Assembly & Test Organization (ATO)
Divisional Philips Semiconductors
Philips Internal Report No.: RNR-83-04/RdH/RdH-2001
QTS Report Database No.: 040068

Self Qualification Results

NiPdAu lead- free solution of

SO14/16/20 large die-pad assembled at Philips Semiconductors Thailand
TSSOP14/16/20/24 assembled Philips Semiconductors Thailand
SO14/16/20 assembled at subcon NS Electronics Bangkok

Author: ***Rob de Heus***
Sr. Project Leader Advanced Development
ATO Innovation
Philips Semiconductors Nijmegen
Building BY-1.052
Gerstweg 2, 6534 AE Nijmegen, the Netherlands

Tel: +31-243534835
Tel: +31-243533085
Fax: +31-243533350
E-mail: *rob.de.heus@philips.com*

Issue Date: ***February 17th, 2004***

Table of Contents

1. Introduction 3

2. Assembly Facilities 4

3. Materials selection background 4

3.1 NiPdAu pre-plated leadframes 4

4. Constructional Details of Test vehicles 5

5. Reliability Test Program 8

5.1 Reliability Test Descriptions 8
5.2 Construction Analysis Tests Descriptions 9

5.3 Summary of Solder Joint Reliability Tests for lead-free, leadframe based packages. 10
5.3.1 Variants included in the Investigation 10
5.3.2 Conclusions 10
5.3.3 Remarks 10

5.4 Self-qualfication results NiPdAu packages 11

6. Conclusion 16

7. Implementation 16

8. Document Revision Sheet 16

1. Introduction

The intention of the change to lead-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 5-6 different phases, each phase showing qualification results of a certain group of packages.

Notification of the 1st phase, covering SO14/16/20 packages in NiPdAu, was issued on 05 November 2003.
Notification of the 2nd phase, covering QFP packages in matte Sn+ postbake, was issued on 16 December 2003.

This self qualification report presents an overview of the qualification data completed to release the following packages in NiPdAu :

- SO14/16/20 large die-pads assembled at PST. (Philips Semiconductors Thailand)
- TSSOP14/16/20/24 assembled at PST. (Philips Semiconductors Thailand)
- SO14/16/20 assembled at subcontractor NSEB. (NS Electronics Bangkok)

The updated qualification plans for the remaining packages can be found in the updated Self Qualification plan, document number RNR-83-04/RdH/RdH-2003, report database # 040069, can be downloaded from the Philips lead-free CPCN website :
http://www.semiconductors.philips.com/green_roadmap/cpcn

In order to validate assembly quality and reliability, a self-qualification program has been performed for above mentioned packages.
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 NiPdAu as lead-free solution, the Bill of Materials (BoM) of the mentioned packages is fully compliant to the RoHS legislation requirements.

2. Assembly Facilities

PST

Philips Semiconductors Thailand has been in operation in Bangkok Thailand since 1974. With a current workforce of approximately 3,800 personnel and its 60,000 square meter site, PST is capable of assembly and test of a wide range of DIP, SILP, SO, T/SSOP, IC Module and Contactless Module packages. Testing for QFP and PLCC is also available at PST.
PST obtained ISO9001 certification in 1991, ISO14001 certification and the internal Philips Quality Award (PQA-90) in 1996, and QS9000 certification in 1997. A strong emphasis on quality improvement programs has also resulted in PST receiving the Golden Pentastar Award from Chrysler Corporation. In August 2003, PST was ISO/TS 16949 2002 certified.

NSEB

NS Electronics Bangkok (NSEB) facility has been operated in Bangkok since 1973 under the flag of National Semiconductors and operates as an independent Assembly and Test subcontractor since 1993. Presently NSEB employs approximately 2,800 employees. The building has a total floor space of 180,000 square feet. NSEB is capable in assembly and test of a wide range of IC packages, which include DIP, SO, SSOP, TSSOP and PLCC packages.
NSEB obtained ISO9002 in 1994 and ISO14001 in 1998 and is certified SAC level 1.

3. Materials selection background

3.1 NiPdAu pre-plated leadframes

main characteristics :

- good solderability with lead-containing and lead free solders
- good solder joint reliability
- used in high volume
- offered by major lead frame suppliers
- non whisker-sensitive technology

NiPdAu pre-plated leadframes are chosen as alternative lead-free solution and will be applied in SO, SSOP and TSSOP packages. Initially just for in-house assembly, later also at subcontractors delivering to Philips. (like first group of packages from NSEB covered in this report).
Untill subcontractors can offer NiPdAu, their packages will be in matte Sn.
In the long term roadmap, the part of NiPdAu might be increased to other families.

4. Constructional Details of Test vehicles

SO14-16-20, large die-pad packages at PST.

Lot	PST-2-01	PST-2-02	PST-2-03	PST-2-04
Assy Site	PST	PST	PST	PST
Package / Pin	SO14	SO14	SO16	SO16
Outline	SOT108-1	SOT108-1	SOT109-1	SOT109-1
Moulding compound	6210	6210	6210	6210
Die-Attach Adhesive	71-1-D	71-1-D	8390P	8390P
Pitch/ E or P	1.27/ P	1.27/ E	1.27/ P	1.27/ P
Die Pad Size (mm)	1.78x1.78	2.26x3.61	2.10x2.29	2.10x2.29
Die Size (mm)	0.99x0.97	2.0x2.86	1.47x1.17	1.52x1.53
Vehicle name	LM339DM	TJA1054T	TDA7088T/V1/M5	TSA5060AT/C1

Lot	PST-2-05	PST-2-06	PST-2-07	PST-2-10
Assy Site	PST	PST	PST	PST
Package / Pin	SO16	SO20	SO14	SO20
Outline	SOT109-1	SOT163-1	SOT108-1	SOT163-1
Moulding compound	6210	6210	6210	6210
Die-Attach Adhesive	71-1-D	8390P	8390P	8390P
Pitch/ E or P	1.27/ P	1.27/ P	1.27/ E	1.27/ P
Die Pad Size (mm)	2.10x3.60	3.20x4.00	2.30x5.40	4.20x5.20
Die Size (mm)	1.73x2.59	1.75x2.18	2.05x3.46	2.54x3.78
Vehicle name	TDA4662T/V3	TEA6101T/N2	AU5790D14	TDA8542AT/N1

SO14-16-20 packages at subcon NSEB.

Lot	NSEB-2-01	NSEB-2-02	NSEB-2-03	NSEB-2-04
Assy Site	NSEB	NSEB	NSEB	NSEB
Package / Pin	SO14	SO14	SO16	SO16
Outline	SOT108-1	SOT108-1	SOT109-1	SOT109-1
Moulding compound	6210	6210	6210	6210
Die-Attach Adhesive	84-1LMISR4	84-1LMISR4	84-1LMISR4	84-1LMISR4
Pitch/ E or P	1.27/P	1.27/P	1.27/ P	1.27/ P
Die Pad Size (mm)	1.20x1.20	1.20x1.20	2.10x2.29	2.10x2.29
Die Size (mm)	0.71x0.69	0.71x0.69	0.96x1.47	0.96x1.47
Vehicle name	74HC14D	74HC14D	74HCT123	74HCT123

Lot	NSEB-2-05	NSEB-2-06	NSEB-2-07
Assy Site	NSEB	NSEB	NSEB
Package / Pin	SO16	SO16	SO16
Outline	SOT109-1	SOT109-1	SOT109-1
Moulding compound	6210	6210	6210
Die-Attach Adhesive	84-1LMISR4	84-1LMISR4	84-1LMISR4
Pitch/ E or P	1.27/ P	1.27/ P	1.27/ P
Die Pad Size (mm)	2.10x3.60	2.10x3.60	2.10x3.60
Die Size (mm)	1.80x2.07	1.80x2.07	1.80x2.07
Vehicle name	74HC221D	74HC221D	74HC221D

Lot	NSEB-2-08	NSEB-2-09	NSEB-2-10
Assy Site	NSEB	NSEB	NSEB
Package / Pin	SO20	SO20	SO20
Outline	SOT163-1	SOT163-1	SOT163-1
Moulding compound	6210	6210	6210
Die-Attach Adhesive	8390P	8390P	8390P
Pitch/ E or P	1.27/ P	1.27/ P	1.27/ P
Die Pad Size (mm)	1.80x2.10	1.80x2.10	1.80x2.10
Die Size (mm)	0.76x0.89	0.76x0.89	0.76x0.89
Vehicle name	74HC244D	74HC244D	74HC244D

TSSOP14-16-20-24 packages at PST.

Lot	PST-6-01	PST-6-02	PST-6-03	PST-6-04
Assy Site	PST	PST	PST	PST
Package / Pin	TSSOP14	TSSOP16	TSSOP20	TSSOP24
Outline	SOT402-1	SOT403-1	SOT360-1	SOT355-1
Moulding compound	MP8000	MP8000	MP8000	MP8000
Die-Attach Adhesive	8390P	8390P	8390P	8390P
Pitch/ E or P	0.65/P	0.65/P	0.65/P	0.65/P
Die Pad Size (mm)	1.78x1.78	2.10x2.29	2.75x4.00	2.70x3.50
Die Size (mm)	0.69x0.72	1.61x1.50	2.91x2.43	1.4x1.95
Vehicle name	74LVC08APW	74HC4538PW	P87LPC764BDH	SA2421DHA

Lot	PST-6-05	PST-6-06	PST-6-07
Assy Site	PST	PST	PST
Package / Pin	TSSOP20	TSSOP20	TSSOP16
Outline	SOT360-1	SOT360-1	SOT403-1
Moulding compound	MP8000	MP8000	MP8000
Die-Attach Adhesive	8390P	8390P	8390P
Pitch/ E or P	0.65/P	0.65/P	0.65/P
Die Pad Size (mm)	2.40x2.70	2.75x4.00	2.10x2.29
Die Size (mm)	1.75x1.45	2.91x2.43	1.61x1.50
Vehicle name	74LVT273PWDH B	P87LPC764BDH	74HC4538PW

5. Reliability Test Program

An extensive qualification program has been executed to demonstrate that PST and NSEB can assemble lead-free NiPdAu 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). AEC_Q100 is used as a guideline for specific automotive products.

Pcon – Preconditioning
SMD Qualification samples for PPOT, HAST/THBS and TMCL 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 260°C.

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.

THBS – Temperature Humidity Bias Stress
Temperature Humidity Bias Stress (85°C/85% R.H., 1000 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. This test is sometimes done instead of HAST

TMCL – Temperature Cycling
Temperature Cycling (air to air –65°C ⇔ +150°C, 500 cyc release point) with Pcon. This test is aimed at the mechanical integrity of the whole product, under the severe circumstances of rapid changes in temperature.

HTSL – High Temperature Storage Life
High Temperature Storage Life (150°C, 1000 hrs release time point). This test evaluates the reliability of the product after long term storage

5.2 Construction Analysis Tests Descriptions

In addition to the reliability evaluation, qualification lots will be subjected to Construction Analysis and Moisture Sensitivity Level assessment testing per the following test methods :

- Visual/Mechanical Inspection (V/M) SNW-FQ-612B
- Lead Finish Inspection (LFNH) Local document
- Moisture Sensitivity Level Assessment SNW-FQ-225B
- X-Ray Inspection (X-RAY) SNW-FQ-312
- SCAT Inspection (SCAT) SNW-FQ-311
- Die Shear Testing (DISH) SNW-FQ-322
- Bond Pull Testing (BPT) SNW-FQ-322
- Bond Shear Testing (BST) SNW-FQ-322
- Cross Section Inspection (CROSS) SNW-FQ-314
- Solderability Inspection (SOLD) SNW-FQ-221

5.3 Summary of Solder Joint Reliability Tests for lead-free, leadframe based packages.

5.3.1 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 -40ºC/125ºC according to IEC60068-2-14.
- Electrical test (Daisy Chain) at around 2k intervals and visual inspection.

5.3.2 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.

5.3.3 Remarks

- All package variants applied with lead-containing and lead-free soldering process
- Weibull graphs are shown in the “E3 presentation”.

5.4 Self-qualfication results NiPdAu packages

Table 1 : *Reliability Tests NiPdAu*

	Lot		**PPOT**			**HAST**			**TMCL**			**HTSL**	
Package	**No.**	**Device**	Pcon	**96 hrs**	192 hrs	pcon	**96 hrs**	192 hrs	Pcon	**200c**	500c	**1000h**	2000h
SO14	PST-2-01	LM339DM	L1 0/77	0/77	-	-	-	-	L1 0/77	0/77	-	0/77	-
SO14	PST-2-02	TJA1054T	L2 0/77	0/77	-	-	-	-	L2 0/77	0/77	-	0/77	-
SO16	PST-2-03	TDA7088T/V1/M5	L1 0/77	0/77	-	-	-	-	L1 0/77	0/77	-	0/77	-
SO16	PST-2-04	TSA5060AT/C1	L1 0/77	0/77	-	-	-	-	L1 0/77	0/77	-	0/77	-
SO16	PST-2-05	TDA4662T/V3	L1 0/77	0/77	-	-	-	-	L1 0/77	0/77	-	0/77	-
SO20	PST-2-06	TEA6101T/N2	L1 0/77	0/77	-	-	-	-	L1 0/77	0/77	-	0/77	-
SO14	PST-2-07	AU5790D14	L3 0/77	0/77	-	L3 0/77	0/77	-	L3 0/77	0/77	0/77	0/77	0/77
SO20	PST-2-10	TDA8542AT/N1	L3 0/77	0/77	-	-	-	-	L3 0/77	0/77	-	0/77	-

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

	Lot		PPOT			HAST			TMCL			HTSL	
Package	**No.**	**Device**	Pcon	**96 hrs**	192 hrs	pcon	**96 hrs**	192 hrs	Pcon	**200c**	500c	**1000h**	2000h
SO14	NSEB-2-01	74HC14D	L1 0/77	0/77	-	L1 0/45	0/45	-	L1 0/77	0/77	-	0/77	-
SO14	NSEB-2-02	74HC14D	L1 0/77	0/77	-	L1 0/45	0/45	-	L1 0/77	0/77	-	0/77	-
SO16	NSEB-2-03	74HCT123	L1 0/77	0/77	-	L1 0/45	0/45	-	L1 0/77	0/77	-	0/77	-
SO16	NSEB-2-04	74HCT123	L1 0/77	0/77	-	L1 0/45	0/45	-	L1 0/77	0/77	-	0/77	-
SO16	NSEB-2-05	74HC221D	L1 0/77	0/77	-	L1 0/45	0/45	-	L1 0/77	0/77	-	0/77	-
SO16	NSEB-2-06	74HC221D	L1 0/77	0/77	-	L1 0/45	0/45	-	L1 0/77	0/77	-	0/77	-
SO16	NSEB-2-07	74HC221D	L1 0/77	0/77	-	L1 0/45	0/45	-	L1 0/77	0/77	-	0/77	-
SO20	NSEB-2-08	74HC244D	L1 0/77	0/77	-	L1 0/45	0/45	-	L1 0/77	0/77	-	0/77	-
SO20	NSEB-2-09	74HC244D	L1 0/77	0/77	-	L1 0/45	0/45	-	L1 0/77	0/77	-	0/77	-
SO20	NSEB-2-10	74HC244D	L1 0/77	0/77	-	L1 0/45	0/45	-	L1 0/77	0/77	-	0/77	-

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

	Lot		PPOT			HAST			TMCL			HTSL	
Package	**No.**	**Device**	Pcon	**96 hrs**	192 hrs	pcon	**96 hrs**	192 hrs	Pcon	**200c**	500c	**1000h**	2000h
TSSOP14	PST-6-01	74LVC08APW	L1 0/77	0/77	-	-	-	-	L1 0/77	0/77	-	0/77	-
TSSOP16	PST-6-02	74HC4538PW	L1 0/77	0/77	-	-	-	-	L1 0/77	0/77	-	-	-
TSSOP20	PST-6-03	P87LPC764BDH	L1 0/77	0/77	-	-	-	-	L1 0/77	0/77	-	0/77	-
TSSOP24	PST-6-04	SA2421DHA	L1 0/77	0/77	-	-	-	-	L1 0/77	0/77	-	0/77	-
TSSOP20	PST-6-05	74LVT273PWDH B	-	-	-	L1 0/45	0/45	-	-	-	-	-	-
TSSOP20	PST-6-06	P87LPC764BDH	L1 0/77	0/77	-	-	-	-	L1 0/77	0/77	-	0/77	-
TSSOP16	PST-6-07	74HC4538PW	L1 0/77	0/77	-	-	-	-	L1 0/77	0/77	-	-	-

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

Table 2: *Construction Analysis tests NiPdAu.*

	Lot		Construction Analysis Tests								
Package	**No.**	**Device**	MSLA 260°C	V/M	LFNH	SOLD See note	XRAY	SCAT	DISH	BP/BS	CROSS
SO14	PST-2-01	LM339DM	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO14	PST-2-02	TJA1054T	L2	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO16	PST-2-03	TDA7088T/V1/M5	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO16	PST-2-04	TSA5060AT/C1	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO16	PST-2-05	TDA4662T/V3	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO20	PST-2-06	TEA6101T/N2	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO14	PST-2-07	AU5790D14	L4	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO20	PST-2-10	TDA8542AT/N1	L3	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO14	NSEB-2-01	74HC14D	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO14	NSEB-2-02	74HC14D	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO16	NSEB-2-03	74HCT123	L1	-	-	-	-	-	-	-	-
SO16	NSEB-2-04	74HCT123	L1	-	-	-	-	-	-	-	-
SO16	NSEB-2-05	74HC221D	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO16	NSEB-2-06	74HC221D	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO20	NSEB-2-08	74HC244D	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO20	NSEB-2-09	74HC244D	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO20	NSEB-2-10	74HC244D	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3

Note:
11 parts tested in SnPb solder after 8h steam age, 5 sec, 215 ºC
11 parts tested in SnPb solder after 16h dry-bake, 5 sec, 215 ºC
11 parts tested in SAC solder after 8h steam age, 3 sec, 245 ºC
11 parts tested in SAC solder after 16h dry-bake, 3 sec, 245 ºC
RMA flux used for all tests.

	Lot		Construction Analysis Tests								
Package	**No.**	**Device**	MSLA 260°C	V/M	LFNH	SOLD See note	XRAY	SCAT	DISH	BP/BS	CROSS
TSSOP14	PST-6-01	74LVC08APW	L1	-	-	-	-	-	-	-	-
TSSOP16	PST-6-02	74HC4538PW	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
TSSOP20	PST-6-03	P87LPC764BDH	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
TSSOP24	PST-6-04	SA2421DHA	L1	-	-	-	-	-	-	-	-
TSSOP20	PST-6-05	74LVT273PWDH B	L1	-	-	-	-	-	-	-	-
TSSOP20	PST-6-06	P87LPC764BDH	L1	-	-	-	-	-	-	-	-
TSSOP16	PST-6-07	74HC4538PW	L1	-	-	-	-	-	-	-	-

Note:
11 parts tested in SnPb solder after 8h steam age, 5 sec, 215 ºC
11 parts tested in SnPb solder after 16h dry-bake, 5 sec, 215 ºC
11 parts tested in SAC solder after 8h steam age, 3 sec, 245 ºC
11 parts tested in SAC solder after 16h dry-bake, 3 sec, 245 ºC
RMA flux used for all tests.

Table 3: *Construction Analysis tests NiPdAu, additional tests for automotive.*

	Lot		Construction Analysis Tests		
Package	**No.**	**Device**	BPT after TMCL 500c		
SO14	PST-2-02	TJA1054T	0/5		
SO14	PST-2-07	AU5790D14	0/5		

6. Conclusion

An extensive qualification program has been executed to demonstrate that PST and NSEB can assemble SO and TSSOP packages in NiPdAu pre-plated lead-frames 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 NiPdAu pre-plated leadframes for use in SO14/16/20 assembled in PST and NSEB and for TSSOP14/16/20/24 assembled at PST, via final CPCN 20030525F supplement 2.

7. Implementation

Deliveries will start from April 2004 onwards.

8. Document Revision Sheet

R E V I S I O N S H E E T			
DATE yyyy/mm/dd	REV	DESCRIPTION	AUTHOR
2004-01-27	01	Self Qualification Results phase 3 for Lead (Pb) free lead-finish of leadframe-based IC packages. SO14/16/20 large pad PST, SO14/16/20 at NSEB, TSSOP14/16/20/24 at PST.	Rob de Heus
2004-02-03	02	Minor update, add more results.	Rob de Heus
2004-02-06	03	Added last results	Rob de Heus
2004-02-17	04	Added last results	Rob de Heus