Alpha & Omega Semiconductor

Reliability Annual Report

ALPHA & OMEGA Semiconductor, Inc

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Commitment to Excellence at Quality & Reliability

To achieve this vision, AOS continuously strive for the excellence in design, manufacturing, reliability and proactively response to the customer's feedback.

AOS ensures that all the product quality and reliability exceed the customer's expectation by constantly assessing any potential risk, identifying cause of the suspected failures, driving corrective actions and developing prevention plan within the committed time through the continuously improvement.

This AOS product reliability report summarizes AOS Product Reliability result. The published product reliability data combines the results from new product Qualification Test Plan and routine Reliability Monitor Program activities. Accelerated environmental tests are performed on a specific sample size, and then followed by electrical test at end point. The released product will be categorized by the process family and be monitored on a monthly for short term program and quarterly basis for long term program. Table 1 lists the generic reliability qualification requirements and conditions for process / product in plastic package:

Table 1: AOS Generic Reliability Qualification Requirements

Test Item	Test Condition	Time Point	Sample Size	Acc/Reject & LTPD
HTGB	Temp = 150°C, Vgs=100% of Vgsmax	168 / 500 / 1000 hrs	77 pcs / lot	0/1 <3%
HTRB	Temp = 150°C, Vds=100% of Vdsmax	168 / 500 / 1000 hrs	77 pcs / lot	0/1 <3%
Pre-condition	168hrs 85°C/85%RH @245°C or 260°C (depending on the package size)	0hrs	231 pcs / lot	0/1 <3%
HAST	130 +/- 2°C, 85%RH, 33.3 psi, Vgs = 80% of Vgs max,	96 hrs	77 pcs / lot	0/1, <3%
Pressure Pot	121°C, 29.7 psi, RH=100%	96 hrs	77 pcs / lot	0/1, <3%
Temperature Cycle	-65 to 150°C, air to air, 2-3 cycles per hour	1000 cycles	77 pcs / lot	0/1, <3%

High Temperature Gate Bias & High Temperature Reverse Bias (HTGB&RB)

HTGB burn-in stress is used to stress gate oxide at the elevated temperature environment hence any of the gate oxide integrity issue can be identified. HTRB burn-in stress is used to verify junction degradation under the maximum operation temperature.

Through HTGB & HTRB B/I stress test, the device lifetime in field operation & long term device level reliability can be determined. FIT rate is calculated by applying the Arrhenius equation with the activation energy of 0.7eV and 60% of upper confidence level of “Chi-Square” (χ^2) distribution at 55 deg C operating conditions.

Solder reflow precondition (pre-con)

Solder reflow precondition is the test that simulates shipment and storage of package in uncontrollable environment. Precondition is the pre requirement for the mechanical related reliability tests, such as Temperature Cycle, Pressure Pot (PCT) and Highly Accelerated Stress TEST (HAST). The routine of the test including parts are soaked in moisture in 85%RH, 85 deg C environment for 168 hrs. Then they will be run through a solder reflow oven 3 times to simulate the SMT stress condition.

Temperature Cycling (TC)

Temperature cycling test is to evaluate the mechanical integrity of the package and the interaction between the die and the package. This is an air to air test at temperature range from -65°C to 150°C and stress duration is from 250 cycles to 1000 cycles, 2~3 cycles per hour.

Pressure Pot (PCT)

PCT test is the test that measures the ability of the device withstand to moisture and contaminant environment. The test is done under enclosed chamber with the condition 121°C, 29.7 psi, 100%RH and stress duration is 96 hrs.

Highly Accelerated Stress Test (HAST)

Highly accelerated stress test is to stress the devices under high humidity, high pressure environment under DC bias condition. If ionic contamination involved, the corrosion from metal layer can be accelerated by the HAST stress condition.
(H3TRB is the alternative of HAST)

The following tables summarize the qualification results based on the device / process families and the package types, respectively.

Summary of AOS Device / Process Qualification Monitor Results

To present the actual FIT rate from the different process and device technologies, AOS categorized the device / process family FIT rate by N channel and P channel.

Table 2 listed the summary of HTGB and HTRB results.

Table 2:

Process	Equivalent MTTF		Sample Size	# of failure	FIT Rate
	In hours	In Years			
N channel	**2.0531E+10**	**2343687**	**72380**	**0**	**0.05**
AMOS5	4.06E+09	463751	14322	0	0.25
G1N	1.31E+08	14960	462	0	7.63
G4N	1.31E+08	14960	462	0	7.63
G5H/G5S	2.25E+09	256808	7931	0	0.44
G5N+	3.39E+09	386459	11935	0	0.3
HV0/HV1	8.08E+08	92252	2849	0	1.24
IGB/FRD	2.40E+08	27426	847	0	4.16
SDM/SGM	3.06E+08	34906	1078	0	3.27
SGL1/SGL2	3.08E+09	351553	10857	0	0.32
SGM	2.95E+09	336593	10395	0	0.34
SGT0M	3.28E+08	37399	1155	0	3.05
TML1	2.25E+09	256808	7931	0	0.44
Volga	6.12E+08	69812	2156	0	1.64
P channel	**1.97E+08**	**22440**	**693**	**0**	**5.09**
G4P	1.97E+08	22440	693	0	5.09

Summary of AOS Package Qualification and Monitor Results

Package	Equivalent MTTF		Sample Size	# of failure	FIT Rate
	In hours	In Years			
N channel	**2.36E+10**	**2692747**	**83160**	**0**	**0.04**
DFN Family	9.70E+09	1107018	34188	0	0.1
SO8	4.37E+07	4987	154	0	22.89
SOT23	8.74E+07	9973	308	0	11.45
TO220	5.24E+08	59839	1848	0	1.91
TO220F	5.66E+09	645761	19943	0	0.18
TO247	4.59E+08	52359	1617	0	2.18
TO252	2.18E+07	2493	77	0	45.79
TO263	5.90E+08	67319	2079	0	1.70
TOLL	2.47E+09	281741	8701	0	0.41
CSP	4.04E+09	461258	14245	0	0.25
P channel	**2.62E+08**	**29919**	**924**	**0**	**3.82**
DFN Family	1.09E+08	12466	385	0	9.16
SOT23	1.53E+08	17453	539	0	6.54

Summary of AOS Package Qualification and Monitor Results

DFN Family	**PCT**	**TC**	**HAST**
Total stress hours or cycles	**1064448**	**13244000**	**983136**
# of failure / S.S.	**0 / 11088**	**0 / 13244**	**0/10241**
N channel	11011	13013	10164
P channel	77	231	77
Complementary	n/a	n/a	n/a
Subtotal	**11088**	**13244**	**10241**

SO8	**PCT**	**TC**	**HAST**
Total stress hours or cycles	**14784**	**154000**	**22176**
# of failure / S.S.	**0 / 154**	**0 / 154**	**0/231**
N channel	77	77	154
P channel	77	77	77
Complementary	n/a	n/a	n/a
Subtotal	**154**	**154**	**231**

SOT23	**PCT**	**TC**	**HAST**
Total stress hours or cycles	**14784**	**308000**	**29568**
# of failure / S.S.	**0 / 154**	**0 / 308**	**0 / 308**
N channel	77	154	77
P channel	77	154	231
Complementary	n/a	n/a	n/a
Subtotal	**154**	**308**	**308**

Summary of AOS Package Qualification and Monitor Results Cont'd

TO220	PCT	TC	HAST
Total stress hours or cycles	59136	616000	59136
# of failure / S.S.	0/616	0/616	0/616
N channel	616	616	616
P channel	n/a	n/a	n/a
Complementary	n/a	n/a	n/a
Subtotal	616	616	616

TO220F	PCT	TC	HAST
Total stress hours or cycles	576576	7777000	591360
# of failure / S.S.	0/ 6006	0/ 7777	0 / 6160
N channel	6006	7777	6160
P channel	n/a	n/a	n/a
Complementary	n/a	n/a	n/a
Subtotal	6006	7777	6160

TO247	PCT	TC	HAST
Total stress hours or cycles	51744	539000	51744
# of failure / S.S.	0/539	0/539	0/539
N channel	539	539	539
P channel	n/a	n/a	n/a
Complementary	n/a	n/a	n/a
Subtotal	539	539	539

TOLL	PCT	TC	HAST
Total stress hours or cycles	251328	4774000	125664
# of failure / S.S.	0 / 2618	0 / 4774	0 / 1309
N channel	2618	4774	1309
P channel	n/a	n/a	n/a
Complementary	n/a	n/a	n/a
Subtotal	2618	4774	1309

Summary of AOS Package Qualification and Monitor Results Cont'd

TO252 (DPAK)	PCT	TC	HAST
Total stress hours or cycles	**n/a**	**n/a**	**7392**
# of failure / S.S.	**n/a**	**n/a**	**0 / 77**
N channel	n/a	n/a	77
P channel	n/a	n/a	n/a
Complementary	n/a	n/a	n/a
Subtotal	**n/a**	**n/a**	**77**

TO263 (D2PAK)	PCT	TC	HAST
Total stress hours or cycles	**44352**	**1155000**	**44352**
# of failure / S.S.	**0 / 462**	**0 / 1155**	**0 / 462**
N channel	462	1155	462
P channel	n/a	n/a	n/a
Complementary	n/a	n/a	n/a
Subtotal	**462**	**1155**	**462**

CSP	PCT	TC	HAST
Total stress hours or cycles	**354816**	**8701000**	**177408**
# of failure / S.S.	**0 / 3696**	**0 / 8701**	**0 / 1848**
N channel	3696	8701	1848
P channel	n/a	n/a	n/a
Complementary	n/a	n/a	n/a
Subtotal	**3696**	**8701**	**1848**

The presentation of FIT rate for the individual product reliability is restricted by the actual burn-in sample size. Failure Rate Determination is based on JEDEC Standard JESD 85. FIT means one failure per billion hours.

Failure Rate = $Chi^2 \times 10^9$ **/ [**2 (N) (H) (Af)**]**
MTTF = 10^9/ FIT

Chi² = Chi Squared Distribution, determined by the number of failures and confidence interval
N = Total Number of units from burn-in tests
H = Duration of burn-in testing
Af = Acceleration Factor from Test to Use Conditions (Ea = 0.7eV and Tuse = 55°C)
Acceleration Factor [**Af**] = **Exp** [Ea / **k** (1/Tj u – 1/Tj s)]

	55 deg C	70 deg C	85 deg C	100 deg C	115 deg C	130 deg C	150 deg C
Af	**259**	**87**	**32**	**13**	**5.64**	**2.59**	**1**

Tj s = Stressed junction temperature in degree (Kelvin), K = C+273.16
Tj u =The use junction temperature in degree (Kelvin), K = C+273.16
k = Boltzmann's constant, 8.617164 X 10^{-5}eV / K