Industrial Experience in the Soldering Process without Lead

Elimination of Lead in the Electronic Production Process

Barcelona 27.6.2006

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Agenda:

1 Technology Roadmap

2 Legislation in Europe

3 Lead Free (LF) Powder

4 Process qualification Solder Paste

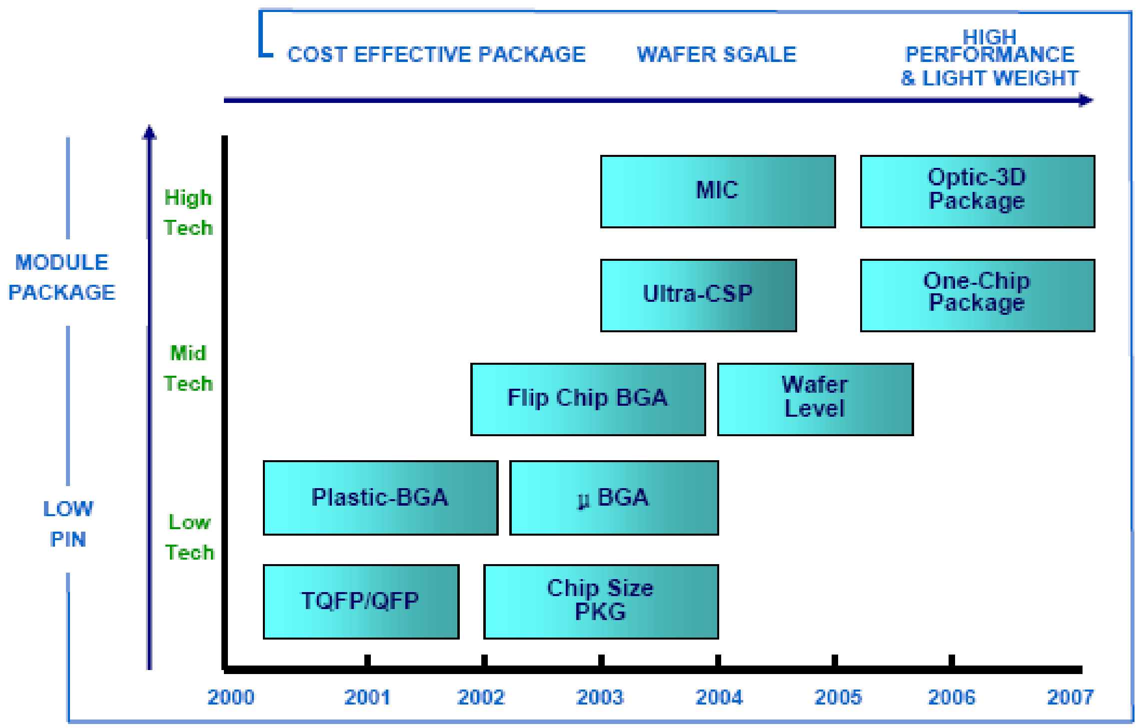
5 Assembling

6 Reliability

7 Summary

1.1 Technology Trend vs. Lead Free

Package Technology

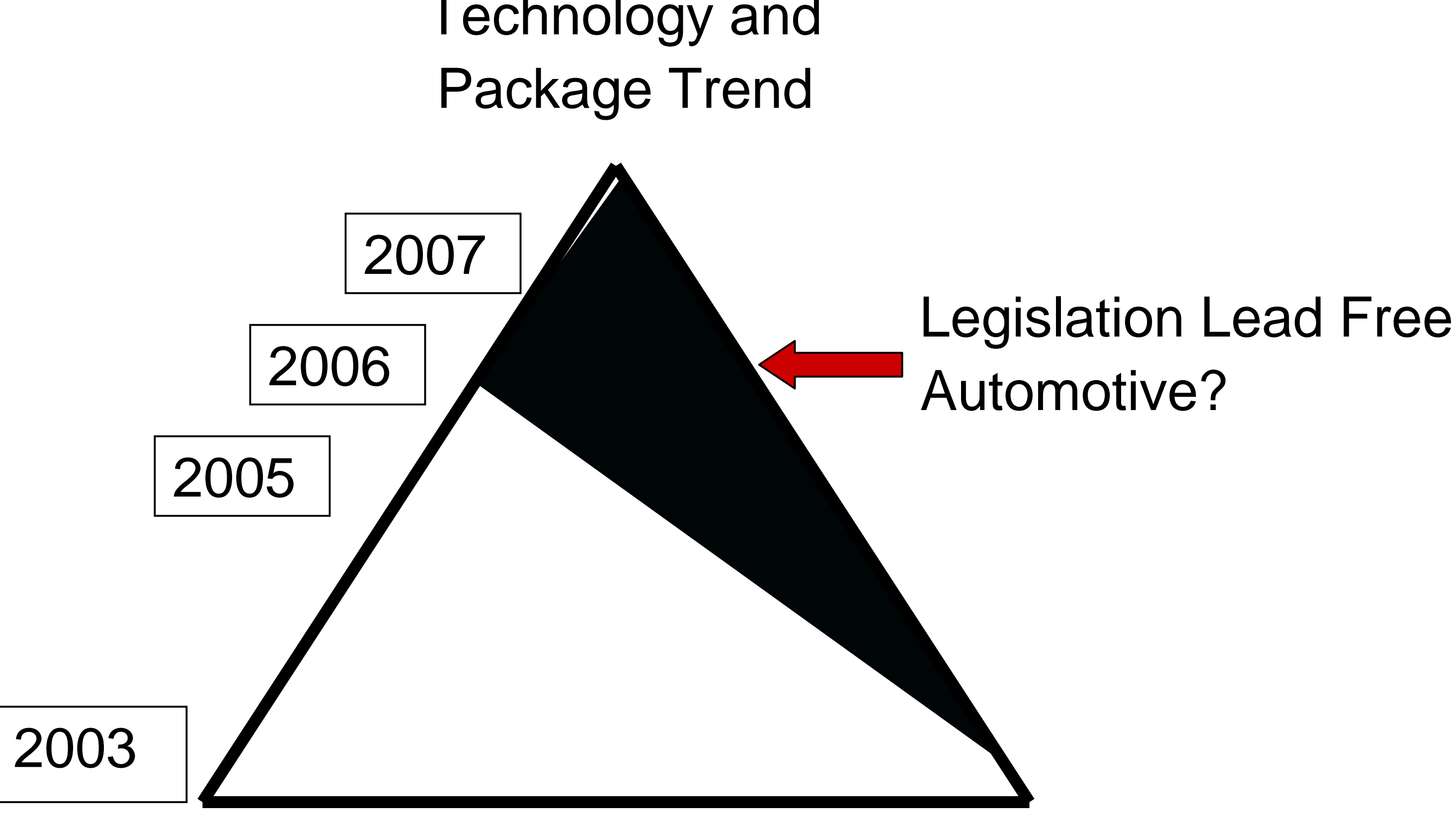


IMAPS Seoul, Sep. 2./3. 2004 Y-E Shin (KMJA/Korea) Thermal Fatigue Life in µBGA and Flip Chip Solder Joints

1.1 Technology Trend vs. Lead Free

IMAPS Seoul, Sep. 2./3. 2004
Y-E Shin (KMJA/Korea) Thermal Fatigue Life in µBGA and Flip Chip Solder Joints

1.1 Technology Trend vs. Lead Free



1.2 Lead Free Legislations World wide

IPC Roadmap:
A guide for assembly of lead-free electronics

(first version released 1999)

EU Directives on waste electrical and electronic equipment (WEEE) from 27.01.2003

(lead-free from 1 July 2006)

China Waste electronic equipment (WEEE) regulation tracking from 08.04.2003

(goal 1 July 2006, or 6 month earlier)

JEITA:
Challenges and efforts towards commercialisation of lead-free solder

(version 2.1; 2002)

Legislation in Europe

2002/96/EG and 2002/95EG EC OF THE EUROPEAN PARLAMENT AND OF THE COUNCIL of/on waste electrical and electronic equipment (WEEE); Brussels 27.Jan. 2003

Directive on the Restriction of the Use of Certain Hazardous Substances (RoHS) in Electrical and Electronic Equipment, dated 13 Feb. 2003.

2002/96/EG and 2002/95EG EC OF THE EUROPEAN PARLAMENT AND OF THE COUNCIL of/on waste electrical and electronic equipment (WEEE); Brussels 27.Jan. 2003

Article 4

Prevention

1. **Member** States shall ensure that, **from 1 July 2006**, new electrical and electronic equipment put on the market does not contain lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls **(PBB) or** polybrominated diphenyl ethers (PBDE). **National measures restricting or prohibiting the use of these substances in electrical and electronic equipment which were adopted in line with Community legislation before the adoption of this Directive may be maintained until 1 July 2006.**

Directive (ROHS) on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment, dated 13 Feb. 2003

Art. 4: Prohibition of:

Lead, mercury, cadmium, hexavalent chromium, PBB (polybrominated biphenyls) and PBDE (polybrominated diphenyl ethers)

Deadlines for Prohibitions of Materials:

EU Comission (1998 bzw. 2000):	1st Jan. 2004, resp. 2008
EU Parliament (04/2001):	1st Jan. 2006
EU Council of Ministers (12/2001):	1st. Jan. 2007
EU Parliamant 2nd reading (04/2002):	1st. Jan. 2006
Official Journal of the European Communities dtd. 13 Feb. 2003:	1st July 2006

Directive on the Restriction of the Use of Certain Hazardous Substances (ROHS)

Following equipments are concerned

- Large and small household appliances
- IT and telecommunications equipment
- Consumer equipment
- Lighting equipment
- Electrical and electronic tools (exception: large-scale stationary industrial tools)
- Toys, leisure and sports equipment
- Medical devices (exceptions: implanted or infected products)
- Monitoring and control instruments
- Automatic dispensers.

Directive on the Restriction of the Use of Certain Hazardous Substances (ROHS), **Exceptions for Pb:**

- Pb in solder materials with high melting points (SnPb alloy with >85% Pb)
- Pb in solder materials for servers, storage systems and storage-array-systems (until 2010)
- Pb in solder materials for network infrastructure devices for switching, for signal processing, transfer and network management, in telecom.
- Pb in ceramic electronic components (e.g. piezo-electric components)
- Pb in the glass of cathode-ray tubes, electronic components and fluorescent tubes
- Pb as an element of the alloy in steal (<0.35%), in Al (<0,4%) and in Cu (<4% W/W)
- Military applications.

Main topic for changing to LF: costs, technologies and others

Kostenfaktor verbunden mit technologischen und logistischen Problemen

RoHS-Umstellung

Kosten, technologische Herausforderungen und organisatorische Anpassungen sind die Hauptprobleme bei der Umstellung

ELEKTRONIK PRAXIS GRAFIK

Hauptprobleme

- Kosten: 35%
- Technologie: 35%
- andere: 30%

Kosten

- Lote: 11%
- Material: 11%
- Prozesse: 33%
- Investitionen: 45%

Technologie

- Temperaturstress: 33%
- Benetzungsprobleme: 11%
- Qualität/Zuverlässigkeit: 56%

andere Probleme

- Bauteileverfügbarkeit: 48%
- Patente: 4%
- Schulung: 39%
- andere: 9%

Quelle: ELFNET

3 Lead Free Powder

- **3.1 Preferred Solder**
- **3.2 Patents SAC**
- **3.3 LF solders of different composition in use**

3.1 Preferred SnAgCu (SAC) Solder

SnAg3.9Cu0.6	**NEMI**
SnAg3.5Cu0.75	**JEITA-Project**
SnAg3.0Cu0.5	**JEITA-Roadmap**
SnAg(3.4-4.1)Cu(0.45-0.8	**ITRI**
Examples:	
SnAg4.0Cu0.5	**Intel**
SnAg(3.2-4.0)Cu(0.5-0.9)	**Nokia**
SnAg3.8Cu0.7	**Motorola**
SnAg3.0Cu0.5	**SEA**
SnAg(3.3-4.7)Cu(0.3-1.8)	**National under Evaluation**
SnAg3/4Cu0.5	**Heraeus (Customers)**

3.2 Patens / Composition

Alloy name	Patent #	Patent holder
▪ Sn96.5Ag3Cu0.5	JP PAT #. 3027441	Senju
		US PAT #. 5527628 IOWA U.C.
▪ Sn95.8Ag3.5Cu0.7	JP PAT #. 3027441	Senju
		US PAT #. 5527628 IOWA U.C.
▪ Sn95,5Ag3.8Cu0.7	JP PAT #. 3027441	Senju
		US PAT #. 5527628 IOWA U.C.

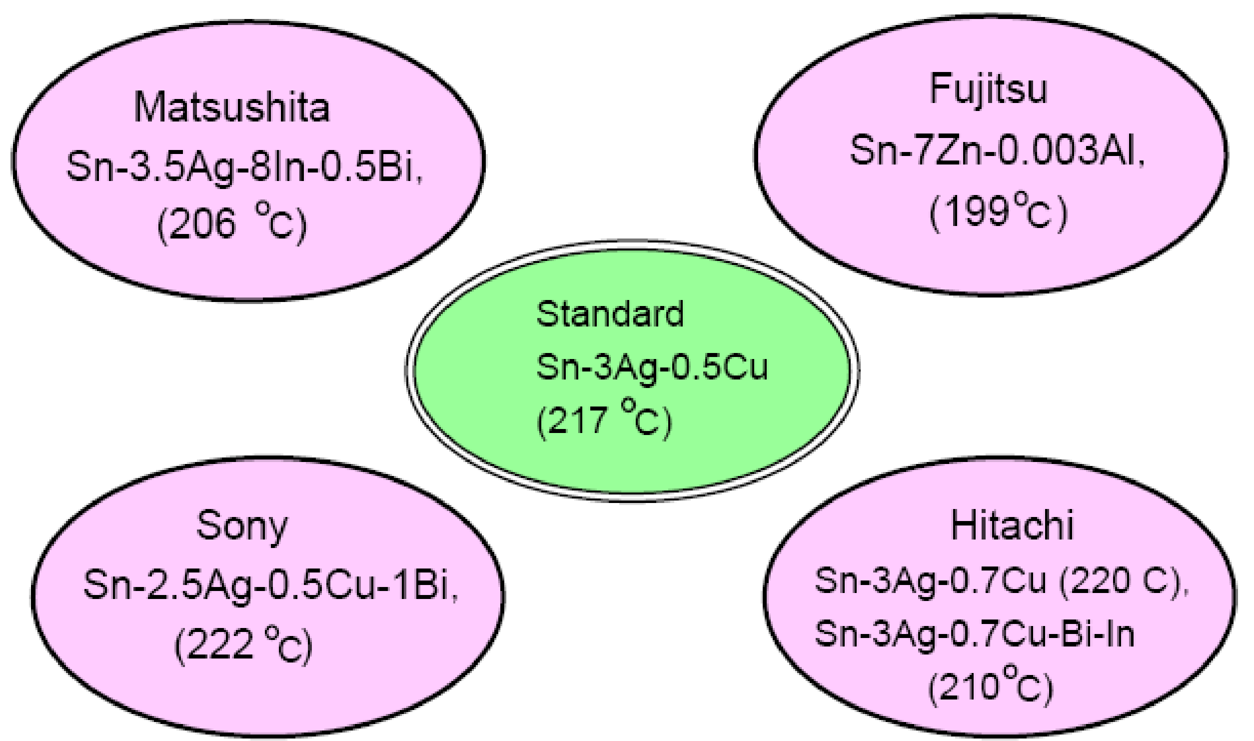
3.2 Patens / International LF

Pb-free patents

Company	Number of patents and Applications
Matusushita Electric	43
IBM	26
Mitsui M&S	18
Hitachi	17
AT&T	12
Indiun Corp.	11
Senju Metal Industry	10
Nihon Superior Sha	9
Alpha Fry	8
Mitsubishi	8
J.W. Harris	7
Fujitsu	7
Murata	7
Ford Motor	7
Nippon sheet Glass	6
Multicore Solders	6
Fuji Electric	5
Cookson Group	5
Seelig & Lockard (CASTIN)	5
Topy Industries	5
Samsumg	5
Advanced Interconnect Tech.	4
H-Technologies Group	4
Uchihashi Estec	4
Tokuriki Honten	4
Delphi Technologies	3
Tokyo First Trading	3
Weilang-Werker	3
Iowa State / Ames Lab	3
Fukuda Metal Foil & Powder	3
Engelhard	3
Seiko Epson	3
Lucent Technologies	3

IMAPS Seoul, Sep. 2./3. 2004 K-L Lin (National Cheng Kung Univ./Taiwan) Review of Pb-free Activities in Taiwan

3.3 LF- solders of different composition in use



IMAPS Seoul, Sep. 2./3. 2004
S. Denda (Nagano Institute of Technology/Japan) History and Current State of Pb-free Soldering Technology in Japan

4 Process qualification

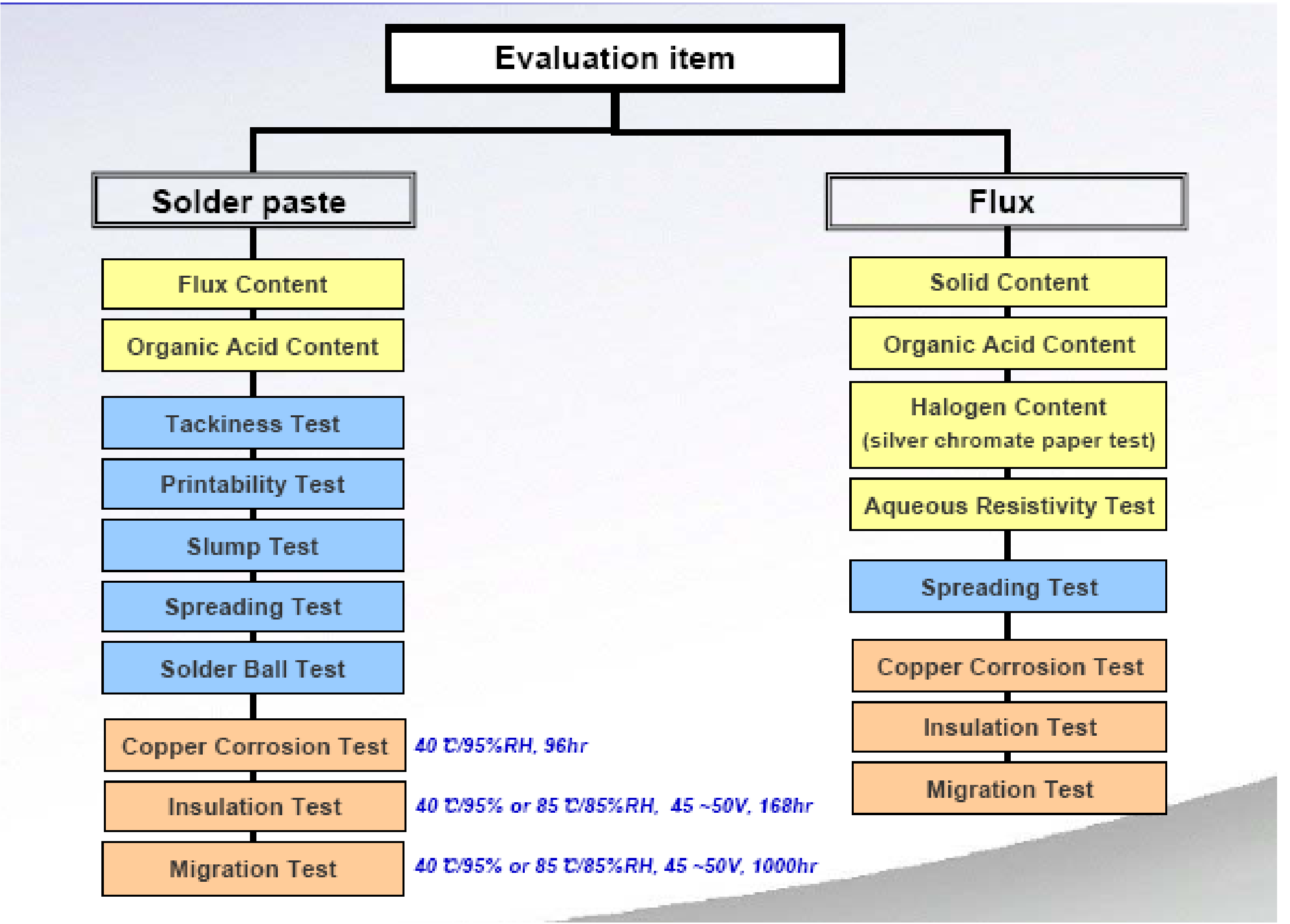
- **4.1 Complex of Solder Material and Process Evaluation**
- **4.2 Solder Paste Qualification**
- **4.3 Temperature Profiles**
- **4.4 Wetting**
- **4.5 Solder Balling Test**
- **4.6 SIR**
- **4.7 Benchmarking Procedure**
- **4.8 Process Window**

4.1 Complex of Solder Material and Process Evaluation

Process Reliability	**vs.**	**Product Reliability**
Solder paste quality (Standards)		SIR
Wetting		Voids
Spreading		TCT
Phys./chem. Properties		RH
Metallurgical Properties		Thermo-/ mechanical stress
Dissolution		……
IMC – Formation		
T – Profiling		Target:
Compatible to Comp./Board Finishes		SAC $\geq$ SP/SPA
Inspection		
……		

ZVEI 15.Sep. 2004; J.Albrecht, Siemens AG CT MM6; Anforderungen an bleifreie Elektronik in den einzelnen Anwendungsbereichen - Industrieelektronik

4.1 Complex of Solder Material and Process Evaluation



IMAPS Seoul, Sep. 2./3. 2004 S-M Hong (Samsung Electronics/Korea) Lead-free Implementation and Issues in Electronic Set Makers

4.1 Complex of Solder Material and Process Evaluation

To insure materials & mfg. process integrity

To insure quality & reliability in market

- **Materials and Mfg. Test**
  - **Materials Tests** (PCB, Solder, Comp.)
    - Solder Properties Evaluation (10 Items)
    - PCB Surface Finish OSP, Ni/Au, Sn
    - Component Plating SnPb, Sn, SnBi
  - **Mfg. Evaluation**
    - Printing Test
    - Bridge Test
    - Wetting Test
    - Solder ball
    - Non Melting
    - Tombstone
    - Self-Alignment
    - TH-hole filing
  - Materials & Mfg. SPEC.
- **Reliability Tests**
  - **Board Level Test**
    - Thermal Shock
    - Temp./Humidity
    - High Temp. Storage
    - HALT
    - Migration Test
    - Ionic Test
    - Bond Strength
    - Cross Section (crack occurrence)
    - Whisker
    - Electronic Function
  - **SET Level Test**
    - ALT TEST
    - Temp./ Humidity Cycle Test
    - Vibration Test
    - Drop Test
    - Shock Test
    - Voltage Limit Test
    - Power Noise Test
    - ESD, EOS

IMAPS Seoul, Sep. 2./3. 2004S -M Hong (Samsung Electronics/Korea) Lead-free Implementation and Issues in Electronic Set Makers

4.2 Solder Paste Qualification

4.2 Solder Paste Qualification

Reliability Printing Process

Reliability Board Level

Boards
Type + Surface

Components Type + Finishes

Printing

3 D-Inspection

Pick and Place

Soldering

AOI

X - Ray

Cross Section

Pull Test

Electrical stress

Thermo/ mech. stress

Climate stress

Reports etc.

Parameter

Solder Paste Volume

Profile Window
N / 0
V$_2$P. Soldering

Parameter Optimizing

4.3 Temperature Profiles

- **4.3.1 Profile Window**
- **4.3.2 Linear Profile (HLF)**
- **4.3.3 Profile P5**
- **4.3.4 Profile acc. J-STD 020B**

4.3.1 Profile Window

Profile Window

Temperature [°C]

300
250
200
150
100
50
0

0 50 100 150 200 250 300 350 400 450

TIme [sec.]

LF high
LF low
LC low
LC high

4.3.1 Profile Window

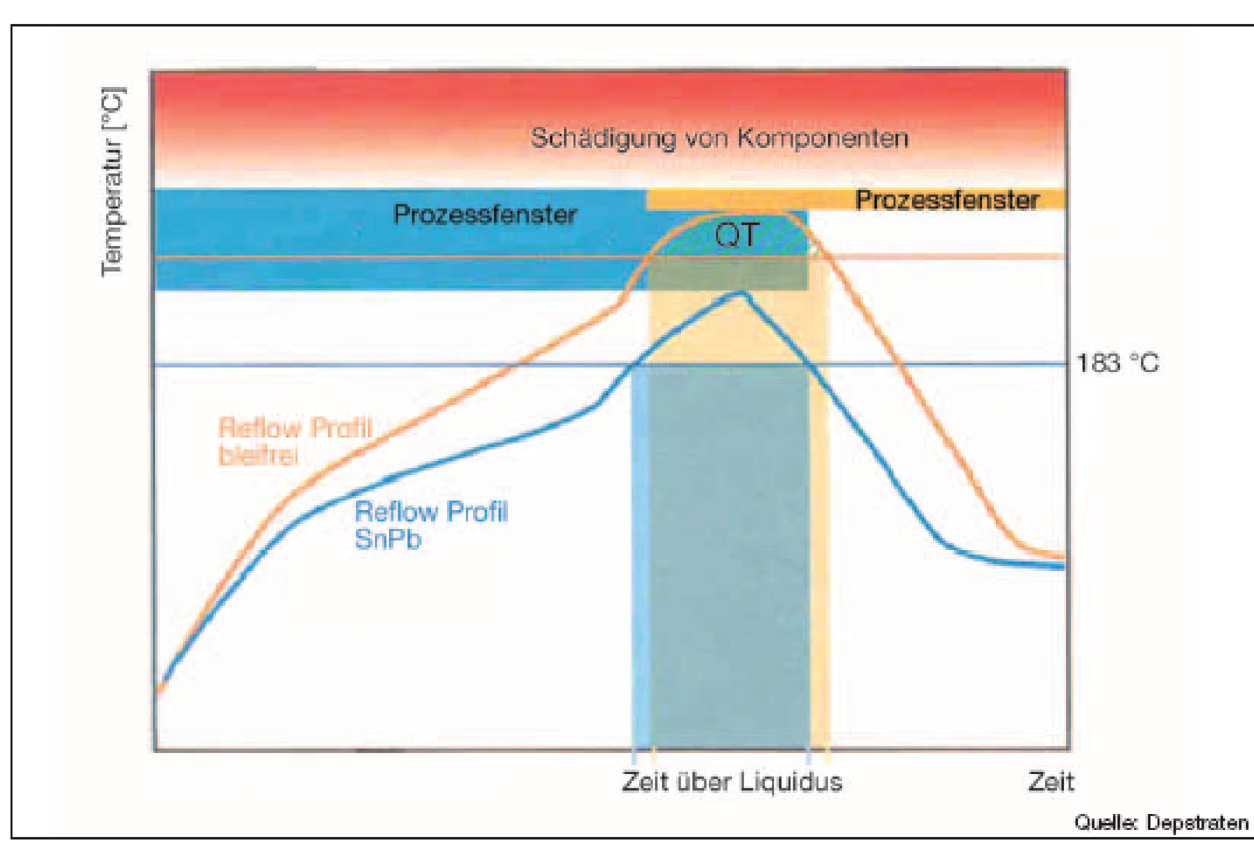


Bild 10 Reflow Prozessfenster für SnAg und SnAgCu

4.3.2 Linear Profile (HLF)

Heraeus LeadFree modifiziert — Wednesday February 26, 2003 12:00:33

Company: Heraeus
Oven Name: rehm SMS-V6-N2 3300_80-400

Site: Heraeus LeadFree modifiziert (HLF O2+N2)

Setpoints (Celsius)

Zone	1	2	3	4	5	6	7
Top	185	160	175	220	250	310	290
Bottom	185	160	175	220	250	310	290

Conveyor Speed (cm/min): 80.0

PWI= 130%	Max Rising Slope		Preheat 60-200C		Soak Time 200-217C		Reflow Time /217C		Peak Temp		Tot Time /230C	
PCB	2.3	89%	192.7	111%	6.7	-122%	59.8	32%	253.8	88%	46.5	6%
BQFP	1.9	62%	188.3	93%	12.6	-83%	54.6	-2%	238.6	-64%	28.2	-67%
SO8	1.9	58%	193.5	114%	8.2	-112%	57.9	19%	252.0	70%	41.8	-13%
BGA08	1.5	33%	197.6	130%	11.5	-90%	50.7	-29%	242.6	-24%	33.5	-46%

KIC Thermal Profiling
San Diego, CA USA

Profiled Using KIC 2000 Technology
Tel: +1 858 673 6050
Fax: +1 858 673 0085

www.kicthermal.com
tech@kicmail.com

4.3.3 Profile P5

BLEIFREI - TESTPROFIL — Tuesday February 25, 2003 19:25:04

Company: Heraeus

Oven Name: rehm SMS-V6-N2 3300_80-400

Site: BLEIFREI (JLF O2 + N2)

Setpoints (Celsius)

Zone	1	2	3	4	5	6	7
Top	132	213	255	200	214	293	294
Bottom	132	213	255	200	214	293	294

Conveyor Speed (cm/min): 53.9

PWI= 433%	Max Rising Slope		Preheat 150-190C		Soak Time 190-200C		Reflow Time /217C		Peak Temp		Tot Time /230C	
PCB	1.8	51%	39.6	-4%	129.1	191%	92.8	28%	263.3	166%	79.4	70%
BQFP	1.6	43%	83.3	433%	73.4	-366%	96.7	67%	253.1	-38%	76.9	63%
SO8	1.5	39%	42.7	27%	128.8	188%	90.0	0%	260.6	111%	73.4	53%
BGA08	1.1	25%	70.3	303%	87.4	-226%	87.2	-28%	255.3	6%	68.6	39%

KIC Thermal Profiling
San Diego, CA USA

Profiled Using KIC 2000 Technology
Tel: +1 858 673 6050
Fax: +1 858 673 0085

www.kicthermal.com
tech@kicmail.com

4.3.4 Profile acc. J-STD 020B

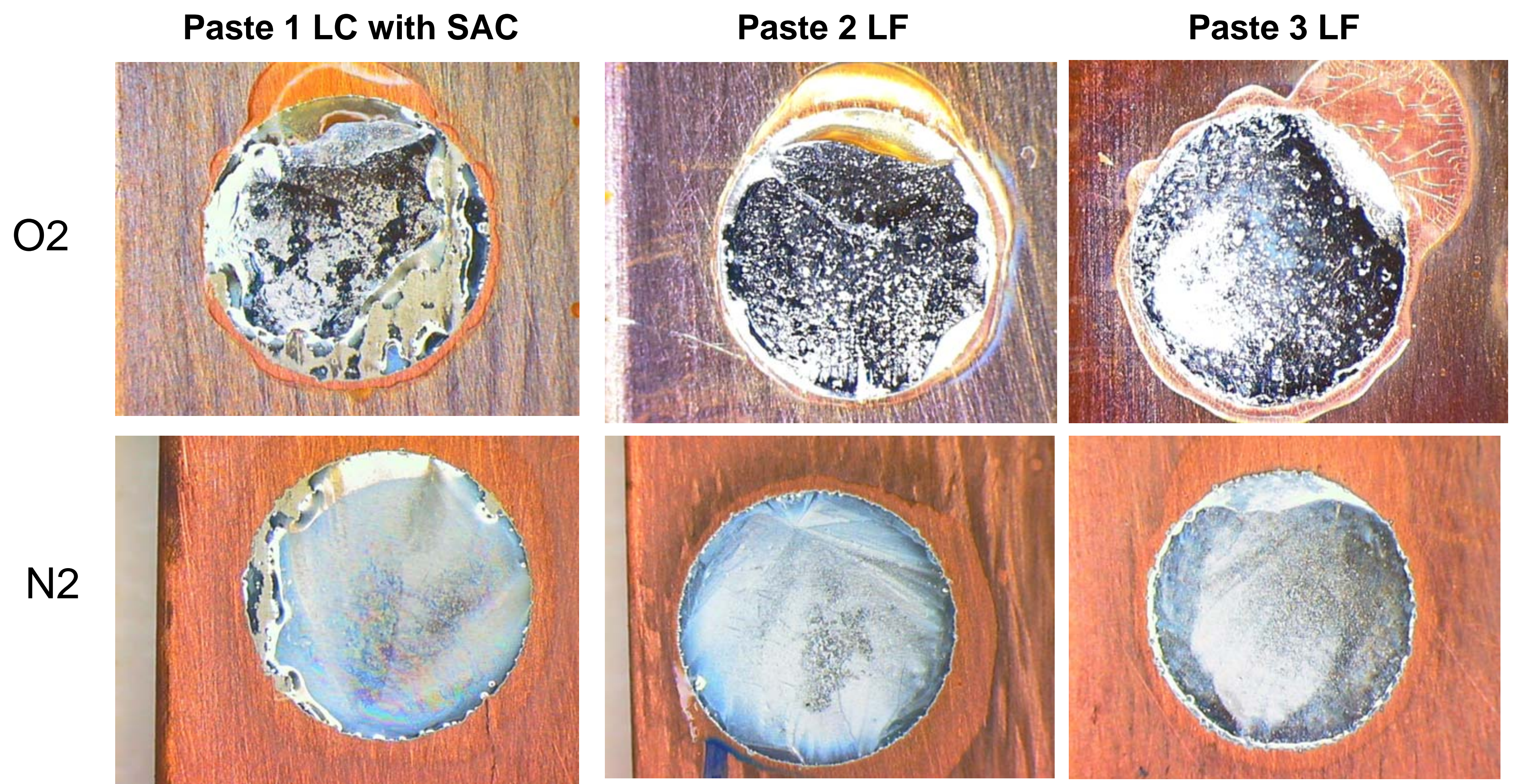
Tp
tp
Critical Zone
T_L to Tp
Ramp-up
T_L
Tsmax
t_L
Tsmin
ts
Preheat
Ramp-down
25
t 25°C to Peak
Temperature
Time
IPC-020b-5-1

4.3.4 Profile acc. J-STD020B

Profile Feature	Sn-Pb Eutectic Assembly		Pb-Free Assembly	
	Large Body	Small Body	Large Body	Small Body
Average ramp-up rate (T_L to Tp)	3°C/second max.		3°C/second max.	
Preheat – Temperature Min (Ts_{min}) – Temperature Max (Ts_{max}) – Time (min to max) (ts)	100°C 150°C 60-120 seconds		150°C 200°C 60-180 seconds	
Tsmax to T_L – Ramp-up Rate			3°C/second max	
Time maintained above: – Temperature (T_L) – Time (t_L)	183°C 60-150 seconds		217°C 60-150 seconds	
Peak Temperature (Tp)	225 +0/-5°C	240 +0/-5°C	245 +0/-5°C	250 +0/-5°C
Time within 5°C of actual Peak Temperature (tp)	10-30 seconds	10-30 seconds	10-30 seconds	20-40 seconds
Ramp-down Rate	6°C/second max.		6°C/second max.	
Time 25°C to Peak Temperature	6 minutes max.		8 minutes max.	

Note: All temperatures refer to topside of the package, measured on the package body surface.

4.4 Wetting HLF



4.4 Wetting P5

	Paste 1 LC with SAC	Paste 2 LF	Paste 3 LF
O2			
N2			

4.5 Solder Balling HLF

	Paste 1 LC with SAC	**Paste 2 LF**	**Paste 3 LF**
O2			
N2			

4.5 Solder Balling P5

	Paste 1 LC with SAC	**Paste 2 LF**	**Paste 3 LF**
O2			
N2			

4.6 Surface Insulation Resistance

- **SIR-Measurement: 40°C/92%RH/5V; all 4h; 8 comps**

SIR Messung

Ohm

1,00E+13
1,00E+12
1,00E+11
1,00E+10
1,00E+09
1,00E+08
1,00E+07

Paste 1 LC with SAC
Paste 2 LF
Paste 3 LF

Initial
14 d

Automotive

4.6 Surface Insulation Resistance

- **SIR-Messung: 85°C / 85% r.F / 100 V /Measurement all 4h**

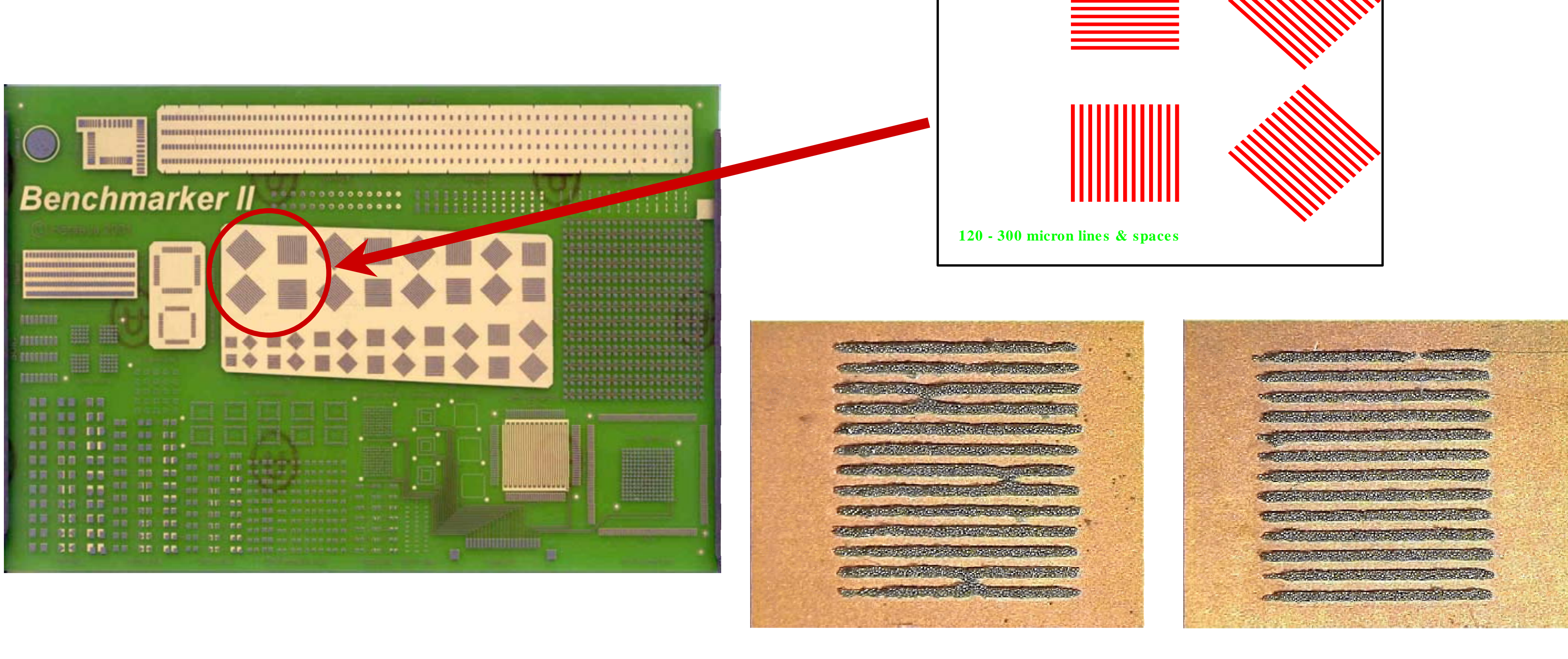
4.7 Benchmarking Procedure

- **4.7.1 Benchmarker II Testboard**
- **4.7.2 Lineresolution**
- **4.7.3 Hot Slump and Spread**
- **4.7.4 Wetting**
- **4.7.5 Print after wait**

4.7.1 Benchmarker II Testboard

4.7.2 Lineresolution

4.7.2 Lineresolution



Bridges

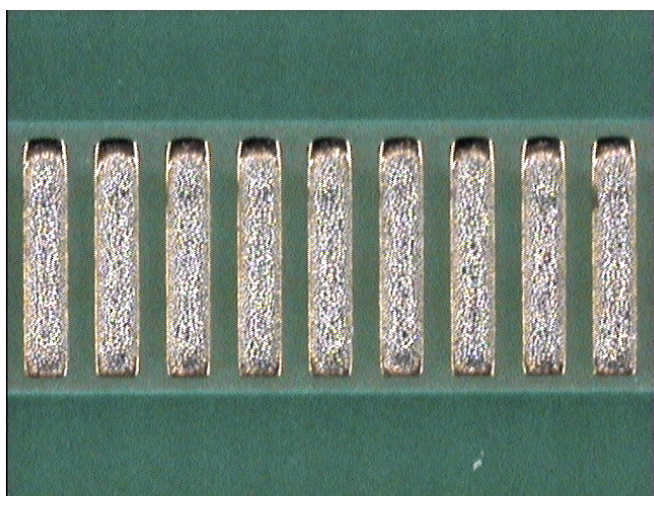
Bridges are defective

Line Opens

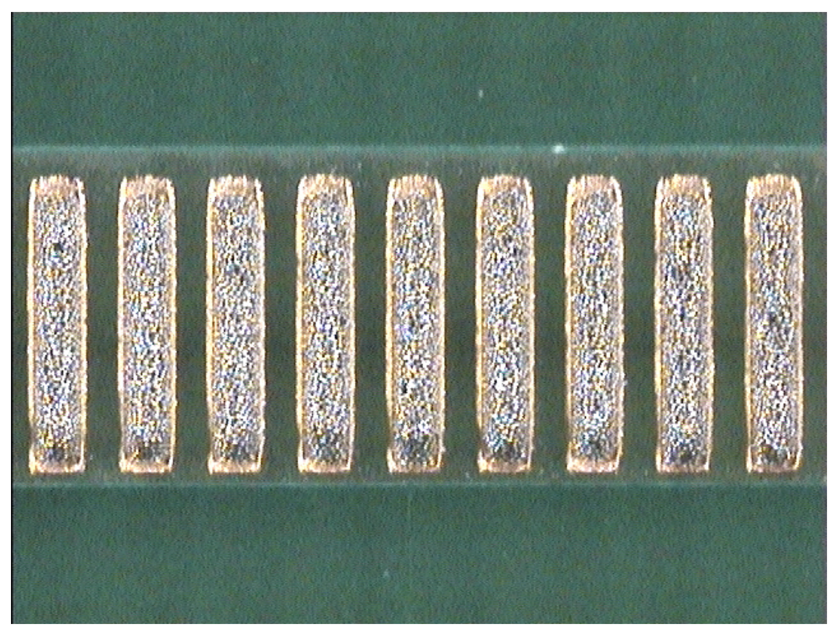
Open lines are defective

4.7.2 Lineresolution

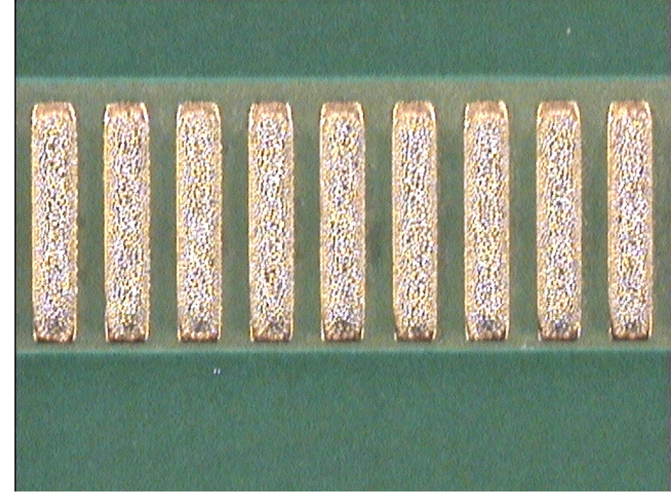
Board 15; 230 µm Aperture, Perpendicular to Squeegee; PS=12 SS=2, 10, 15 [mm/sec]



SS = 10 mm/sec.



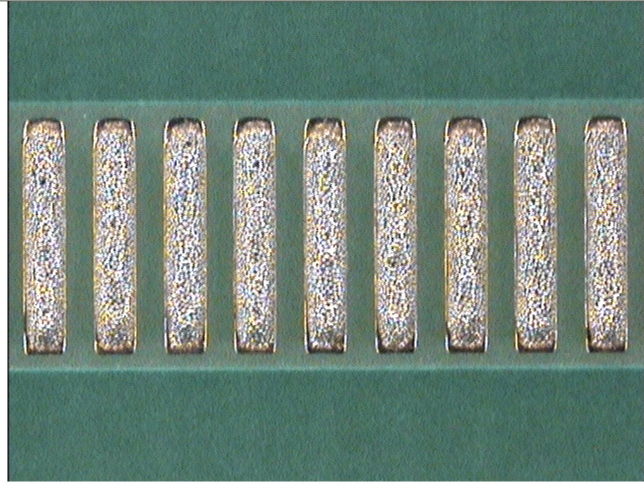
SS = 2 mm/sec.



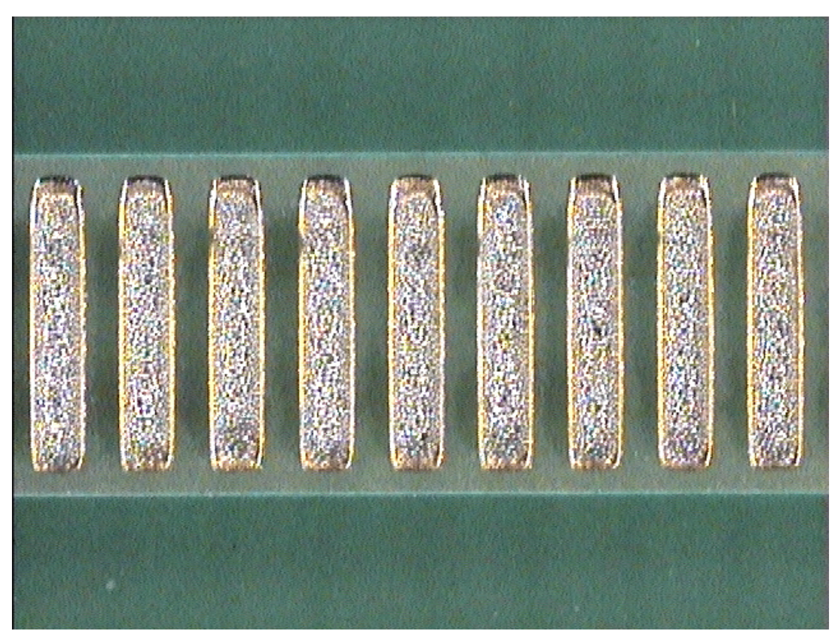
SS = 15 mm/sec.

4.7.2 Lineresolution

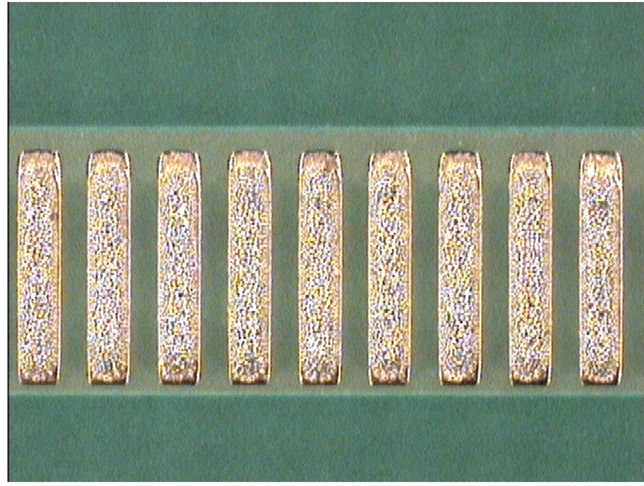
Board 16; 230 µm Aperture, Perpendicular to Squeegee; PS=12 SS=2, 10, 15 [mm/sec]



SS = 10 mm/sec.



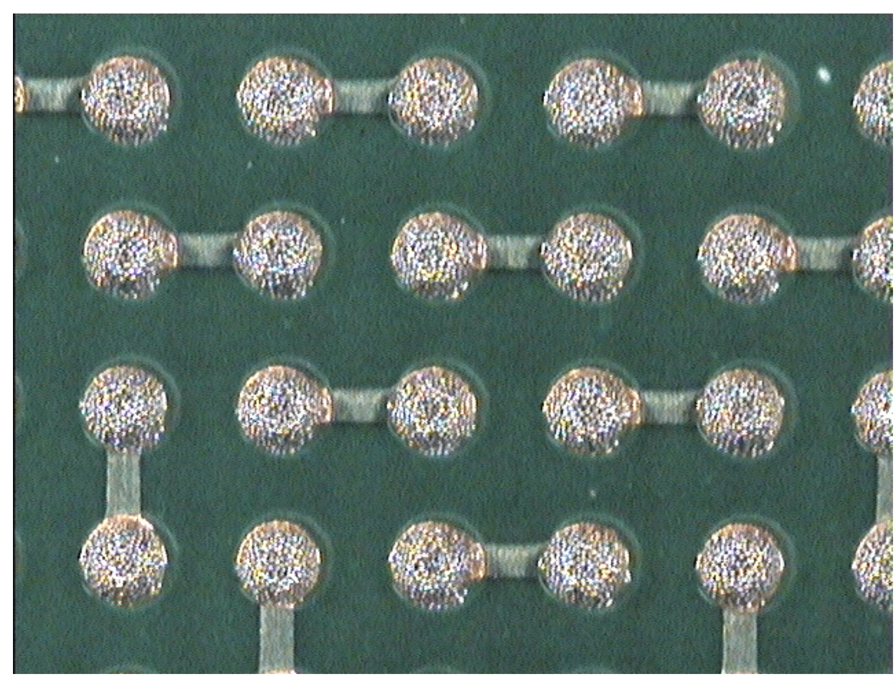
SS = 2 mm/sec.



SS = 15 mm/sec.

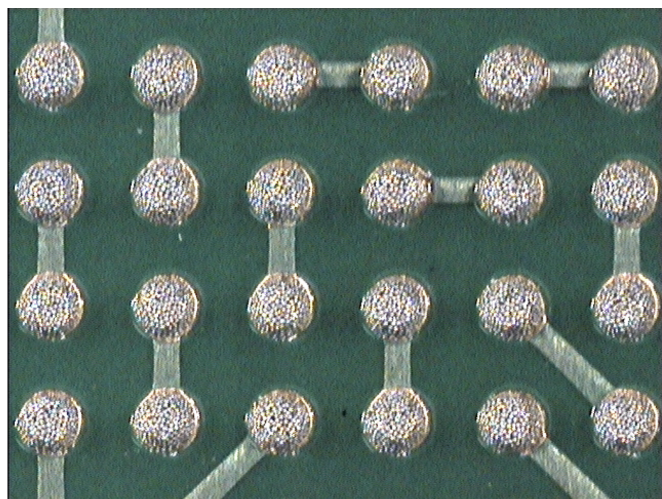
4.7.2 Lineresolution

Board 15; 380 µm Aperture, µBGA;
PS=12 SS=2, 10, 15 [mm/sec]



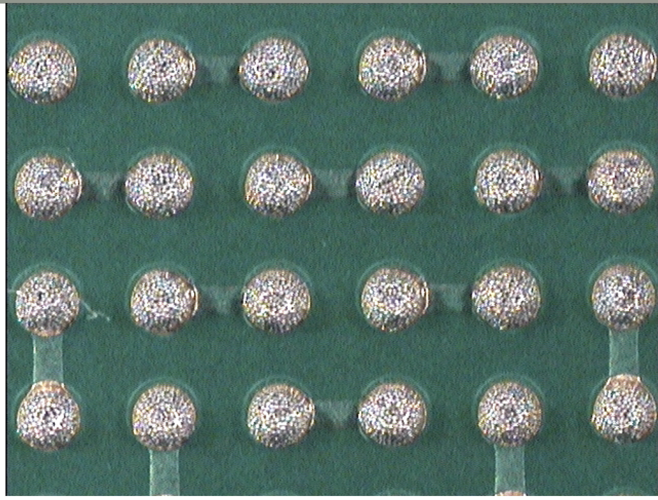
SS = 2 mm/sec.

SS = 10 mm/sec.

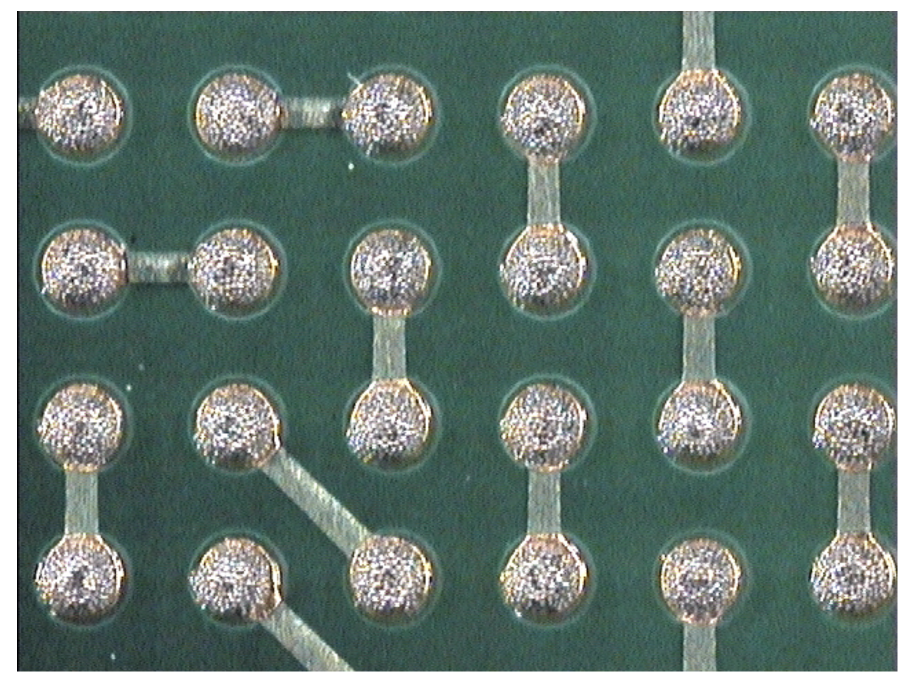


SS = 15 mm/sec.

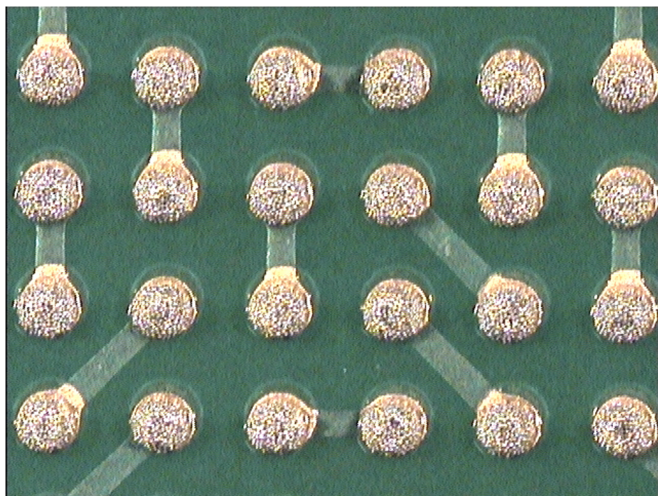
Board 16; 380 µm Aperture, µBGA;
PS=12 SS=2, 10, 15 [mm/sec]



SS = 10 mm/sec.



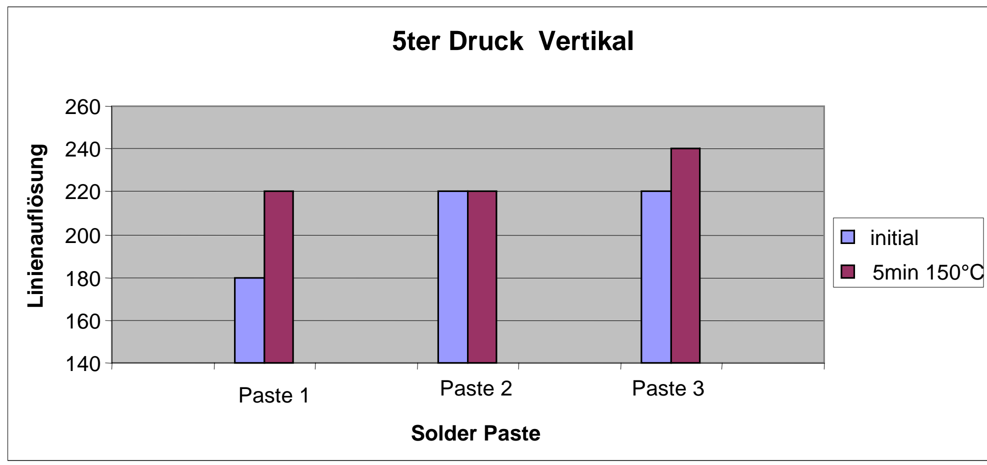
SS = 2 mm/sec.



SS = 15 mm/sec.

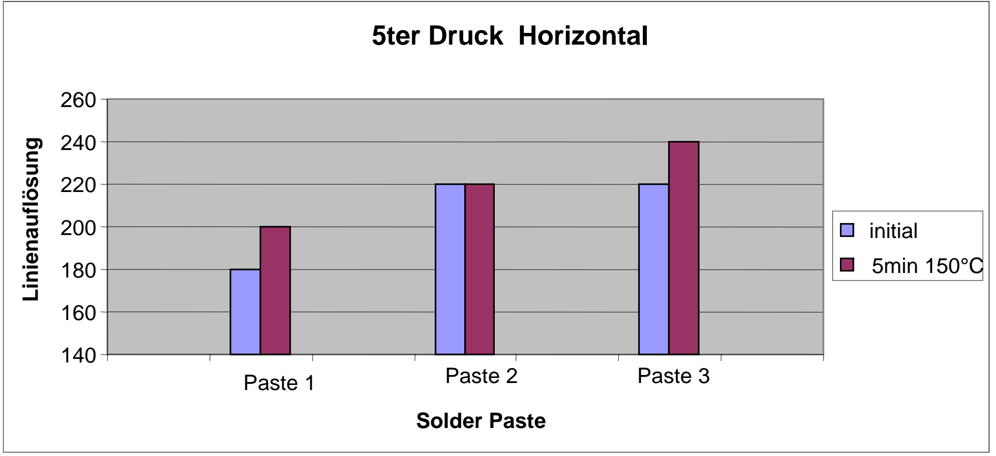
4.7.3 Hot Slump, Spread

- Hot Slump
- (Lineresolution)



Bridges

Line Opens



4.7.3 Hot Slump, Spread

- Hot Slump

Gap

300µm

250µm

200µm

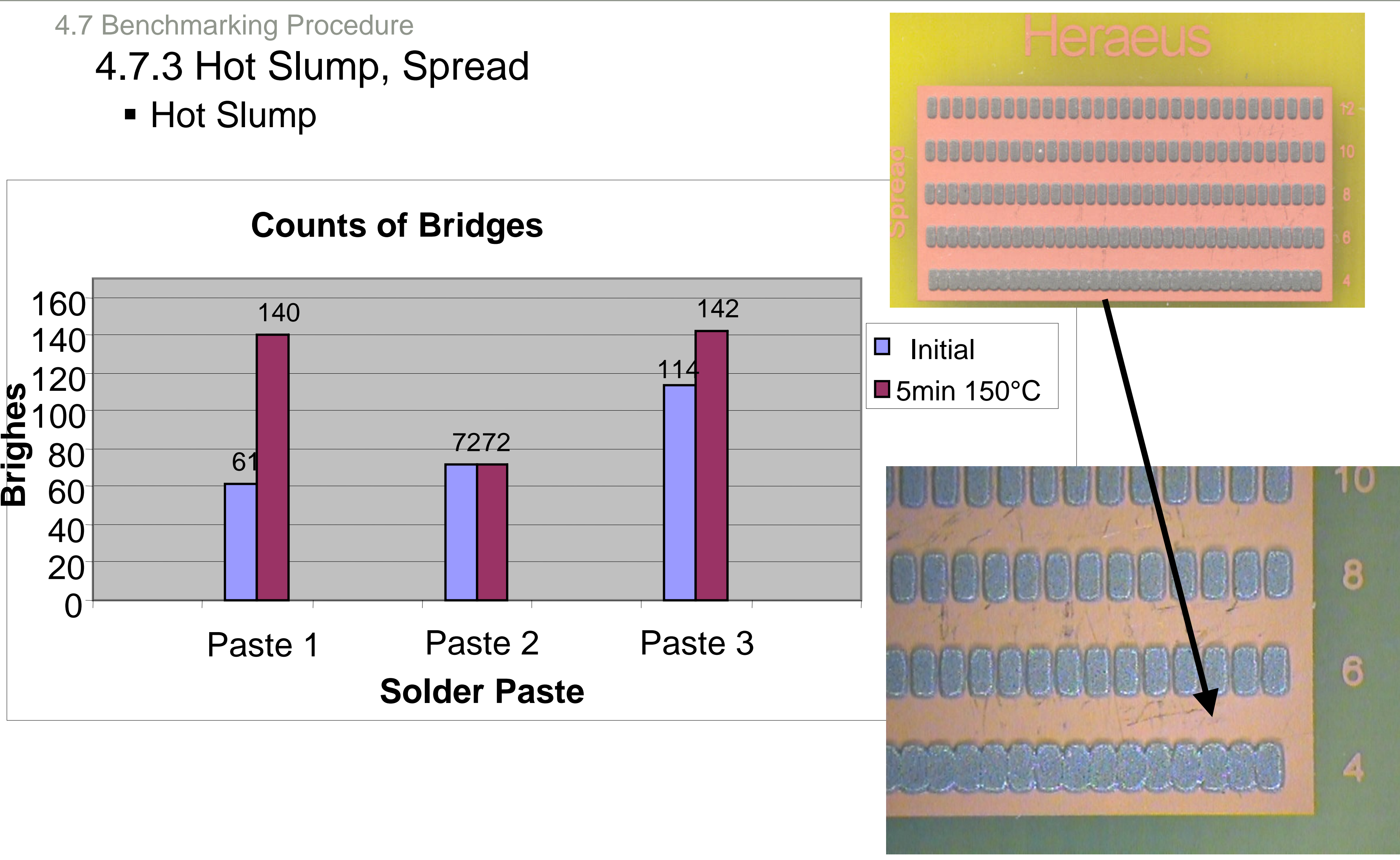
150µm

100µm

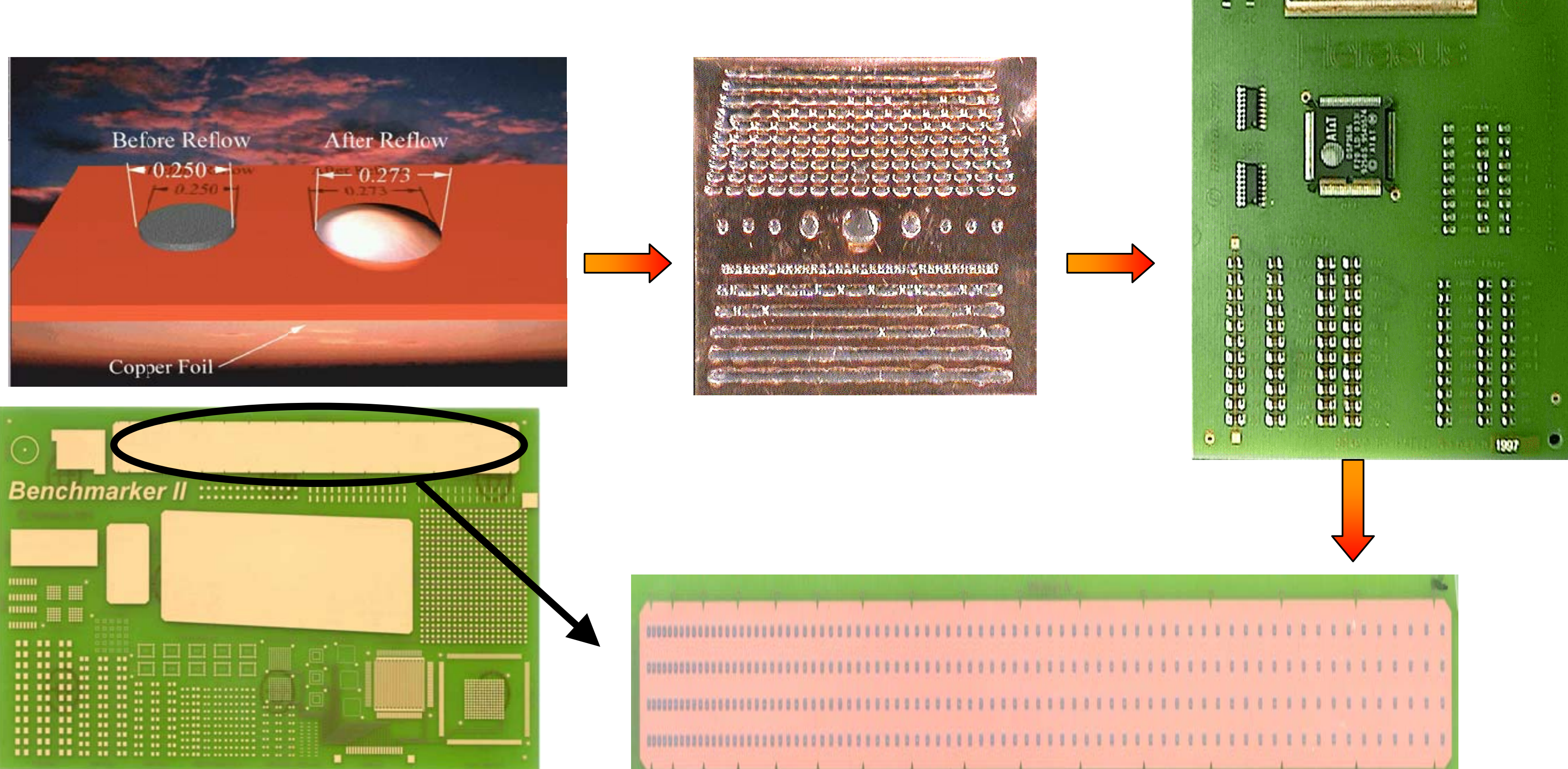
Benchmarker II

4.7.3 Hot Slump, Spread

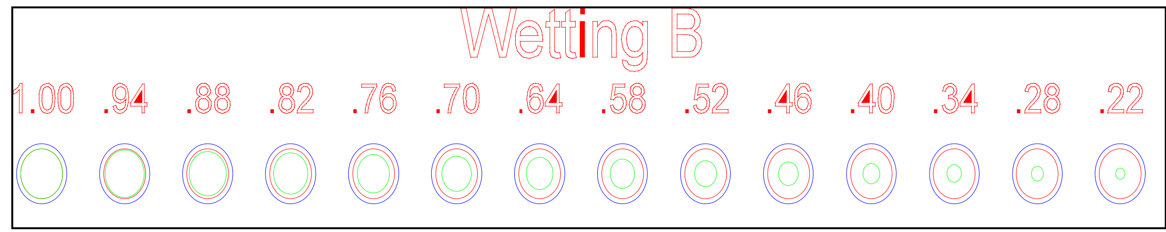
- Hot Slump

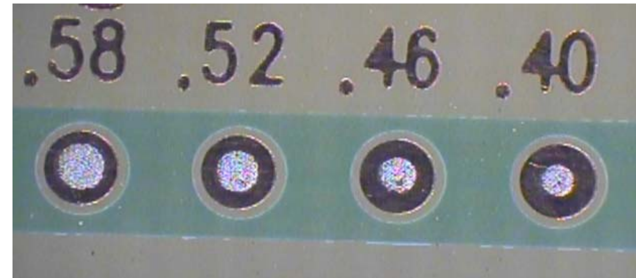


4.7.4 Wetting
Development of Wetting Test Area A

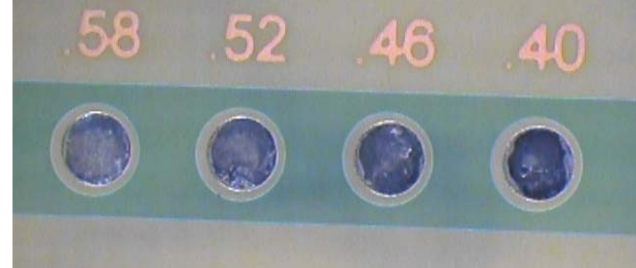


4.7.4 Wetting – Example Area B

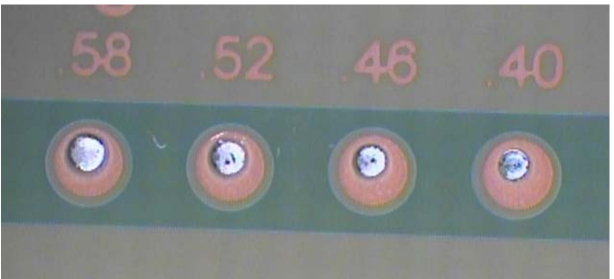




Print

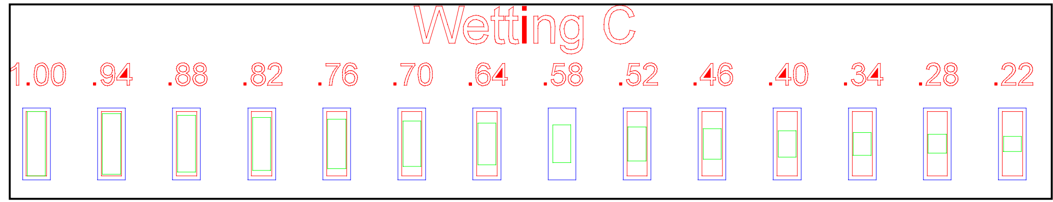


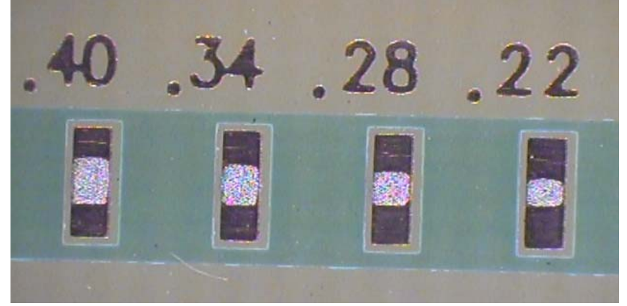
NiAu + N2



OSP + Air

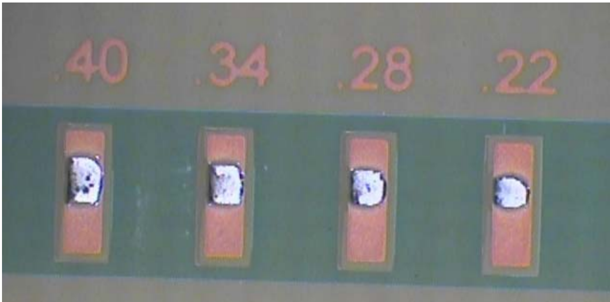
4.7.4 Wetting – Example Area C





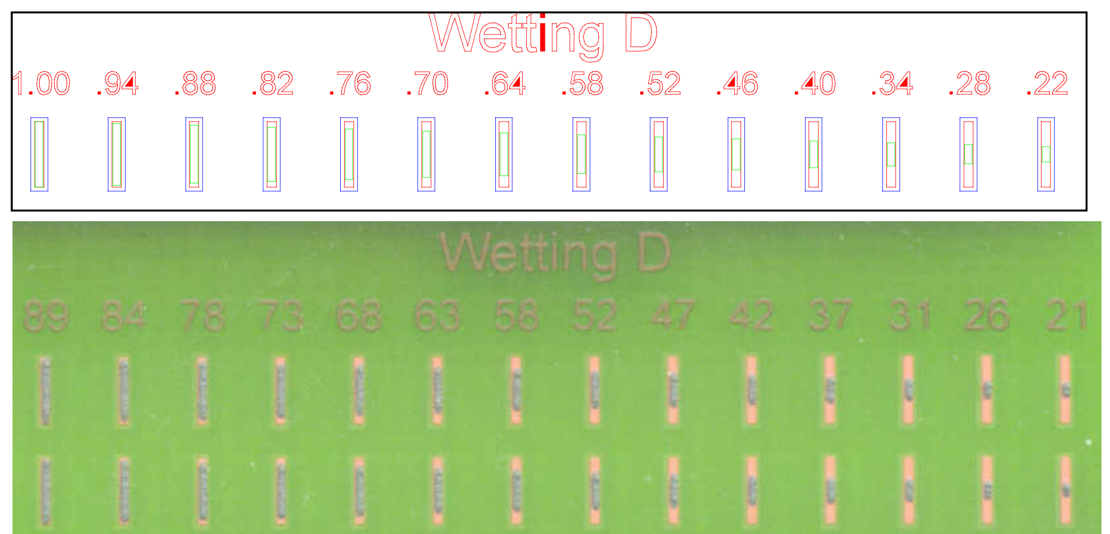
Print

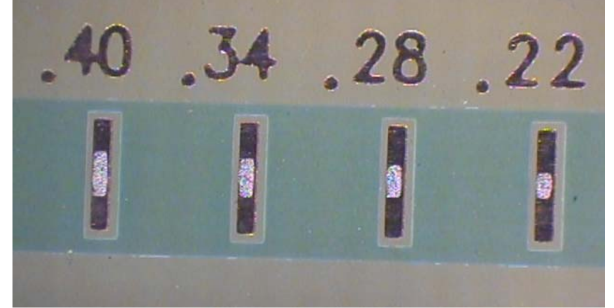
NiAu + N2



OSP + Air

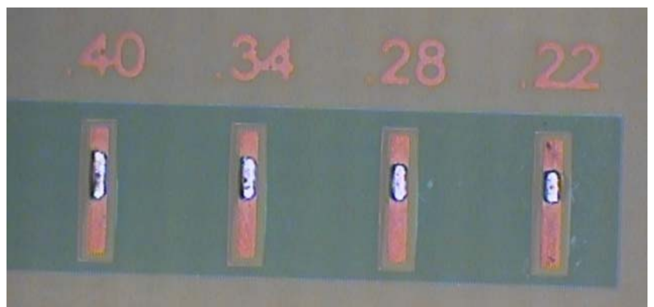
4.7.4 Wetting – Example Area D





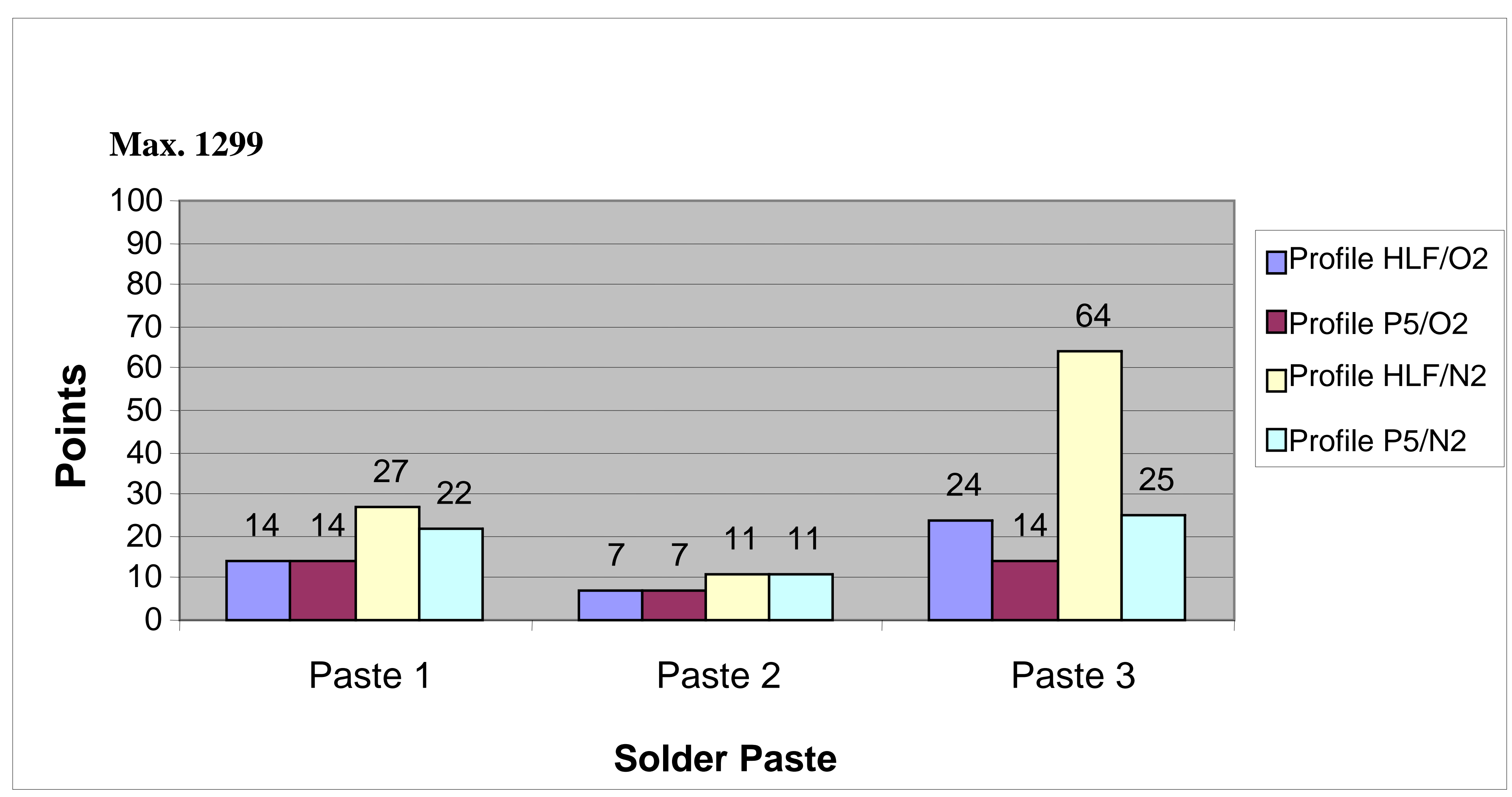
Print

NiAu + N2

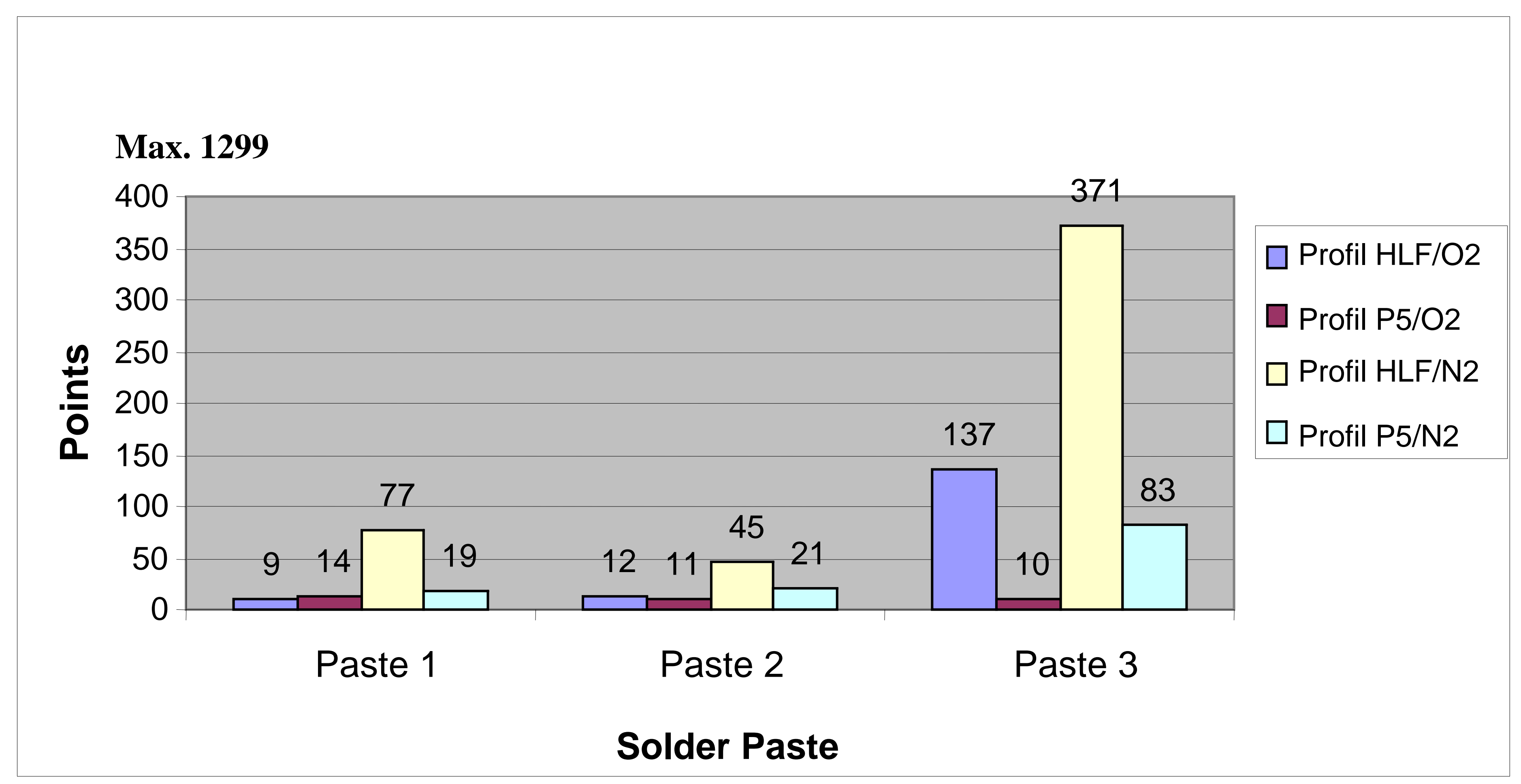


OSP + Air

4.7.4 Wetting on OSP



4.7.4 Wetting on Immersion Sn



4.7.4 Wetting on NiAu

Max. 1299

Points

1300
1200
1100
1000
900
800
700
600

1033 915 1178 1139

967 1071 1258 1268

1138 1100 1268 1278

Paste 1 Paste 2 Paste 3

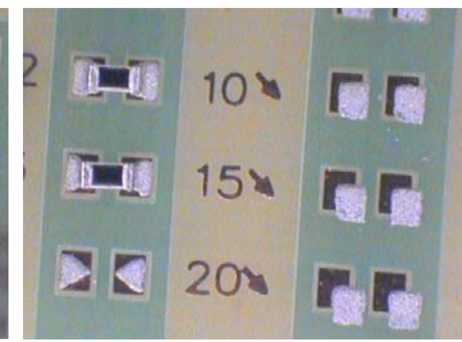
Solder Paste

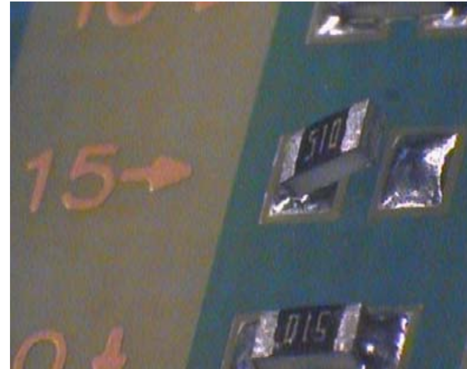
Profil HLF/O2
Profil P5/O2
Profil HLF/N2
Profil P5/N2

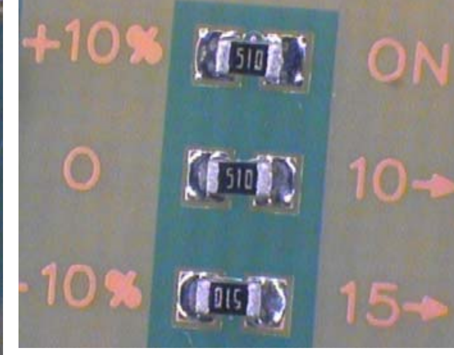
4.7.4 Wetting - other features

Tombstone

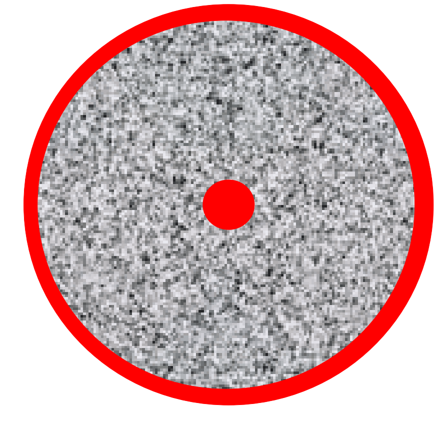
Balls / Beads

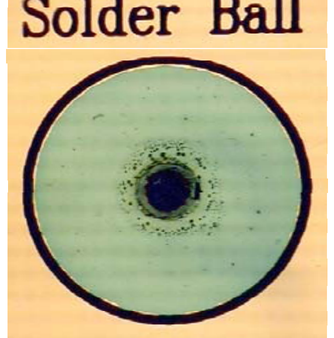






Solder balling on Board

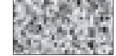




Slight

Solder Ball

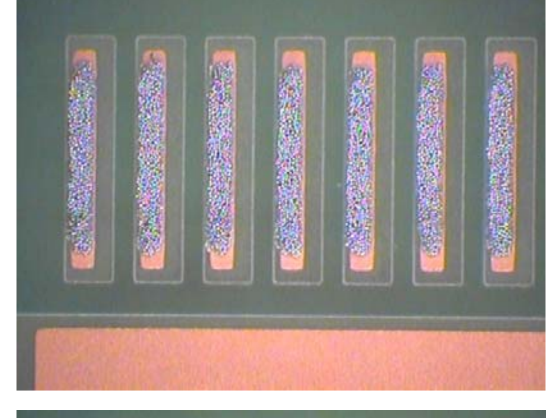
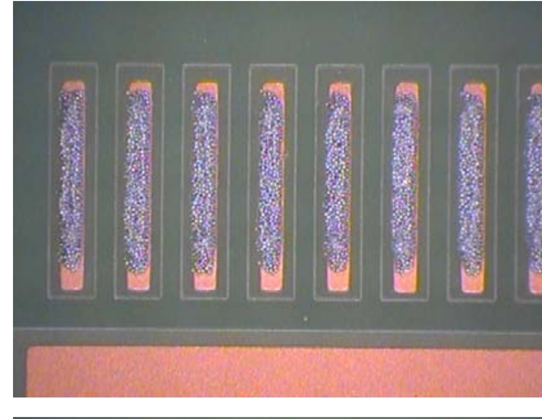
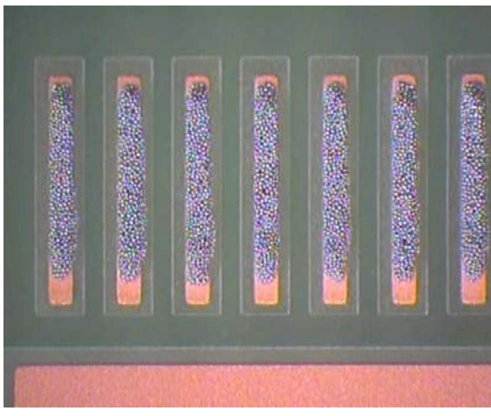
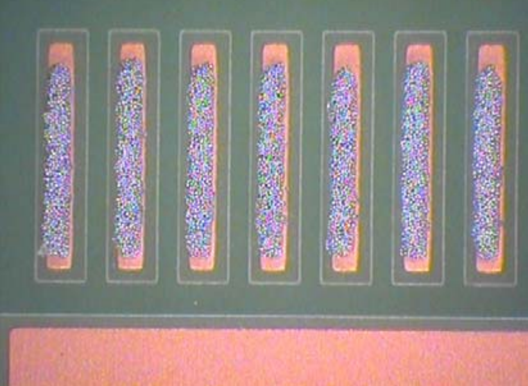
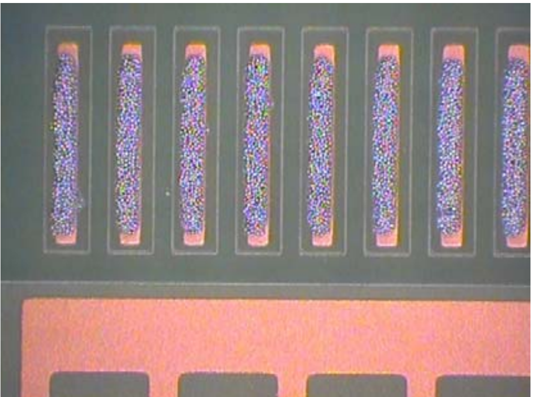
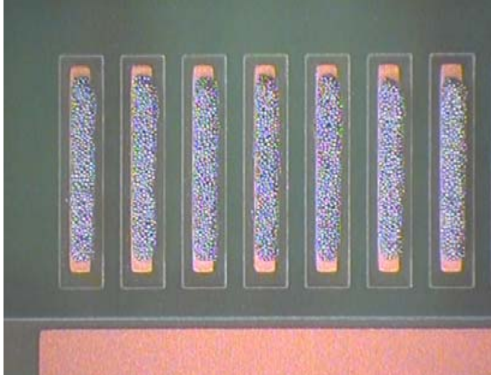
Heavy

 **Solder Paste over Solder Resist**

Solder Resist

4.7.5 Print after wait

QFP100 Pitch 0,63mm → Vertical Stencil Opening: 230µm

	Paste 1 LC with SAC	Paste 2 LF	Paste 3 LF
Initial			
1h			

4.7.5 Print after wait

QFP100 Pitch 0,63mm → Horizontal Stencil Opening: 230µm

	Paste 1 LC with SAC	Paste 2 LF	Paste 3 LF
Initial			
1h			

4.7.5 Print after wait

BGA100 Pitch 0,8mm → Stencil Opening: 380µm

	Paste 1 LC with SAC	Paste 2 LF	Paste 3 LF
Initial			
1h			

4.7.5 Print after wait

CSP56 Pitch 0,5mm → Schablonenöffnung: 280µm

	Paste 1 LC with SAC	**Paste 2 LF**	**Paste 3 LF**
Initial			
1h			

4.8 Process Window

- 4.8.1 Printing
- 4.8.2 Soldering

4.8.1 Printing

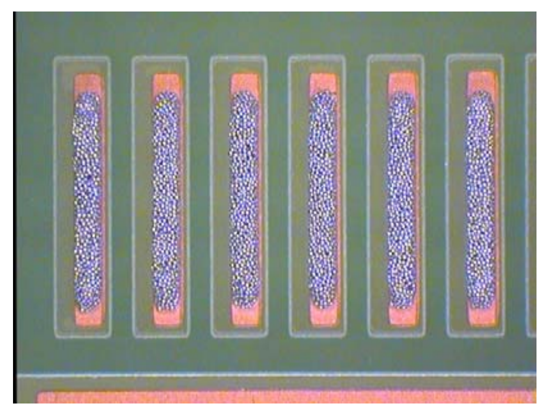
- Analyses by using the doe software Modde 6

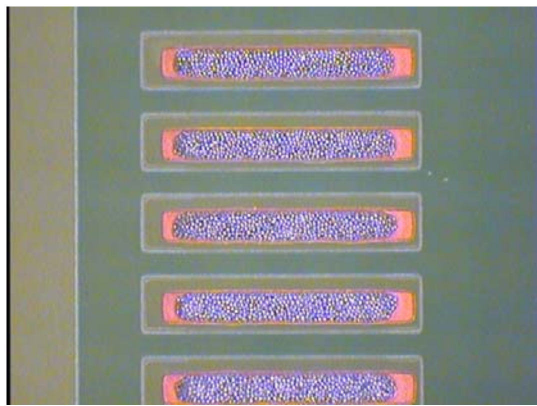
Variable Parameter:

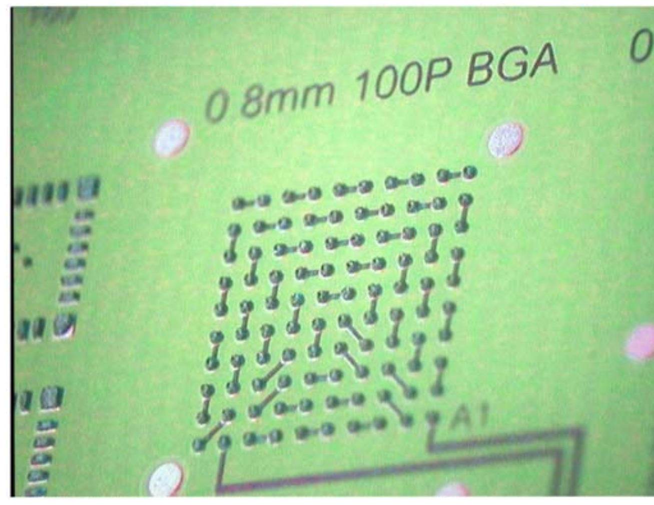
Parameter	Abk.	s.c.	Range
Squeegee pressure	RD	N	0,1 to 15
Temperature	Temp.	°C	20 to 32
Separation speed	Tre.G	mm/s	0,1 to 100
Speed	Rak.G	mm/s	5 to 200

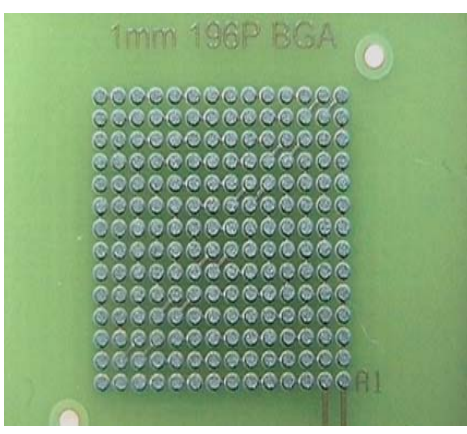
4.8.1 Printing

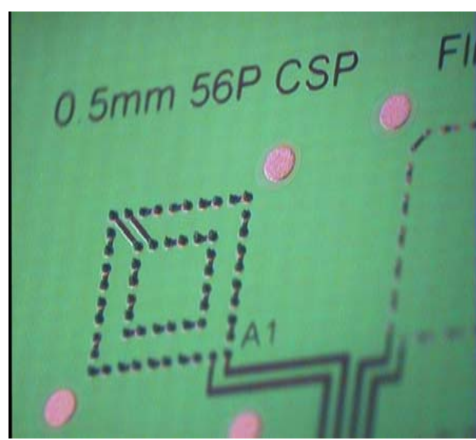
Criteria: Volume by using 2 ½ printing inspections system



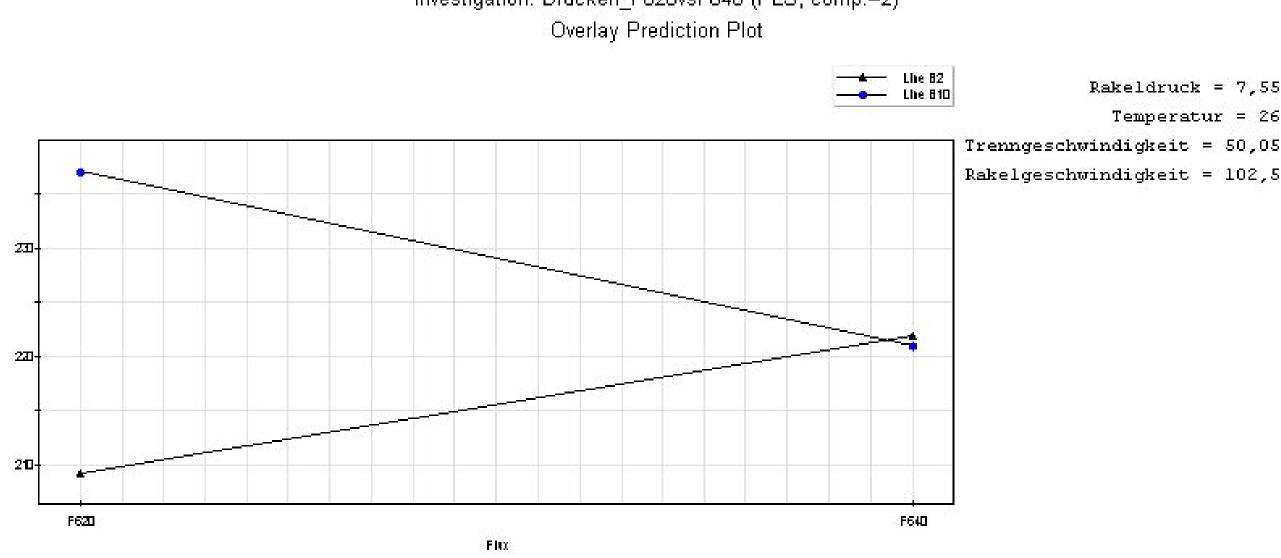








4.8.1 Printing

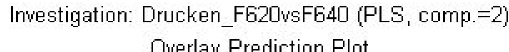


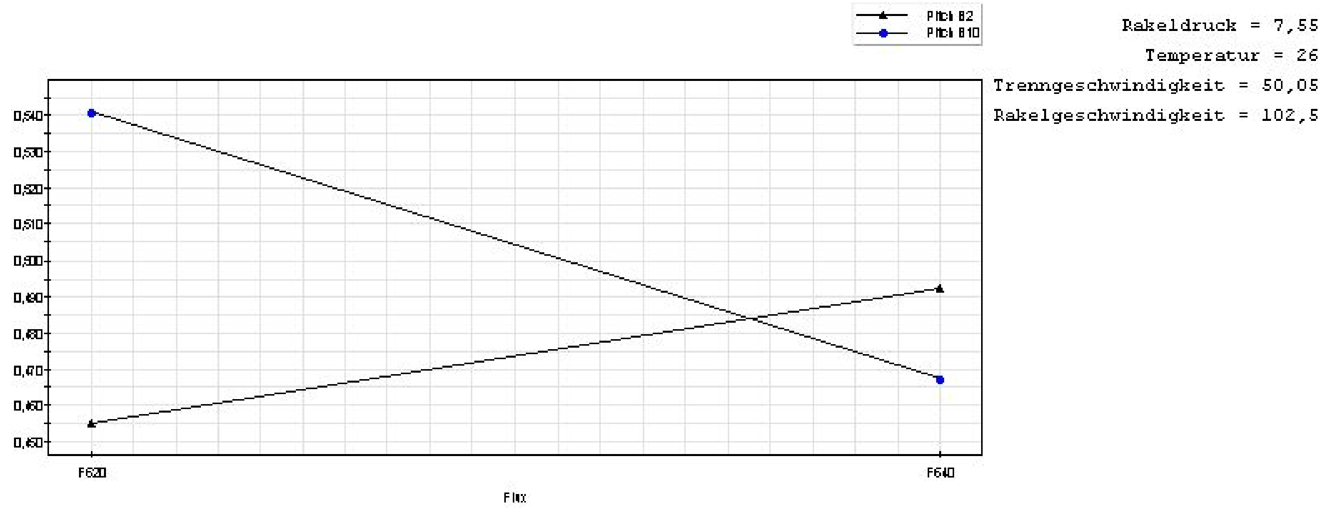
N=26 DF=20

MODDE 7 - 28.06.2005 08:41:03

4.8.1 Printing

Pitch



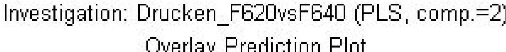


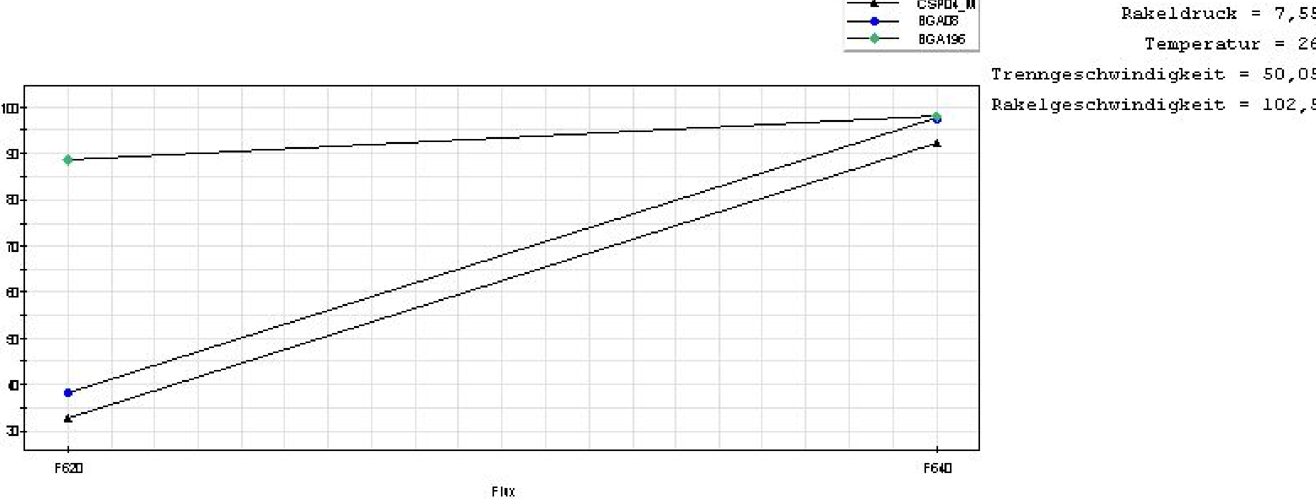
N=26 DF=20

MODDE 7 - 28.06.2005 08:39:41

4.8.1 Printing

Volume





N=26 DF=20

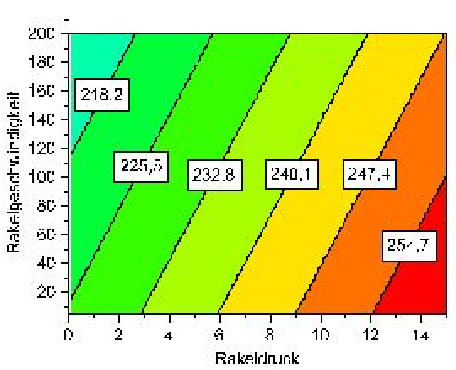
MODDE 7 - 28.06.2005 08:41:47

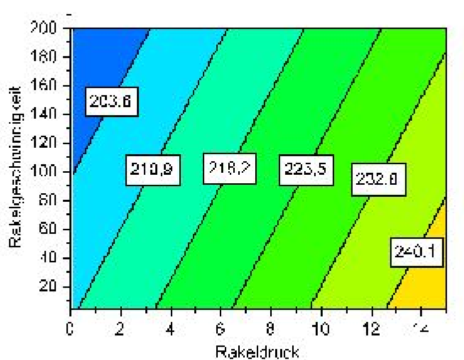
4.8.1 Printing

Line resolution: Speed vs. Pressure

Investigation: Drucken_F620vsF640 (PLS, comp.=2)
4D Contour of Line B10

Temperatur = 26
Trenngeschwindigkeit = 50,05





Flux = F620

Flux = F640

MODDE 7 - 28.06.2005 08:49:12

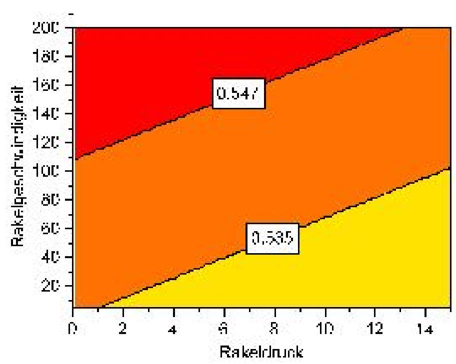
4.8.1 Printing

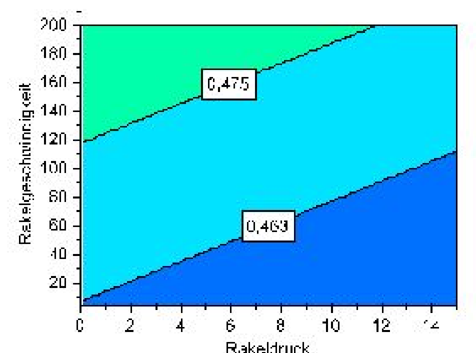
Pitch: Speed

vs. Pressure

Investigation: Drucken_F620vsF640 (PLS, comp.=2)
4D Contour of Pitch B10

Temperatur = 26
Trenngeschwindigkeit = 50,05





Flux = F620

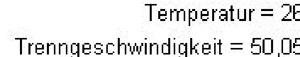
Flux = F640

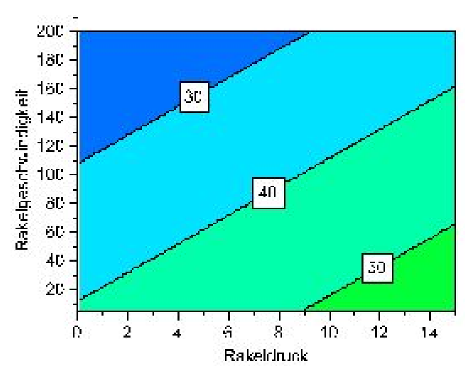
MODDE 7 - 28.06.2005 08:48:14

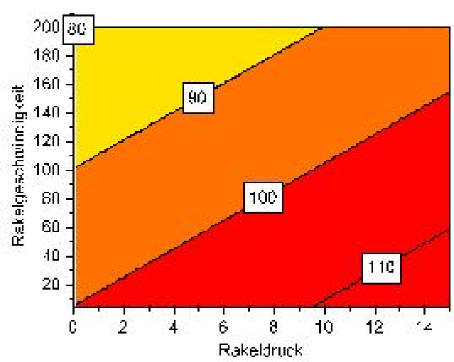
4.8.1 Printing

Volume BGA(100P p=0.8): Speed vs. Pressure

Investigation: Drucken_F620vsF640 (PLS, comp.=2)
4D Contour of BGA08







Flux = F620

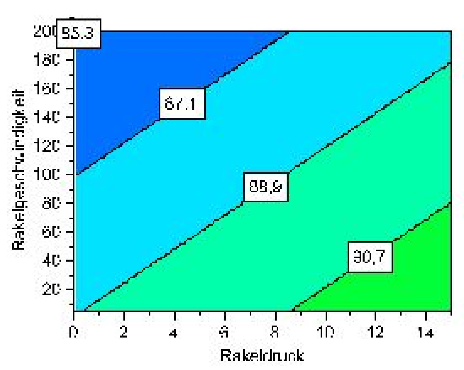
Flux = F640

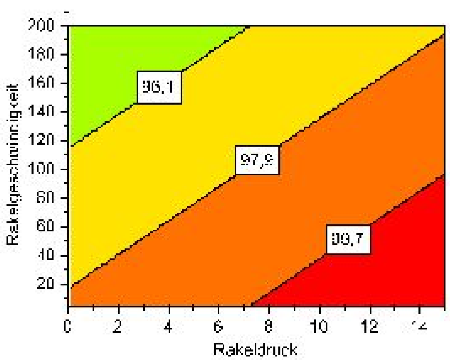
MODDE 7 - 28.06.2005 08:47:00

4.8.1 Printing

Volume BGA(196 P=1): Speed vs. Pressure

Investigation: Drucken_F620vsF640 (PLS, comp.=2)
4D Contour of BGA196





Flux = F620

Flux = F640

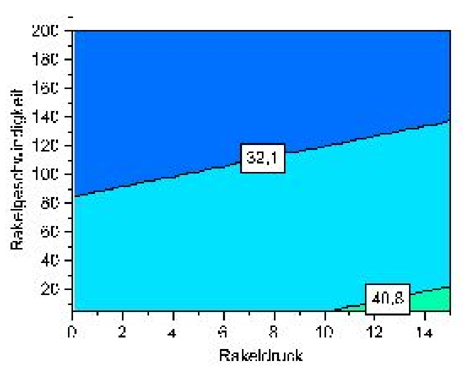
MODDE 7 - 28.06.2005 08:47:33

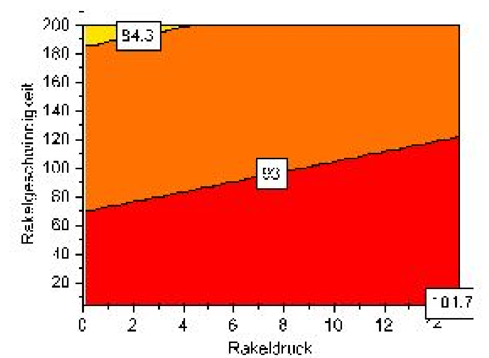
4.8.1 Printing

Volume CSP: Speed vs. Pressure

Investigation: Drucken_F620vsF640 (PLS, comp.=2)
4D Contour of CSP04_M

Temperatur = 26
Trenngeschwindigkeit = 50,05





Flux = F620

Flux = F640

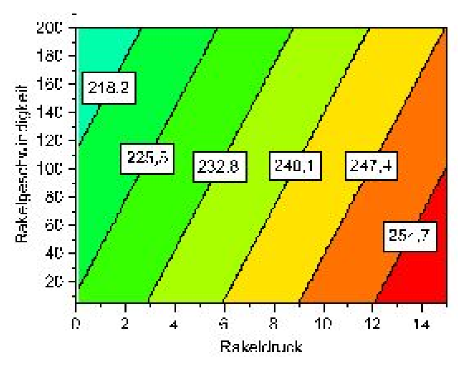
MODDE 7 - 28.06.2005 08:46:28

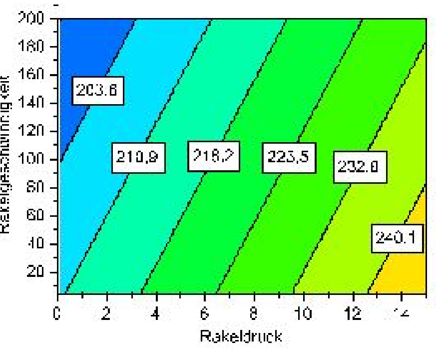
4.8.1 Printing

Line resolution print 10: Speed vs. Pressure

Investigation: Drucken_F620vsF640 (PLS, comp.=2)
4D Contour of Line B10

Temperatur = 26
Trenngeschwindigkeit = 50,05





Flux = F620

Flux = F640

MODDE 7 - 28.06.2005 08:48:45

4.8.2 Soldering

Optimization for SAC soldering by DOE

- SVP1
- SVP2
- SVP4
- SVP5
- SVP6
- SVP7
- SVP8
- SVP11

4.8.2 Soldering - Profiles

SVP-Löten F620 - Profile

Temperatur in °C

300
250
200
150
100
50
0

0 50 100 150 200 250 300 350 400 450 500

Zeit in sec

SVP1
SVP2
SVP4
SVP5
SVP6
SVP7
SVP8
SVP11

4.8.2 Soldering - Profiles

SVP 1

SVP-1-F620 — Tuesday August 26, 2003 13:11:39

Company: W.C. Heraeus GmbH — Site: Profil SVP 1 F620
Oven Name: rehm SMS-V6-N2 3300_80-400 — Process Window Name: SVP-1-F620

Setpoints (Celsius)

Zone	1	2	3	4	5	6	7
Top	167	205	207	240	237	299	235
Bottom	167	205	207	240	237	299	235

Conveyor Speed (cm/min): 99.5

PWI= 482%										
2	2.0	60%	76.9	129%	61.0	198%	42.7	423%	244.5	482%
3	1.5	40%	71.3	-56%	53.9	-37%	25.3	-157%	219.4	
4	1.7	47%	71.2	-60%	61.5	215%	37.3	243%	234.0	133%
5	1.2	29%	71.1	-63%	55.7	23%	30.5	18%	223.0	-233%
Delta	0.8	31%	5.8	73%	7.6	192%	17.4	406%	25.1	349%

Process Window:

Solder Paste: SYSTEM DEFAULT

Statistic Name	Low Limit	High Limit	Units
Max Rising Slope (Target=0.5) (Calculate Slope over 30 Seconds)	0.0	3.0	Degrees/Second
Preheat Time 100-167C	70	76	Seconds
Soak Time 167-217C	52	58	Seconds
Time Above Reflow - 217C	27	33	Seconds
Peak Temperature	227	233	Degrees Celsius

Profiled Using KIC 2000 Technology
KIC Thermal Profiling, San Diego, CA USA — Tel: +1 858 673 6050, Fax: +1 858 673 0085 — www.kicthermal.com, tech@kicmail.com

SVP 2

SVP-2-F620 — Wednesday October 22, 2003 08:57:42

Company: W.C. Heraeus GmbH — Site: Profil SVP 2 F620
Oven Name: rehm SMS-V6-N2 3300_80-400 — Process Window Name: SVP-2-F620

Setpoints (Celsius)

Zone	1	2	3	4	5	6	7
Top	232	216	281	224	213	286	273
Bottom	232	216	281	224	213	286	273

Conveyor Speed (cm/min): 77.9

PWI= 299%										
0603 Tumbstone	2.9	96%	69.4	-86%	121.0	33%	63.4	113%	245.6	19%
25 mil Narrow Pa	2.1	65%	73.9	64%	113.0	-233%	60.7	24%	236.0	
SOIC	2.4	77%	66.6	-182%	120.2	7%	60.2	6%	243.3	-58%
Rückseite	1.7	49%	69.4	-88%	115.5	-149%	56.6	-113%	237.8	-239%
Delta	1.2	47%	7.4	118%	8.0	226%	6.8	107%	9.5	281%

Process Window:

Solder Paste: SVP-2-F620

Statistic Name	Low Limit	High Limit	Units
Max Rising Slope (Target=0.5) (Calculate Slope over 30 Seconds)	0.0	3.0	Degrees/Second
Preheat Time 100-167C	69	75	Seconds
Soak Time 167-217C	117	123	Seconds
Time Above Reflow - 217C	57	63	Seconds
Peak Temperature	242	248	Degrees Celsius

Profiled Using KIC 2000 Technology
KIC Thermal Profiling, San Diego, CA USA — Tel: +1 858 673 6050, Fax: +1 858 673 0085 — www.kicthermal.com, tech@kicmail.com

SVP 4

SVP-4-F620 — Friday October 24, 2003 13:39:09

Company: W.C. Heraeus GmbH — Site: Profil SVP 4 F620
Oven Name: rehm SMS-V6-N2 3300_80-400 — Process Window Name: SVP-4-F620

Setpoints (Celsius)

Zone	1	2	3	4	5	6	7
Top	235	295	226	223	276	296	293
Bottom	235	295	226	223	276	296	293

Conveyor Speed (cm/min): 49.9

PWI= 499%										
0603 Tumbstone	1.9	57%	75.8	-8%	167.3		165.0	499%	266.8	226%
25 mil Narrow	1.9	55%	71.0	-166%	172.9		157.6	252%	260.8	26%
SOIC	1.8	53%	74.8	-40%	169.6		156.2	208%	266.1	204%
Rückseite	1.5	39%	73.0	-99%	179.0	-98%	144.0	-199%	260.7	24%
Delta	0.5	19%	4.8	158%	11.7	392%	20.9	300%	6.0	202%

Process Window:

Solder Paste: SVP-4-F620

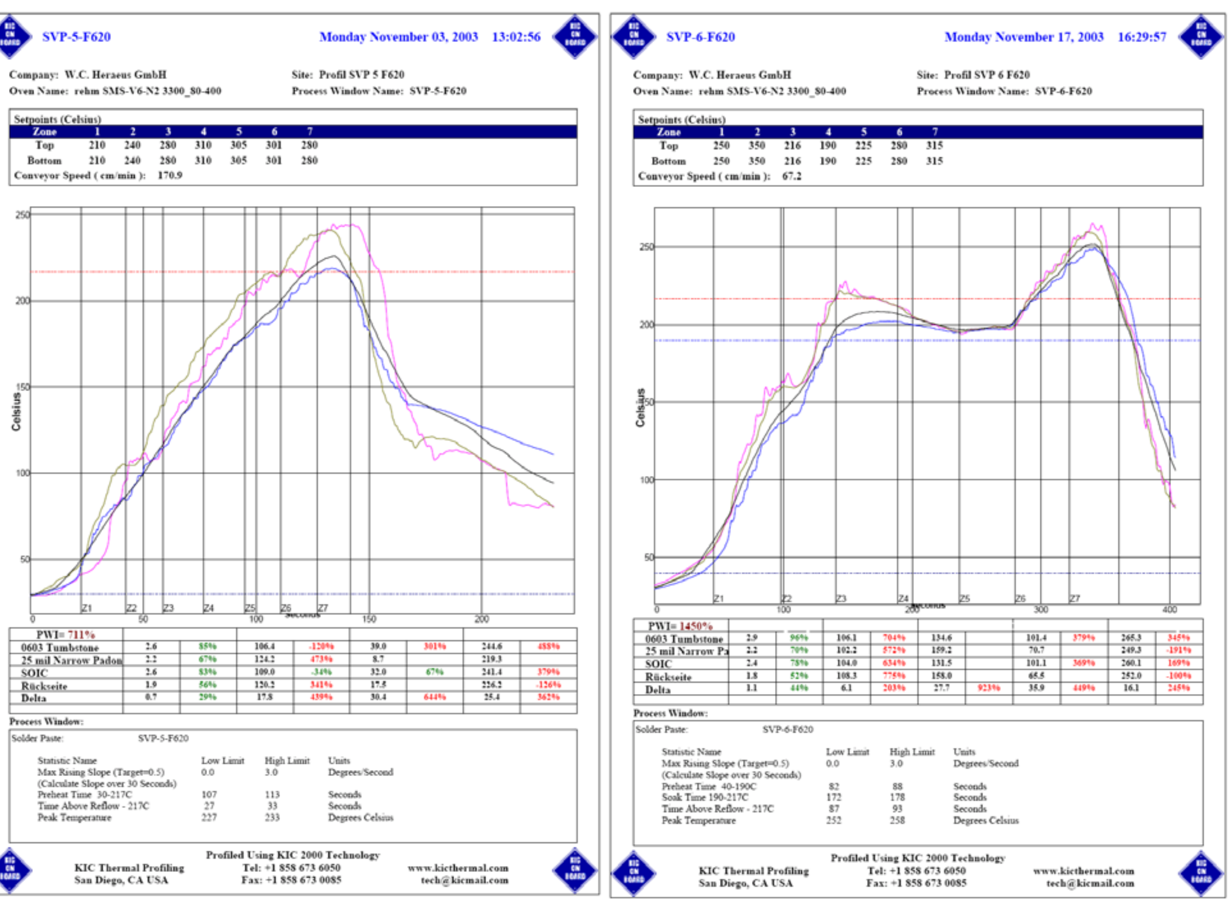
Statistic Name	Low Limit	High Limit	Units
Max Rising Slope (Target=0.5) (Calculate Slope over 30 Seconds)	0.0	3.0	Degrees/Second
Preheat Time 100-167C	73	79	Seconds
Soak Time 167-217C	179	185	Seconds
Time Above Reflow - 217C	147	153	Seconds
Peak Temperature	257	263	Degrees Celsius

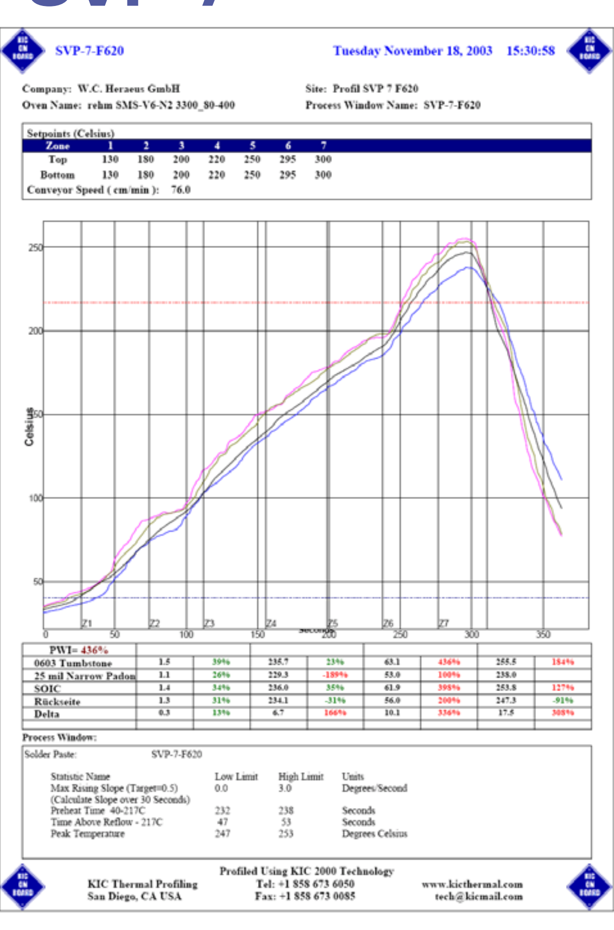
Profiled Using KIC 2000 Technology
KIC Thermal Profiling, San Diego, CA USA — Tel: +1 858 673 6050, Fax: +1 858 673 0085 — www.kicthermal.com, tech@kicmail.com

Measured profiles by SlimKic

4.8.2 Soldering - Profiles

SVP 5 SVP 6 SVP 7

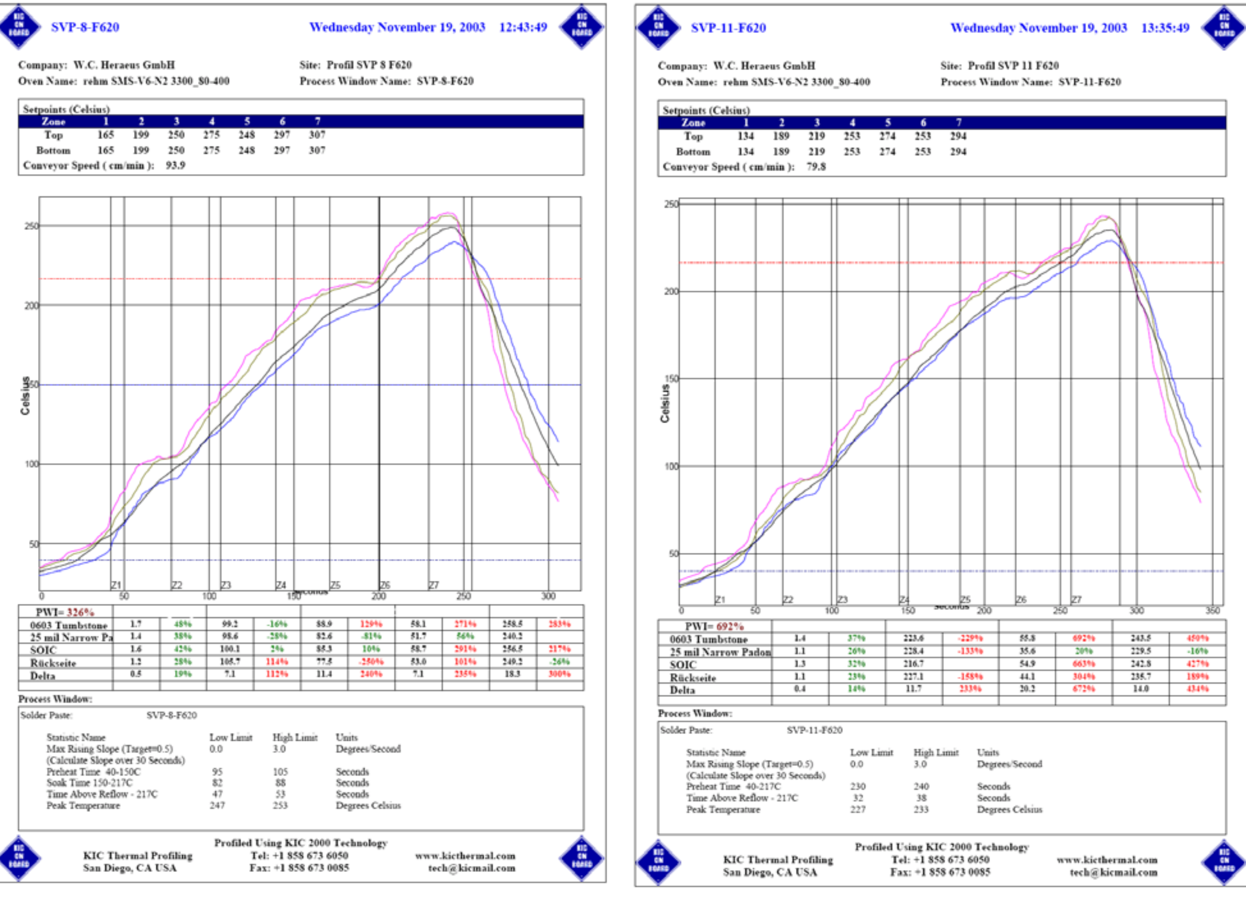




Measured profiles by SlimKic

4.8.2 Soldering - Profiles

SVP 8   SVP 11



SVP-8-F620 — Wednesday November 19, 2003 12:43:49

Company: W.C. Heraeus GmbH — Site: Profil SVP 8 F620
Oven Name: rehm SMS-V6-N2 3300_80-400 — Process Window Name: SVP-8-F620

Setpoints (Celsius)

Zone	1	2	3	4	5	6	7
Top	165	199	250	275	248	297	307
Bottom	165	199	250	275	248	297	307

Conveyor Speed (cm/min): 93.9

PWI= 326%										
0603 Tumbstone	1.7	48%	99.2	-16%	88.9	129%	58.1	271%	258.5	283%
25 mil Narrow Pa	1.4	38%	98.6	-28%	82.6	-81%	51.7	56%	240.2	
SOIC	1.6	42%	100.1	2%	85.3	10%	58.7	291%	256.5	217%
Rückseite	1.2	28%	105.7	114%	77.5	-250%	53.0	101%	249.2	-26%
Delta	0.5	19%	7.1	112%	11.4	240%	7.1	235%	18.3	300%

Process Window:

Solder Paste: SVP-8-F620

Statistic Name	Low Limit	High Limit	Units
Max Rising Slope (Target=0.5) (Calculate Slope over 30 Seconds)	0.0	3.0	Degrees/Second
Preheat Time 40-150C	95	105	Seconds
Soak Time 150-217C	82	88	Seconds
Time Above Reflow - 217C	47	53	Seconds
Peak Temperature	247	253	Degrees Celsius

Profiled Using KIC 2000 Technology
KIC Thermal Profiling, San Diego, CA USA — Tel: +1 858 673 6050, Fax: +1 858 673 0085 — www.kicthermal.com, tech@kicmail.com

SVP-11-F620 — Wednesday November 19, 2003 13:35:49

Company: W.C. Heraeus GmbH — Site: Profil SVP 11 F620
Oven Name: rehm SMS-V6-N2 3300_80-400 — Process Window Name: SVP-11-F620

Setpoints (Celsius)

Zone	1	2	3	4	5	6	7
Top	134	189	219	253	274	253	294
Bottom	134	189	219	253	274	253	294

Conveyor Speed (cm/min): 79.8

PWI= 692%										
0603 Tumbstone	1.4	37%	223.6	-229%	55.8	692%	243.5	450%
25 mil Narrow Padon	1.1	26%	228.4	-133%	35.6	20%	229.5	-16%
SOIC	1.3	32%	216.7		54.9	663%	242.8	427%
Rückseite	1.1	23%	227.1	-158%	44.1	304%	235.7	189%
Delta	0.4	14%	11.7	233%	20.2	672%	14.0	434%

Process Window:

Solder Paste: SVP-11-F620

Statistic Name	Low Limit	High Limit	Units
Max Rising Slope (Target=0.5) (Calculate Slope over 30 Seconds)	0.0	3.0	Degrees/Second
Preheat Time 40-217C	230	240	Seconds
Time Above Reflow - 217C	32	38	Seconds
Peak Temperature	227	233	Degrees Celsius

Profiled Using KIC 2000 Technology
KIC Thermal Profiling, San Diego, CA USA — Tel: +1 858 673 6050, Fax: +1 858 673 0085 — www.kicthermal.com, tech@kicmail.com

Measured profiles by SlimKic

4.8.2 Soldering - Execution of the test

- 8 profiles and 2 pretestes

- 2 Benchmarker II Boards per profile
  - Atmosphere : Air
  - Board surface : NiAu
  - Components : Chip-Components 1206-0402
    QFP
    BGA 0,8mm

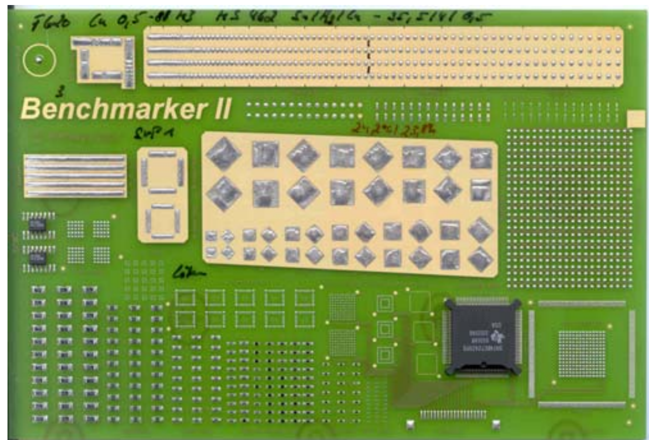
- <u>analyses:</u> wetting / dewetting Bench2
  solder balls at components / tombstone
  solder balling on board

4.8.2 Soldering – Constant print parameters

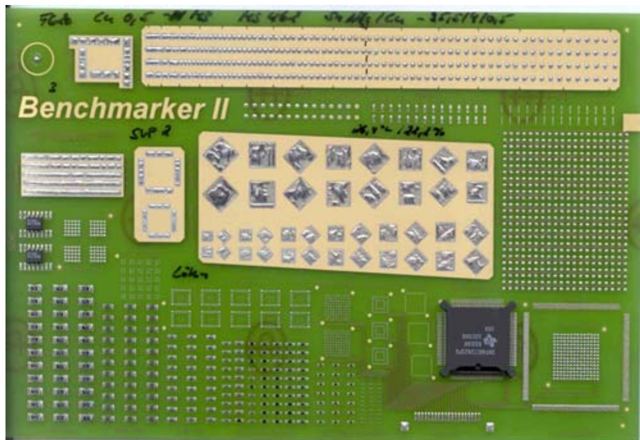
Printing of solder paste:

Printer:	Ekra X5 (or DEK also possible)
Metal Squeegee:	60°
Squeegee length:	200 mm
Squeegee pressure:	50 N/cm
Seperation Speed:	10 mm/s
Print Speed:	50 mm/s
PCB:	Bench 2
Stencil:	150 µm / B6

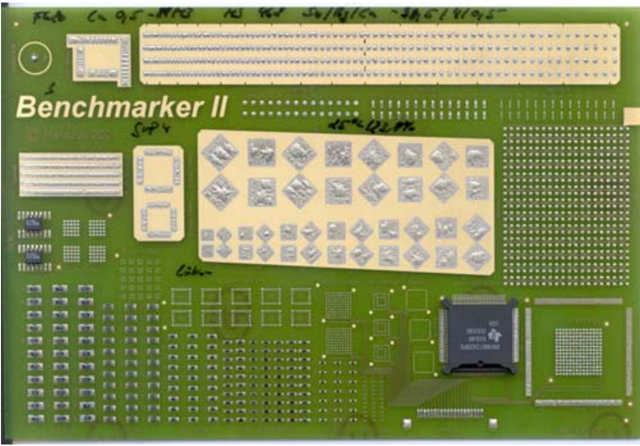
4.8.2 Soldering – Results



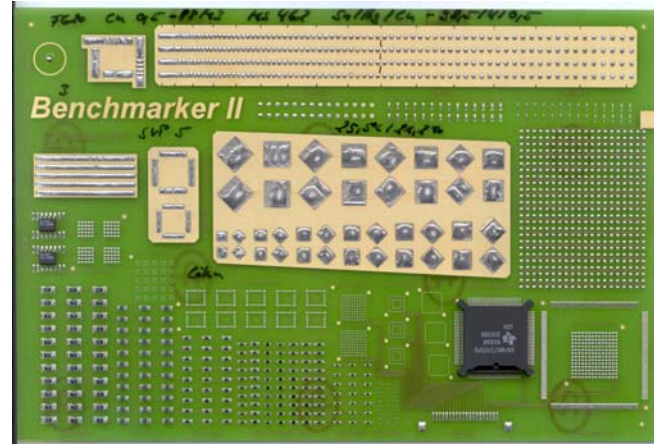
SVP 1



SVP 2

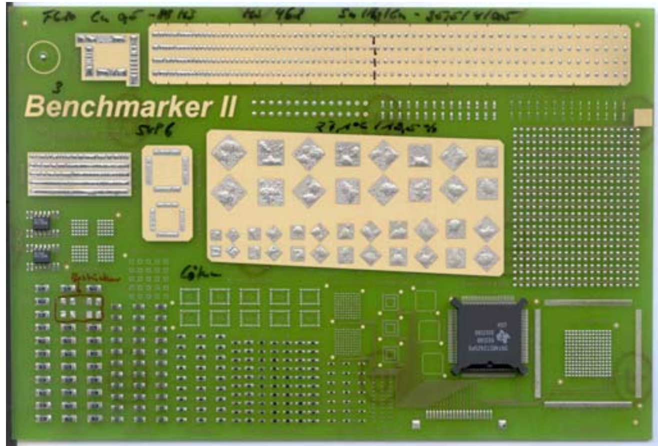


SVP 4

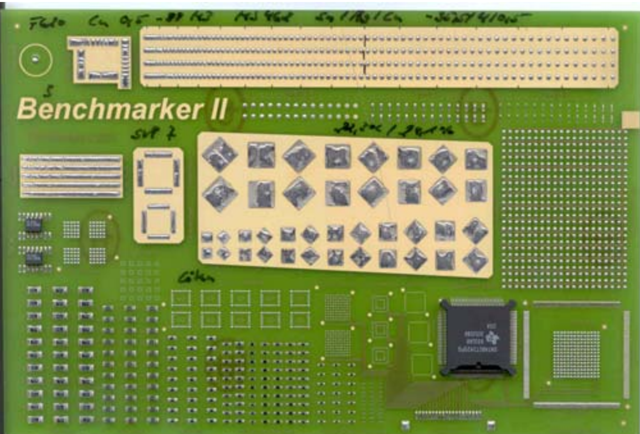


SVP 5

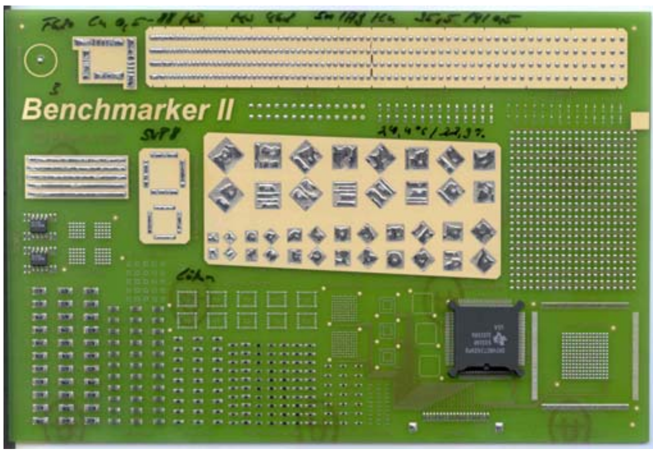
4.8.2 Soldering – Results



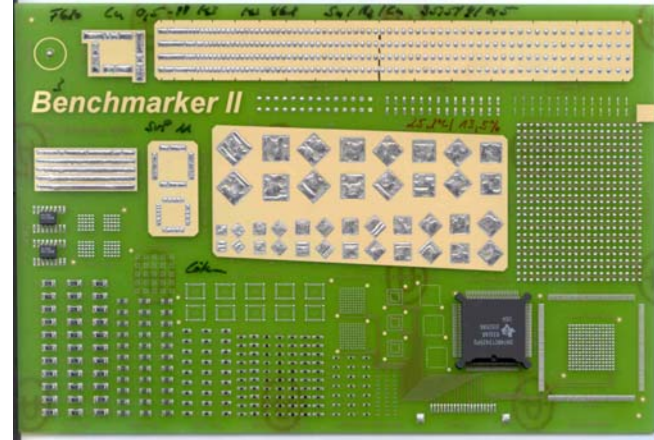
SVP 6



SVP 7

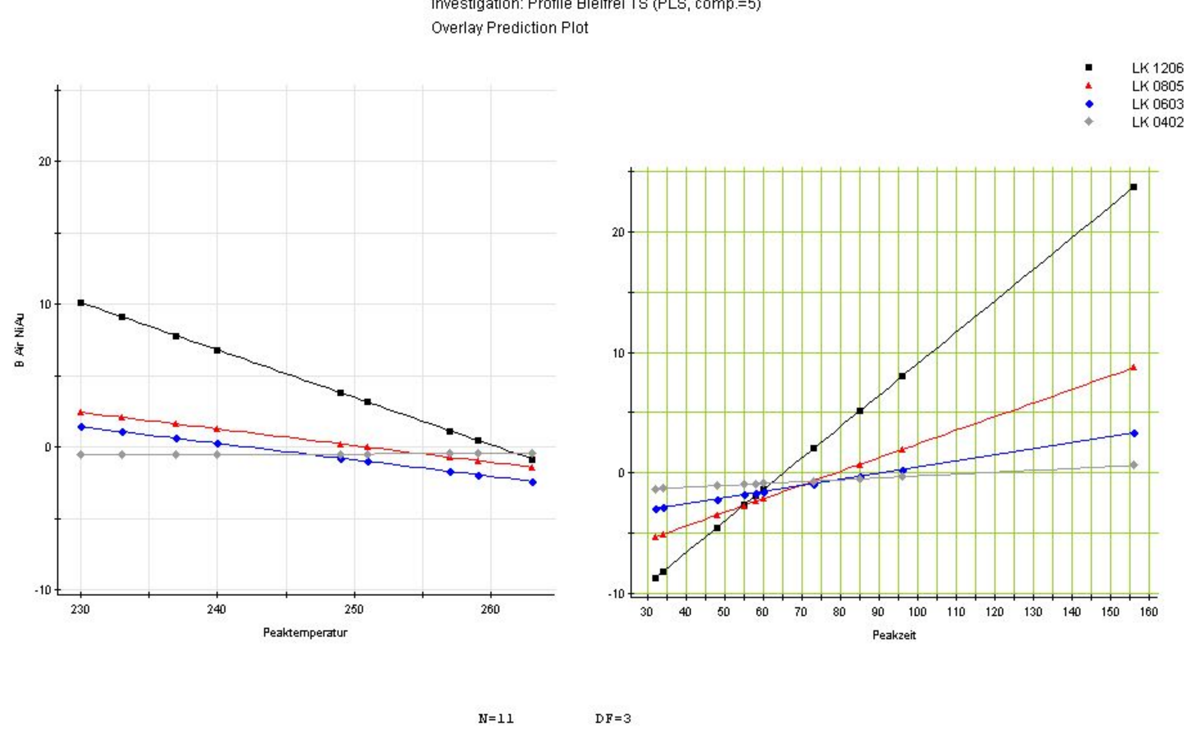


SVP 8



SVP 11

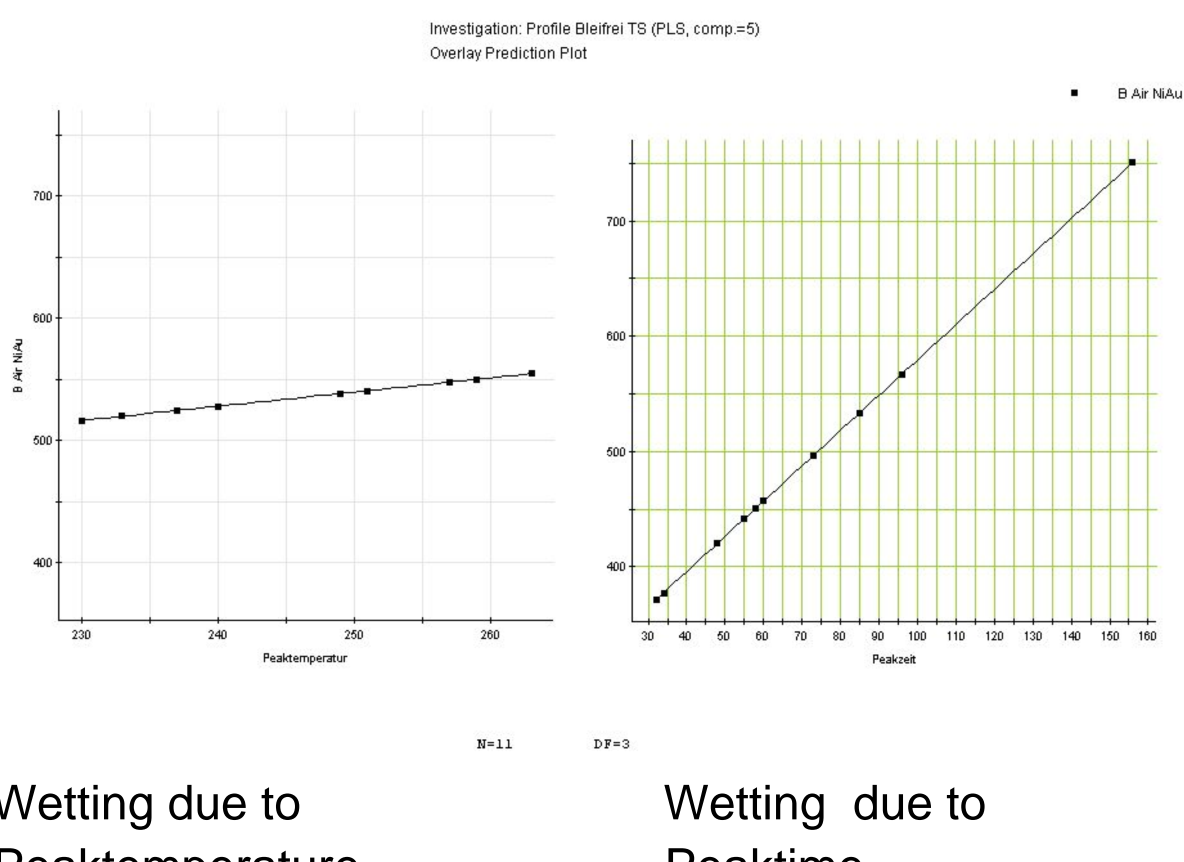
4.8.2 Soldering – Results



Solder Balls / Beats due to Peaktemperature

Solder Balls / Beats due to Peaktime

4.8.2 Soldering – Results



Wetting due to Peaktemperature

Wetting due to Peaktime

4.8.2 Soldering – Results

Investigation: Profile Bleifrei TS (PLS, comp.=5)
Overlay Prediction Plot

LK 1206
LK 0805
LK 0603
LK 0402

B Ar Ni/Au

Preheat Temp Start

Preheat Temp Ende

Prheatzeit

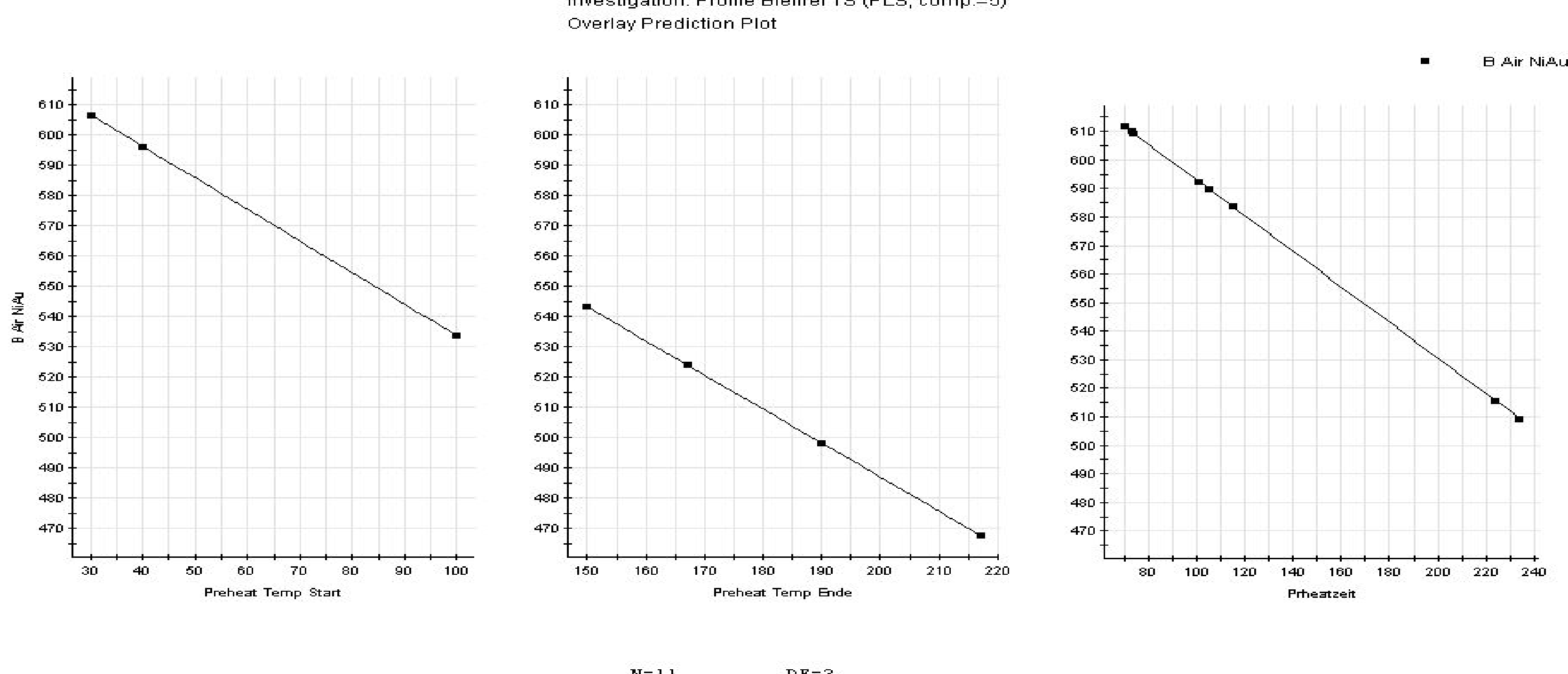
N=11 DF=3

Solder balls / beats vs. board Start-temperature

Solder balls / beats vs.Preheat End temperature

Solder balls / beats vs.Preheat Time

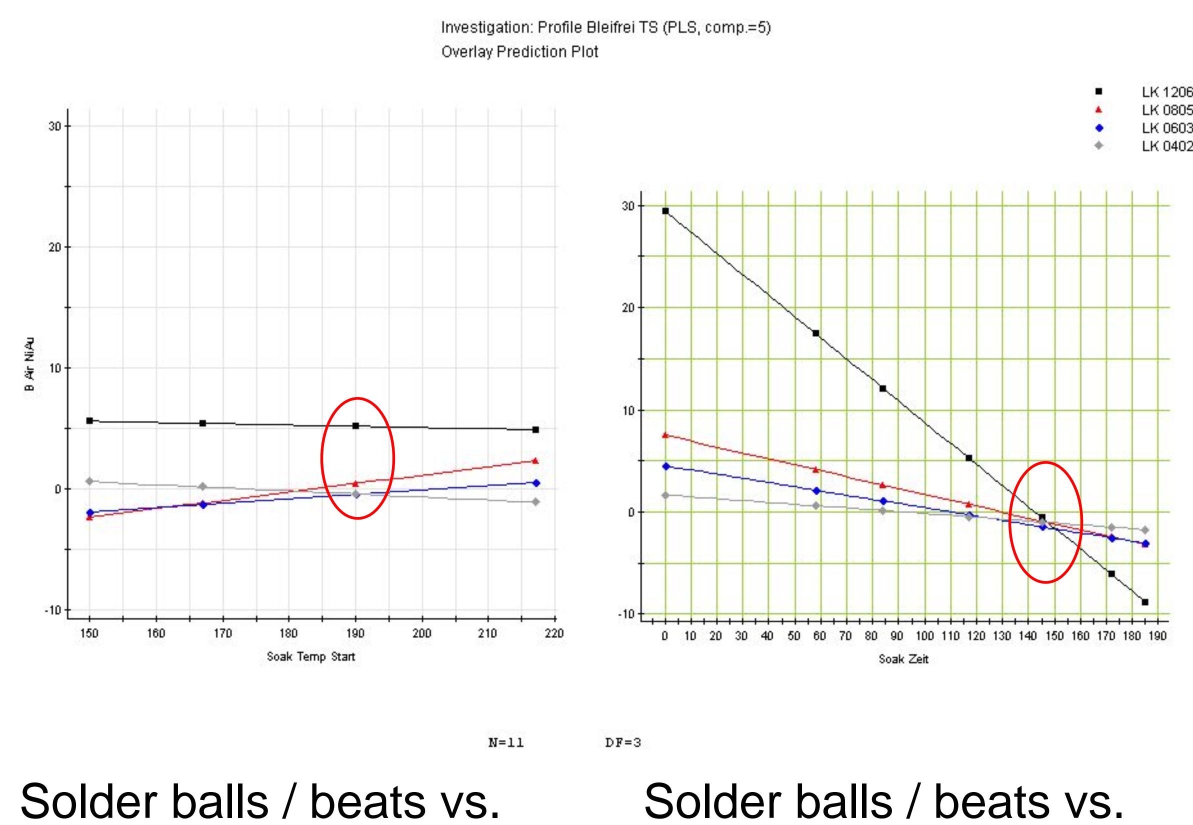
4.8.2 Soldering – Results



Wetting vs. Preheat

Start-temperature End-temperature Time

4.8.2 Soldering – Results

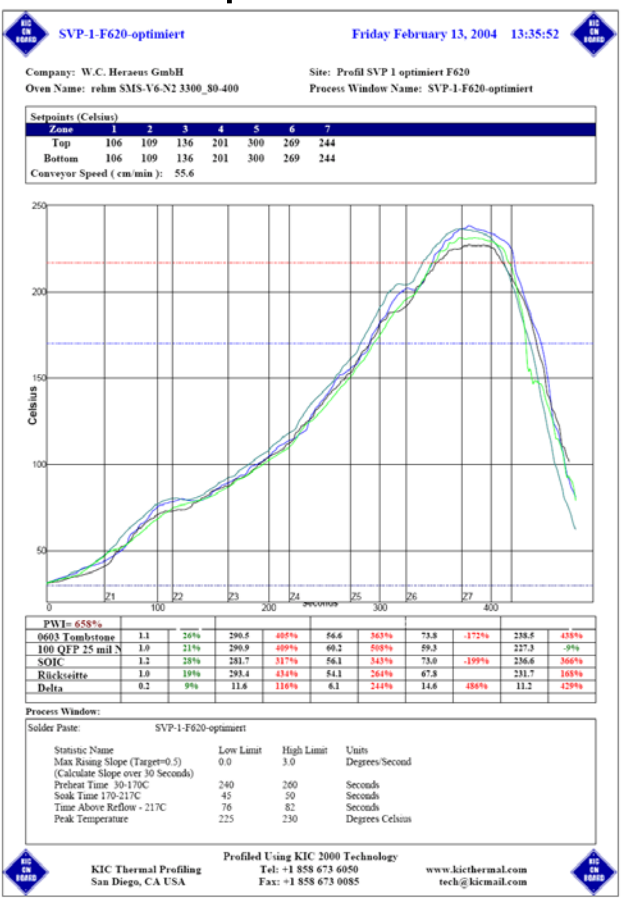


Solder balls / beats vs. soak start-temperature

Solder balls / beats vs. soak time

4.8.2 Soldering – Optimization

SVP 1 - optimized



SVP-1-F620-optimiert — **Friday February 13, 2004 13:35:52**

Company: W.C. Heraeus GmbH — Site: Profil SVP 1 optimiert F620
Oven Name: rehm SMS-V6-N2 3300_80-400 — Process Window Name: SVP-1-F620-optimiert

Setpoints (Celsius)

Zone	1	2	3	4	5	6	7
Top	106	109	136	201	300	269	244
Bottom	106	109	136	201	300	269	244

Conveyor Speed (cm/min): 55.6

PWI= 658%										
0603 Tombstone	1.1	26%	290.5	405%	56.6	363%	73.8	-172%	238.5	438%
100 QFP 25 mil N	1.0	21%	290.9	409%	60.2	508%	59.3		227.3	-9%
SOIC	1.2	28%	281.7	317%	56.1	343%	73.0	-199%	236.6	366%
Rückseitte	1.0	19%	293.4	434%	54.1	264%	67.8		231.7	168%
Delta	0.2	9%	11.6	116%	6.1	244%	14.6	486%	11.2	429%

Process Window:

Solder Paste: SVP-1-F620-optimiert

Statistic Name	Low Limit	High Limit	Units
Max Rising Slope (Target=0.5) (Calculate Slope over 30 Seconds)	0.0	3.0	Degrees/Second
Preheat Time 30-170C	240	260	Seconds
Soak Time 170-217C	45	50	Seconds
Time Above Reflow - 217C	76	82	Seconds
Peak Temperature	225	230	Degrees Celsius

Profiled Using KIC 2000 Technology
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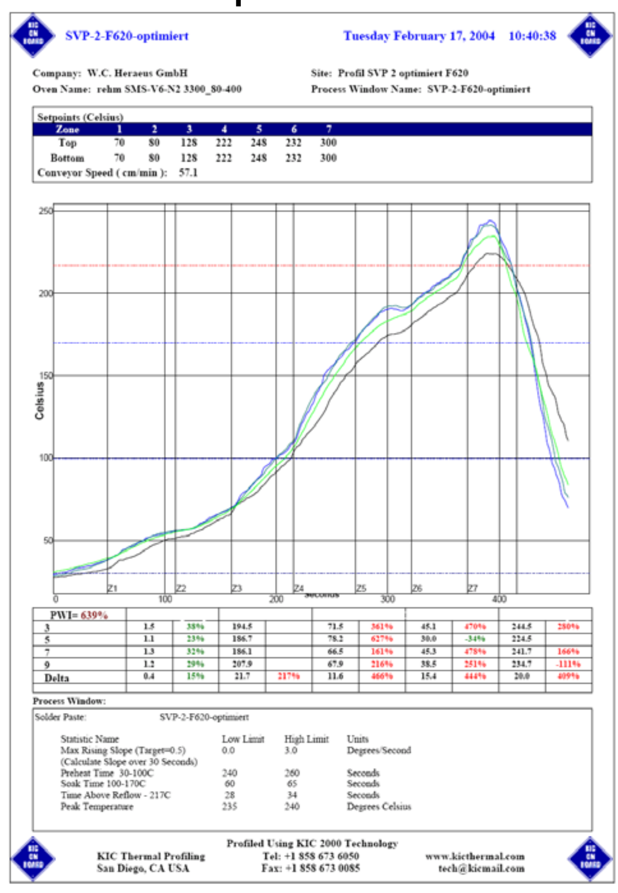
SVP 2 - optimized



SVP-2-F620-optimiert — **Tuesday February 17, 2004 10:40:38**

Company: W.C. Heraeus GmbH — Site: Profil SVP 2 optimiert F620
Oven Name: rehm SMS-V6-N2 3300_80-400 — Process Window Name: SVP-2-F620-optimiert

Setpoints (Celsius)

Zone	1	2	3	4	5	6	7
Top	70	80	128	222	248	232	300
Bottom	70	80	128	222	248	232	300

Conveyor Speed (cm/min): 57.1

PWI= 639%										
3	1.5	38%	194.5		71.5	361%	45.1	470%	244.5	280%
5	1.1	23%	186.7		78.2	627%	30.0	-34%	224.5	
7	1.3	32%	186.1		66.5	161%	45.3	478%	241.7	166%
9	1.2	29%	207.9		67.9	216%	38.5	251%	234.7	-111%
Delta	0.4	15%	21.7	217%	11.6	466%	15.4	444%	20.0	409%

Process Window:

Solder Paste: SVP-2-F620-optimiert

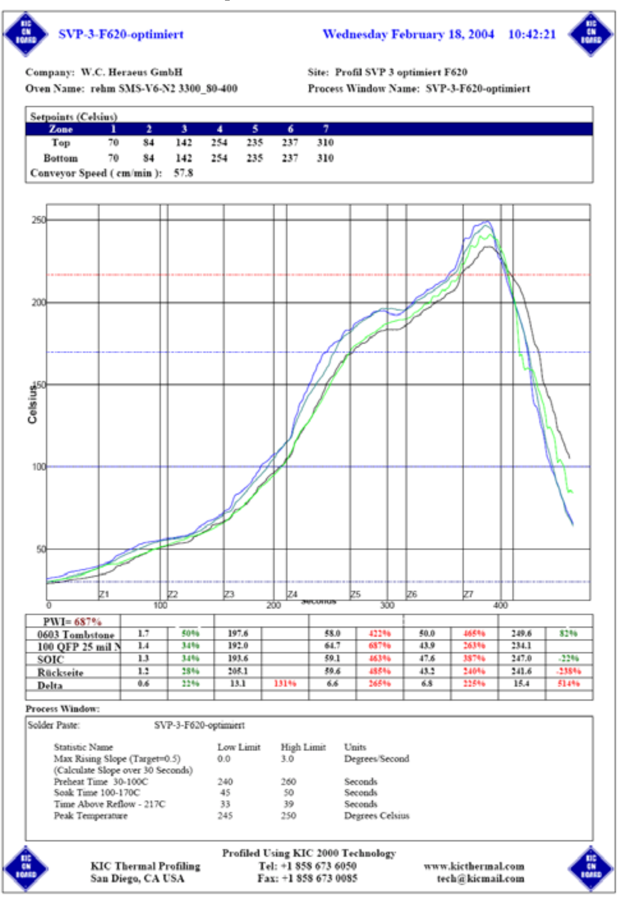
Statistic Name	Low Limit	High Limit	Units
Max Rising Slope (Target=0.5) (Calculate Slope over 30 Seconds)	0.0	3.0	Degrees/Second
Preheat Time 30-100C	240	260	Seconds
Soak Time 100-170C	60	65	Seconds
Time Above Reflow - 217C	28	34	Seconds
Peak Temperature	235	240	Degrees Celsius

Profiled Using KIC 2000 Technology
KIC Thermal Profiling, San Diego, CA USA — Tel: +1 858 673 6050, Fax: +1 858 673 0085 — www.kicthermal.com, tech@kicmail.com

Measured profiles by SlimKic

4.8.2 Soldering – Optimization

SVP 3 - optimized



SVP-3-F620-optimiert Wednesday February 18, 2004 10:42:21

Company: W.C. Heraeus GmbH
Oven Name: rehm SMS-V6-N2 3300_80-400
Site: Profil SVP 3 optimiert F620
Process Window Name: SVP-3-F620-optimiert

Setpoints (Celsius)

Zone	1	2	3	4	5	6	7
Top	70	84	142	254	235	237	310
Bottom	70	84	142	254	235	237	310

Conveyor Speed (cm/min): 57.8

PWI= 687%										
0603 Tombstone	1.7	50%	197.6		58.0	422%	50.0	465%	249.6	82%
100 QFP 25 mil N	1.4	34%	192.0		64.7	687%	43.9	263%	234.1	
SOIC	1.3	34%	193.6		59.1	463%	47.6	387%	247.0	-22%
Rückseite	1.2	28%	205.1		59.6	485%	43.2	240%	241.6	-238%
Delta	0.6	22%	13.1	131%	6.6	265%	6.8	225%	15.4	514%

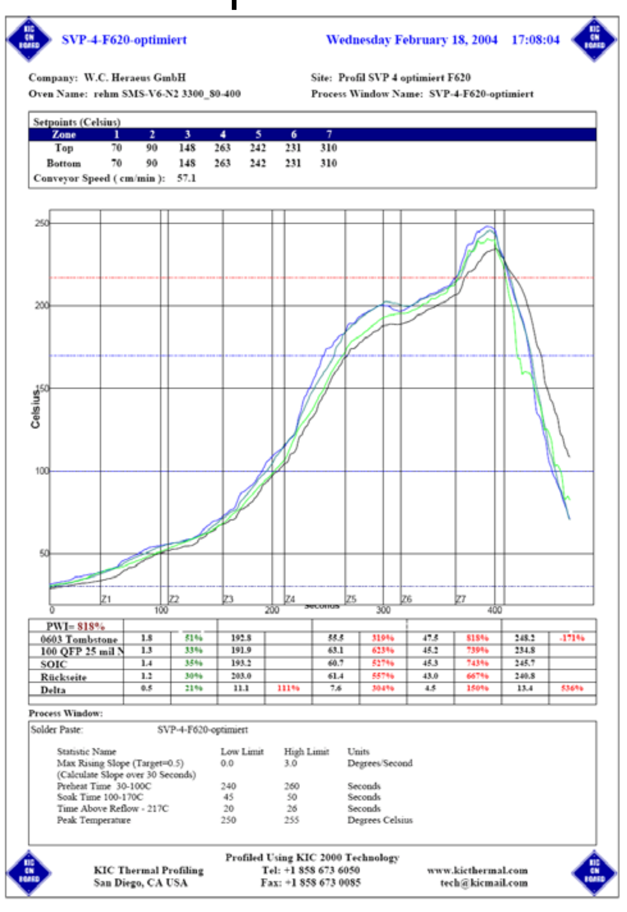
Process Window:

Solder Paste: SVP-3-F620-optimiert

Statistic Name	Low Limit	High Limit	Units
Max Rising Slope (Target=0.5) (Calculate Slope over 30 Seconds)	0.0	3.0	Degrees/Second
Preheat Time 30-100C	240	260	Seconds
Soak Time 100-170C	45	50	Seconds
Time Above Reflow - 217C	33	39	Seconds
Peak Temperature	245	250	Degrees Celsius

Profiled Using KIC 2000 Technology
KIC Thermal Profiling, San Diego, CA USA
Tel: +1 858 673 6050
Fax: +1 858 673 0085
www.kicthermal.com
tech@kicmail.com

SVP 4 - optimized



SVP-4-F620-optimiert Wednesday February 18, 2004 17:08:04

Company: W.C. Heraeus GmbH
Oven Name: rehm SMS-V6-N2 3300_80-400
Site: Profil SVP 4 optimiert F620
Process Window Name: SVP-4-F620-optimiert

Setpoints (Celsius)

Zone	1	2	3	4	5	6	7
Top	70	90	148	263	242	231	310
Bottom	70	90	148	263	242	231	310

Conveyor Speed (cm/min): 57.1

PWI= 818%										
0603 Tombstone	1.8	51%	192.8		55.5	319%	47.5	818%	248.2	-171%
100 QFP 25 mil N	1.3	33%	191.9		63.1	623%	45.2	739%	234.8	
SOIC	1.4	35%	193.2		60.7	527%	45.3	743%	245.7	
Rückseite	1.2	30%	203.0		61.4	557%	43.0	667%	240.8	
Delta	0.5	21%	11.1	111%	7.6	304%	4.5	150%	13.4	536%

Process Window:

Solder Paste: SVP-4-F620-optimiert

Statistic Name	Low Limit	High Limit	Units
Max Rising Slope (Target=0.5) (Calculate Slope over 30 Seconds)	0.0	3.0	Degrees/Second
Preheat Time 30-100C	240	260	Seconds
Soak Time 100-170C	45	50	Seconds
Time Above Reflow - 217C	20	26	Seconds
Peak Temperature	250	255	Degrees Celsius

Profiled Using KIC 2000 Technology
KIC Thermal Profiling, San Diego, CA USA
Tel: +1 858 673 6050
Fax: +1 858 673 0085
www.kicthermal.com
tech@kicmail.com

Measured profiles by SlimKic

4.8.2 Soldering – Profiles optimized

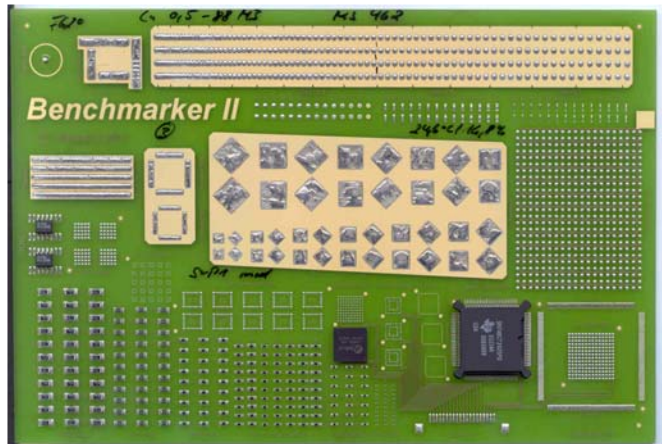
SVP Optimiert

Temperature [°C]: 0, 50, 100, 150, 200, 250, 300

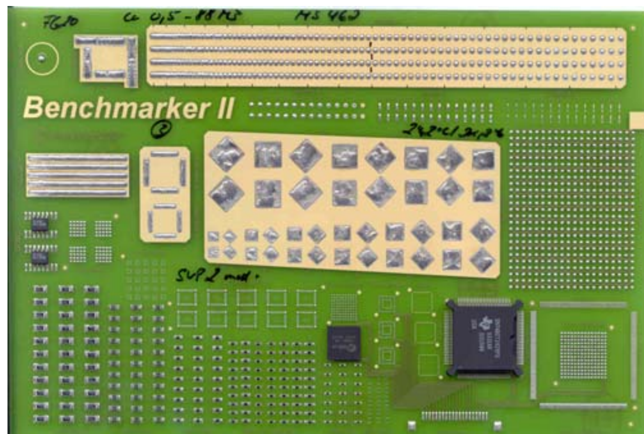
Time [sec.]: 0, 100, 200, 300, 400, 500

- PCB-1
- QFP 100-1
- SO8-1
- LP Unterseite-1
- PCB-2
- QFP 100-2
- SO8-2
- LP Unterseite-2
- PCB-3
- QFP 100-3
- SO8-3
- LP Unterseite-3
- PCB-4
- QFP 100-4
- SO8-4
- LP Unterseite-4

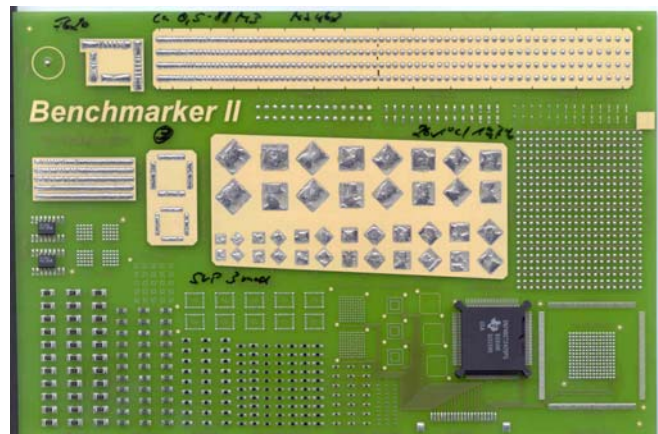
4.8.2 Soldering – Results of soldered boards after optimization



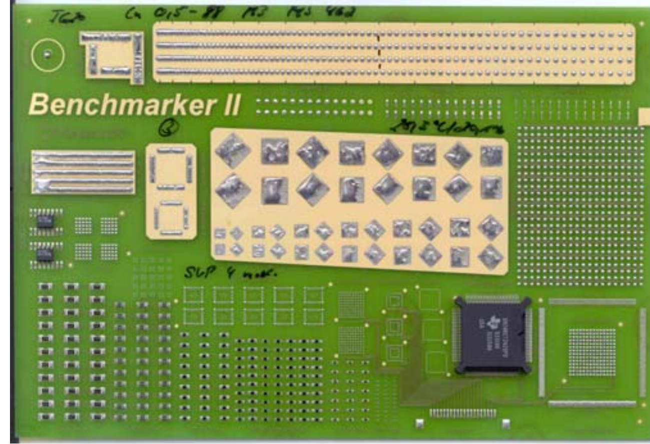
SVP 1 - optimized



SVP 2 - optimized



SVP 3 - optimized



SVP 4 - optimized

5 Assembling

- **5.1 Lead Free Material**
- **5.2 Finishes Components**
- **5.3 Finishes on Printed Circuits Boards (PCB)**
- **5.4 Reaction of Exchange**

5.1 Lead Free Material

The present situation in Fujitsu

Change of viscosity due to reaction between Sn and flux with insensitive saltformation

IMAPS Seoul, Sep. 2./3. 2004 K. Hasihimoto (Fujitsu Laboratories Ltd./Japan) Assembly Technology Using Pb-free Solders: the State of the Art and Issues

5.1 Lead Free Material

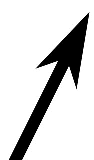
Alloy system	Company	Composition(mass%)
Sn-Ag	NEC (Japan)	Sn-3.5Ag-0.7Cu(Sn-3.5Ag(Mp:494K))
	Oki (Japan)	Sn-3.5Ag(-0.7Cu)
	Iowa State Univ. (USA)	Sn-4.7Ag-1.7Cu
	AIM Inc. (USA)	Sn-2.5Ag-0.8Cu-0.5Sb
Sn-Ag-Bi	Hitachi (Japan)	Sn-Ag-Bi(ex. Sn-2.5Ag-2.0Bi)
	Sony (Japan)	Sn-2Ag-4Bi-3.0In-0.1Ge
	Sandia National Lab. (USA)	Sn-3.4Ag-4.8Bi
	Cookson Technol. C. (USA)	Sn-2Ag-7.5Bi-3.0In
Sn-Ag-Bi-In	Matushita (Japan)	Sn-Ag-Bi-In (Sn-2.5Ag-2Bi-3In)
	Toyata (Japan)	Sn-2.5Ag-3Bi-1In-0.2Cu
	Mitsui (Japan)	Sn-2.5Ag-2.5Bi-2.5In
Sn-Zn	Toshiba (Japan)	Sn-8.8Zn(T_m:472K)
Sn-Cu	IEC electronics corp. (USA)	Sn-0.7Cu (T_m:493K)
	Matushita (Japan)	Sn-0.7Cu-X
Sn-Bi	Fujitsu (Japan)	Sn-58Bi (T_m:412K)

IMAPS Seoul, Sep. 2./3. 2004
Y-E Shin (KMJA/Korea) Thermal Fatigue Life in µBGA and Flip Chip Solder Joints

- Solders being adopted
  - Sn- 3.0~4.0 Ag- 0.5~0.7 Cu
    - Paste, ball
  - Sn-0.7Cu
    - Wave soldering
  - Sn-Ag-Cu-Sb (CASTIN®)
    - Wave soldering, paste

- Solders being under consideration
  - Sn-Ag-Cu-Ni-Ge (patented JPN)
    - paste
  - Sn-Zn-Al (patented JPN)
    - paste, ball
      - Paste for SAC ball attachment
  - Sn-Zn-Bi (not intend to accept)

- Sn-Cu-Ni
  - Wave soldering
- Sn-Zn-Ag-Al-Ga (patented TWN, pending JPN, US)
  - ball



- IMC formation mechanism
  - SAC/Cu-Ni-Au; SAC/Cu
  - SAC/UBM
  - Sn-Zn/Cu-Ni-Au; Sn-Zn/Cu

- Electromigration
  - SAC/UBM
  - Sn-Zn/Cu
- Thermodynamics
  - Ternary phase diagram establishment
- Interfacial Interaction
  - Wetting behavior

- Pb-free solder alloy development
  - Sn-Zn system: Sn-Zn-Ag-Al-Ga
    - Eutectic temperature: 198°C
    - Form layer, instead of columnar, IMC with Cu and Au – no Cu-Sn or Au-Sn IMC
    - Higher UTS and greater ductility than Sn-37Pb
    - Solder ball (Ø 0.3mm~0.76mm being successfully produced)
    - Improved oxidation resistance over Sn-9Zn
    - At least a commercial flux works well for ball attachment
      - Good shear strength (as reflowed, 5 cycle reflow)
  - Cost lowers than SAC

IMAPS Seoul, Sep. 2./3. 2004
K-L Lin (National Cheng Kung Univ./Taiwan) Review of Pb-free Activities in Taiwan

5.2 Finishes Components

	Sn	SnBi	SnAg	SnCu	Pd
IA	SEC (Developing)	SONY, Fujitsu, Matsushita NEC, TOSHIBA, Renesas SANYO, **SEC(Mass Prod.)**	TOSHIBA	TOSHIBA Renesas Rohm	SONY, Matsushita TOSHIBA, Renesas, SEC (Developed)
S	MOTOROLA, TI, Intel National Semiconductor ON Semiconductor AMD, Fairchild	MOTOROLA (for Japan customers)			MOTOROLA, TI, Fairchild On Semiconductor
U	Infineon, Phillips ST Microelectronics				Philips Cypress

	Asia	US	EU	Total
ure Sn	1	6	3	10
Sn-Bi	9	2		11
Sn-Cu	2	1		3
Sn-Ag	1	1		2
iPdAu	5	3	2	10

*20 Companies : Samsung, Intel, Renesas, TI, Toshiba, ST Micronics, Infineon, Philips, NEC, TSMC, Motorola, IBM, Matsushita, Fujitsu, AMD, SONY, Sharp, Seiko-Epson, HP, Amkor

IMAPS Seoul, Sep. 2./3. 2004
S-Y Jeon (Samsung Electronics/Korea) Pb-free Strategy of Semiconductor Business in Samsung Electronics

5.3 Finishes on Printed Circuits Boards (PCB)

- ENIG NiAu
- Immersion Sn
- Immersion Ag
- Cu OSP
- HAL SnCu / SnCuNi
- Cu-Au
- EL Ni-Pd
- EL Pd

ZVEI 15.Sep. 2004; J.Albrecht, Siemens AG CT MM6; Anforderungen an bleifreie Elektronik in den einzelnen Anwendungsbereichen - Industrieelektronik

5.4 Reaction of Exchange - Tombstones

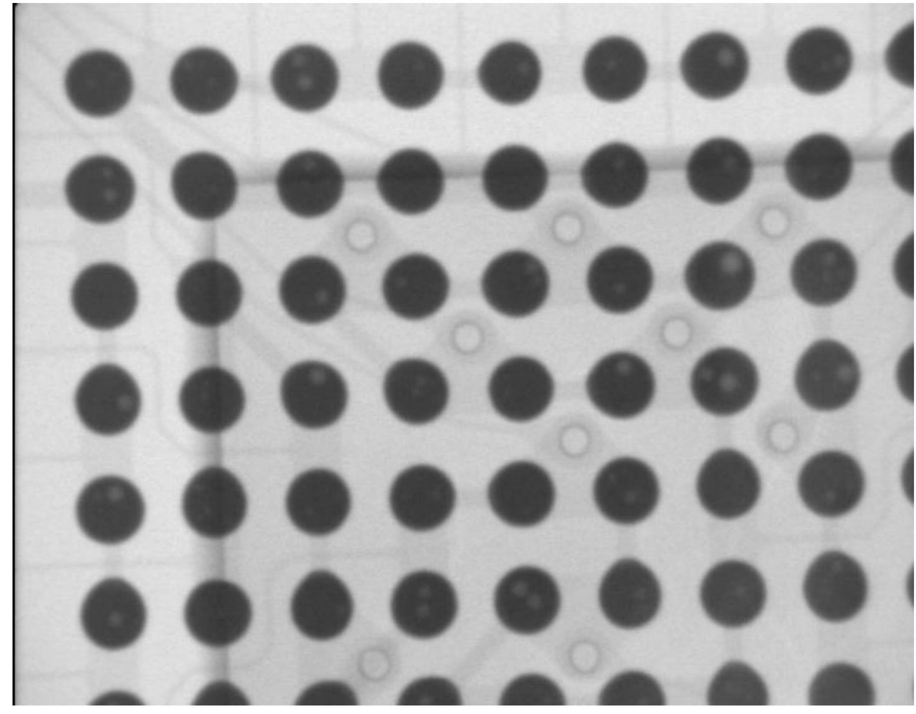
5.4 Reaction of Exchange - Tombstones

Tombstones at LC and LF finishes with placement offset of 200µm

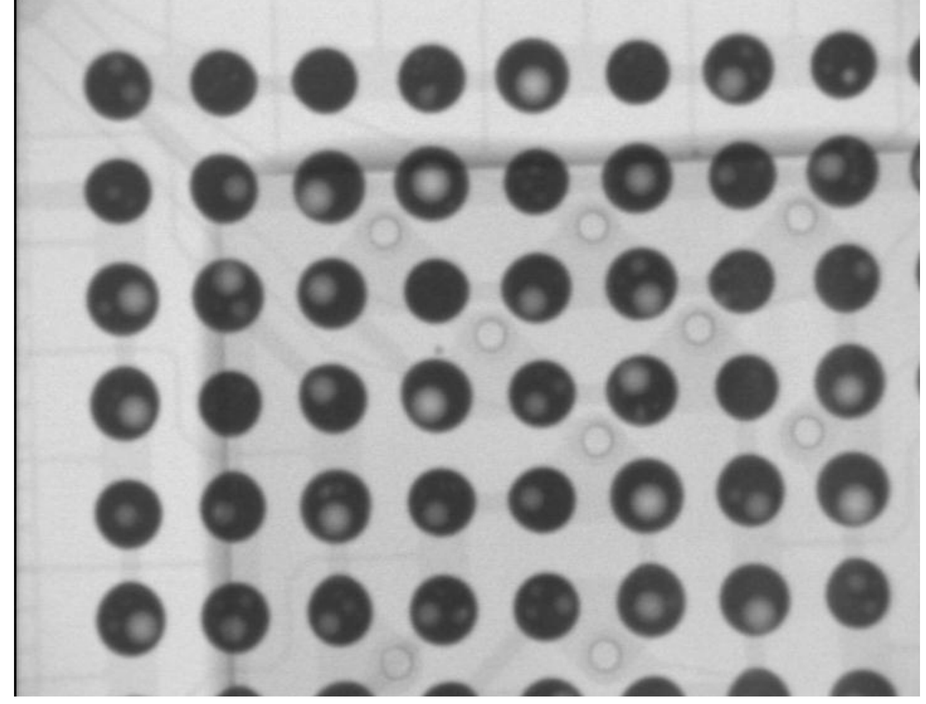
5.4 Reaction of Exchange – Solder Balls vs. Component Finishes

5.4 Reaction of Exchange – Ball material (LF or LC) vs. LF soldering

BGA lead free



BGA lead contain



6 Reliability

- 6.1 Failure Data
- 6.2 Voids
- 6.3 Inter Metallic Connection (IMC)
- 6.4 Future Trends

6.1 Failure Data - Example

Failure Data for 0 C to 100 C (30 min Cycle Time)

Percentile: 99, 95, 90, 75, 50, 25, 10, 5, 1

Legend: 3.8Ag(slow), 3.8Ag(fast), 2.3Ag(slow), 2.3Ag(fast), 2.5Ag(slow), 2.5Ag(fast), 2.1Ag(slow), 2.1Ag(fast)

Cycles to Fail: 800, 1000, 1200, 1400, 1600, 1800

Multiple Sample Lognormal Probability Plot
Global Common σ = 0.153

Failure Data for 0 C to 100 C (120 min Cycle Time)

Percentile: 99, 95, 90, 75, 50, 25, 10, 5, 1

Legend: 3.8Ag(slow), 3.8Ag(fast), 2.3Ag(slow), 2.3Ag(fast), 2.5Ag(slow), 2.5Ag(fast), 2.1Ag(slow), 2.1Ag(fast)

Cycles to Fail: 600, 800, 1000, 1200, 1400

Multiple Sample Lognormal Probability Plot
Global Common σ = 0.153

Thermal Fatigue Life of Sn-Ag-Cu BGA Joints

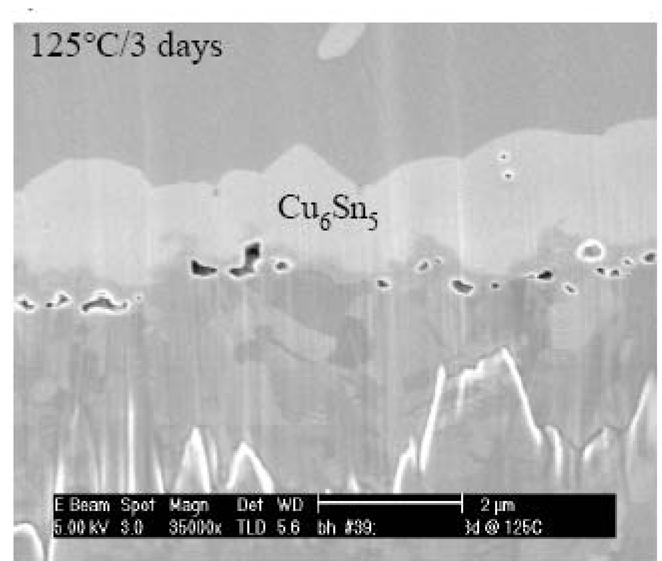
- SAC alloys with reduced Ag
  - Sn-3.8Ag-0.7Cu (control)
  - Sn-2.3Ag-0.4Cu-0.2Bi (optimized alloy)
  - Sn-2.7Ag-0.7Cu (intermediate Ag)
  - Sn-2.3Ag-0.9Cu (low Ag, w/o Bi)

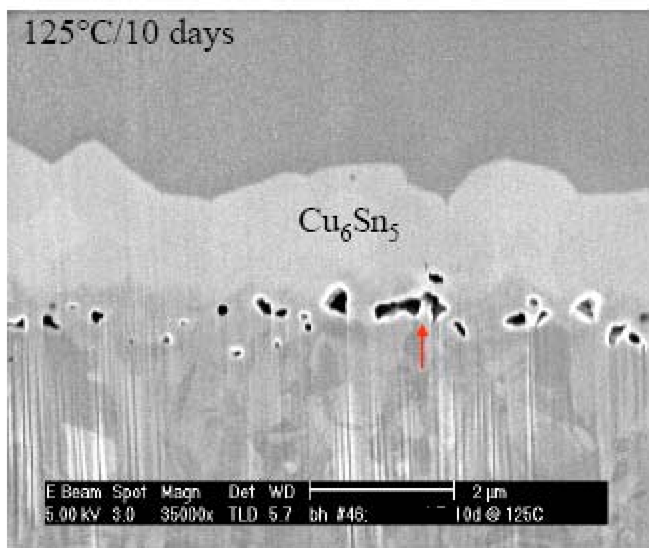
IMAPS Seoul, Sep. 2./3. 2004
S.K. Kang (IBM/USA) Recent Progress in Pb-free Solders and Soldering Technology: Fundamentals, Reliability Issues and Applications

6.2 Voids

Very strong correlation between drop reliability and voiding for Cu/SnAgCu solder interface

- Kirkendall voids at Cu/Cu_3Sn interface are detrimental to the drop reliability after aging
  - Similar trend is expected for temperature cycling reliability
- Voiding process is activated at as low as 100° C
- Bare Cu or OSP-Cu surface finish is not suitable for higher temperature applications





IMAPS Seoul, Sep. 2./3. 2004
S.K. Kang (IBM/USA) Recent Progress in Pb-free Solders and Soldering Technology: Fundamentals, Reliability Issues and Applications

6.2 Voids vs. Temperature profile SAC (Ag4)

Padsize: 160µm

Faktor: 0%

Padsize: 500µm

Faktor: 8%

Bord:	Heraeus Array Bumping System NiAu	
Printer:	Typ:	Ekra E5
	Squeegee pressure:	20N
	Squeegee speed: 9mm/s	
	Separation distance:	3mm
	Separation speed: 0,2mm/s	
	Screen:	Koenen 137473
		Koenen 137437
Inspection:	Viscom X8008	

6.2 Voids vs. Temperature profile SAC (Ag4)

Padsize: 160µm

Faktor: 1%

Padsize: 500µm

Faktor: 8%

Bord:	**Heraeus Array Bumping System NiAu**	
Printer:	**Typ:**	**Ekra E5**
	Squeegee pressure:	**20N**
	Squeegee speed:	**9mm/s**
	Separation distance:	**3mm**
	Separation speed:	**0,2mm/s**
	Screen:	**Koenen 137473**
		Koenen 137437
Inspection:	**Viscom X8008**	

6.2 Voids vs. Temperature profile SAC (Ag4)

Padsize: 160µm

Faktor: 3%

Padsize: 500µm

Faktor: 23%

Bord:	**Heraeus Array Bumping System NiAu**	
Drucker:	**Typ:**	**Ekra E5**
	Rakeldruck:	**20N**
	Rakelgeschwindigkeit:	**9mm/s**
	Trennweg:	**3mm**
	Trenngeschwindigkeit:	**0,2mm/s**
	Schablone:	**Koenen 137473**
		Koenen 137437
Inspektion:	**Viscom X8008**	

6.2 Voids vs. Temperature profile SAC (Ag4)

Padsize: 160µm

Faktor: 0%

Padsize: 500µm

Faktor: 9%

Bord:	**Heraeus Array Bumping System NiAu**	
Printer:	**Typ:**	**Ekra E5**
	Squeegee pressure:	**20N**
	Squeegee speed:	**9mm/s**
	Separation distance:	**3mm**
	Separation speed:	**0,2mm/s**
	Screen:	**Koenen 137473** **Koenen 137437**
Inspection:	**Viscom X8008**	

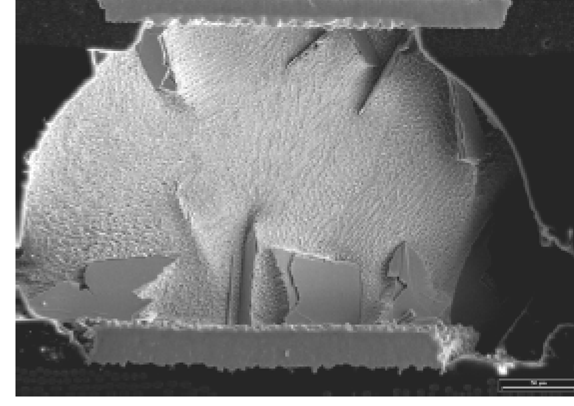
6.2 Voids vs. Temperature profile SAC (Ag4)

Overview over the influence of the different profile‘s

Profil	minimal Voids
8er	☺
SVP 2	😐
SVP 5	☹☹
SVP 7	😐

☺☺	- 0%	☺	- 1 to 8%	😐	- 9 to 15%
☹	- 16 to 20%	☹☹	- >21%		

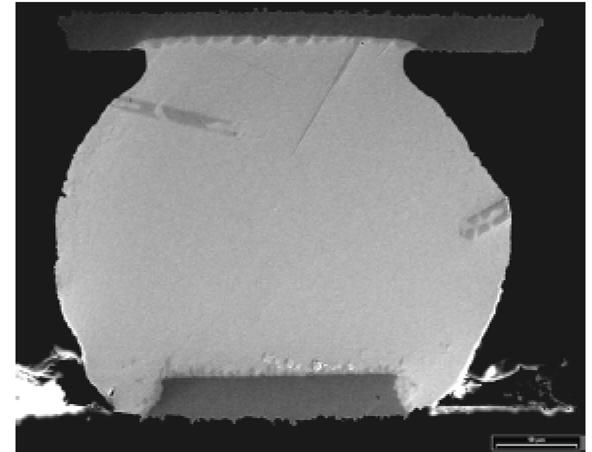
6.3 Inter Metallic Connection (IMC)



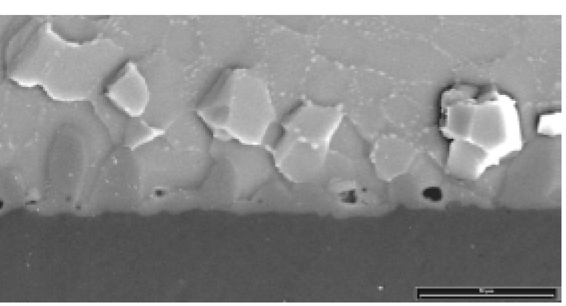
IMC

Characteristics Area Array Connection

IMV and Void formation



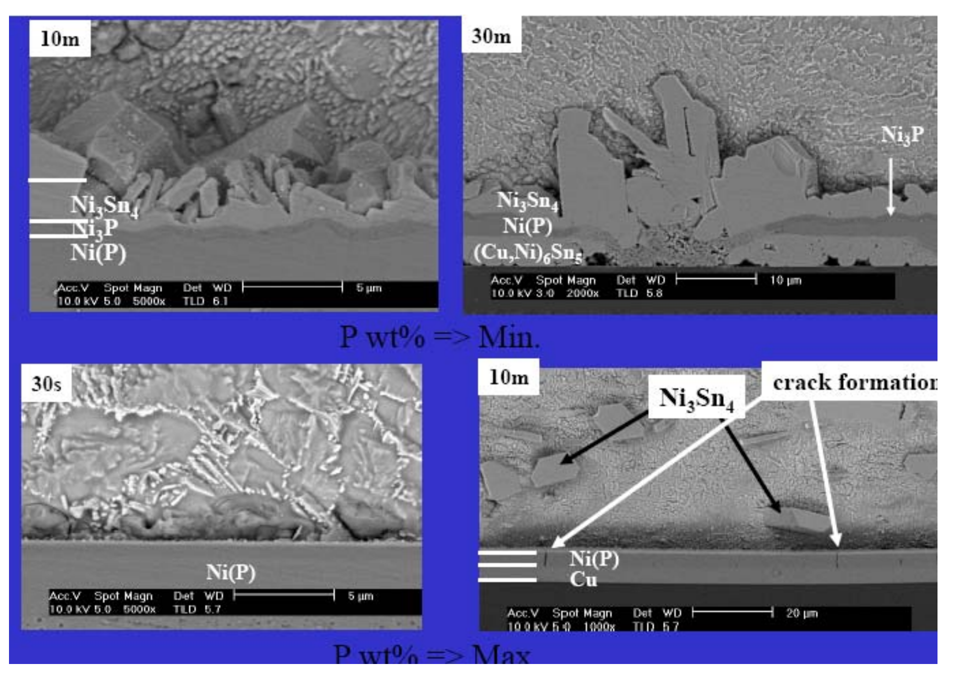
IMC und Void-Formation

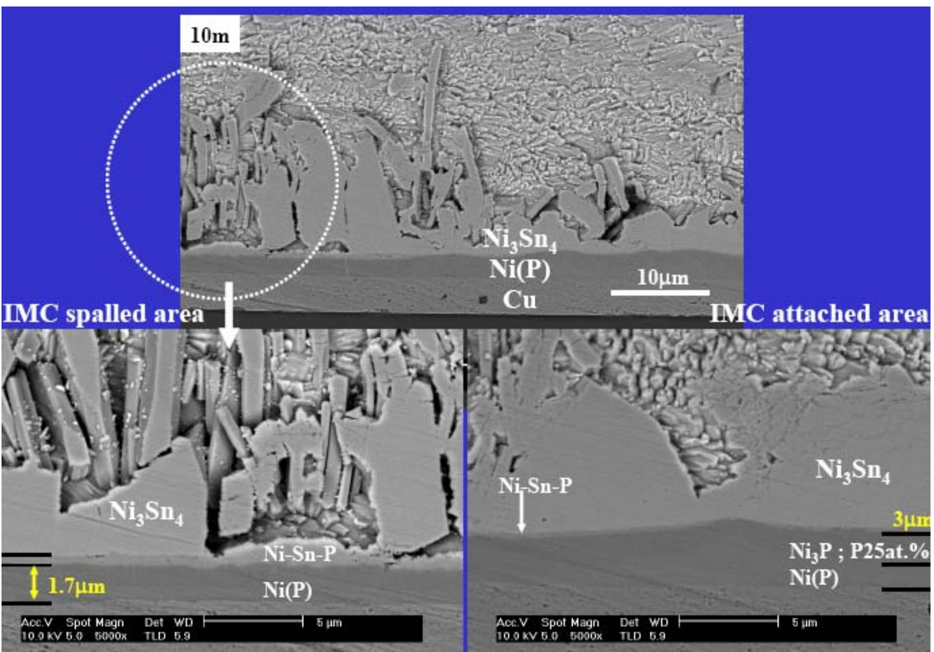


ZVEI 15.Sep. 2004; J.Albrecht, Siemens AG CT MM6; Anforderungen an bleifreie Elektronik in den einzelnen Anwendungsbereichen - Industrieelektronik

6.3 Inter Metallic Connection (IMC)

Reaction between electroless Ni and Sn3.5Ag





IMAPS Seoul, Sep. 2./3. 2004
T-Y Lee (Hanbat National Univ./Korea) Performance and Reliability Issues of Flip Chip Joints

6.3 Inter Metallic Connection (IMC)

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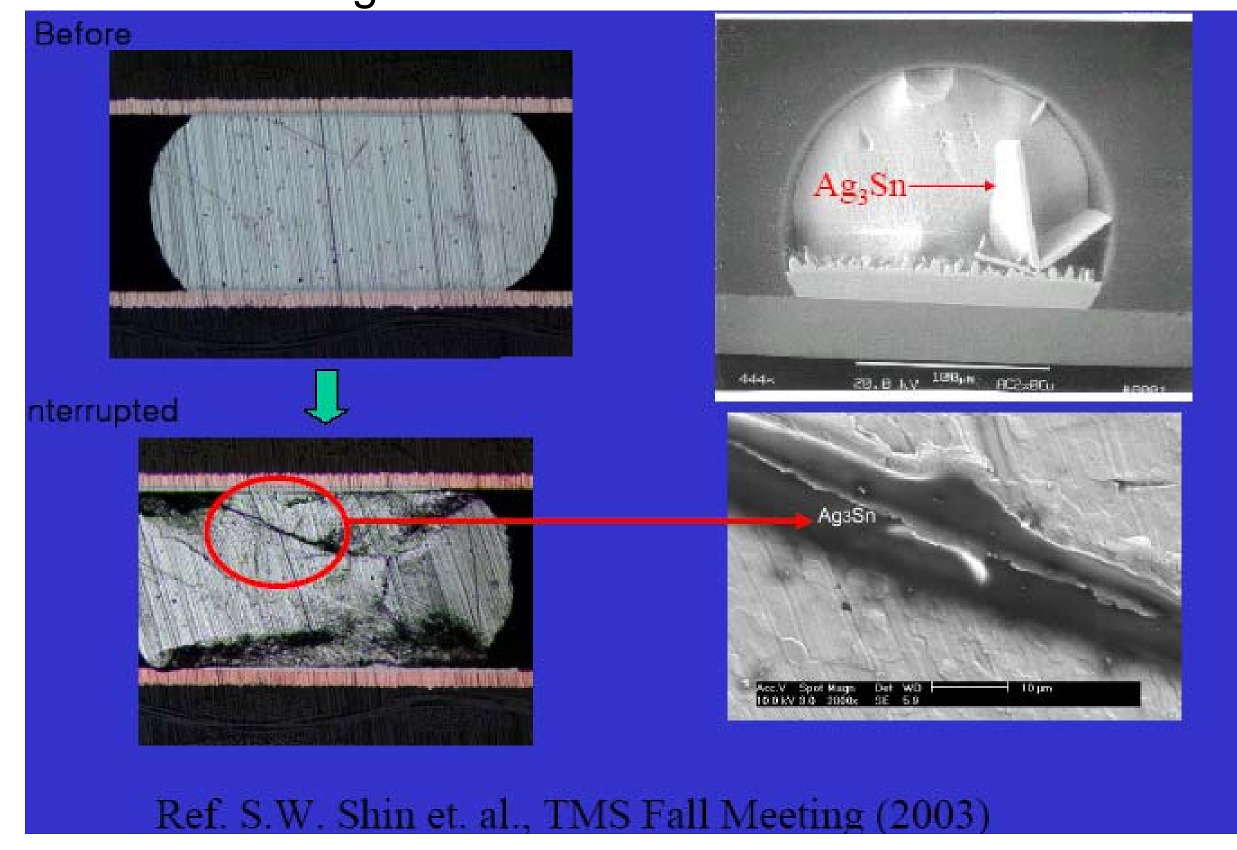

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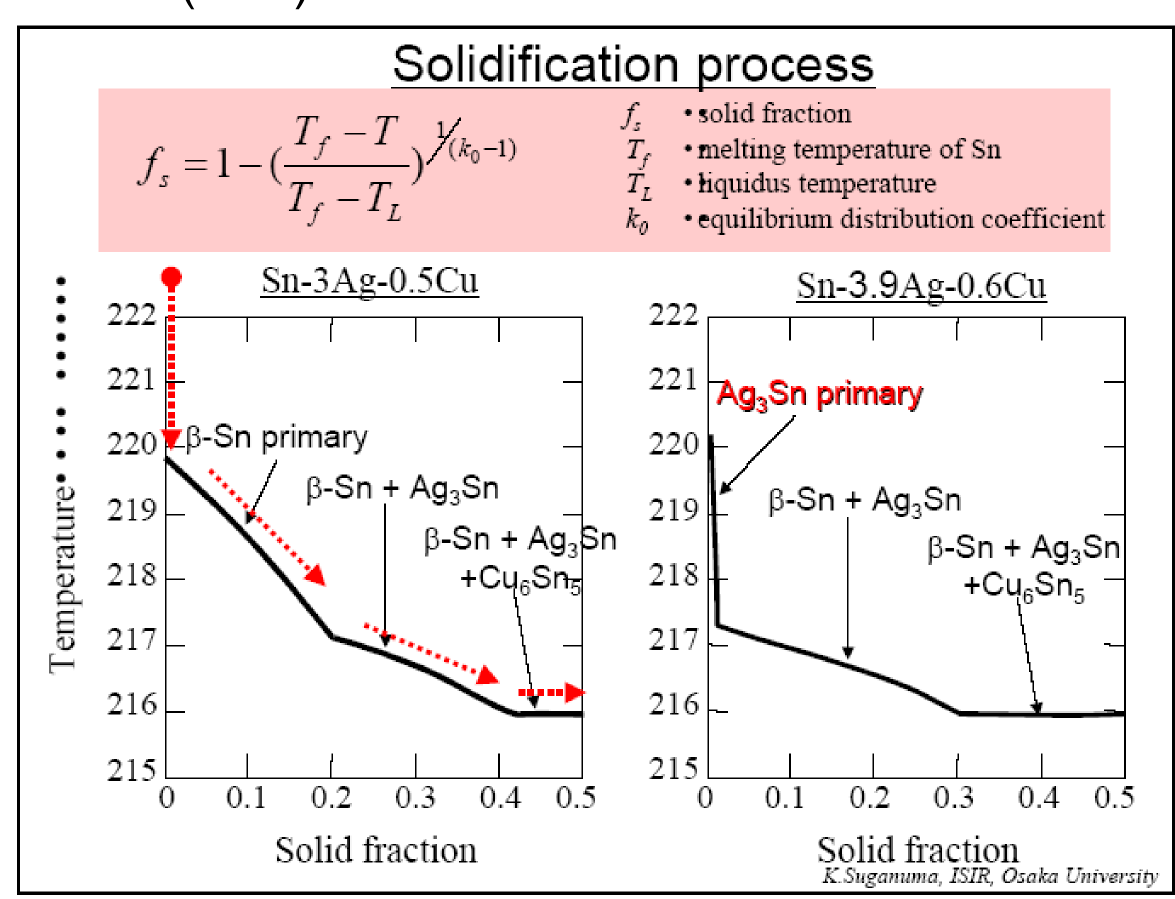
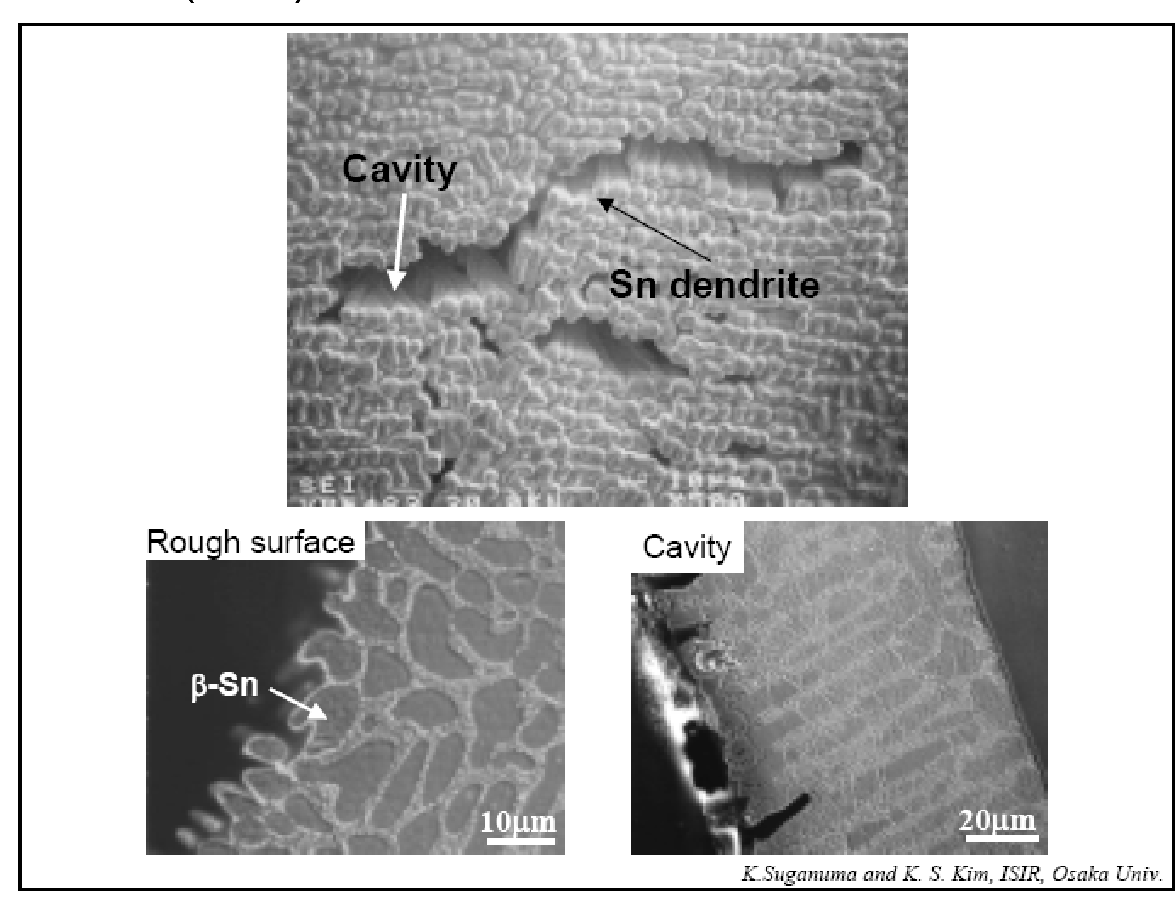


IMAPS Seoul, Sep. 2./3. 2004

K. Suganuma & K-S. Kim (Osaka Univ./Japan) Formation Mechanisms of Various Solderfication Defects in Lead-Free Soldering and Their Prevention

6.3 Inter Metallic Connection (IMC)

Shrinkage / Cavity also inside volume, Effect for Voidung



IMAPS Seoul, Sep. 2./3. 2004
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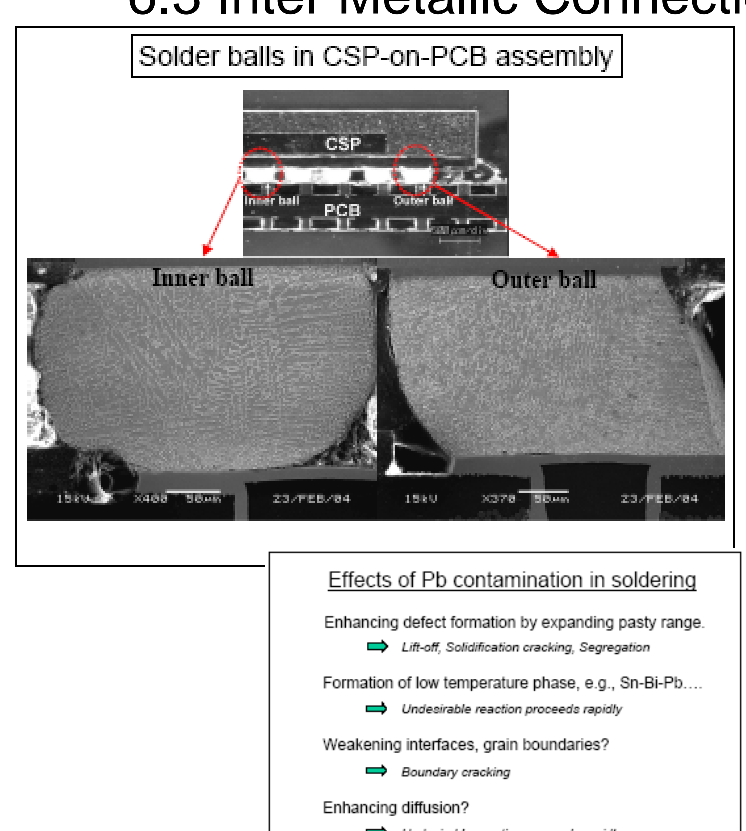
6.3 Inter Metallic Connection (IMC)



Effects of Pb contamination in soldering

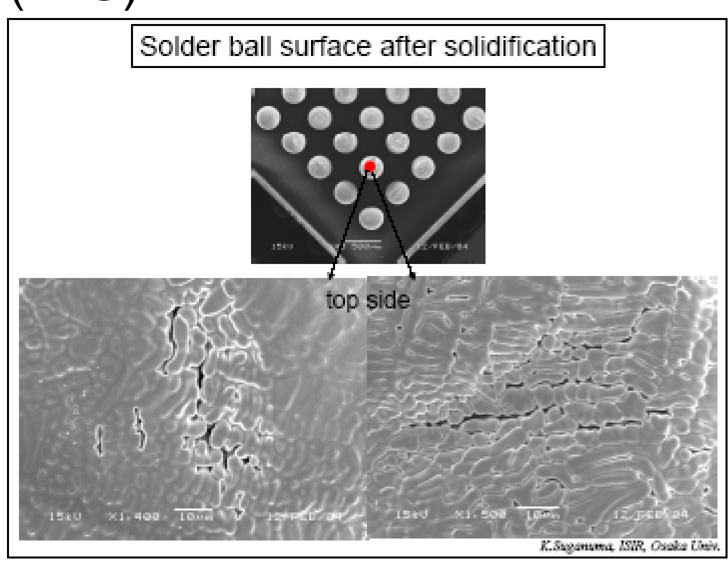
Enhancing defect formation by expanding pasty range.
⇨ *Lift-off, Solidification cracking, Segregation*

Formation of low temperature phase, e.g., Sn-Bi-Pb….
⇨ *Undesirable reaction proceeds rapidly*

Weakening interfaces, grain boundaries?
⇨ *Boundary cracking*

Enhancing diffusion?
⇨ *Undesirable reaction proceeds rapidly*

….. etc.



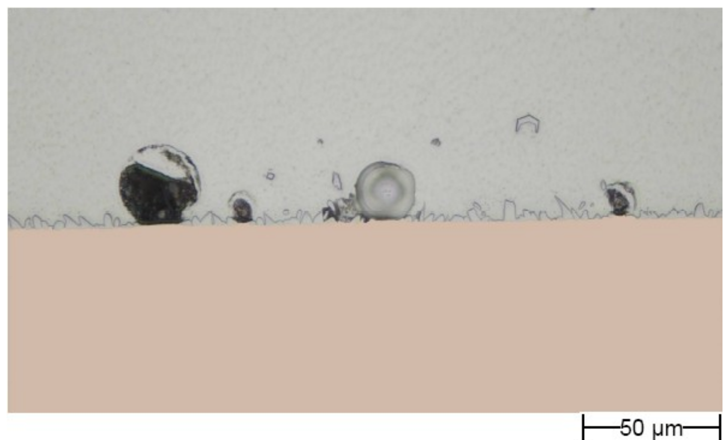
- **Hot cracking depend on solidification direction**
- **Solidification not uniform; IMC formation not uniform**
- **Cooling on board**

IMAPS Seoul, Sep. 2./3. 2004

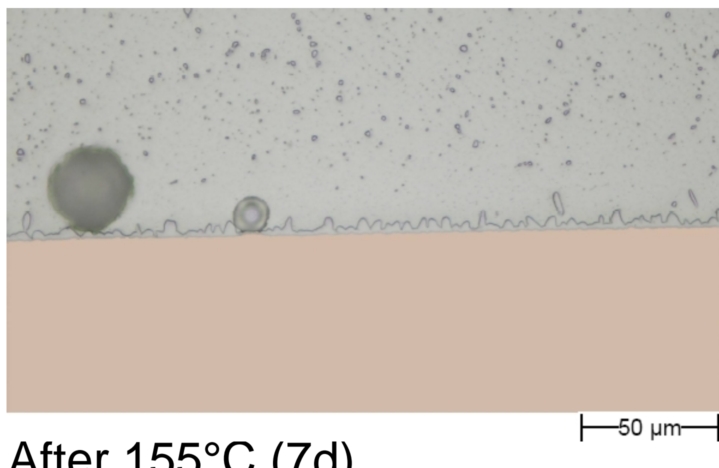
K. Suganuma & K-S. Kim (Osaka Univ./Japan) Formation Mechanisms of Various Solderfication Defects in Lead-Free Soldering and Their Prevention

6.3 Inter Metallic Connection (IMC)

Ag3

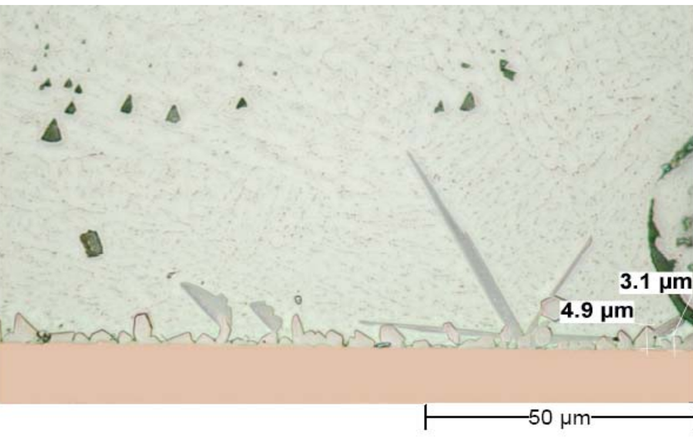


Initial

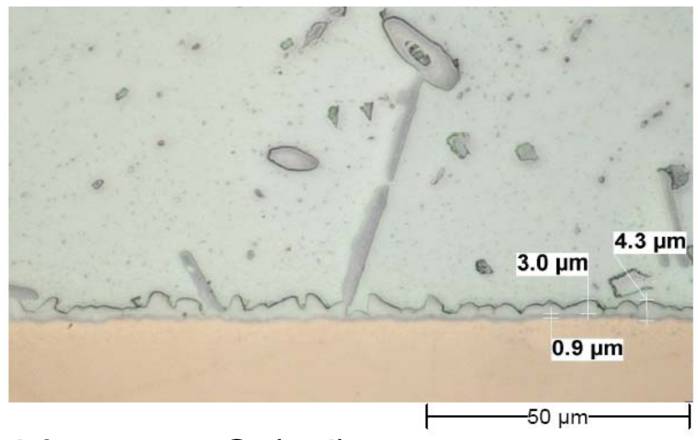


After 155°C (7d)

Ag4

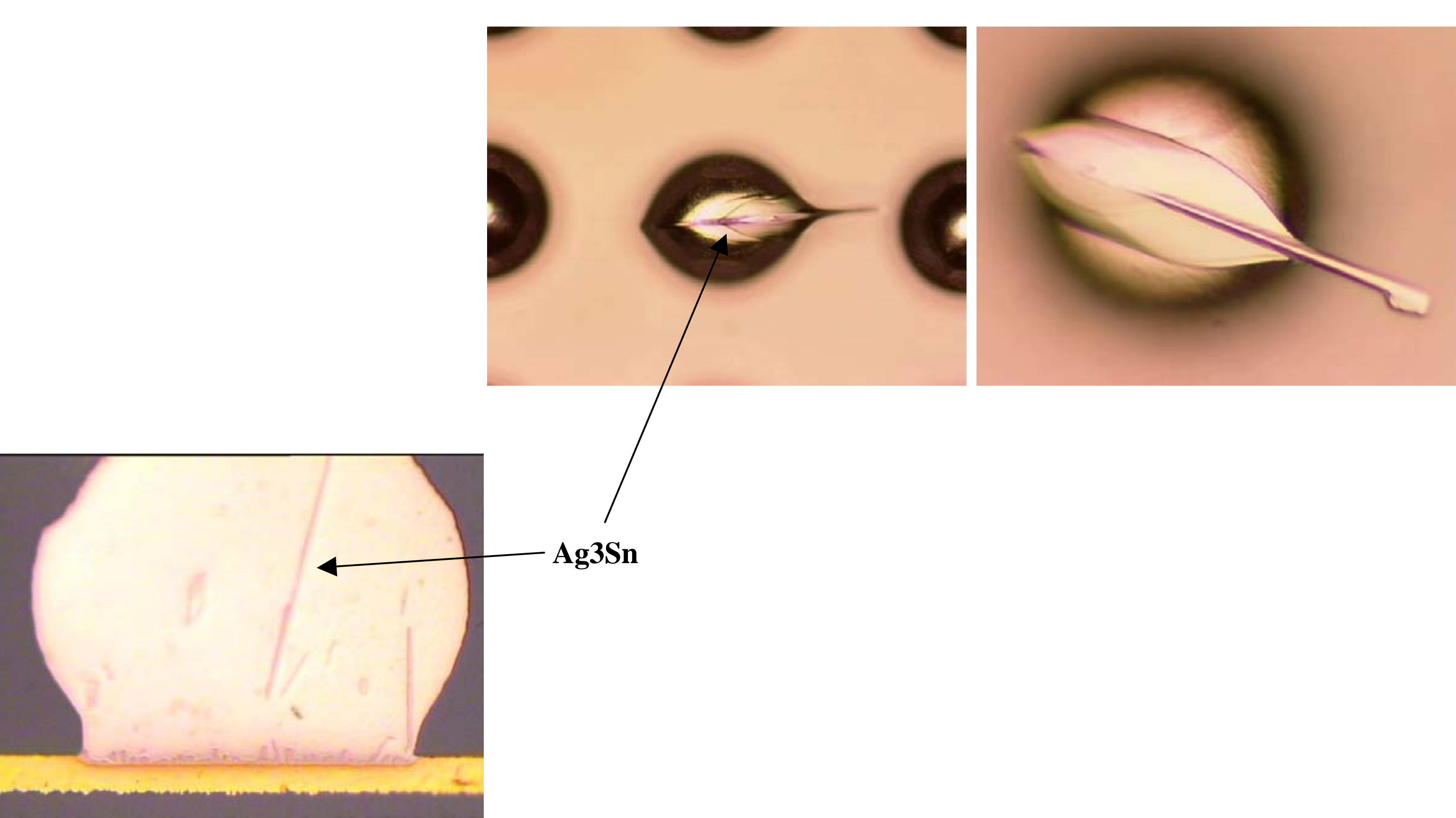


Initial



After 155°C (7d)

6.3 Inter Metallic Connection (IMC)

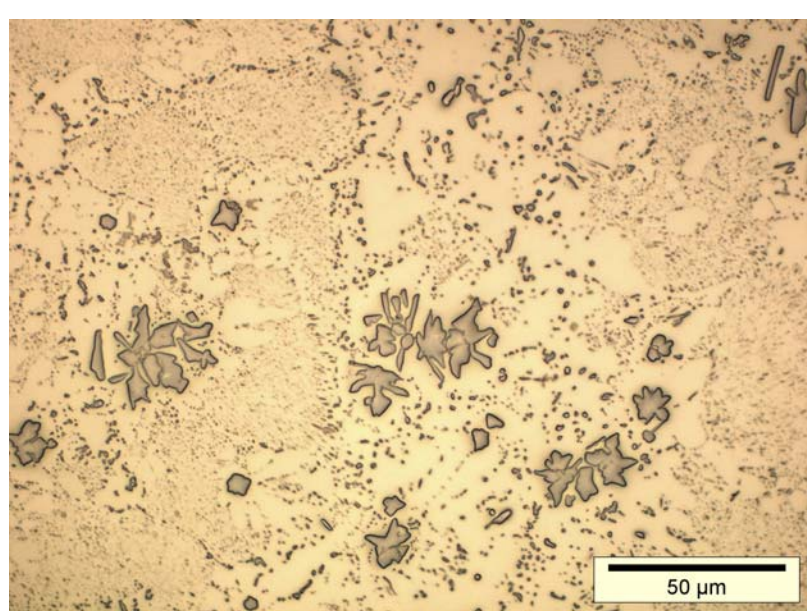


<BGA ball : SAC, Cu OSP> - Ball size : around 300um

6.3 Inter Metallic Connection (IMC)

SnAgCu +In

SnAgCu +In +Nd



Nucleus formation under the influence of elements; Reduction of critical IMC

6.3 Inter Metallic Connection (IMC) – Alternative Alloy for HT - Applications

R

DO

SO

TO

TO

QFP

CSP

C

BGA

6.3 Inter Metallic Connection (IMC) – Alternative Alloy for HT – Applications

Resistance measurement points

Benchmarker TF II

x Messpunkte
x bestückte Bauteile

a
15x 0603
b

c
15x 0402
d

e
15x 1206
f

g
15x 0201
h

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

CSP 56P 0,5mm

CSP 56P 0,5mm Daisy Chain

CSP 56P 0,5mm

BGA 100P 0,8mm

BGA 100P 0,8mm Daisy Chain

6.4 Future Trends

Future Trends of Micro Joining

- The Joining Reaction Layer Control Technology
- The Joining Interface Analysis Technology
- Low Temperature Joining Technology
- New Materials Development
- The Establishment of Evaluation Technology

IMAPS Seoul, Sep. 2./3. 2004
Y-E Shin (KMJA/Korea) Thermal Fatigue Life in µBGA and Flip Chip Solder Joints

6.4 Future Trends

Trends of Microelectronic Devices

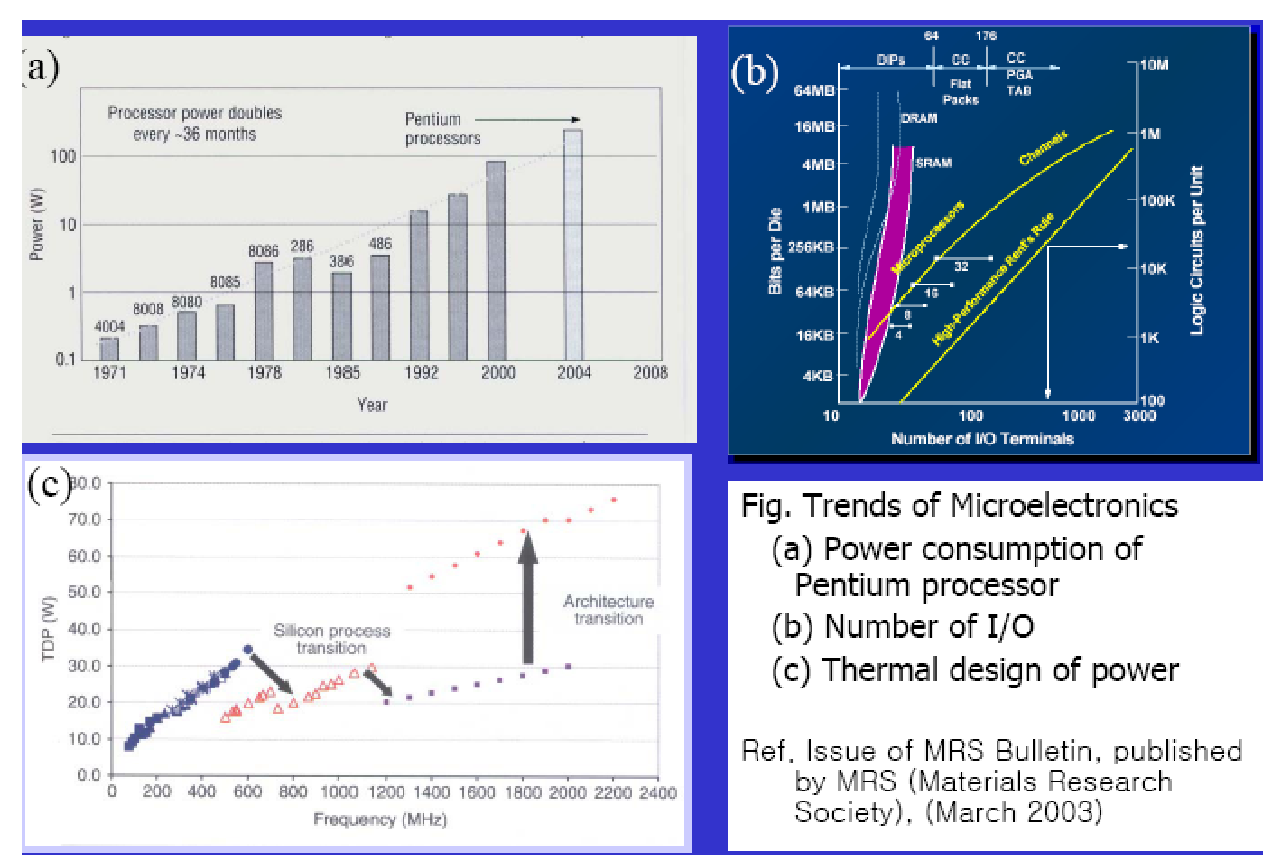


Fig. Trends of Microelectronics
(a) Power consumption of Pentium processor
(b) Number of I/O
(c) Thermal design of power

Ref. Issue of MRS Bulletin, published by MRS (Materials Research Society), (March 2003)

IMAPS Seoul, Sep. 2./3. 2004
T-Y Lee (Hanbat National Univ./Korea) Performance and Reliability Issues of Flip Chip Joints

6 Summary

- Extensive activities LF world wide
- No definition of alloy
- Automotive will follow
- Components, Minimizing compatible to LF ?
- Consumer products in a wide application
- Drop in solution for Pb ?
- Reduction of profile window for SAC
- Application depend on Reliability characteristic (IMC, Voiding, Dissolution…)
- HT properties

If you have further questions pls let us know!