Assembly & Test Organization (ATO)
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Self Qualification Results

NiPdAu pre-plated leadframes, Green Molding Compound and Green Die-Attach

for

TSSOP16/20/28 packages

assembled at Subcontractor Amkor Technologies Philippines

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1. Introduction

The intention of the change to lead-free + green TSSOP packages from Philips (assembly at Amkor) has been announced in the Correction CPCN for Pb-free, issued in November 2004, CPCN # 200305025C.

This self qualification report presents an overview of the qualification data completed to release the following packages in NiPdAu + Ablestik Ablebond 8290 die-attach + Sumitomo EMEG700 mold compound:

- TSSOP14(*)/16/20/24(*)/28 assembled in Amkor Technologies Philippines

(*) TSSOP14 and TSSOP24 to be released by structural similarity

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 above mentioned materials, these packages fully comply to the RoHS 2006 legislations and also fulfils the future legislation on banning of Halogenes and Antimony Oxides. Combination of the new die-attach glues and the new molding compounds improves the package quality, especially towards the higher reflow temperatures which are required for leadfree soldering.

2. Assembly Facilities

AMKOR Technologies Philippines (ATP)
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/ANAM consists of amongst others DIP, SO, SSOP, PLCC, QFP, (LF)BGA and CSP. AMKOR is certified SAC level 1.

3. Material details

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
- whisker free

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.

3.2 Molding Compounds

EMEG600 and EMEG700 are SiO_2 filled epoxy moulding compounds designed for improved JEDEC moisturizing performance and HTSL performance. In Table 1 the properties of EMEG600 and EMEG700 are compared to the reference materials MP8000 and KMC184.

Table 1: Manufacturers Typical Properties of MP8000/KMC and G600/G700

Molding Compound Properties	**Current Production MP8000 NITTO**	**Current Production KMC184 SHIN-ETSU**	**Planned Change EMEG600 SUMITOMO**	**Planned Change EMEG700 SUMITOMO**
Resin type	epoxy cresol novalac	epoxy cresol novalac	multi aromatic epoxy	multi aromatic epoxy
Hardener type	phenol novalac	phenol novalac	multi aromatic	multi aromatic
Filler type (%)	75	81	86	84
Flame-retardant system	brominated epoxy + antimony oxide	brominated epoxy + antimony oxide	none	none
Antimony oxide	yes	yes	no	no
T_g (ºC)	140	160	135	130
Specific gravity	1.88	1.89	1.99	1.95
α_1 (ppm/ºC)	16.1	13	10	12
α_2 (ppm/ºC)	64.7	59	39	49
Flexural strength @RT (N/mm^2)	140	120	185	170
Flexural modulus @RT (N/mm^2)	12200	12300	24000	19000
Flexural strength @240ºC (N/mm^2)	20	16/17	21@260ºC	21
Flexural modulus @240ºC (N/mm^2)	1000	1200	720@260ºC	600
Dielectric Constant at 1MHz	3.8	3.9	4.0	4.2
Dissipation Factor at 1MHz	0.8	0.007	0.005	0.01
Volume Resistivity at 150ºC (Ωm)	$7X10^{12}$	$3X10^{12}$	$> 1X10^{12}$	$1X10^{12}$
Thermal Conductivity (W/mK)	0.75	0.63	0.92	0.88
UL94-V0 Flammability	1/8"	1/8"	1/8"	1/8"
Oxygen index	38	<35	53	35
Polymer mass (%)	22	25	11-15	15-17

3.3 Die Attach Glues

Ablebond 8290 is a silver filled die-attach glue, designed for improved JEDEC moisturizing performance. In Table 2 the properties of Ablebond 8290 is compared to the reference materials Ablebond 84-1LMISR4 and Ablebond 8390.

Table 2: Manufacturers Typical Properties of Ablebond 84-LMISR4/8390 and Ablebond 8290.

Die Attach Properties	**Current Production Ablebond 84-1LMISR4 ABLESTIK**	**Current Production Ablebond 8390 ABLESTIK**	**Planned Change Ablebond 8290 ABLESTIK**
Adhesive Type	Epoxy	Epoxy	Epoxy
Filler	Silver	Silver	Silver
Viscosity @ 25°C	8,000 cps	9,800 cps	9,000 cps
Thixotropic Index	5.6	4.5	5.3
Volume Resistivity	0.0001 Ω-cm	0.002 Ω-cm	0.008 Ω-cm
Thermal Conductivity @ 121°C	2.5 W/m°K	1.0 W/m°K	1.1 W/m°K
Glass Transition Temp	120°C	60°C	38°C
Coefficient of Thermal Expansion - Below Tg - Above Tg	40 ppm/°C 150 ppm/°C	83 ppm/°C 165 ppm/°C	81 ppm/°C 181 ppm/°C
Ionic Data - Chlorine - Sodium - Potassium	< 5 ppm < 3 ppm < 1 ppm	< 1 ppm < 3 ppm < 1 ppm	< 19 ppm < 12 ppm < 1 ppm
Water Extract - Conductivity - pH	13 µmhos/cm 6.0	70 µmhos/cm 7.4	100 µmhos/cm
Storage Life	1 year at –40°C	1 year at –40°C	1 year at –40°C

4. Constructional Details of Test vehicles

Lot	ATP-1-01	ATP-1-02	ATP-1-03	ATP-1-04
Assy Site	ATP	ATP	ATP	ATP
Package / Pin	TSSOP16 (6-rows)	TSSOP16 (7-rows)	TSSOP20	TSSOP20
Outline	SOT403-1	SOT403-1	SOT360-1	SOT360-1
Moulding compound	G700	G700	G700	G700
Die-Attach Adhesive	8290	8290	8290	8290
Pitch/ E or P	0.65 / P	0.65 / P	0.65 / P	0.65 / P
Die Pad Size (mm)	3.0 x 3.0	3.0 x 3.0	3.0 x 4.2	3.0 x 4.2
Die Size (mm)	1.20 x 1.53	1.20 x 1.53	1.48 x 1.79	1.48 x 1.79
Vehicle name	74LV4060PW	74LV4060PW	74LV574PW	74LV574PW
Subpack old	SOT403AA1	SOT403AA1	SOT360AA1	SOT360AA1

Lot	ATP-8-01	ATP-8-02	ATP-8-03
Assy Site	ATP	ATP	ATP
Package / Pin	TSSOP28	TSSOP28	TSSOP28
Outline	SOT361-1	SOT361-1	SOT361-1
Moulding compound	G700	G700	G700
Die-Attach Adhesive	8290	8290	8290
Pitch/ E or P	0.65 / P	0.65 / P	0.65 / P
Die Pad Size (mm)	3.0 x 3.5	3.0 x 3.5	3.0 x 3.5
Die Size (mm)	2.27 x 2.65	2.27 x 2.65	2.27 x 2.65
Vehicle name	PDIUSBD12PW	PDIUSBD12PW	PDIUSBD12PW
Subpack old	SOT361AA1	SOT361AA1	SOT361AA1

5. Reliability Test Program

An extensive qualification program has been executed to demonstrate Amkor can assemble TSSOP16/20/28 packages with a high quality and reliability, using NiPdAu leadframes, Sumitomo G700 molding compound and Ablestik 8290 die-attach glue.

The reliability qualification test matrix can be found in Section 6.

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.

5.1 Reliability Test Details

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-020C specification, as described in Philips Semiconductors specification SNW-FQ-225A. SMD Packages are preconditioned to the appropriate MSL level using 260 ºC reflow temperature only.

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.

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. Abbreviations used in the tables:

- 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

6. Self-qualification results.

Table 3: *"Wet" Reliability Stress Tests TSSOP packages in 4.4 mm body-width*

Package	Lot No.	Device	PCON 260 °C	PPOT			HAST		
				pcon	**96 hrs**	192 hrs	pcon	**96 hrs**	192 hrs
TSSOP16	ATP-1-01	74LV4060PW	L1	0/77	0/77	0/77	-	-	-
TSSOP16	ATP-1-02	74LV4060PW	L1	0/77	0/77	0/77	-	-	-
TSSOP20	ATP-1-03	74LV574PW	L1	-	-	-	0/45	0/45	0/45
TSSOP20	ATP-1-04	74LV574PW	L1	-	-		0/45	0/45	0/45
TSSOP28	ATP-8-01	PDIUSBD12PW	L1	-	-	-	0/45	0/45	0/45
TSSOP28	ATP-8-02	PDIUSBD12PW	L1	-	-	-	0/45	0/45	0/45
TSSOP28	ATP-8-03	PDIUSBD12PW	L1	-	-	-	0/45	0/45	-

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

Table 4: *"Dry" Reliability Stress Tests TSSOP packages in 4.4 mm body-width*

Package	Lot No.	Device	PCON 260 °C	TMCL				HTSL
				Pcon	**200 cyc**	500 cyc	1000 cyc	**1000 hrs**
TSSOP16	ATP-1-01	74LV4060PW	L1	0/77	0/77	0/77	0/77	-
TSSOP16	ATP-1-02	74LV4060PW	L1	0/77	0/77	0/77	-	-
TSSOP20	ATP-1-03	74LV574PW	L1	0/77	0/77	0/77	-	0/77
TSSOP20	ATP-1-04	74LV574PW	L1	0/77	0/77	0/77	-	0/77
TSSOP28	ATP-8-01	PDIUSBD12PW	L1	0/77	0/77	0/77	0/77	-
TSSOP28	ATP-8-02	PDIUSBD12PW	L1	0/77	0/77	0/77	-	-
TSSOP28	ATP-8-03	PDIUSBD12PW	L1	0/77	0/77	0/77	-	-

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

Table 5: *Construction Analysis for TSSOP packages in 4.4 mm body-width*

	Lot		**Construction Analysis Tests**								
Package	**No.**	**Device**	MSLA 260 °C	V/M	LFNH	SOLD See note	XRAY	SCAT	DISH	BP/BS	CROSS
TSSOP16	ATP-1-01	74LV4060PW	L1	0/15	0/3	4x 0/11	0/8	0/8	0/3	0/3	0/3
TSSOP16	ATP-1-02	74LV4060PW	L1	0/15	0/3	4x 0/11	0/8	0/8	0/3	0/3	0/3
TSSOP20	ATP-1-03	74LV574PW	L1	0/15	0/3	4x 0/11	0/8	0/8	0/3	0/3	0/3
TSSOP20	ATP-1-04	74LV574PW	L1	0/15	0/3	4x 0/11	0/8	0/8	0/3	0/3	0/3
TSSOP28	ATP-8-01	PDIUSBD12PW	L1	0/15	0/3	4x 0/11	0/8	0/8	0/3	0/3	0/3
TSSOP28	ATP-8-02	PDIUSBD12PW	L1	0/15	0/3	4x 0/11	0/8	0/8	0/3	0/3	0/3
TSSOP28	ATP-8-03	PDIUSBD12PW	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 6: *Additional tests.*

	Lot		**Construction Analysis Tests**		
Package	**No.**	**Device**	BPT after TMCL 500c		
TSSOP16	ATP-1-01	74LV4060PW	0/5		
TSSOP16	ATP-1-02	74LV4060PW	0/5		
TSSOP20	ATP-1-03	74LV574PW	0/5		
TSSOP20	ATP-1-04	74LV574PW	0/5		

7. Conclusion

An extensive qualification program has been executed to demonstrate that:

- ATP can assemble TSSOP16/20/28 packages using NiPdAu pre-plated leadframes & Ablestik 8290 die-attach & Sumitomo G700 mold compound, with a high quality and reliability, under leadfree (260ºC) soldering conditions.

With the positive completion of the Qualification tests, the Assembly and Test Organization Philips Semiconductors announces the release of TSSOP14/16/20/24/28 packages assembled in ATP using :

- Sumitomo G700 moulding compound and
- Ablestik 8290 die-attach glue and
- NiPdAu pre-plated leadframes.

via CPCN 20030525 Supplement 6

8. Implementation

Deliveries will start from February 2005 onwards.
TSSOP28 products in 3.0mm x 5.5mm die-pad size will be released later.

9. Document Revision Sheet

REVISION SHEET			
DATE yyyy/mm/dd	REV	DESCRIPTION	AUTHOR
2004-12-14	01	Self Qualification Results for NiPdAu pre-plated leadframes + Ablestik 8290 die-attach + Sumitomo G600/G700 mold compounds for TSSOP16/20/28 packages in ATP.	Rob de Heus