72mm [28,3mil]
0,025 [0,984mil]	0,90mm [35,4mil]
0,030 [1,181mil]	1,08mm [42,5mil]
0,050 [1,969mil]	1,80mm [70,9mil]
0,080 [3,14 mil]	2,88mm [113,4mil]
0,100 [3,937mil]	3,60mm [141,7mil]

Special Solutions:

Patch in Patch – Step in Step

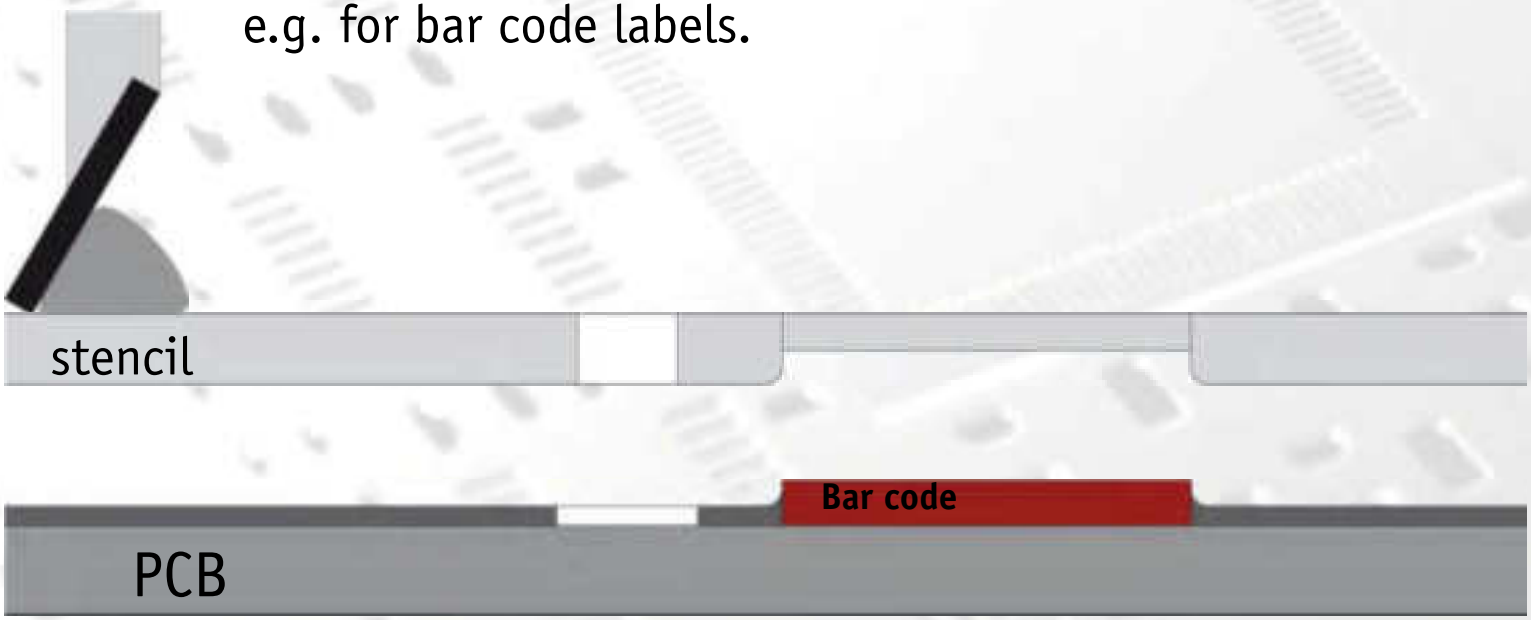


Special Solutions:

Step-down stencil on PBC side

Application:

– This type of stencil is used to hide thick labels on the printed circuit board, by welding a thin foil in the stainless steel sheet, e.g. for bar code labels.



Example from Practice

Step-up on squeegee side :

Application:

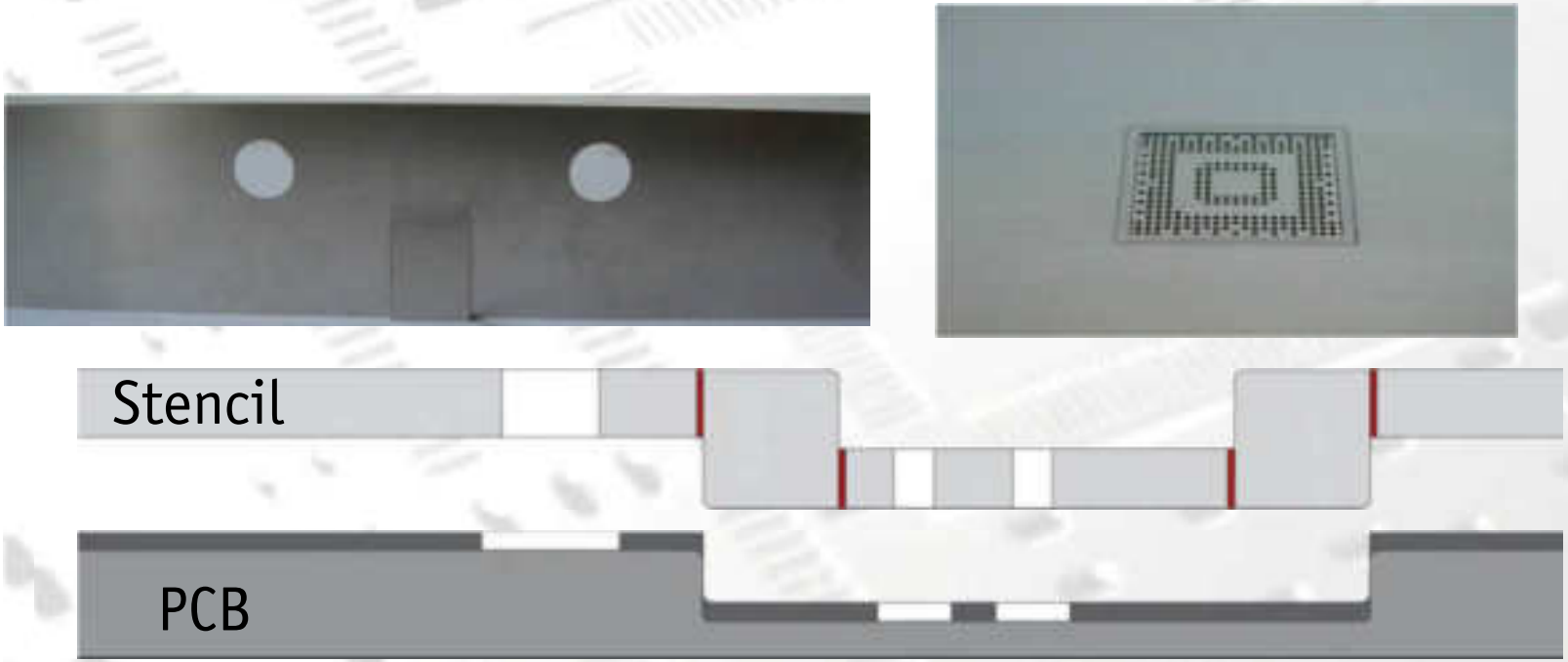
– This type of stencil is used to hide components on the printed circuit board, by welding a thicker foil with bevel in the stainless steel sheet

Special Solutions:

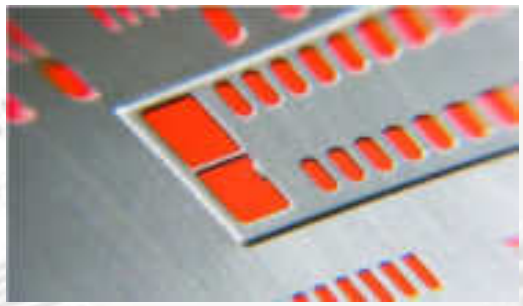
3D-PatchWork ® Stepstencil

Application:

– This type of stencil is used to print in deeper layers of the printed circuit board, by welding a foil in the stainless steel stencil



PatchWork® step-up/step-down

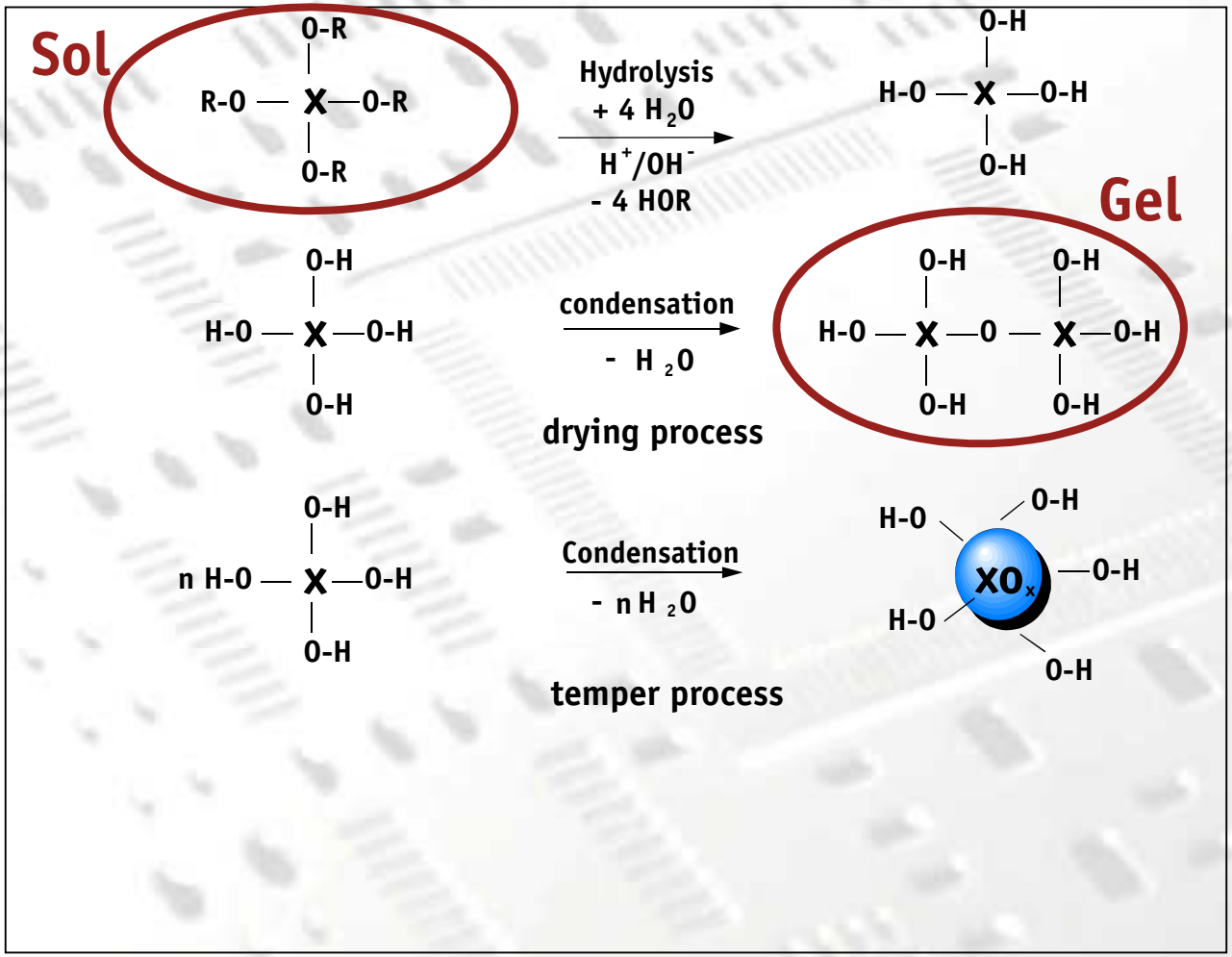


Benefits of LaserJob step stencils:

- Adapted paste volume in one print process
- 10µm- steps possbile up to 300µm
- Afterwards integration of patches in standard SMD stencils and PatchWork® stencils
- Available with NanoWork® coating
- Exact patch thickness due to special pretreatment
- The same high precision for the patch like the rest of foil
- Rounded patch edges due to laserwelding process
- Step-up and step-down stencil is available on stencil- and PCB side
- Short delivery time (6 hours service)

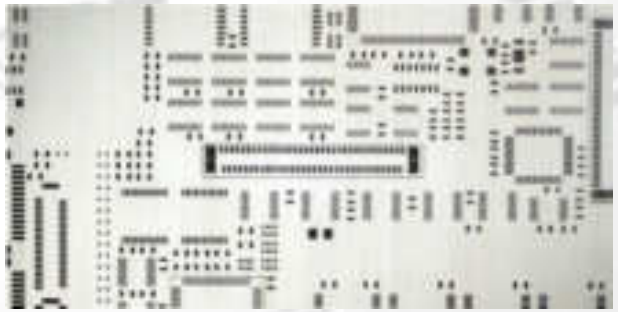
NanoWork Stencil (nanocoated Stencil)

NanoWork® chemical structure



Pre-treatment of stencil foil

After lasercutting process:



1. Alcoholic degreasing process
2. brushing process with water on squeegee and printed circuit board side
3. Cleaning step with demineralized water

Coating process

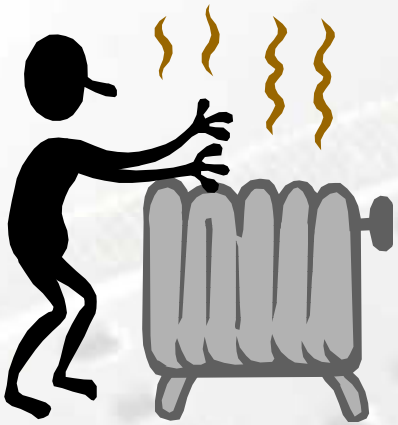
Pretreatment

Chemical treatment of

stencil foil

Coating process

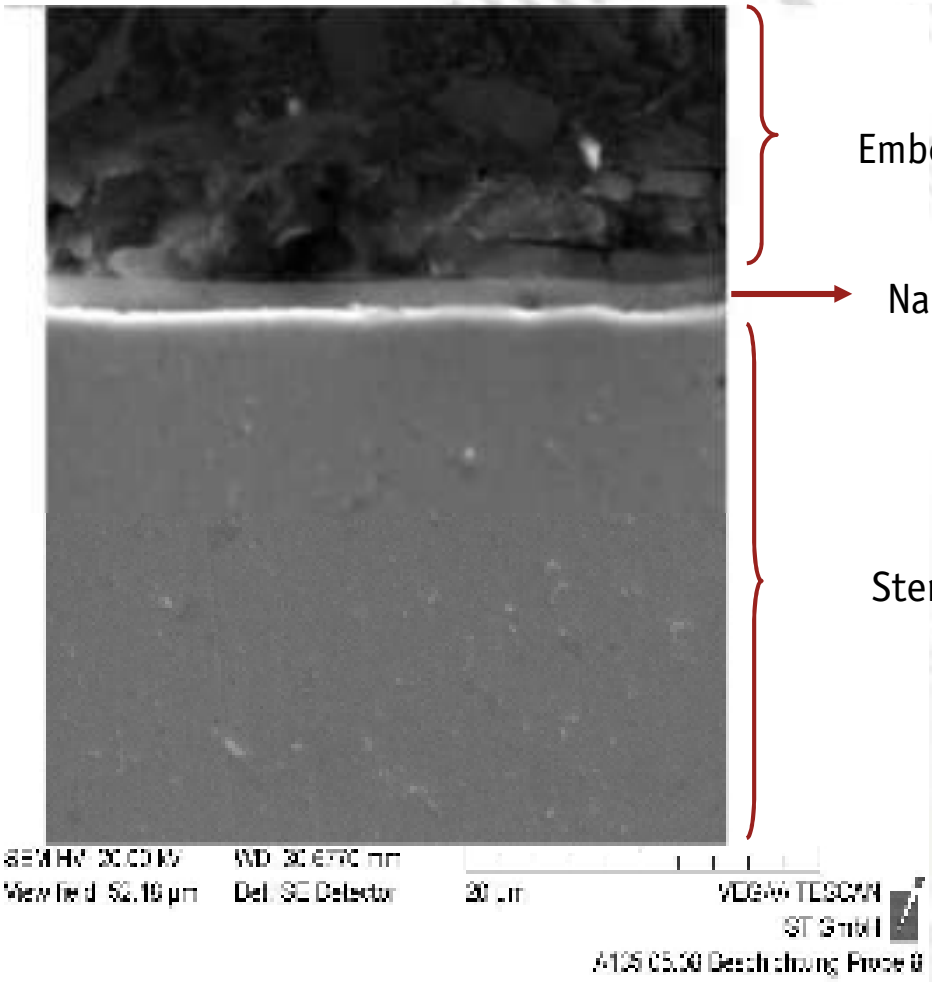
Drying process



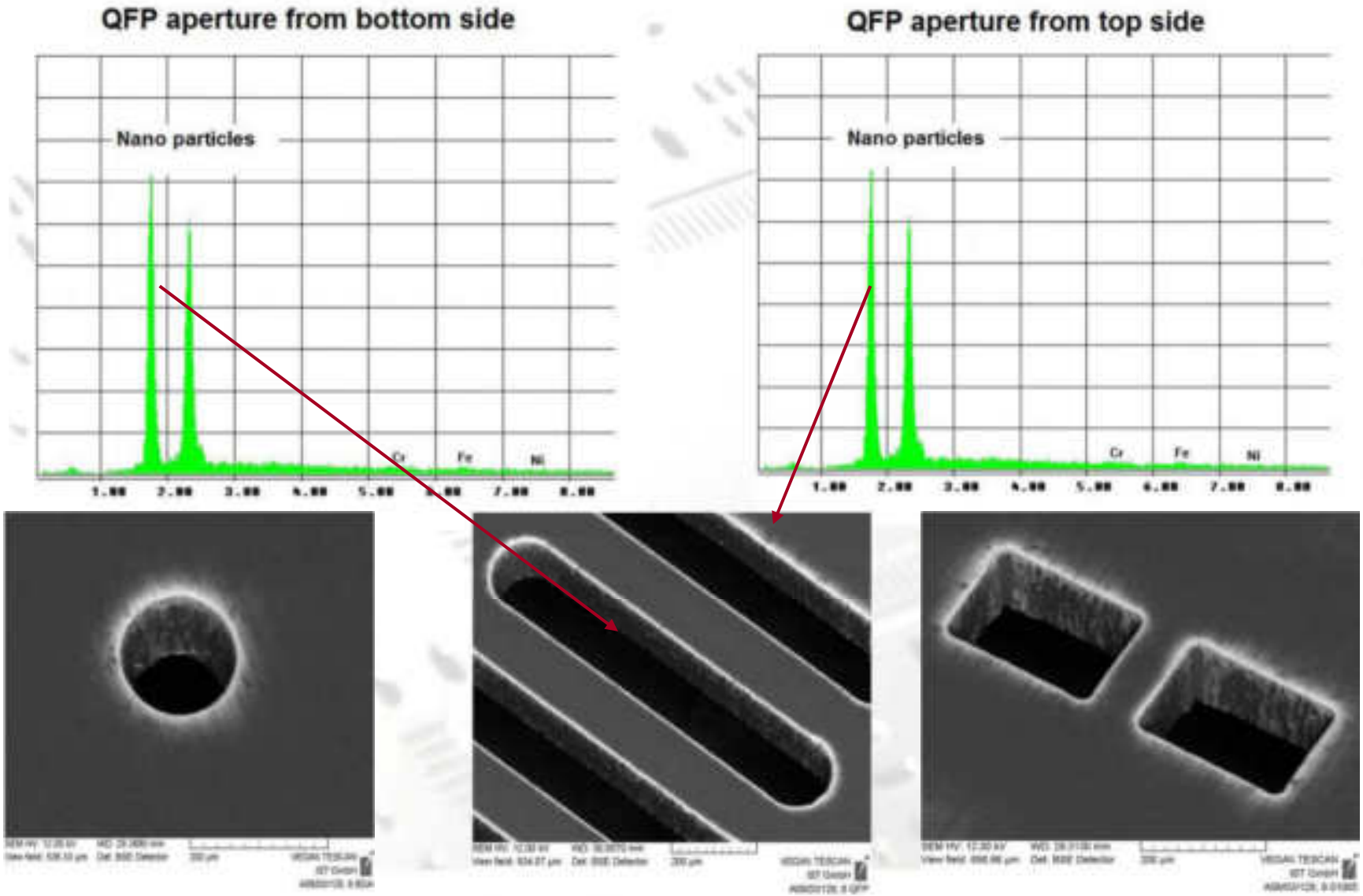
Temper process

Quality control

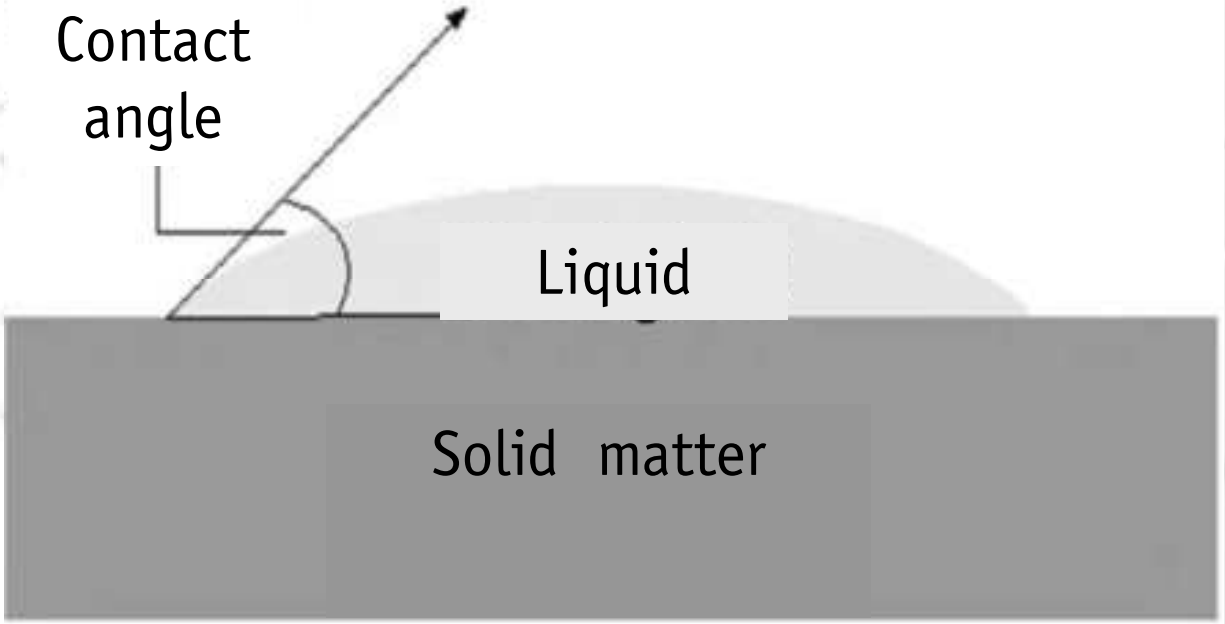
Quality control: cross-section of nanocoated stencil



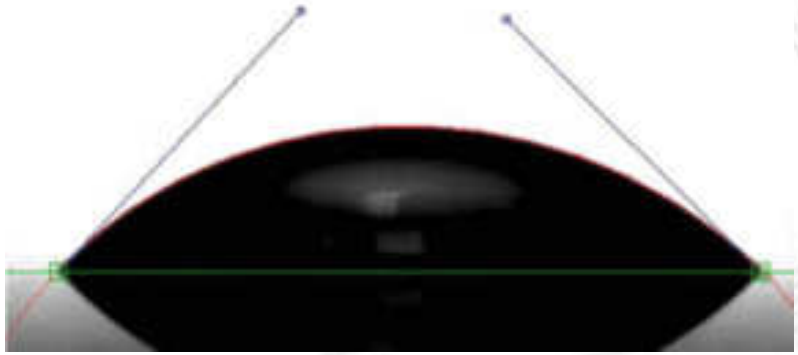
EDX –of nanocoating



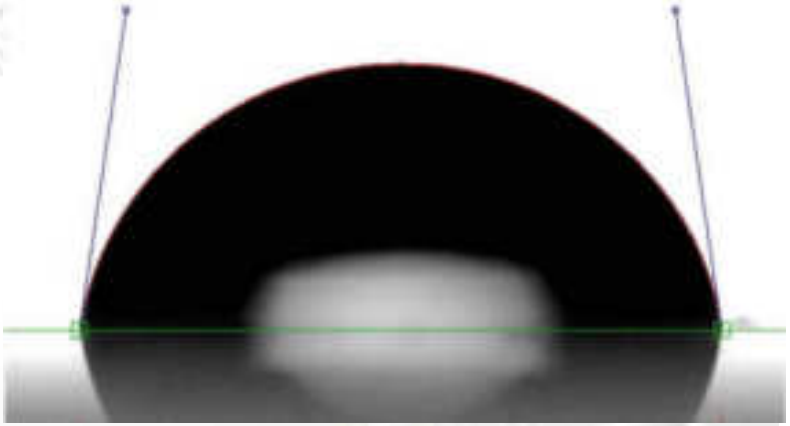
Quality control of NanoWork coating



Quality control of NanoWork coating

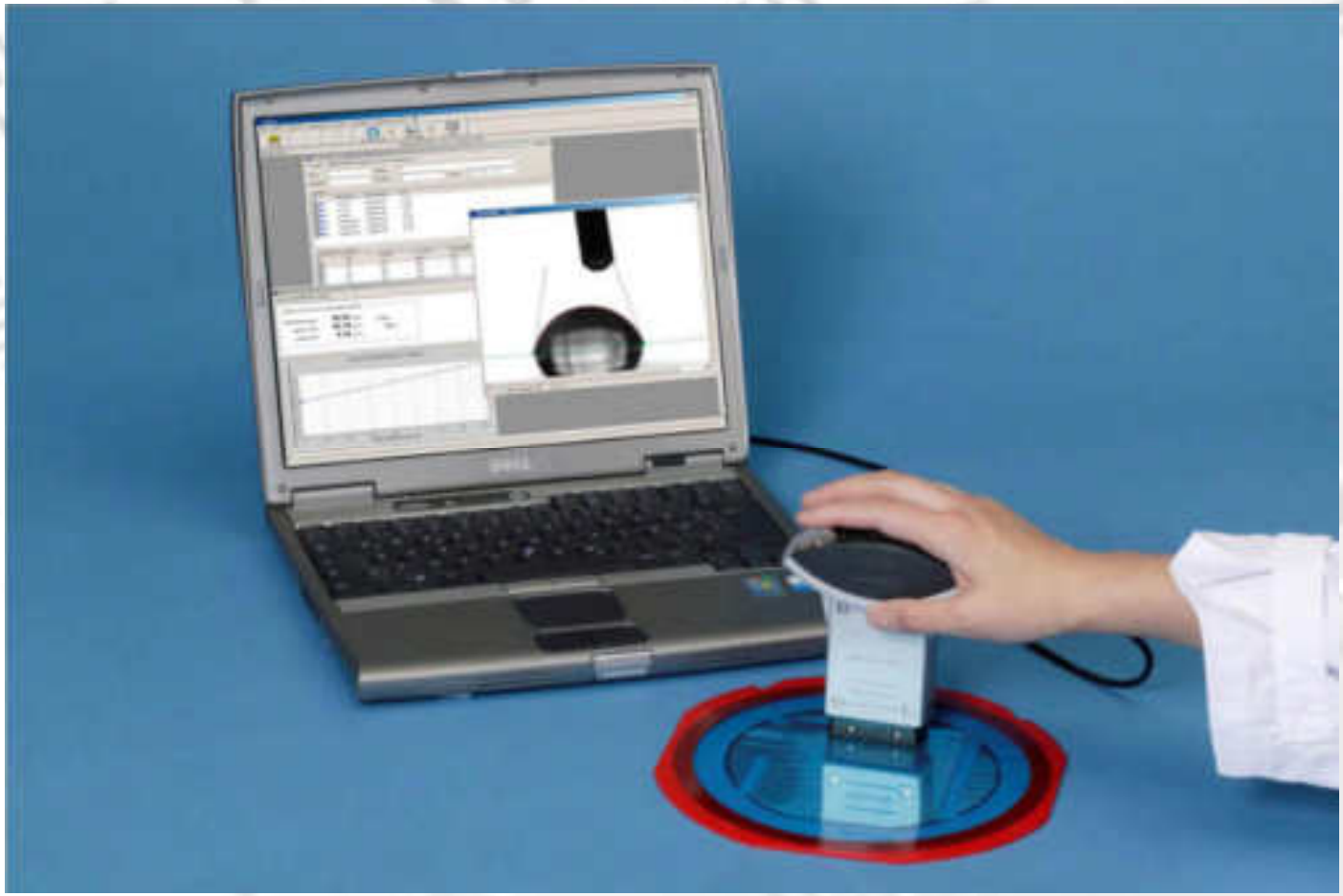


Low contact angle



High contact angle

Measurement: MobileDrop



Compatability of cleaners with NanoWork®

In general all water based neutral cleaners and all solvent based cleaners are compatible, all water based alkaline cleaners are not compatible with NanoWork ®-coated stencils.

Hersteller producer	Handelsname Reiniger Tradename cleaner	Verträglichkeit Compatibility
Zestron	Vigon SC 200	X
	Vigon SC 202	- -
	Vigon SC 210	X
	Vigon SC 400	X
	Vigon UC 140(water based, neutral cleaner)	X
	Zestron SW	X
Kolb	MultiEx-N7	X
	MultiEx-N8	X
	WipeEx SA 120	X
	MultiEx B11	--

Compatability of cleaners with NanoWork®

In general all water based neutral cleaners and all solvent based cleaners are compatible, all water based alkaline cleaners are not compatible with NanoWork ®-coated stencils.

Henkel	Lixton 2603-8	X
	Lixton TS 260	X
	Lixton 2601 (solvent based)	x
Kissel + Wolf GmbH	KiwoClean EL 8400	X
	KiwoClean EL 8200	X
	KiwoClean EL 7300	X
Dow	Dowanol PX 165	X
Kester	5252	X
SMT Detergent Corp.	Smart Sonic´s 440-R SMT Detergent	--
EMS GmbH	Puran SC	X
Petroferm	Axarel 2200 (solvent based)	x

X = verträglich / compatible
-- = nicht verträglich / not compatible

SMT-printing stencils technologies and properties

LaserJob

Stencil material

- ❑ Stainless steel
- ❑ Nickel
- ❑ Polymer

Production technology

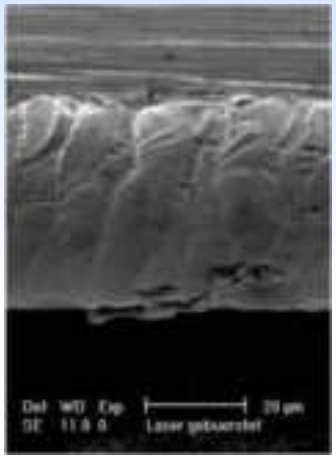
- ❑ Etching technology
- ❑ Lasercut technology
- ❑ Galvanotechnology

Finishing process

- ❑ Brushing
- ❑ Electropolishing
- ❑ NanoWork® coating

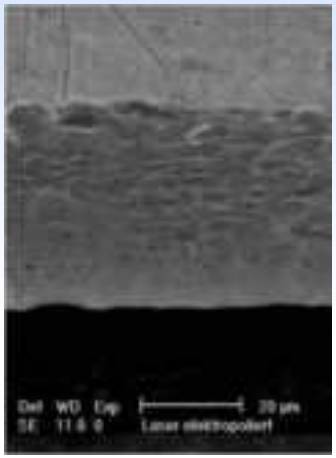
Stenciltype A

- ❑ Stainless steel
- ❑ Lasercut technology
- ❑ Brushing



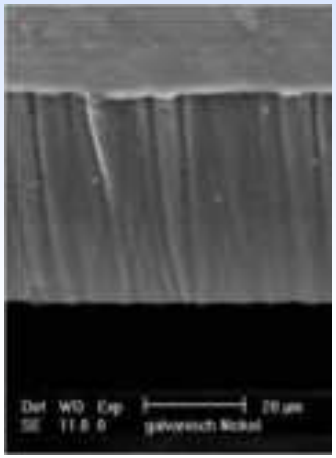
Stenciltype B

- ❑ Stainless steel
- ❑ Lasercut technology
- ❑ Electropolishing



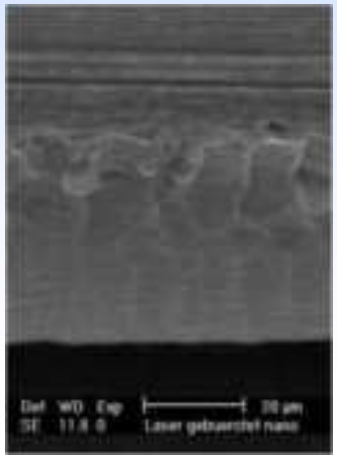
Stenciltype C

- ❑ Nickel
- ❑ Galvanotechnology



Stenciltype D

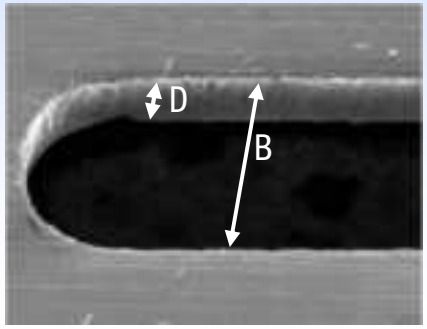
- ❑ Stainless steel
- ❑ Lasercut technology
- ❑ coating



Design rules for SMT-printing stencils

Aspect ratio

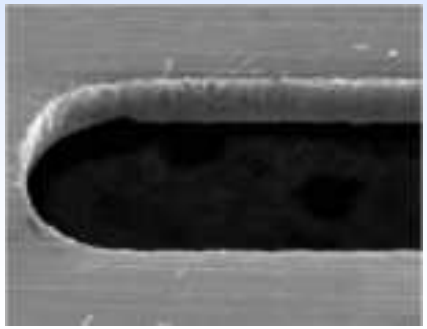
$$\frac{\text{Aperture width B}}{\text{Stencil thickness D}} \geq 1{,}5$$



IPC-7525A

Area ratio

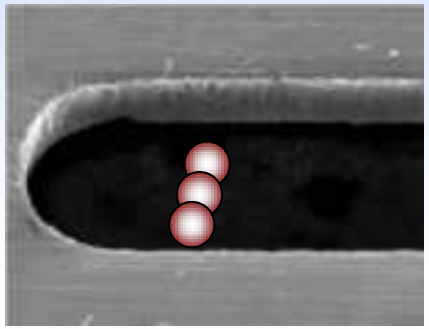
$$\frac{\text{Area opening}}{\text{Wall area}} \geq 0{,}66$$



IPC-7525A

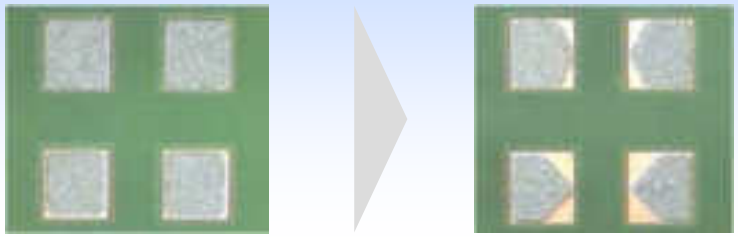
5-ball-rule

$$\frac{\text{Aperture width}}{\text{Ø Paste powder}} \geq 5$$



FED

Aperture specific layout optimization



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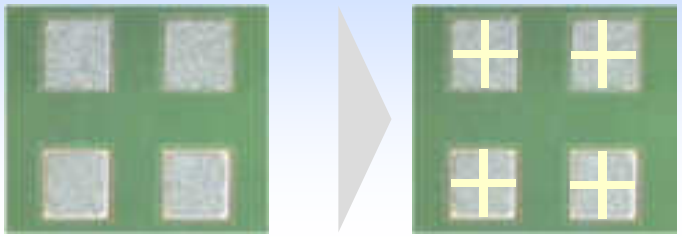
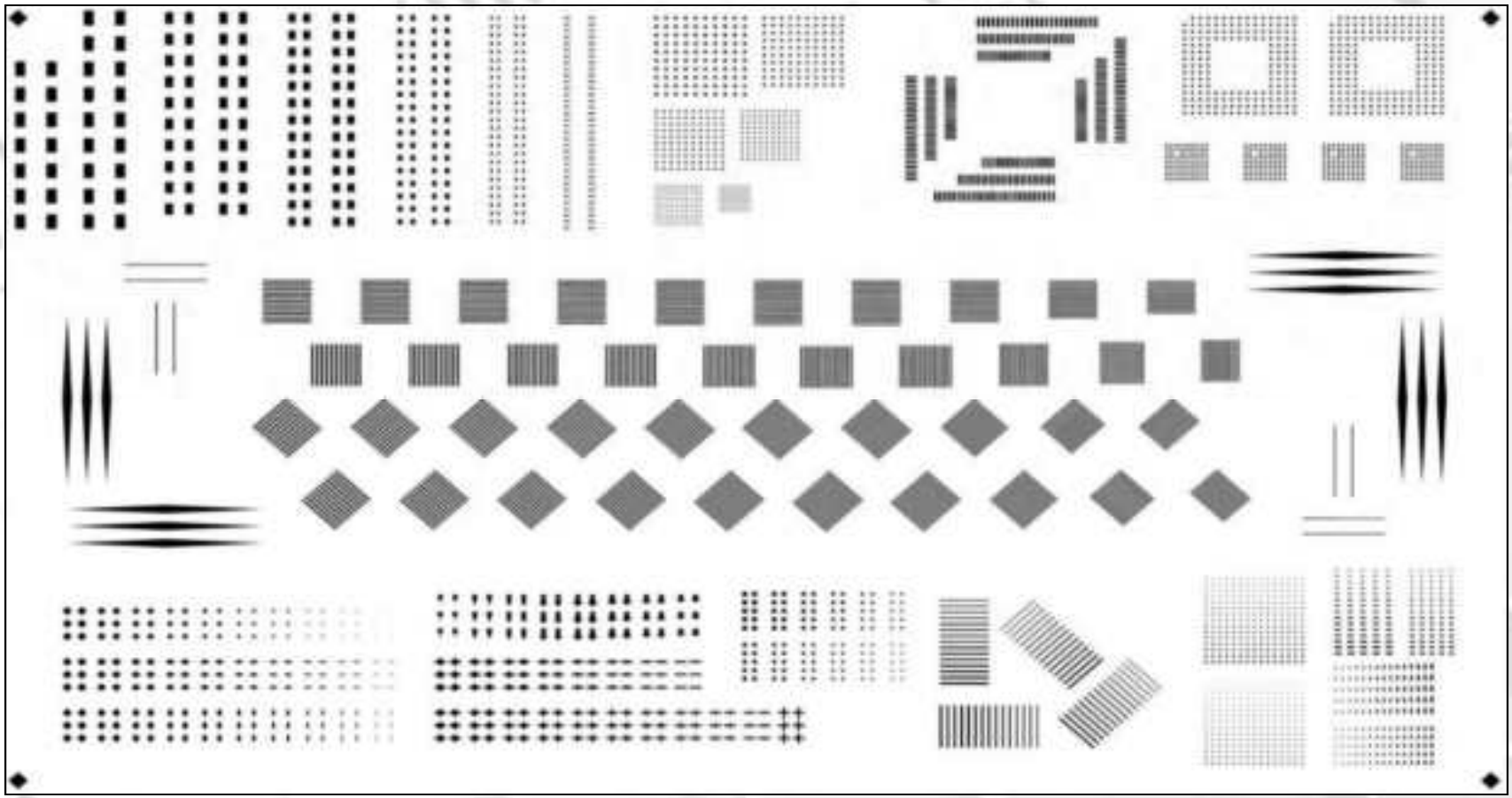
Divide big apertures



FED

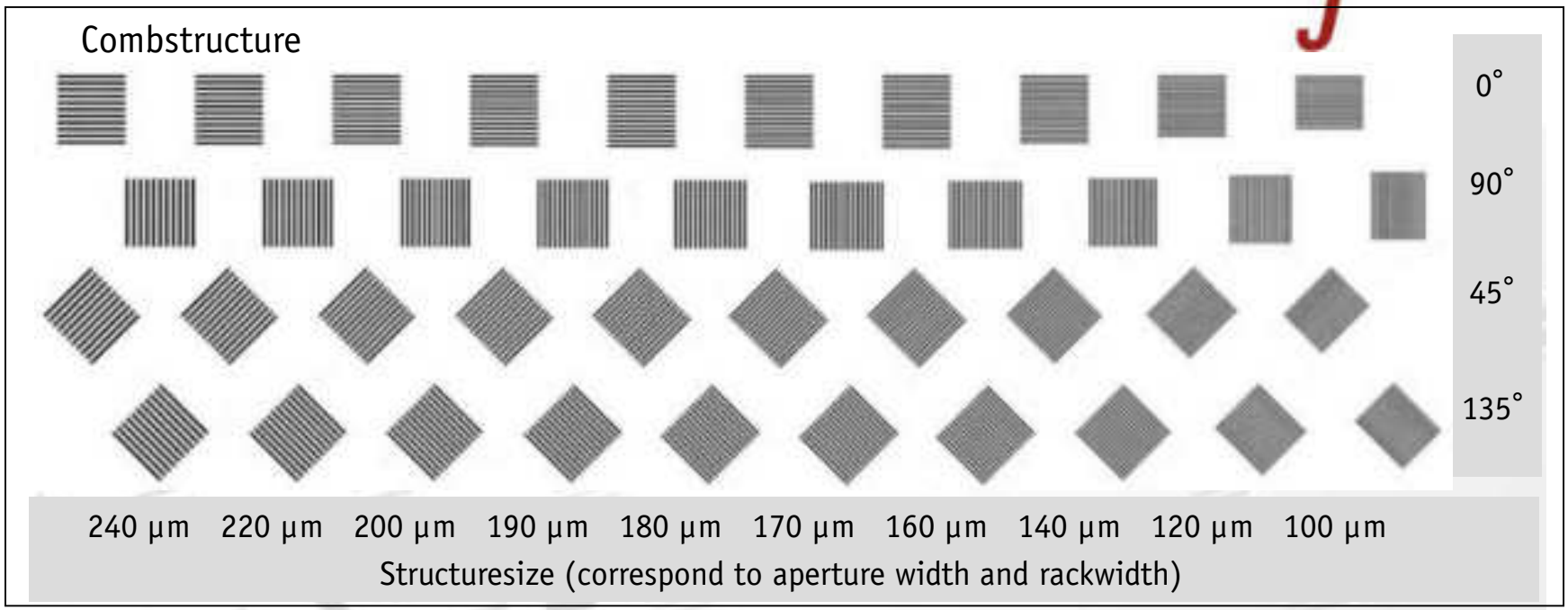
Test planing for qualification of alternative SMT-Stencil technology

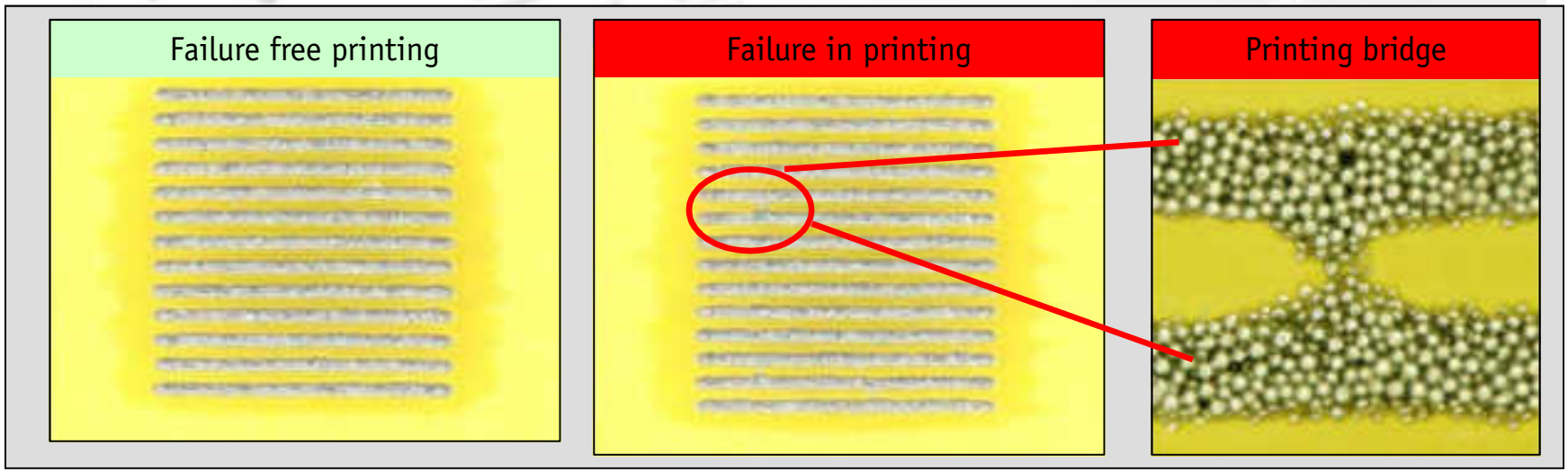


- Testlayout for stencil types A, B, C und D – Stencil thickness: 127 µm
- SAC-Solderpaste Type 3 (25 µm – 45 µm)
- Process parameter: 2,2 N/cm squeegee presssure, 50 mm/s squeegee speed, 10 mm/s separation speed

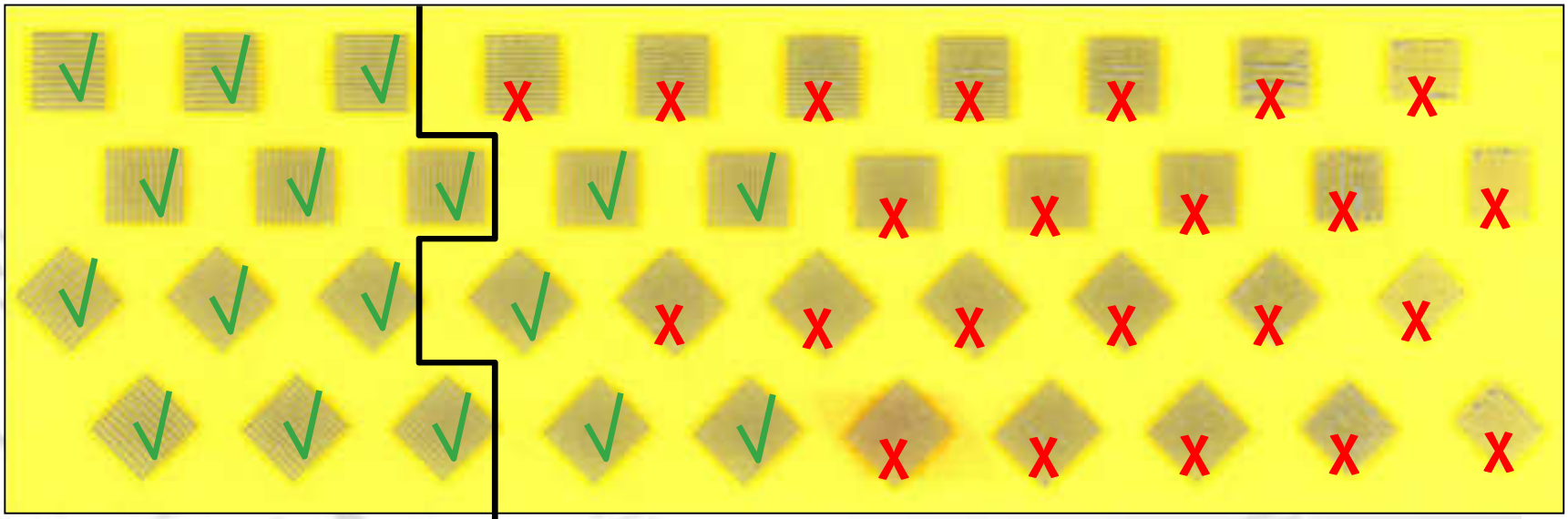
Optical benchmark of printed combstructures

LaserJob





Optical benchmark of printed combstructures

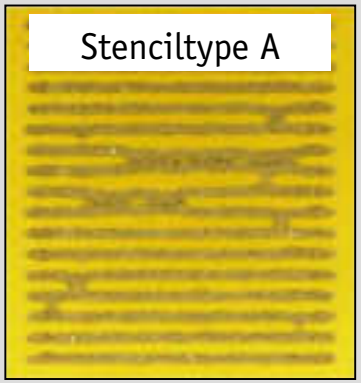


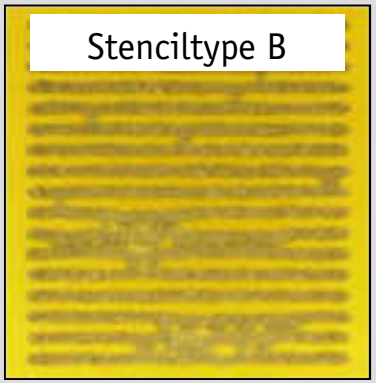
Stencilype

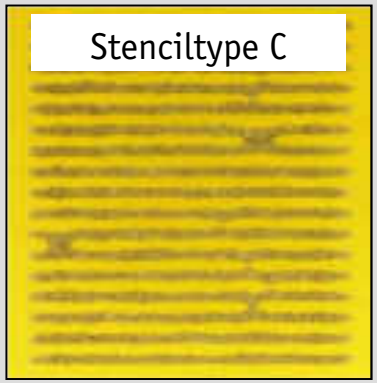
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
A	/	190	180	190	200	220	220	220	240	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
B	/	180	220	220	220	240	220	/	/	/	240	/	240	/	/	/	/	/	/	/	/	/	/	/	/
C	240	180	190	200	240	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
D	180	140	140	140	140	160	160	160	160	160	140	140	170	170	170	190	170	190	170	190	160	170	160	160	160

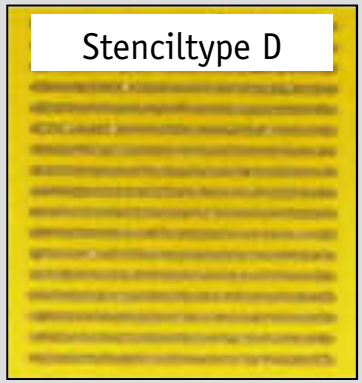
Number of prints

Results of comb structure

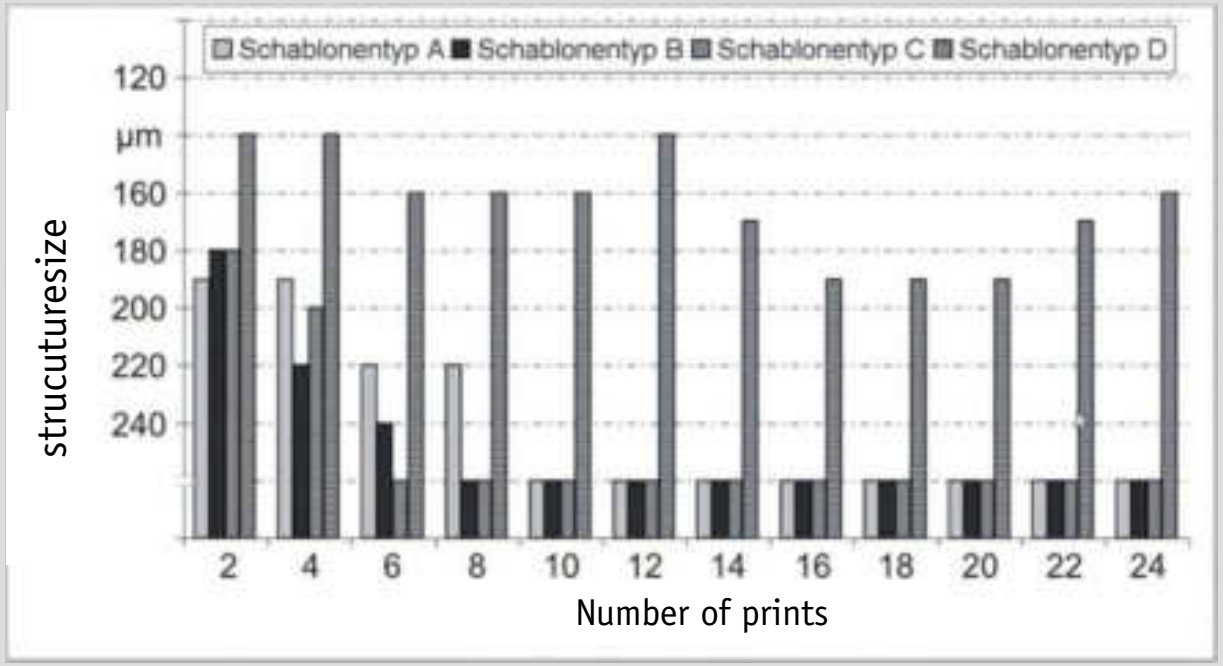








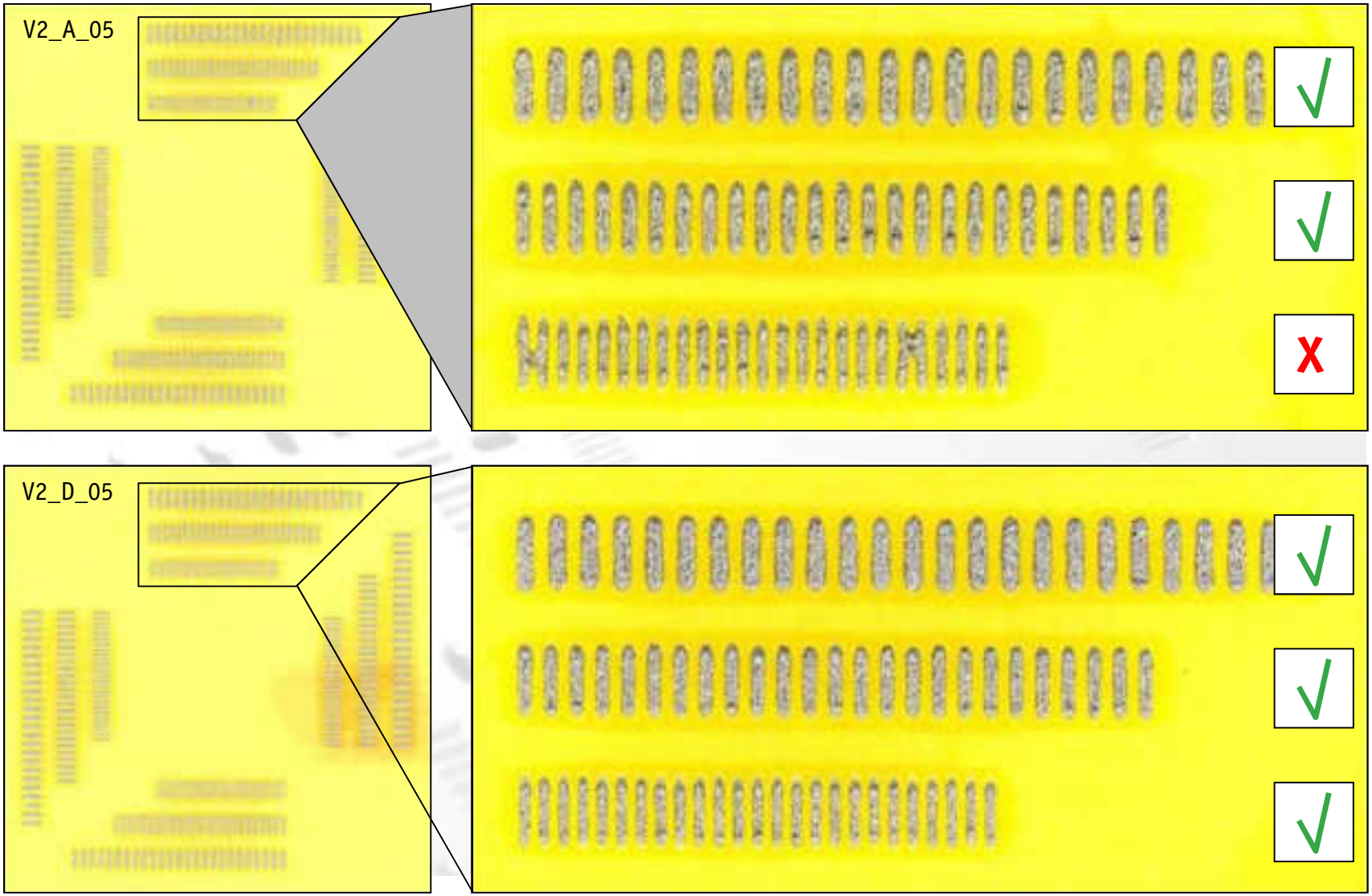
Printing results after 5. printings (Orientation 0° , structuresize 160 µm)



- Aspectratio = 1,5 by 190 µm
- 5-ball-rules by 225 µm

→ additional influence factor

Classification of printed QFP-structures with optical inspection



Comparison of feasibility of QFP-structures

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pitch 500 µm

Stencil type	1	2	3	4	5	6	7	8	9	Number of paste prints	17	18	19	20	21	22	23	24	25
A	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0
B	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	1
C	0	0	0	0	0	0	0	0	0		1	0	1	1	1	0	0	1	1
D	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0

pitch 400 µm

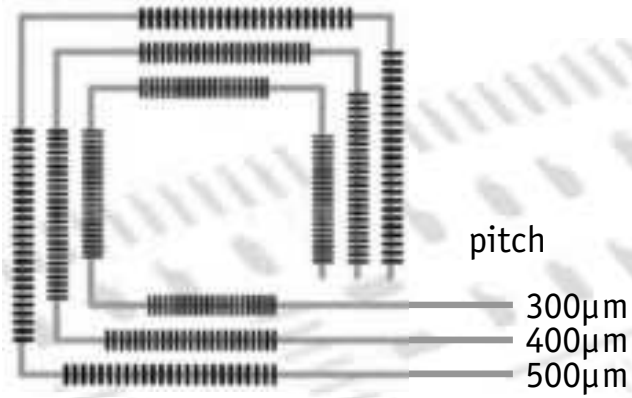
Stencil type	1	2	3	4	5	6	7	8	9	Number of paste prints	17	18	19	20	21	22	23	24	25
A	0	0	0	0	0	1	0	0	2		6	1	6	4	7	3	7	3	8
B	0	0	0	0	0	1	0	1	2		16	9	16	9	15	12	15	12	14
C	0	0	0	0	2	0	2	0	3		18	11	24	14	23	18	31	18	33
D	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0

pitch 300 µm

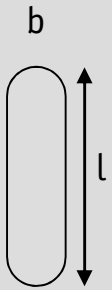
stencil type	1	2	3	4	5	6	7	8	9	Number of paste prints	17	18	19	20	21	22	23	24	25
A	0	0	1	5	14	16	22	26	28		40	36	42	37	36	33	40	36	48
B	0	0	4	13	22	28	32	36	37		>50	>50	>50	>50	>50	>50	>50	>50	>50
C																			
D	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0

Optical evaluation of printed QFP-structure

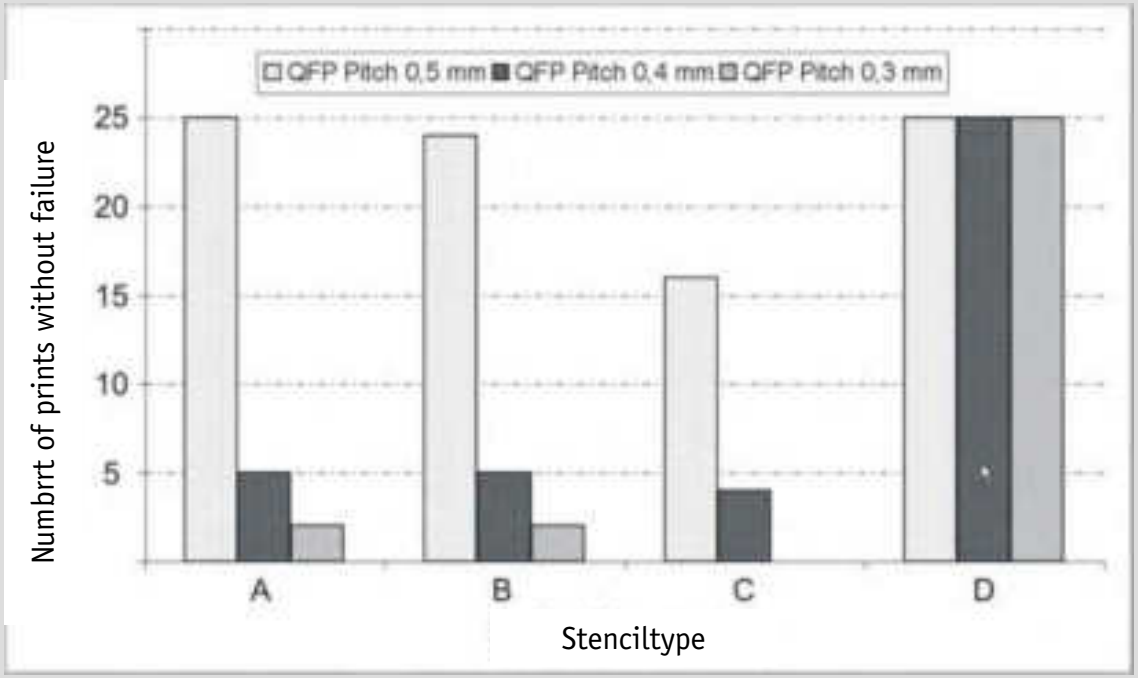
QFP-Structure



Aperturetype: Oblong



Pitch	300µm	400µm	500µm
b	150µm	200µm	250µm
l	1200µm	1200µm	1200µm

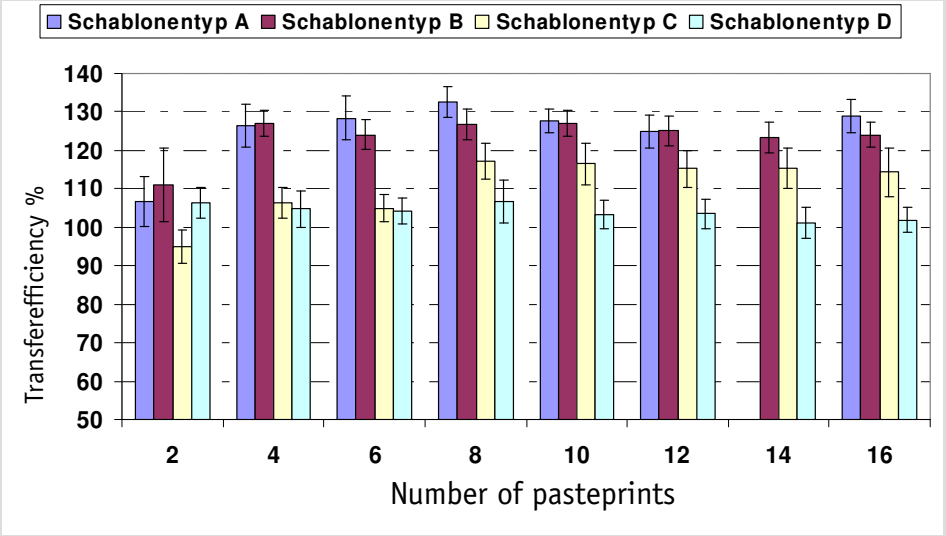


- Aspect ratio:
  QFP(300µm) = 1,18
  QFP(400µm) = 1,57
  QFP(500µm) = 1,97

- 5-Bal-rules:
  QFP(300µm) n.i.O
  QFP(400µm) n.i.O.
  QFP(500µm) i.O.

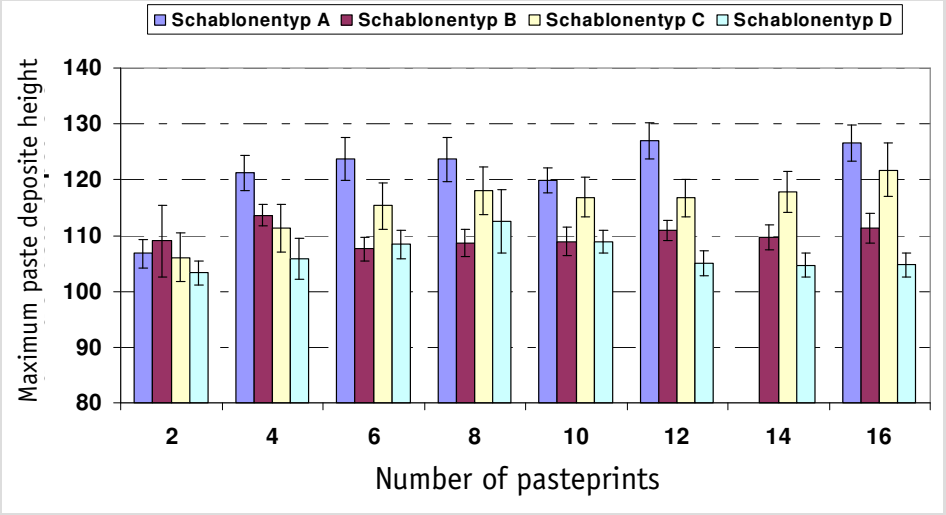
→ additional influence factor:
contamination

Transfer efficiency QFP(400µm)



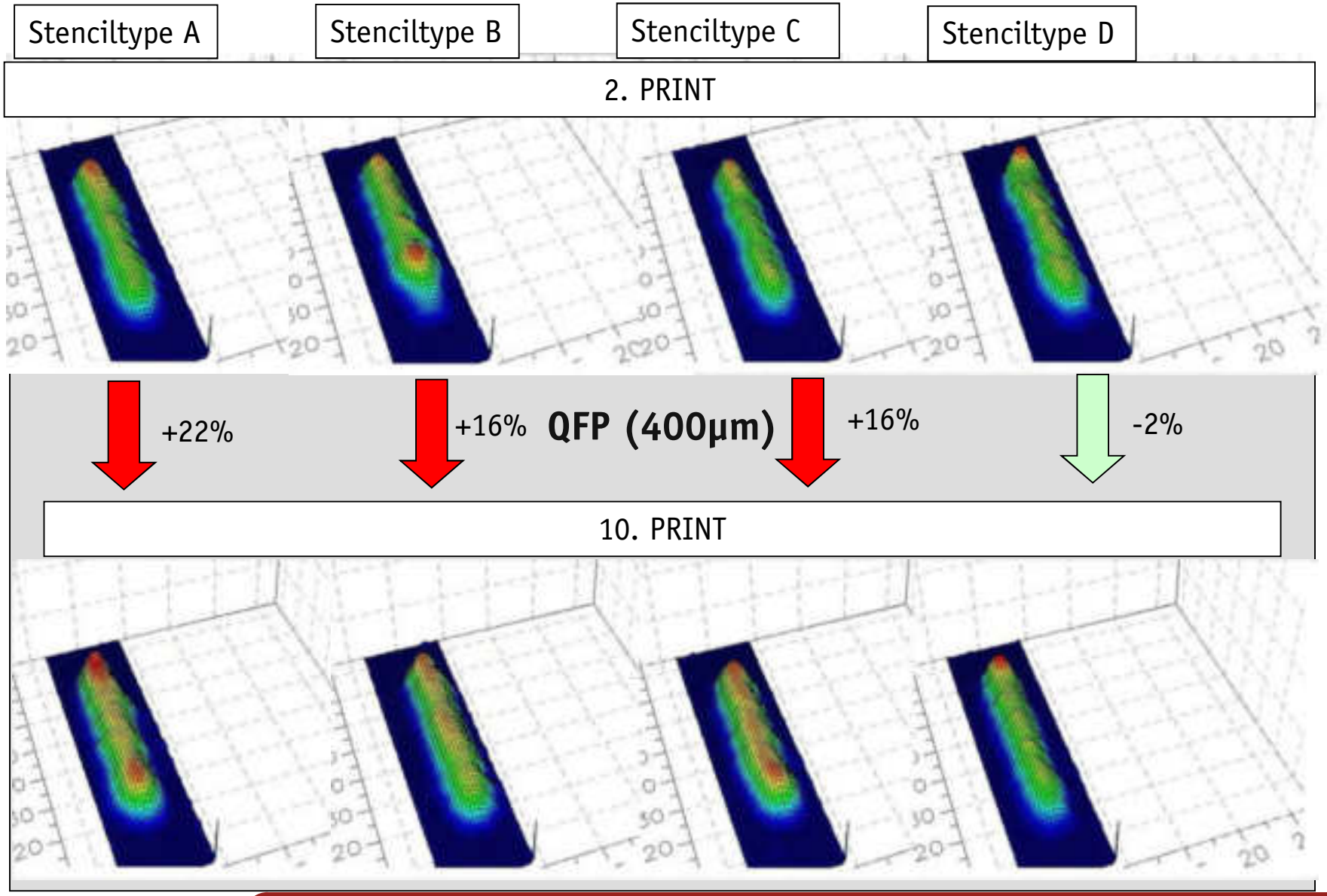
- Stenciltype A, B and C:
  increase of transfer efficiency with increased printing number
- Stenciltype D:
  Constant transfer efficiency with increased printing number
- Stenciltype D:
  Value of transfer efficiency ca. 100% very close to setpoint

Maximum paste depot height QFP(400µm)

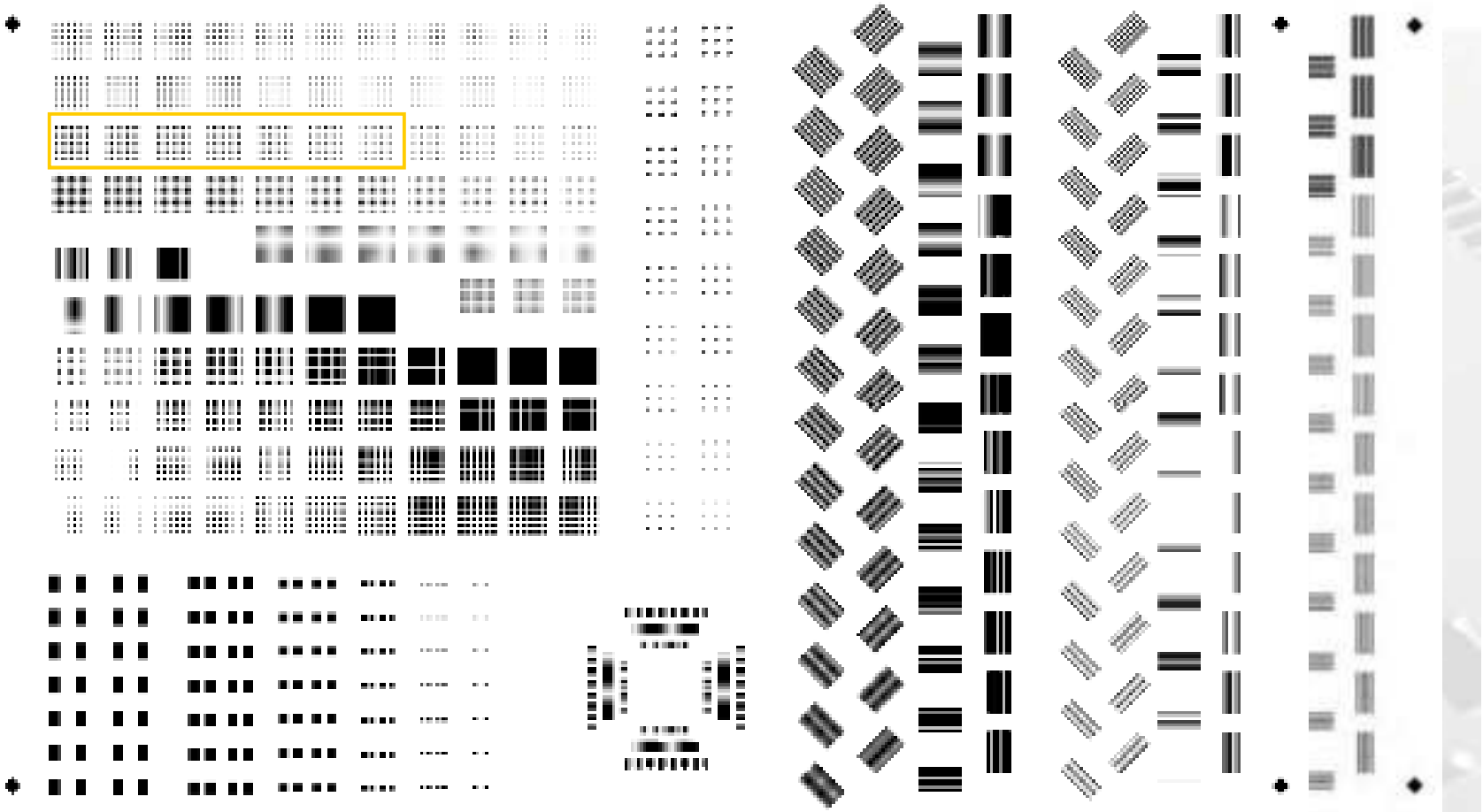


- Analysis of maximum paste depot height correspond with calculated transfer efficiency and confirm the thesis:

→ Tendency of contamination of stencil type A, B and C causes bridging and is mirrowed in higher transfer efficiency and paste depot hights.

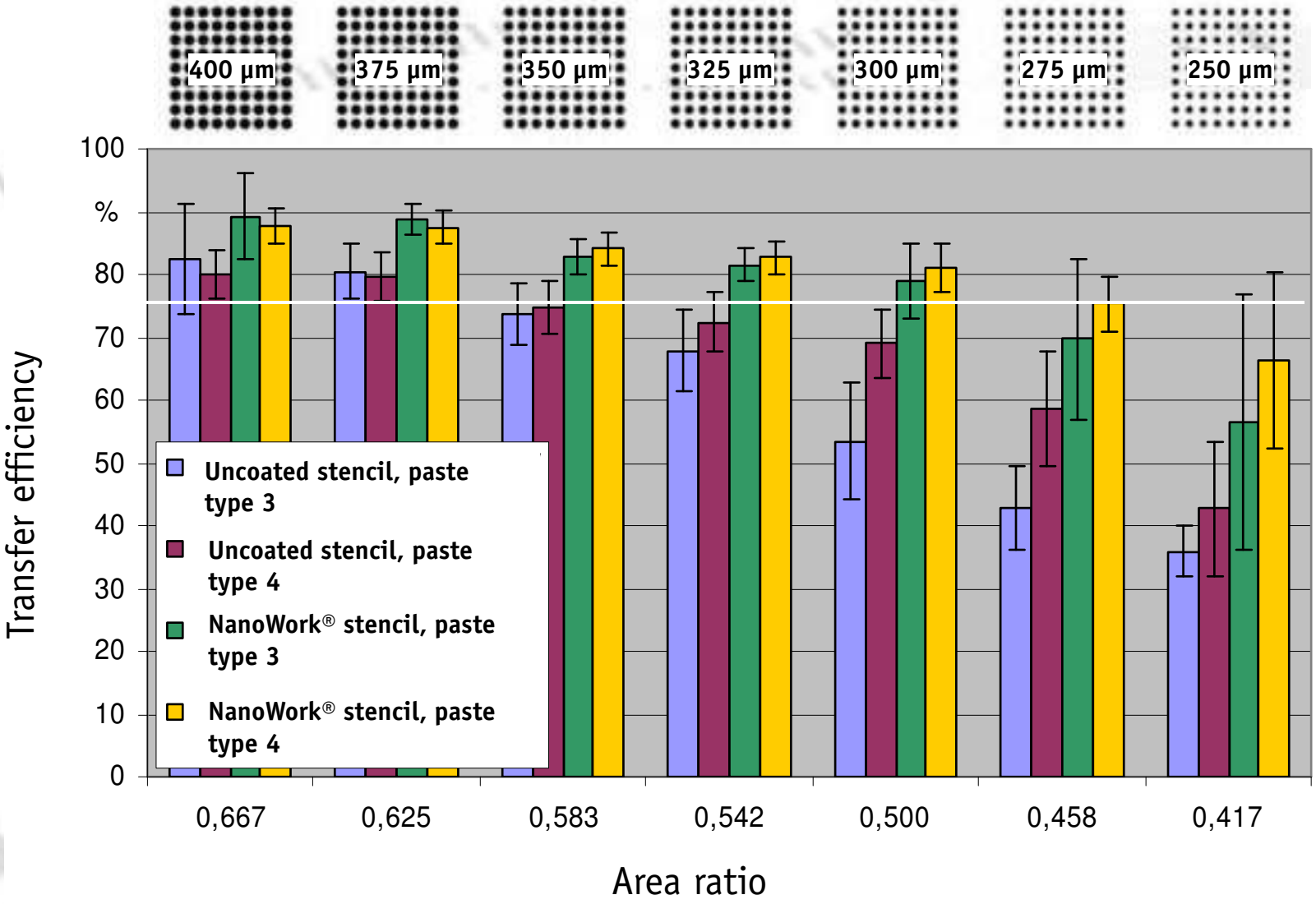

Stenciltype A
Stenciltype B
Stenciltype C
Stenciltype D
2. PRINT
+22%
+16%
QFP (400µm)
+16%
-2%
10. PRINT

Stencil layout to qualify transfer efficiency

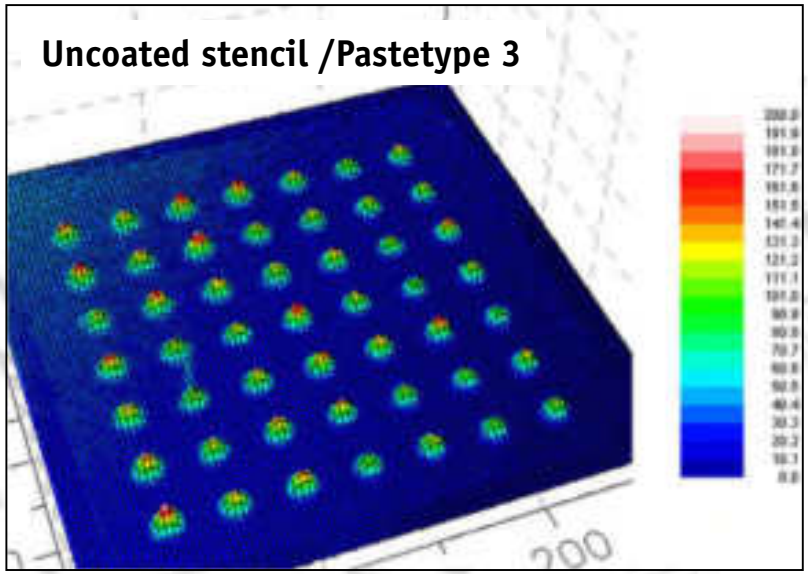


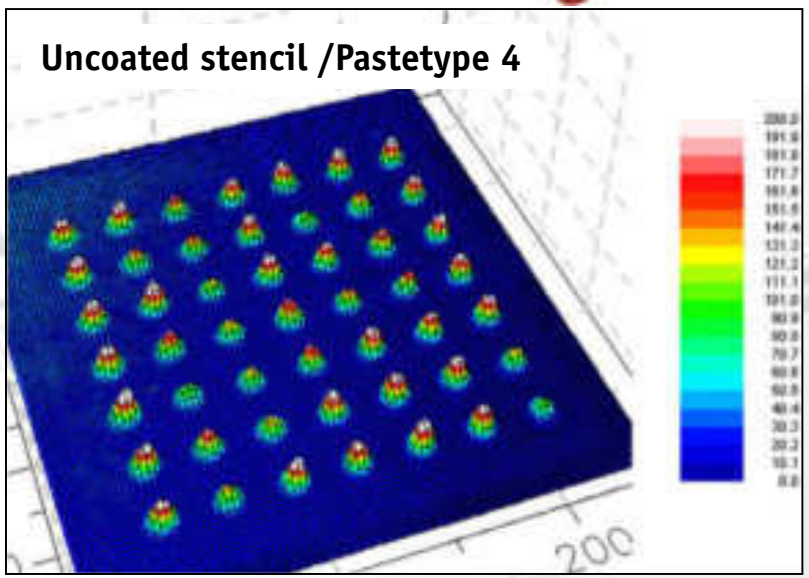
- Stencil:stainless steel, finishing process: brushing, uncoated and coated with NanoWork®, 150 µm thickness
- SAC-solder paste type 3 und type 4 (Heraeus: F640)
- Process parameter: 2,2 N/cm squeegee pressure, 50 mm/s squeegee speed, 10 mm/s, separation speed
- 5 prints without cleaning stencil bottom side (Initial print not considered)

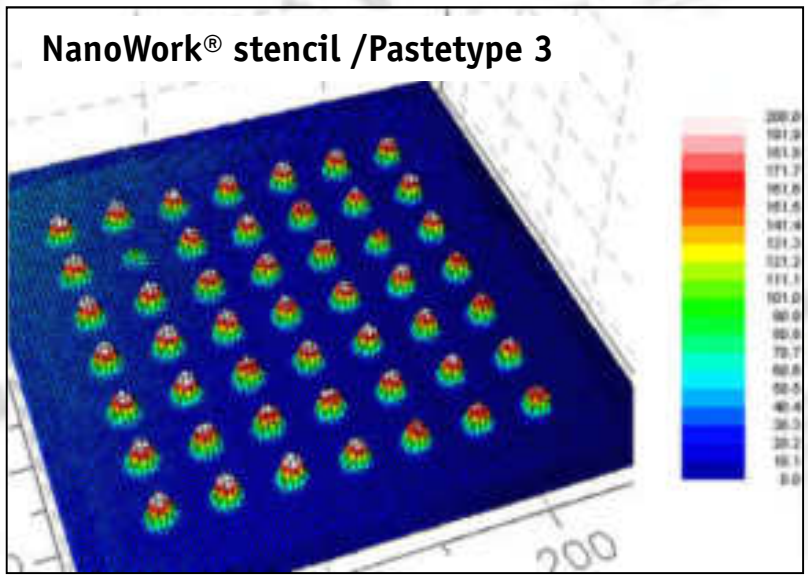
Transfer efficiency in relation to area ratio for BGA´s

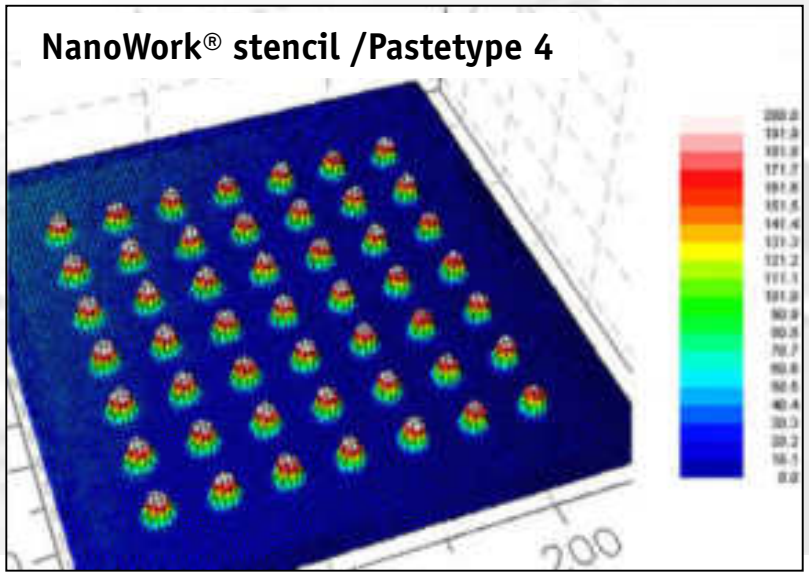


Pastedepot topography after 5 th. print – Area ratio: 0,458









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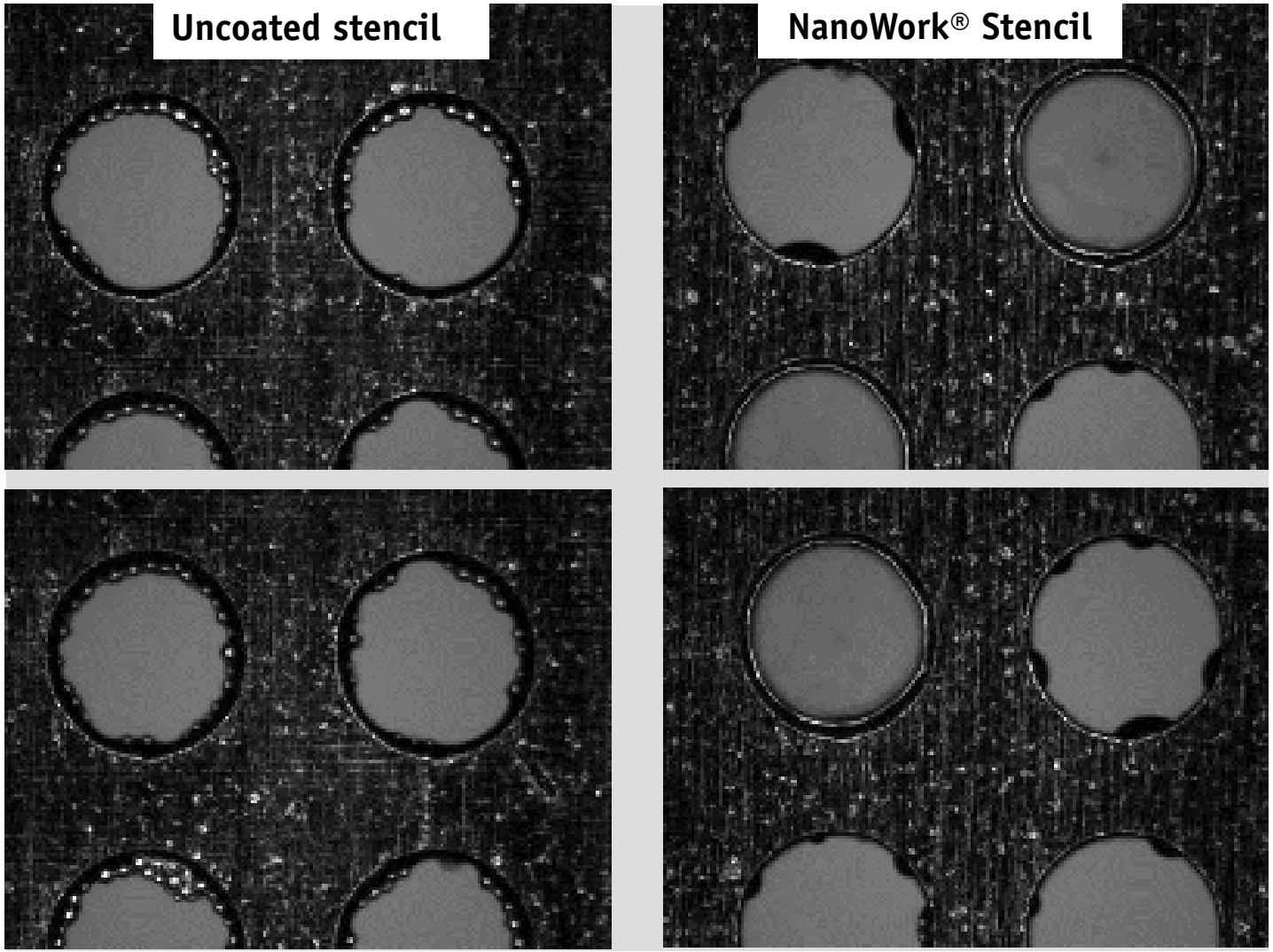
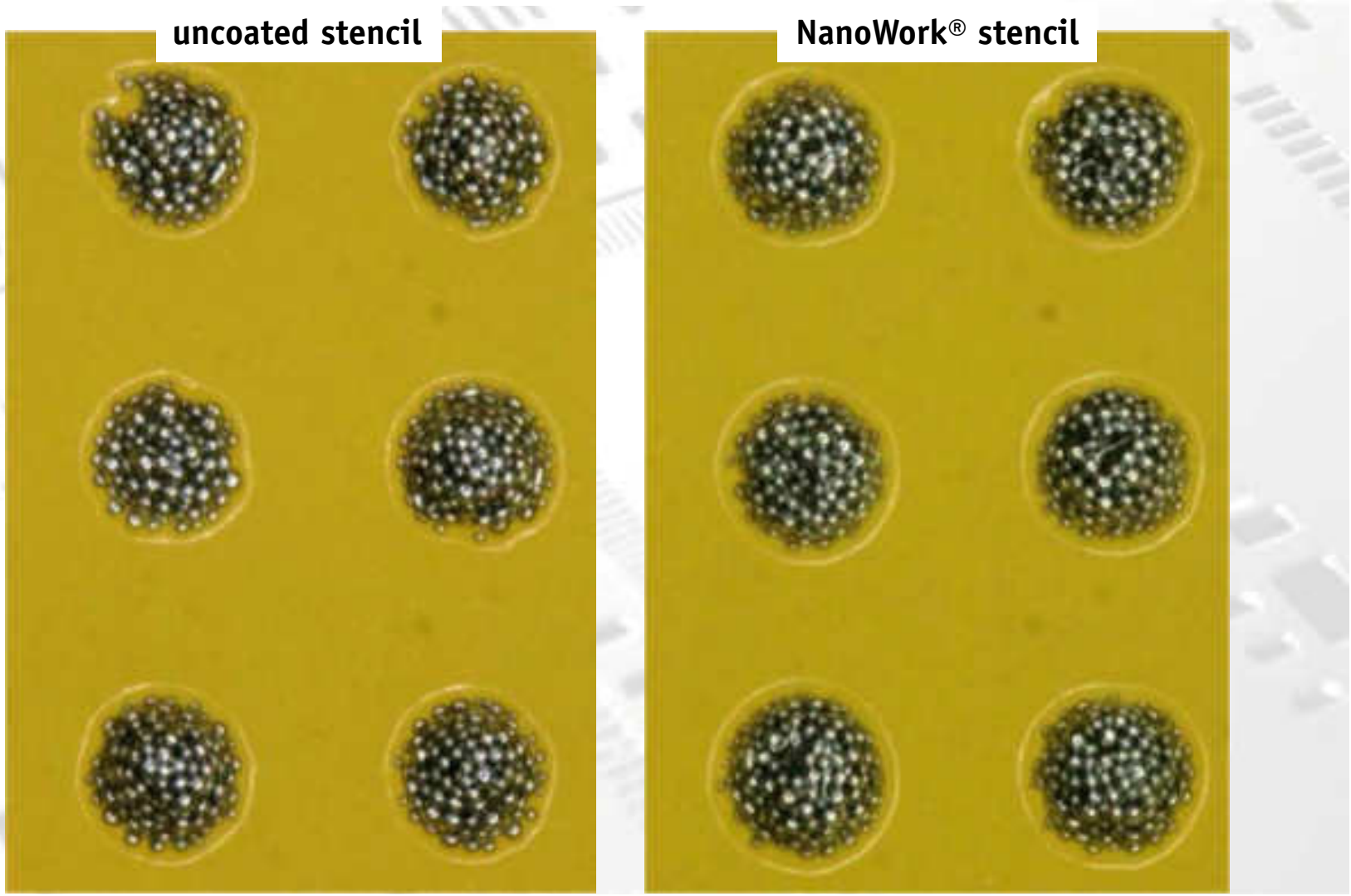
Visual inspection of stencil bottom side after 5th print.
Pastetype 3 – Area ratio: 0,667 (reflected light)



Visual inspection of paste deposites after 5th. print.
Pastetype 3 – Area ratio 0,500



Summary NanoWork® Stencil

- optimized aera ratio
- much better paste release
- better shape of the printed depot
- less cleaning cycles at the board side of stencil, thereby a higher printercapacity
- higher process stabiltiy at board assembly
- constant transfered paste volume over the complete printing process
- less bridging due to the reduced contamination of the stencil bottom side
- Also possible in combination with PatchWork® Technology

LaserJob

Thank you for your attention!