Assembly & Test Organization (ATO)
Divisional Philips Semiconductors
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Self Qualification Results

NiPdAu lead- free solution of

SO14/16/20

Products for General Purpose Logic,
Specialty Logic and Digital Datacom

assembled in

Philips Semiconductors Thailand (PST)

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1. Introduction

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

The final CPCN will be issued in 5 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 the first group of packages to be assembled in NiPdAu.
This report covers the results of SO14/16/20 packages (in small die-pads for General Purpose Logic, Specialty Logic and Digital Datacom products) assembled in NiPdAu in assy factory PST (Philips Semiconductors Thailand).

The updated qualification plans for the other packages can be found in the updated Self Qualification plan, document number RNR-83-02/RdH/RdH-2076, report database # 021285.

In order to validate assembly quality and reliability, a self-qualification program has been performed for NiPdAu pre-plated leadframes in SO14/16/20 family from assy center PST.
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 Pb-free solution, the Bill of Materials (BoM) of the mentioned packages is fully compliant to the RoHS legislation requirements.

2. Assembly Facility

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.

3. Materials selection background

3.1 NiPdAu pre-plated leadframes

main characteristics :

- good solderability with SnPb and Pb 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 Pb-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.
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

Small pad SO14-16-20 for General Purpose Logic, Specialty Logic and Digital Datacom.

Lot	**PST-1-01**	**PST-1-02**	**PST-1-03**	**PST-1-04**
Assy Site	PST	PST	PST	PST
Package / Pin	SO14	SO14	SO14	SO16
Outline	SOT108-1	SOT108-1	SOT108-1	SOT109-1
Moulding compound	6210	6210	6210	6210
Die-Attach Adhesive	8390P	71-1-D	71-1-D	8390P
Wire diameter in µ	18	23	23	20
Pitch/ E or P	1.27/ P	1.27/ P	1.27/ P	1.27/ P
Die Pad Size (mm)	1.00x1.00	1.78x1.78	1.78x1.78	1.20x1.40
Die Size (mm)	0.68x0.70	1.23x1.27	1.48x1.35	1.08x0.88
Vehicle name	74HC14D	74HC10D	74LV4066D	HEF4094BT

Lot	**PST-1-05**	**PST-1-06**	**PST-1-07**	**PST-1-08**
Assy Site	PST	PST	PST	PST
Package / Pin	SO16	SO16	SO16	SO20
Outline	SOT109-1	SOT109-1	SOT109-1	SOT163-1
Moulding compound	6210	6210	6210	6210
Die-Attach Adhesive	8390P	8390P	71-1-D	8390P
Wire diameter in µ	18	20	23	20
Pitch/ E or P	1.27/ P	1.27/ P	1.27/ P	1.27/ P
Die Pad Size (mm)	1.20x1.40	2.10x2.29	2.10x3.60	1.80x2.10
Die Size (mm)	0.85x1.06	1.29x1.23	1.90x2.25	0.88x0.76
Vehicle name	74AHC595D	HEF4794BT	HEF4516BT	74LVC573AD

Lot	**PST-1-09**	**PST-1-10**	**PST-1-11**
Assy Site	PST	PST	PST
Package / Pin	SO20	SO20	SO20
Outline	SOT163-1	SOT163-1	SOT163-1
Moulding compound	6210	6210	6210
Die-Attach Adhesive	8390P	8390P	8390P
Wire diameter in µ	20	23	23
Pitch/ E or P	1.27/ P	1.27/ P	1.27/ P
Die Pad Size (mm)	1.80x2.10	3.20x4.00	3.20x4.00
Die Size (mm)	1.00x0.89	1.7x2.49	2.32x2.24
Vehicle name	74ALVC573D	HEF4894BT	74HC299D

5. Reliability Test Program

An extensive qualification program has been executed to demonstrate that PST can assemble Pb-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 leadfree, 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 Pb and Pb-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-1-01	74HC14D	0/77	0/77	-	-	-	-	0/77	0/77	0/77	0/77	-
SO14	PST-1-02	74HC10D	0/77	0/77	-	-	-	-	0/77	0/77	0/77	0/77	-
SO14	PST-1-03	74LV4066D	0/77	0/77	-	-	-	-	0/77	0/77	0/77	0/77	-
SO16	PST-1-04	HEF4094BT	0/77	0/77	-	0/45	0/45	-	0/77	0/77	0/77	0/77	-
SO16	PST-1-05	74AHC595D	0/77	0/77	-	-	-	-	0/77	0/77	0/77	0/77	-
SO16	PST-1-06	HEF4794BT	0/77	0/77	-	0/45	0/45	-	0/77	0/77	0/77	0/77	-
SO16	PST-1-07	HEF4516BT	0/77	0/77	-	-	-	-	0/77	0/77	0/77	0/77	-
SO20	PST-1-08	74LVC573AD	0/77	0/77	-	-	-	-	0/77	0/77	0/77	0/77	-
SO20	PST-1-09	74ALVC573D	0/77	0/77	-	-	-	-	0/77	0/77	0/77	0/77	-
SO20	PST-1-10	HEF4894BT	0/77	0/77	-	0/45	0/45	-	0/77	0/77	0/77	0/77	-
SO20	PST-1-11	74HC299D	0/77	0/77	-	-	-	-	0/77	0/77	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-1-01	74HC14D	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO14	PST-1-02	74HC10D	L1	-	-	-	-	-	-	-	-
SO14	PST-1-03	74LV4066D	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO16	PST-1-04	HEF4094BT	L1	-	-	-	-	-	-	-	-
SO16	PST-1-05	74AHC595D	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO16	PST-1-06	HEF4794BT	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO16	PST-1-07	HEF4516BT	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO20	PST-1-08	74LVC573AD	L1	-	-	-	-	-	-	-	-
SO20	PST-1-09	74ALVC573D	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO20	PST-1-10	HEF4894BT	L1	0/15	0/9	4x0/11	0/8	0/8	0/3	0/3	0/3
SO20	PST-1-11	74HC299D	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-1-01	74HC14D	0/5		
SO14	PST-1-02	74HC10D	0/5		
SO14	PST-1-03	74LV4066D	0/5		
SO16	PST-1-04	HEF4094BT	0/5		
SO16	PST-1-05	74AHC595D	0/5		
SO16	PST-1-06	HEF4794BT	0/5		
SO16	PST-1-07	HEF4516BT	0/5		
SO20	PST-1-08	74LVC573AD	0/5		
SO20	PST-1-09	74ALVC573D	0/5		
SO20	PST-1-10	HEF4894BT	0/5		
SO20	PST-1-11	74HC299D	0/5		

6. Conclusion

An extensive qualification program has been executed to demonstrate that PST can assemble SO14/16/20 packages in NiPdAu pre-plated lead-frames at a high quality and reliability level.

All parts tested in this qualification program, show that the Moisture Sensitivity Levels at 260 ºC are level 1, as before with Cu-Ag-spot leadframes.

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 products for General Purpose Logic, Specialty Logic and Digital Datacom, assembled in PST, via final CPCN 20030525F phase 1.

7. Implementation

Deliveries will start from December 2003 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
2003-10-07	01	Self Qualification Results phase 1 for Lead (Pb) free lead-finish of leadframe-based IC packages. SO14/16/20 for General Purpose Logic.	Rob de Heus
2003-11-03	02	Minor update	Rob de Heus