

Self Qualification Results

Matte Sn + postbake leadfree solution for

Products with Copper based lead-frames

- *SQFP208 packages assembled in Philips Semiconductors Calamba.*
- *PLCC and SOJ packages assembled in ASE Kaohsiung and Amkor Philippines.*
- *HVQFN packages assembled in Amkor Korea.*
- *H(S)QFP assembled in Amkor Korea.*
- *TSSOP8/10/14/16/20/24/28/30 assembled in Amkor Philippines.*
- *SSOP14/16/20 assembled in Amkor Philippines.*

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Assembly & Test Organization Philips Semiconductors	Self Qualification Results: Matte Sn + postbake for SQFP at PSC, PLCC+SOJ at ASE and PLCC, HVQFN. H(S)QFP, SSOP and TSSOP at Amkor.	Document Number RNR-83-04/RdH/RdH-2030
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1. Introduction

The intention of the change to Pb-free packages from Philips has been announced in the Advance CPCN for Pb-free, issued in May 2003, CPCN # 200305025.

The final CPCN will be issued in different phases, each phase showing qualification results of a certain group of packages.

This self qualification report presents an overview of the qualification data completed to release a group of packages to be assembled in matte Sn + postbake solution.

This report covers the results of :

- SQFP208 packages assembled in Philips Semiconductors Calamba.
- PLCC and SOJ packages assembled in ASE Kaohsiung and Amkor Philippines.
- HVQFN packages assembled in Amkor Korea.
- H(S)QFP assembled in Amkor Korea.
- TSSOP8/10/14/16/20/24/28/30 assembled in Amkor Philippines.
- SSOP14/16/20 assembled in Amkor Philippines.

In order to validate assembly quality and reliability, a self-qualification program has been performed. The results of this qualification demonstrate that Philips Semiconductors can achieve distinctive assembly quality with equal or better product quality and reliability when compared to the lead-tin plated versions of these products.

With the introduction of matte Sn as Pb-free solution, the Bill of Materials (BoM) of the mentioned packages is fully compliant to the RoHS legislation requirements.

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2. Assembly Facilities

PSC

Philips Semiconductors Calamba is a new, state-of-art facility for the assembly and testing of IC's located at the Light Industry and Science Park II in Calamba. The plant occupies an area of 85,000 square meters of land. Construction of the first phase with a floor area of 17,900 square meters was completed in 1998, while the second phase is already in construction.

Package family portfolio and test capabilities of PSC consists of SSOP/TSSOP, QFP, HVQFN and LF/TFBGA.

Philips Semiconductors Calamba successfully passed certification to the QS9000 standard, while ISO 14001 certification was achieved in March 2000.

AMKOR

AMKOR is one of Philips preferred subcontractors and is established in 1968. Amkor has grown to be a world-class leader in integrated circuit (IC) packaging, assembly and test services. AMKOR has assembly factories in Korea (ATK), Taiwan (ATT), China (ATC) and the Philippines (ATP). Package family portfolio of AMKOR consists of amongst others DIP, SO, SSOP, PLCC, QFP, (LF)BGA and CSP. AMKOR is certified SAC level 1.

ASE

Advanced Semiconductor Engineering, Inc. (ASE Inc.) is the largest independent IC packaging company in Taiwan. The Company was founded in 1984. Commercial production began at the packaging facility located in the Nantze Export Processing Zone ("Nantze EPZ") in Kaohsiung, Taiwan in July 1984.

Package family portfolio of ASE consists of amongst others DIP, SO, SSOP, PLCC, CSP, QFP and (LF)BGA. ASE is certified SAC level 1.

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3. Material Selection background matte Sn + postbake

Main characteristics :

- material availability is good
- closest to SnPb in cost and process
- good solderability with SnPb and Pb free solders
- good solderjoint reliability
- “whisker free” process available (see section 5.3)

A comparison of the available post-plating finishes is showed in below table 1 :

Table 1 : Comparison Post-Plating Materials (source: E3)

Aspect	Sn Bright	Sn Matte	Sn Matte Baked	SnBi Bi<4%	SnCu	SnAg	SnPb
(1) Solder Wettability	+	+	+	+	+/-	+	++
(2) Adhesion to lead-frame	+	+	+	+	+	+	+
(3) Resistance to Leadbending	-	+	+	+/-			++
(4) Soldered joint Reliability	(+)	+	+	+	+	+	+
(5) Corrosion Resistance	+	+	+	+		+	+
(6) Whisker resistance	-	+/-	++	+	-		++
(7) Migration resistance	+	+	+				+
(8) Cost	+	+	+ / ++	-	-	--	++
(9) Mass Productivity	++	++	++	+	+	-	++
(10) Compatibility	+	+	+	+	(+)	(+)	+
(11) Eco Impact	++	++	++	+/-	+/-	--	-

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4. Constructional Details of Test vehicles

Lot	PSC-07
Assy Site	PSC
Package / Pin	SQFP208
Outline	SOT316-1
Moulding compound	MP8000
Die-Attach Adhesive	EN4085/S2
LF-mat/ pitch/ E or P	CuNi3/0.8/P
Die Pad Size (mm)	10.00x10.00
Die Size (mm)	8.22x8.68
Vehicle name	VY21754A

Lot	ATK-02	ATK-04	ATK-06
Assy Site	ATK	ATK	ATK
Package / Pin	SQFP208	HVQFN64	HVQFN40
Outline	SOT316-1	SOT804-1	SOT
Moulding compound	MP8000	EME G700	EME G700
Die-Attach Adhesive	8361J	8290	8290
LF-mat/ pitch/ E or P	CuNi3/0.5/E	CuFe2P/0.5/U	CuFe2P/0.5/U
Die Pad Size (mm)	9.50x9.50	4.90x4.90	4.30 x 4.30
Die Size (mm)	8.038x8.728	2.65x2.36	3.23 x 3.60
Vehicle name	SAA7219HS/C3	ISP1583BS	TEA5767

Lot	ASE-01	ASE-02
Assy Site	ASE	ASE
Package / Pin	PLCC68	SOJ40
Outline	SOT188-2	SOT449-2
Moulding compound	MP8000	CEL9200
Die-Attach Adhesive	8361J	8361H
LF-mat/ pitch/ E or P	CuZr/1.27/P	CuFe2P/1.27/U
Die Pad Size (mm)	6.60x6.60	6.10x10.16
Die Size (mm)	4.2x3.92	4.72x7.31
Vehicle name	V83C552V8	SAA4955TJ/V1

PSC = Philips Semiconductors Calamba factory
ATK = Amkor Korea factory
ASE = ASE Kaohsiung factory

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Lot	ATP-01	ATP-02	ATP-04
Assy Site	ATP	ATP	ATP
Package / Pin	TSSOP28	PLCC68	TSSOP10
Outline	SOT361-1	SOT188-2	SOT552-1
Moulding compound	G700	MP8000	MP8000
Die-Attach Adhesive	8290	8361J	8390A
LF-mat/ pitch/ E or P	CuNi3/0.65/P	CuCr/1.27/U	CuNi3/0.5/P
Die Pad Size (mm)	3.00x3.50	9.40x9.40	1.73x2.39
Die Size (mm)	2.27x2.65	8.44x6.78	0.92x1.03
Vehicle name	PDIUSB12PW	SAA7110AWP/00	OM5968TT/C1

ATP = Amkor Philippines factory

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5. Reliability Test Program

An extensive qualification program has been executed to demonstrate that PSC, Amkor and ASE can assemble matte Sn packages with a high quality and reliability.

5.1 Reliability Test Descriptions

In this section the reliability tests are described in detail. These tests are stated in Philips Semiconductors' General Quality Specification (SNW-FQ-611) and the Plastic Package Qualification Guideline (SNW-FA-04-07).

Pcon – Preconditioning

SMD Qualification samples for PPOT and HAST undergo SMD reflow preconditioning before reliability test is performed. This preconditioning is performed in accordance with the latest revision of the IPC/JEDEC J-STD-020B specification, as described in Philips Semiconductors specification SNW-FQ-225A. SMD Packages are preconditioned to the appropriate MSL level. Peak temperature applied is 240-245°C for large bodies and 255-260°C for small bodies.

PPOT – Pressure Pot Test

Pressure Pot Test – autoclave (121°C, 100%R.H., 96 hrs release time point), unbiased with Pcon. This test is particularly suitable to evaluate the moisture resistance of the package.

HAST – Highly Accelerated Stress Test

Highly Accelerated Stress Test (130°C/85% R.H., 96 hrs release time point), with electrical bias and Pcon. This test stresses both the electrical endurance of the design/process, as well as the resistance to moisture of the package.

5.2 Construction Analysis Tests Descriptions

In addition to the reliability evaluation, qualification lots will be subjected to Construction Analysis tests which are relevant for the plating change per below test methods :

- Visual/Mechanical Inspection (V/M) SNW-FQ-612B
- Lead Finish Inspection (LFNH) Local document
- Solderability Inspection (SOLD) SNW-FQ-221

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5.3 Whisker Testing

5.3.1 Whisker Mechanism

In order to understand the impacts of matte Sn plating, Philips is performing an extensive whisker research program. Topics of interest are a.o. :

- definition what is a whisker, understand the growing-mechanism
- plating characteristics such as layer thickness, grain size, crystal orientation
- leadframe base material impact
- counter measures for whisker growth
- recommendations for process control and process/product release tests.
- cooperate within E3 to have consensus within Europe's large players

The E3 presentation on the Pb-free CPCN website is showing the results and conclusions of the whisker research activities by the E3. The website address is :

http://www.semiconductors.philips.com/acrobat/other/green_roadmap/e3_presentation.pdf

5.3.2 Whisker Tests Description

The following whisker tests have been performed on the test vehicles.

Despite huge amount of research, an acceleration test is not available at this moment. Philips (and the E3) do consider the 2 years ambient test as best suitable.

However, based on industry and customer demanding, test B and test C per below were performed as a reference.

Test A

Storage at ambient (18°C -25 °C / 30-70% RH).

Inspect after 0, 4, 12 and 26 wks. Keep parts and do extended readpoints after 52 , 78 and 104 weeks.

Sample size : 10 post-baked samples

Accept when after 26 weeks not any whisker longer than 15 µm is found

Test B

TMCL 500 cycles -35°C/ 125 °C, minimum dwell time 7 minutes

Sample size : 10 post-baked samples.

Accept when no whiskers above 40 µm are found.

Test C

Storage at 55 °C and 85% RH.

Inspect after 8 weeks and after 26 weeks.

Sample size : 10 post-baked samples.

Accept when after 8 weeks no whiskers above 20 µm are found.

Accept when after 26 weeks no whiskers above 40 µm are found.

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5.4 Summary of Solder Joint Reliability Tests for leadfree, leadframe based packages.

Variants included in the Investigation

- SMD packages with gull wing and J –leads (SO.....,VSO, QFP.....,PLCC.....)
- Lead frame material : Copper-alloy (mainly) and FeNi42 .
- Terminal finish : Matte Tin 100 , NiPdAu (only for Copper alloy)

- 2 layer FR4 board, (CE 5004)
- Reflow soldering : SnPb36Ag2 and SnAg 3.8Cu0.7
- Wave soldering with SnPb38Bi2 and SnAg3.8Cu0.7

- Temperature Cycling -40°C/125°C according to IEC60068-2-14.
- Electrical test (Daisy Chain) at around 2k intervals and visual inspection.

Conclusions

- No rejects up to 2000 cycles for all combinations.
- Mean time to failure over 6600 cycles except for FeNi based VSO56 and HTQFP100.
- Reflow solder : No significant difference in failure times/fracture modes between SnPb paste and SnAgCu paste.
- Wave solder : No significant difference in failure times/fracture modes between SnPb solder and SnAgCu solder.
- High profile packages / lead forms show less degradation due to a better compliancy.

Remarks

- All package variants applied with Pb and Pb-free soldering process
- Weibull graphs are shown in the E3 presentation which can be found on the Pb-free CPCN website : http://www.semiconductors.philips.com/acrobat/other/green_roadmap/e3_presentation.pdf

6. Self-qualification results matte Sn packages

Table 2 : Reliability Tests matte Sn

Package	Lot No.	Device	MSL/ temp.	PPOT			HAST		
				pcon	96 hrs	192 hrs	pcon	96 hrs	192 hrs
SQFP208	ATK-02	SAA7219HS/C3	3/245	0/77	0/77	-	-	-	-
SQFP208	PSC-07	VY21754A	3/245	0/77	0/77	0/77	-	-	-
SOJ40	ASE-02	SAA4955TJ/V1	3/245	0/77	0/77	-	0/77	0/77	0/77
HVQFN64	ATK-04	ISP1583BS	2/260	0/77	0/77	0/77	0/77	0/77	0/77
PLCC68	ATP-02	SAA7110AWP/00	3/245	0/77	0/77	-	-	-	-
PLCC68	ASE-01	V83C552V8	3/225	0/77	0/77	-	-	-	-
PLCC68	ASE-01	V83C552V8	4/245	0/77	0/77	-	-	-	-
TSSOP10	ATP-04	OM5968TT/C1	1/260	0/77	0/77	-	0/45	0/45	-
TSSOP28	ATP-01	PDIUBS12PW	1/260	0/77	0/77	-	0/45	0/45	-

Reliability qualification requirements time points are shown in **bold**, additional points are for engineering evaluation.

Table 3: Construction Analysis tests matte Sn

Package	Lot No.	Device	Construction Analysis Tests					
			V/M	LFNH	SOLD-A ⁽¹⁾	SOLD-B ⁽¹⁾	SOLD-C ⁽¹⁾	SOLD-D ⁽¹⁾
SQFP208	ATK-02	SAA7219HS/C3	0/15	0/9	0/11	0/11	0/11	0/11
SQFP208	PSC-07	VY21754A	0/15	0/9	0/11	0/11	0/11	0/11
SOJ40	ASE-02	SAA4955TJ/V1	0/15	0/9	0/11	0/11	0/11	0/11
HVQFN64	ATK-04	ISP1583BS	0/15	0/9	0/11	0/11	0/11	0/11
PLCC68	ATP-02	SAA7110AWP/00	0/15	0/9	0/11	0/11	0/11	0/11
PLCC68	ASE-01	V83C552V8	0/15	0/9	0/11	0/11	0/11	0/11
TSSOP10	ATP-04	OM5968TT/C1	0/15	0/9	0/11	0/11	0/11	0/11
TSSOP28	ATP-01	PDIUBS12PW	0/15	0/9	0/11	0/11	0/11	0/11

(1) conditions for solderability testing :

A : SnPb solder after 8h steam age, 5 sec, 215 °C

B : SnPb solder after 16h dry-bake, 5 sec, 215 °C

C : SAC solder after 8h steam age, 3 sec, 245 °C

D : SAC solder after 16h dry-bake, 3 sec, 245 °C

RMA is the standard flux.

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Table 4: Whisker Tests Results matte Sn

Package	Lot No.	Device	Whisker Test Results				
			Whisker Test A		Whisker Test B	Whisker Test C	
			Readpoint in wks from assy	longest whisker in μm	longest whisker in μm After TMCL 500x	Readpoint in wks from assy	longest whisker in μm
SQFP208	ATK-02	SAA7219HS/C3	26	0	14	26	0
SQFP208	PSC-07	VY21754A	26	0	0	26	0
SOJ40	ASE-02	SAA4955TJ/V1	26	0	16	26	0
HVQFN64	ATK-04	ISP1583BS	26	0	10	26	0
HVQFN40	ATK-06	TEA5767	26	0	0	26	0
PLCC68	ATP-02	SAA7110AWP/00	26	0	13	26	0
PLCC68	ASE-01	V83C552V8	26	0	18	26	0
TSSOP10	ATP-04	OM5968TT/C1	26	0	0	26	0
TSSOP28	ATP-01	PDIUBS12PW	26	0	0	26	0

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7. Conclusion

An extensive qualification program has been executed to demonstrate that PSC can assemble SQFP, ASE can assemble PLCC and SOJ, and that Amkor can assemble PLCC, SSOP and TSSOP packages in matte Sn + postbake solution at a high quality and reliability level.

With the positive completion of the Qualification tests, the Assembly and Test Organization Philips Semiconductors announces the release of matte Sn + postbake for use in above mentioned packages via final CPCN 20030525F supplement 3.

8. Implementation

Deliveries will start from August 2004 onwards.

9. Document Revision Sheet

R E V I S I O N S H E E T			
DATE yyyy/mm/dd	REV	DESCRIPTION	AUTHOR
2004-05-13	01	Self Qualification Results phase 4 for Lead (Pb) free lead-finish of leadframe-based IC packages.	Rob de Heus