Solid-State Light. Done Right.

APPROVAL SHEET

AOT MODEL NAME	SMD LED
AOT PART NUMBER	AOT-3228 MINI-0452BZ-H
CUSTOMER NAME	General Customer
DATE	20050516

MAKER			CUSTOMER			
Prepared	Checked	Approved				

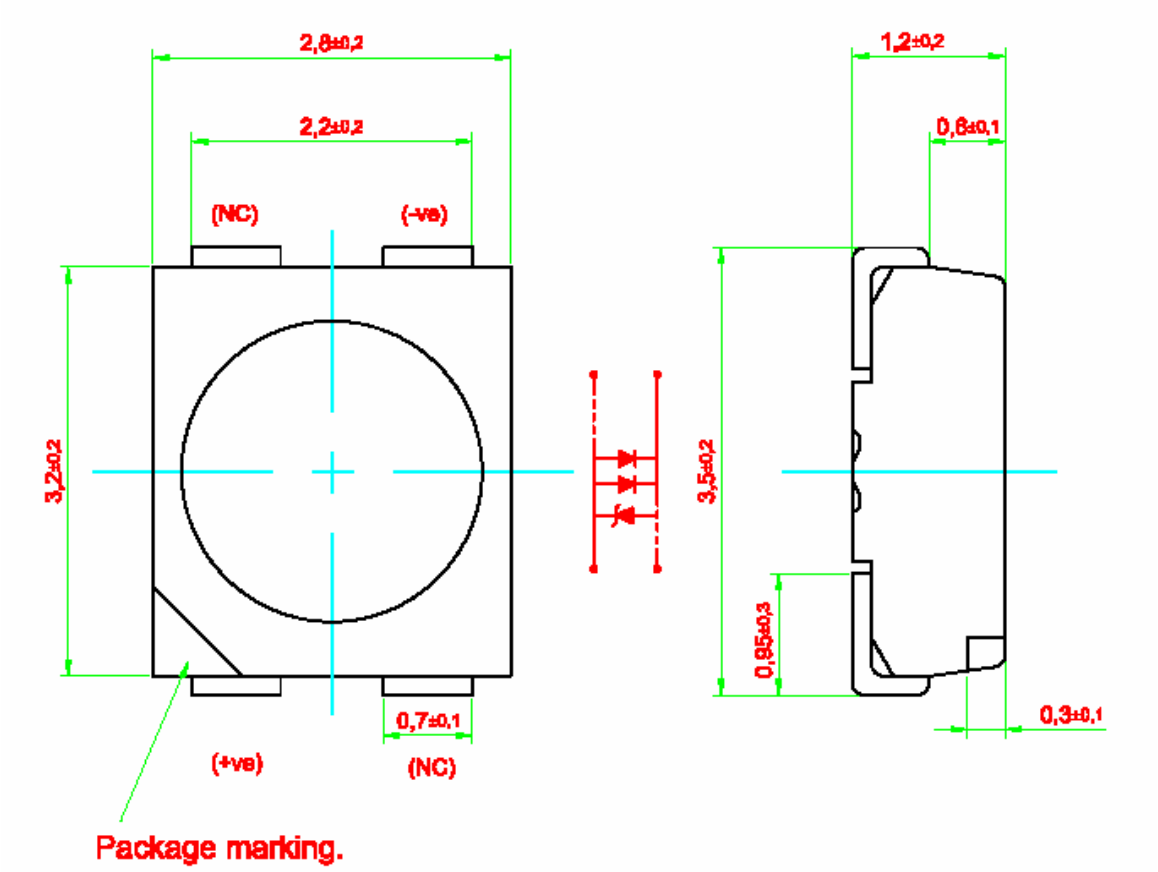
Solid-State Light. Done Right.

Revision note

Date	Revision	Page	Remark
2005-04-01	Initiate Document		
2005-05-16	Add reliability test result	15~25	
2005-05-16	Add heavy metal analysis data	8~9	

Solid-State Light. Done Right.

AOT-3228MINI-0452BZ-H



Unit : mm, Tolerance :±0.2

- High brightness surface mount LED.
- Based on InGaN technology.
- Small package outline (LxWxH) of 3.2 x 2.8 x 1.2 mm.
- Qualified according to JEDEC moisture sensitivity Level 2.
- Compatible to both IR reflow soldering and TTW soldering.

Absolute Maximum Ratings.

	Maximum Value	Unit
Total DC forward	90	mA
Peak pulse current	150	mA
Reverse voltage.	5	V
LED junction temperature.	125	°C
Operating temperature.	-40 … +100	°C
Storage temperature.	-40 … +100	°C

Optical Characteristics at Ta=25°C.

		Intensity @ If = 90mA (mcd)			Viewing
Part Number	Color	Min	Typ.	Max	Angle
3228 MINI 0452BZ	White	2,850	4,000	4,500	120

Pulse driving mode	Pulse driving @ If = 150mA	
On time : 2 sec	Typ. Iv (mcd)	Typ. Vf (V)
Off time : 5 sec	6,000	4.2

	Intensity @ If = 90mA (mcd)	
IV Bin	Min	Max
Y1	2850	3550
Y2	3550	4500

1. Luminous intensity is measured with an accuracy of ±10%.
2. All optical and electrical data are measured at 25°C.
3. Wavelength binning is carried for all units as per the wavelength-binning table. Only one wavelength group is allowed for each reel.

Electrical Characteristics at Ta=25°C.

	Vf @ If = 90mA			Vf @ If = 150mA
Part Number	Min. (V)	Typ. (V)	Max. (V)	Typ. (V)
3228 MINI 0452B	3.5	3.8	4.0	4.2

Forward voltages are tested using a current pulse of 1 ms and has an accuracy of ± 0.1V.

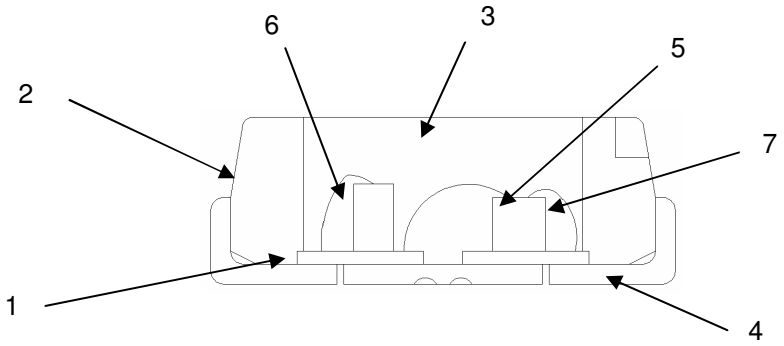
Zener Diode:

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Reverse Leakage Current	Ir	Vr=4V		30	100	nA
Zener Voltage	Vz	Iz=5mA	5.6	6.0	6.4	V
Forward Voltage	Vf	If=20mA			1.2	V

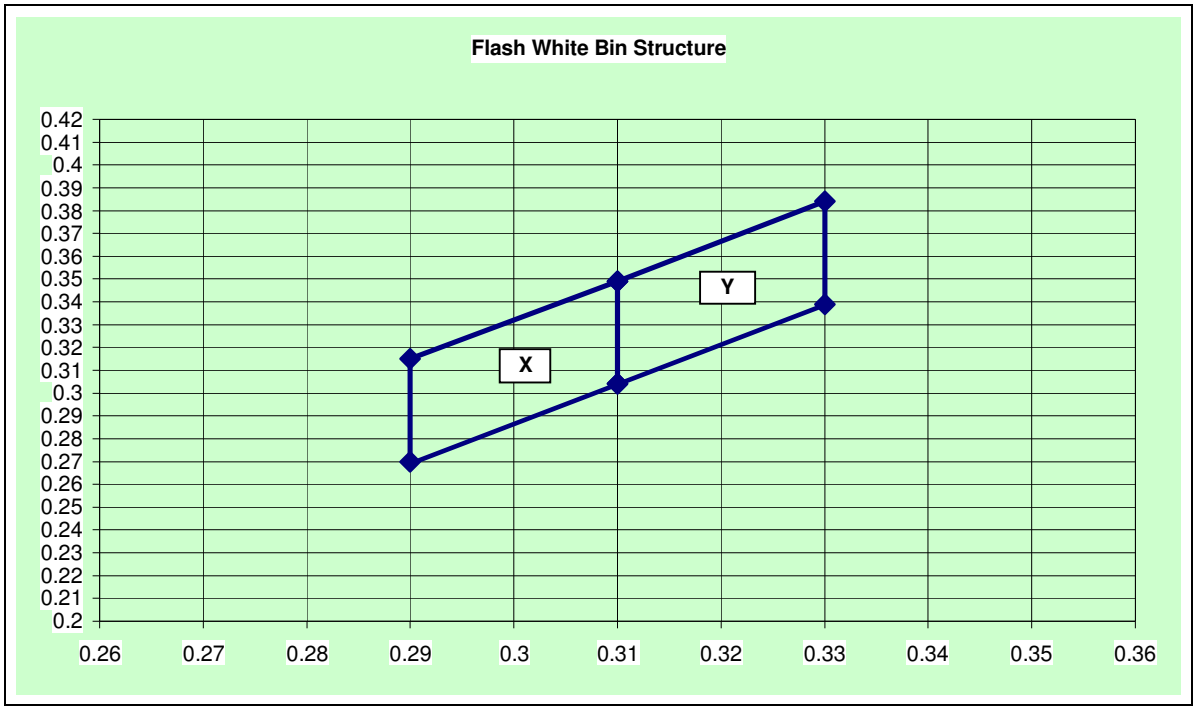
Material

	Material
1. Lead-frame	Copper alloy.
2. Package	High temperature resistant plastic, PPA.
3. Encapsulant	Diffused epoxy resin.
4. Soldering Leads	Pure tin plating, Sn.
5. Die	InGaN based, 2dies
6. Zenor Diode	Si diode
7. Bonding Wire	Au Chip : Ball Bonding / PCB : Wedge Bonding

Note: Product is lead-free (Pb free).



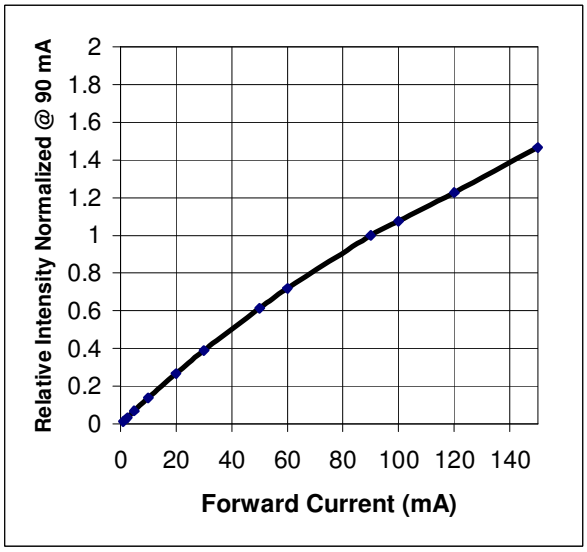
Color Bin



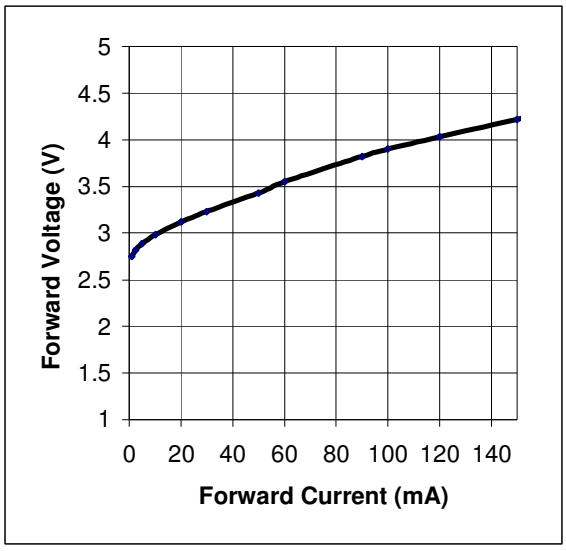
Chromaticity coordinate groups are measured with an accuracy of ±0.01.

Bin		1	2	3	4
X	Cx	0.290	0.310	0.310	0.290
	Cy	0.270	0.304	0.349	0.315
Y	Cx	0.310	0.330	0.330	0.310
	Cy	0.304	0.339	0.384	0.349

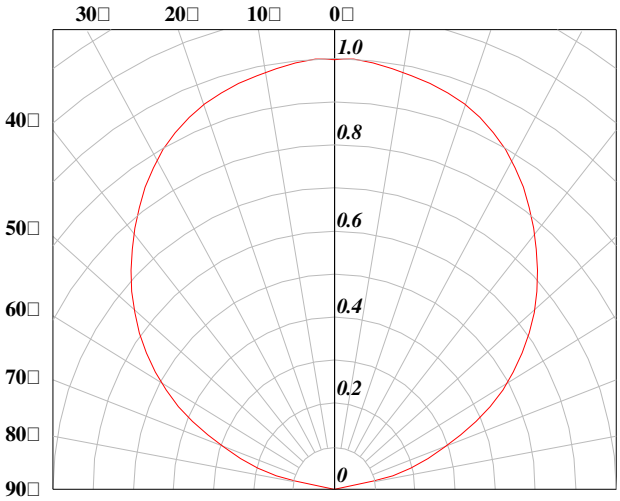
Relative intensity vs. forward current.



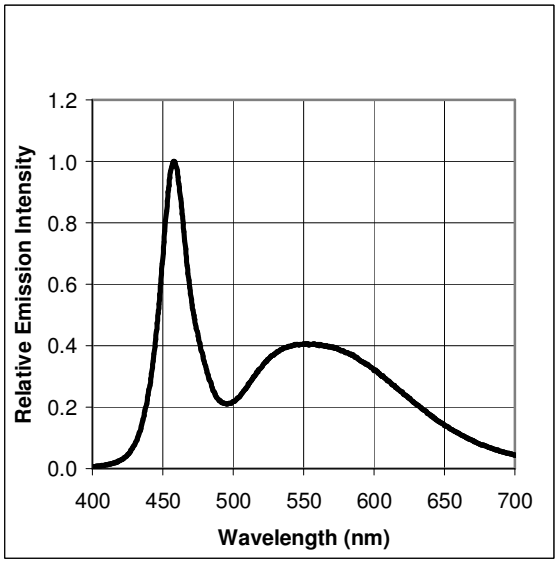
Forward current vs. forward voltage.



Radiation pattern.



Color Spectrum



Heavy Metal Analysis

SGS Testing Korea Co., Ltd.

#18-34, Sanbon-dong, Gunpo-city, Kyunggi-do, Korea 435-040
Tel : 031-4285-777, Fax : 031-427-2374/9, InterNet>http://www.sgslab.co.kr

Test Report No. F690501/LF-CTS100050 Date : May 12, 2005 Page 1 of 2

AOT KOREA
Room 1410 Windstone B/D 275-2, Yangjae-dong, Seocho-ku,
Seoul, Korea

The Following merchandise was submitted and identied by the clients as : -

Type of Product	:	LED (Light Emitting Diode) AOT 3328MINI 0452BZ
SGS File No	:	G-49/2005-0784/2
Buyer	:	
Materials	:	Cu, Ag, High temperature resistance plastic(PPA), Epoxy resin, Sn
Style / Item No.	:	AOT 3228MINI 0452BZ
Sample Receiving Date	:	May. 04, 2005
Test Performing Date	:	May. 06, 2005
Test Performed	:	SGS Testing Korea tested the sample which ws selected by applicant with following result.
Test Results	:	For further detail, please refer to following page.

SGS Testing Korea Co., Ltd.
Jae S. Han

KHJ/ysh

Jason Han / Director

SGS Testing Korea Co., Ltd.

#18-34, Sanbon-dong, Gunpo-city, Kyunggi-do, Korea 435-040
Tel : 031-4285-777, Fax : 031-427-2374/9, InterNet>http://www.sgslab.co.kr

Test Report No. F690501/LF-CTS100050 Date : May 12, 2005

Heavy Metal

Test Items	Unit	Test Method	MDL	Results
Cadmium (Cd)	mg/kg	USEPA 3050B, ICP-AES	0.5	n. d.
Lead (Pb)	mg/kg	USEPA 3050B, ICP-AES	5	n. d.
Mercury (Hg)	mg/kg	USEPA 3052,ICP-AES	2	n. d.
Hexavalent Chromium (Cr VI)	mg/kg	USEPA 3060A, UV-Vis	1	n. d.

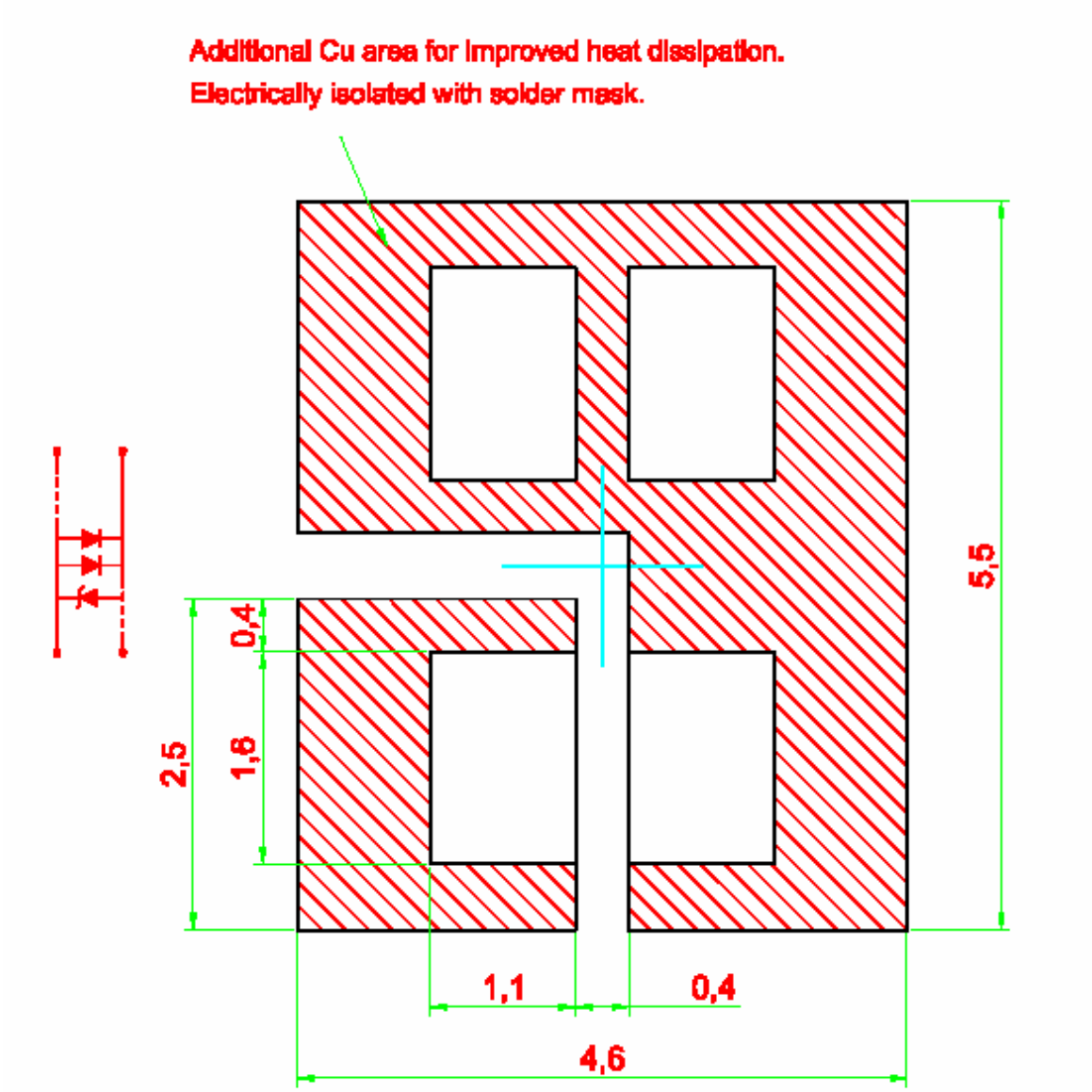
Flame Retardants

Test Items	Unit	Test Method	MDL	Results
Polybrominated Biphenyls (PBBs)				
Bromobiphenyl	mg/kg	With reference to USEPA 3450C. Analysis was performed by GC/MS.	5	n. d.
Dibromobiphenyl	mg/kg		5	n. d.
Tribromobiphenyl	mg/kg		5	n. d.
Tetrabromobiphenyl	mg/kg		5	n. d.
Pentabromobiphenyl	mg/kg		5	n. d.
Hexabromobiphenyl	mg/kg		5	n. d.
Heptabromobiphenyl	mg/kg		5	n. d.
Octabromobiphenyl	mg/kg		5	n. d.
Nonabromobiphenyl	mg/kg		5	n. d.
Decabromobiphenyl	mg/kg		5	n. d.
Polybrominated Diphenyl Ethers (PBDEs)				
Bromodiphenyl ether	mg/kg	With reference to USEPA 3450C. Analysis was performed by GC/MS.	5	n. d.
Dibromodiphenyl ether	mg/kg		5	n. d.
Tribromodiphenyl ether	mg/kg		5	n. d.
Tetrabromodiphenyl ether	mg/kg		5	n. d.
Pentabromodiphenyl ether	mg/kg		5	n. d.
Hexabromodiphenyl ether	mg/kg		5	n. d.
Heptabromodiphenyl ether	mg/kg		5	n. d.
Octabromodiphenyl ether	mg/kg		5	n. d.
Nonabromodiphenyl ether	mg/kg		5	n. d.
Decabromodiphenyl ether	mg/kg		5	n. d.

Note : n. d. = Not detected
MDL = Method Detection Limit

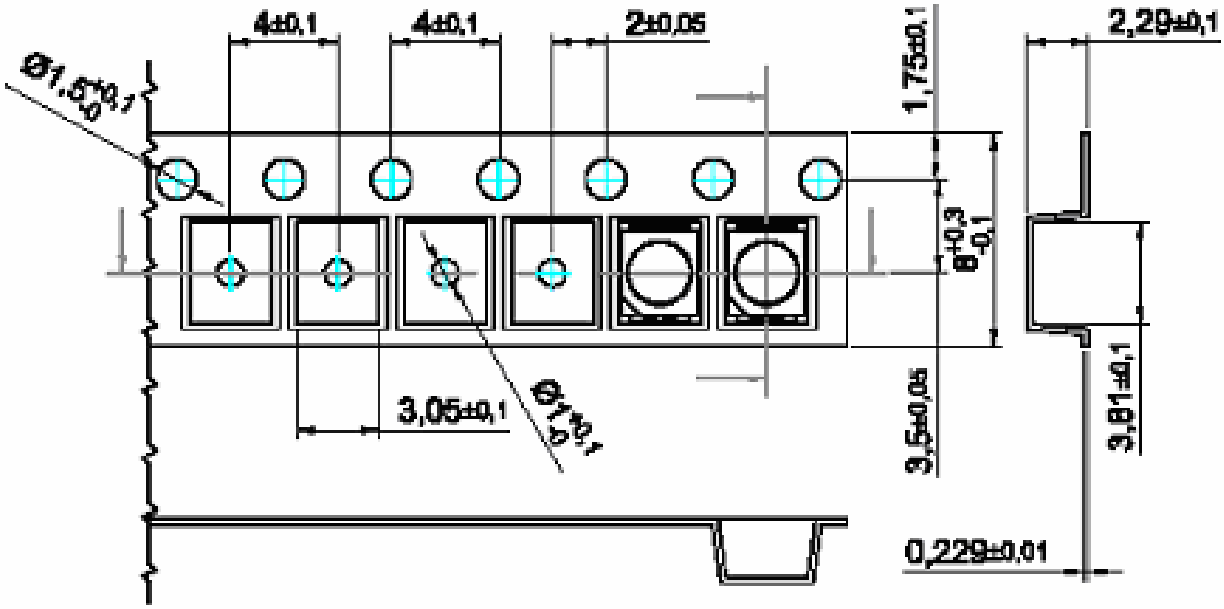
********** End **********

Recommended Solder Pad



Taping And Orientation.

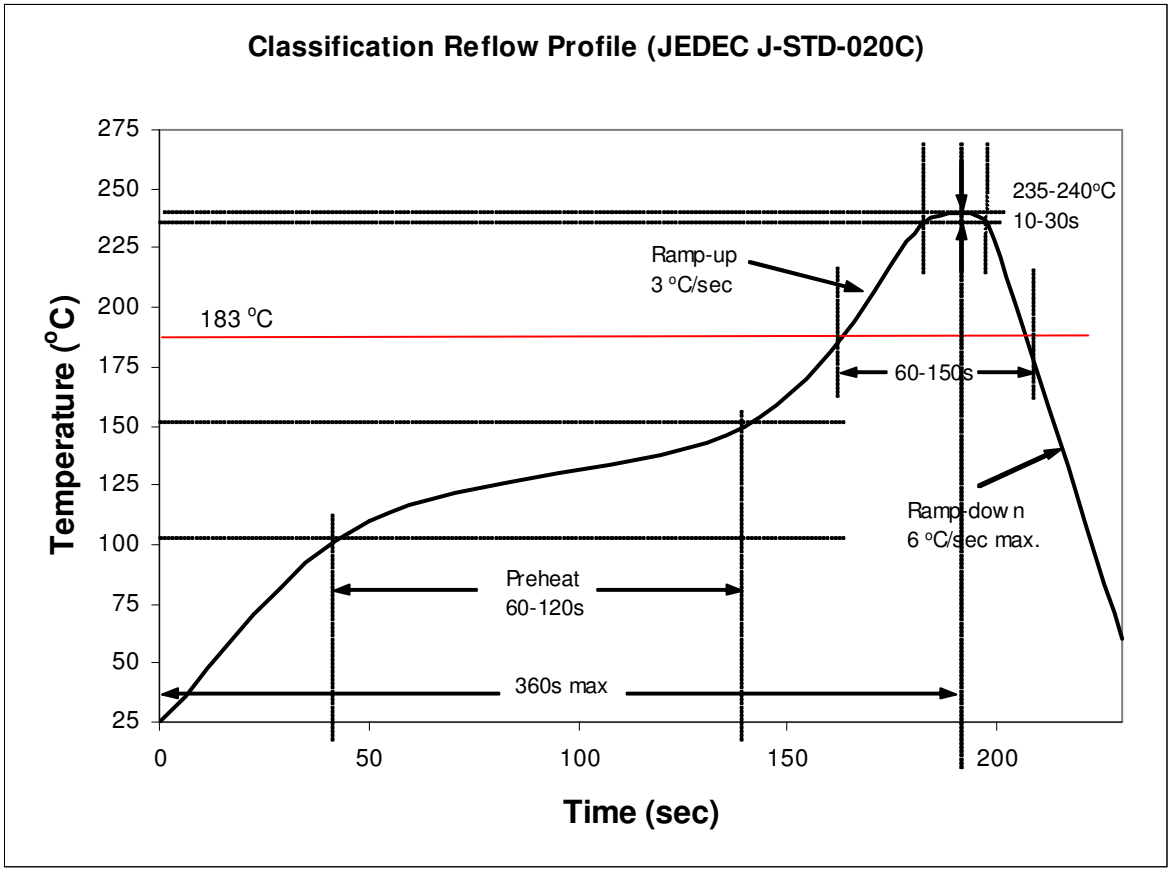
Reels come in standard quantity of 1000 units.
Reel diameter is 180 mm.



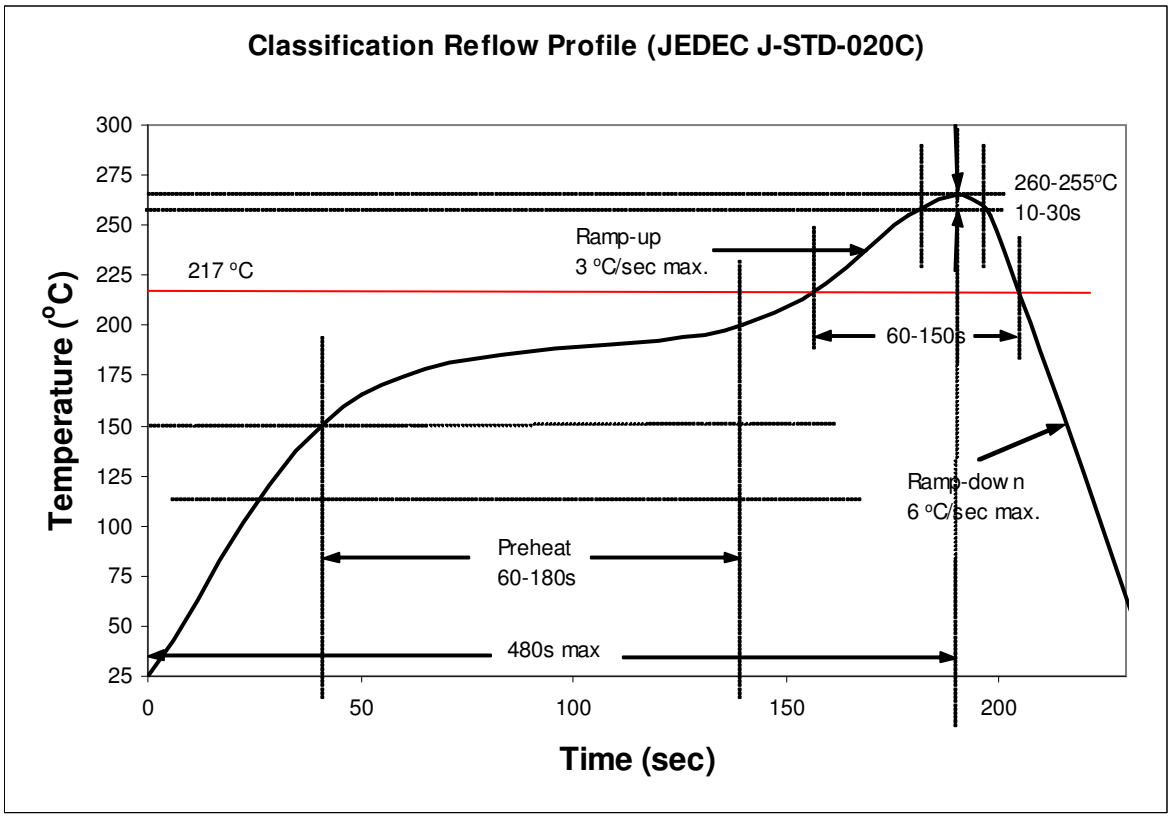
Materials and Characteristics

Carrier Tape			Cover Tape		
Description	**Typical Value**	**Unit**	**Description**	**Typical Value**	**Unit**
Material	Polycarbonate		Thickness	0.061+-0.013	mm
Tensile Strength(yield)	63	Mpa	Tensile Strength(break)	70	Mpa
Impact strength(notched)	10.2	Kg-cm/cm	Elongation(length)	150	%
Elongation	105	%	Elongation(lateral)	145	%
Shrinkage	<1.0	%	Tear Strength(length)	0.20	N
Surface resistivity	10E4-10E6	Ohm/sq	Tear Strength(lateral)	0.19	N
Volume resistivity	<10E6	Ohm-cm	Surface resistivity (surface)	<2.0E+09	Ohm/sq
			Surface resistivity (sealing)	<2.0E+09	Ohm/sq

Recommended Sn-Pb IR-Reflow Soldering Profile.



Recommended Pb Free IR-Reflow Soldering Profile.



Surface Mounting Condition

In automatic mounting of the SMD LEDs on printed circuit boards, any bending, expanding and pulling forces or shock against the SMD LEDs shall be kept min. to prevent them form electrical failures and mechanical damages of the devices.

Soldering Reflow

-Soldering of the SMD LEDs shall conform to the soldering condition in the individual specifications.

-SMD LEDs are designed for Reflow Soldering.

-In the reflow soldering, too high temperature and too large temperature gradient such as rapid heating/cooling may cause electrical & optical failures and damages of the devices.

-AOT cannot guarantee the LED after they have been assembled using the solder dipping method.

Solid-State Light. Done Right.

Product Type:	Package:	Chip Type:
AOT 3228MINI 0452BZ-H	**PLCC – 4**	InGaN

Title:

AOT 3228MINI 0452BZ LED (PLCC4) Product Qualification for flashlighting

Purpose: To qualify the AOT 3228MINI 0452BZ package for flash applications.

Sample History: All parts are assembled and tested in AOT.

Product Reliability Qualification Plan:

All units are to be pre-conditioned before proceeding to the respective test.

	Conditions
• Pre-conditioning as per JEDEC L 2A requirement (JESD22-A113-B)	- Bake @ 125°C, 24 hrs. - Moisture soak @ 60°C/60% RH, 120 hrs.
• IR re-flow soldering on FR4 board.	- 3xIR re-flow soldering at 260°C/10 sec. min.(JEDEC)

Failure criteria:

- Electrical failures:
  - Vf shift >=10%
- Light Output Degradation:
  - % Iv shift <= -50%
- Visual failures:
  - Broken or damaged package or lead
  - Solderability < 95% wetting
  - Dimension out of tolerance

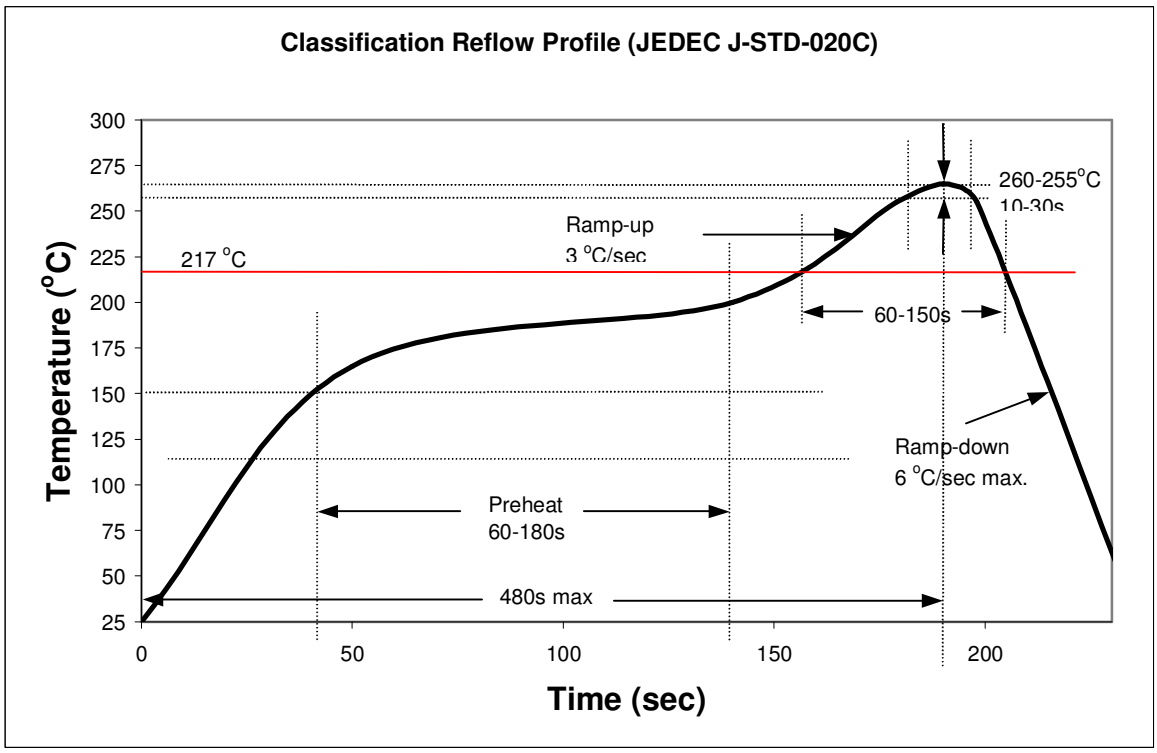
Reliability Test Matrix.

IR/Convective Reflow Process at Peak Temperature 235℃±5℃ for 10-20 sec.

Pre-conditioning @ 60℃/60% RH for 120 hours.

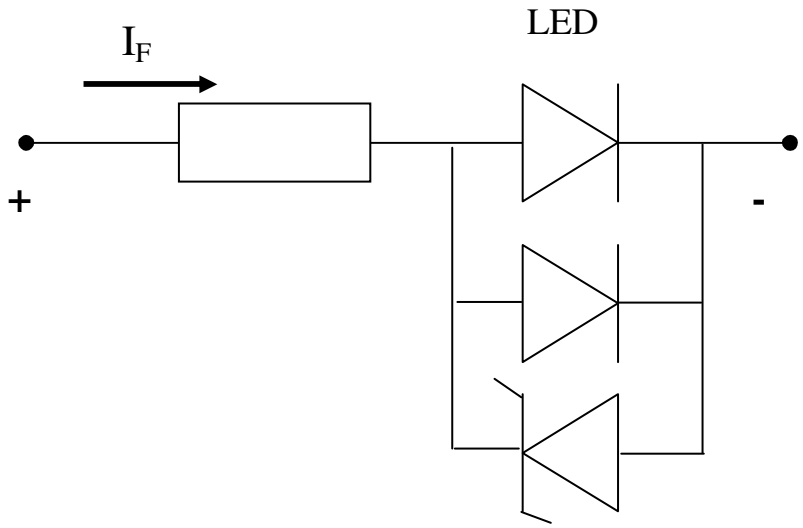
No	Test Type	Stress Condition	S/S	Test Point
1	Ambient life test (ALT)	a) Pre-conditioning b) IR re-flow soldering - T_a = 25°C, - I_f = 90 mA (45 mA / chip)	20	0 hrs 168 hrs
2	Pulse life test (PLT)	a) Pre-conditioning b) IR re-flow soldering - T_a = 25°C, - I_f = 150 mA (total) - 2 sec ON, 5 sec OFF	20	0x 100,000x
3	Thermal shock (TSK)	a) Pre-conditioning b) IR re-flow soldering c) Liquid-to-liquid, -55°C to 100°C, 15 min dwell, < 10 sec transfer	25	0x 50x 100x
4	Solderability	Ageing : 150℃, 16hrs T_a = 215℃ for 3 seconds T_a = 260℃ for 10 seconds	 10 10	 2x 2x

Pb Free IR re-flow Profile.

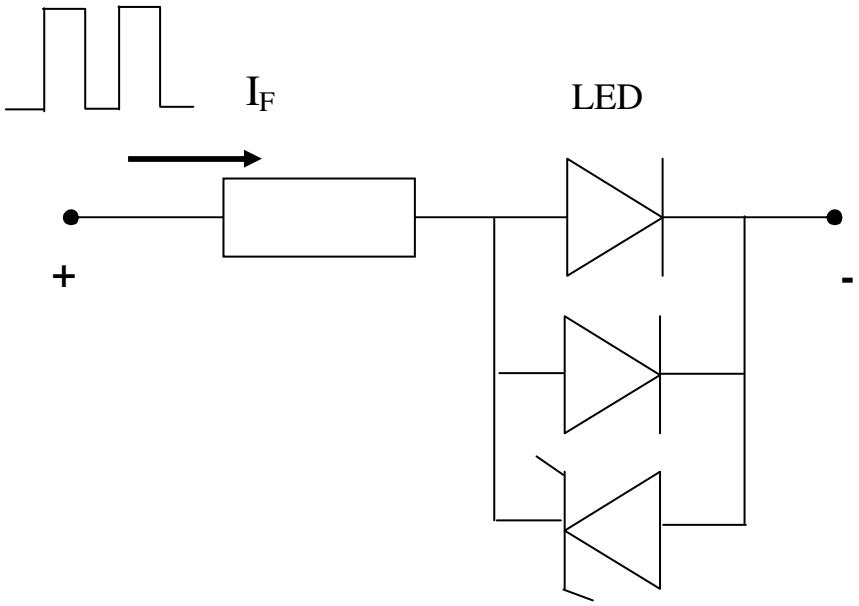


Reliability Test Circuit.

Ambient life test and elevated life test.



Pulse life test.



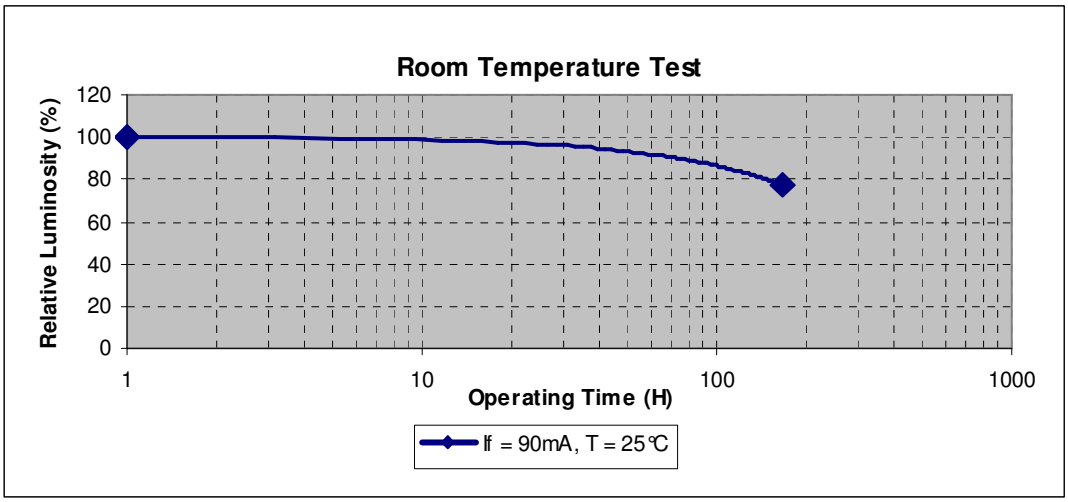
Reliability Test Result.

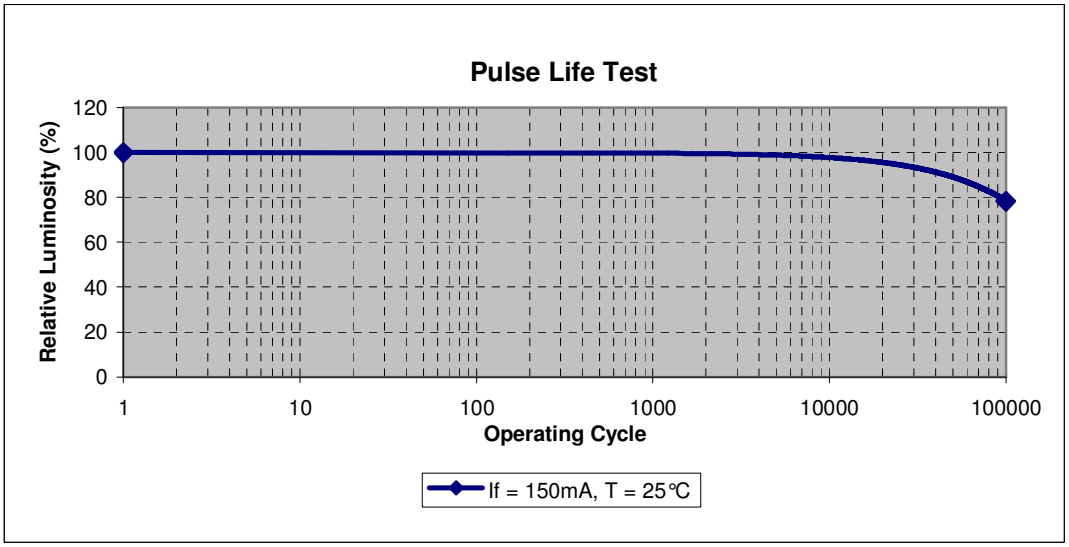
No	Test Type	Stress Condition	Samp	Test Poi	Vf	IV
1	Ambient life test (ALT)	a) Pre-conditioning b) IR re-flow soldering - T_a = 25°C, - I_f = 90 mA (45 mA / chip)	20	0 hr	0/20	0/20
				168hr	0/20	0/20
2	Pulse life test (PLT)	c) Pre-conditioning d) IR re-flow soldering - T_a = 25°C, - I_f = 150 mA (total) - 2 sec ON, 5 sec OFF	20	0X	0/20	0/20
				100,000 X	0/20	0/20
3	Thermal shock (TSK)	a) Pre-conditioning b) IR re-flow soldering c) Liquid-to-liquid, -55°C to 100°C, 15 min dwell, < 10 sec transfer	25	0X	0/25	0/25
				100X	0/25	0/25
4	Solderability	Ageing : 150℃, 16hrs T_a = 215℃ for 3 sec T_a = 260℃ for 10 sec	10 10	2x 2x	0/10 0/10	

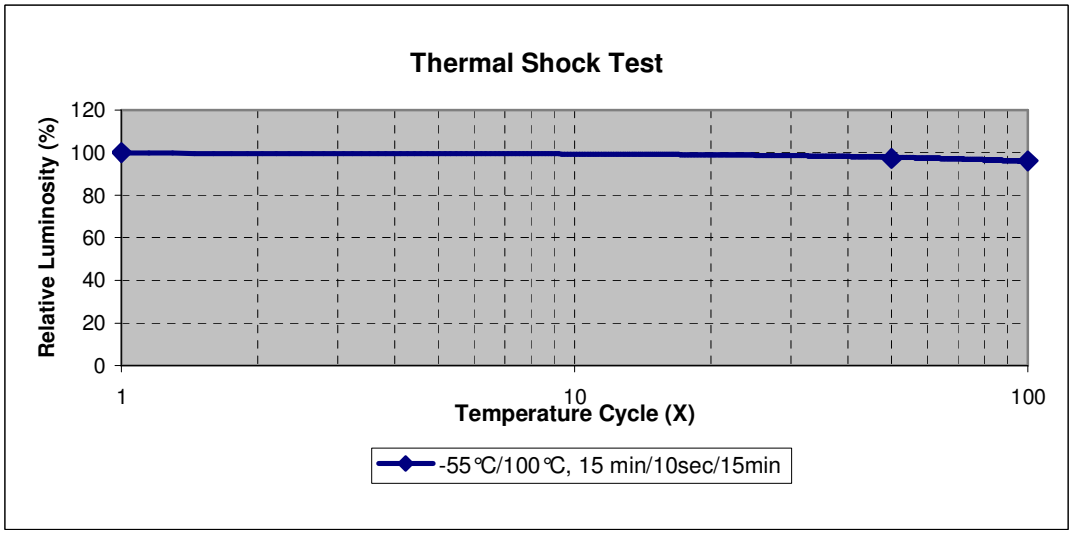
Conclusions:

All qualification samples passed.

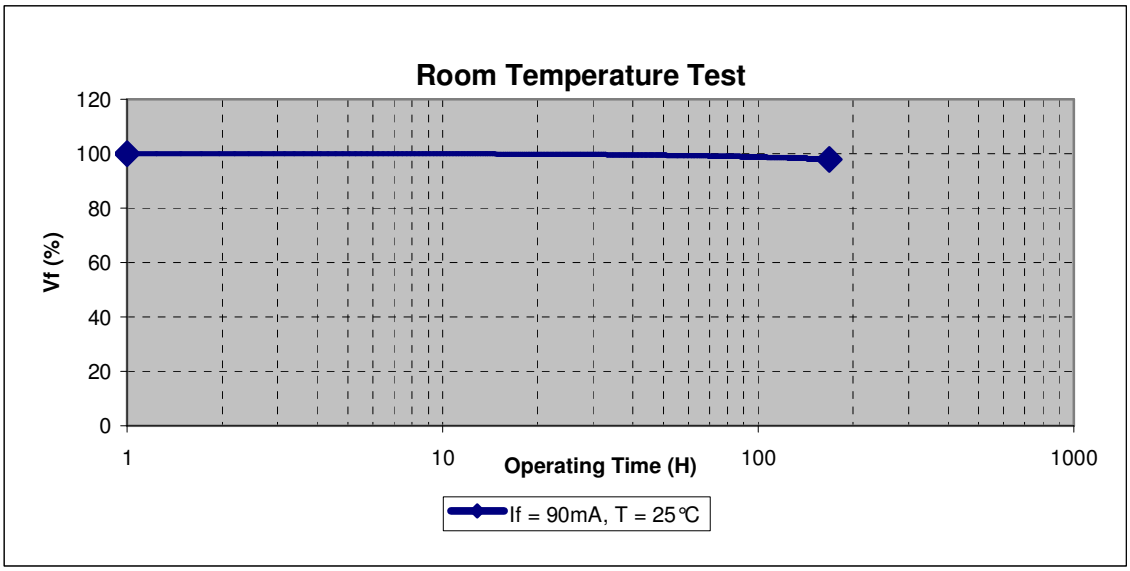
IV Degradation Graph

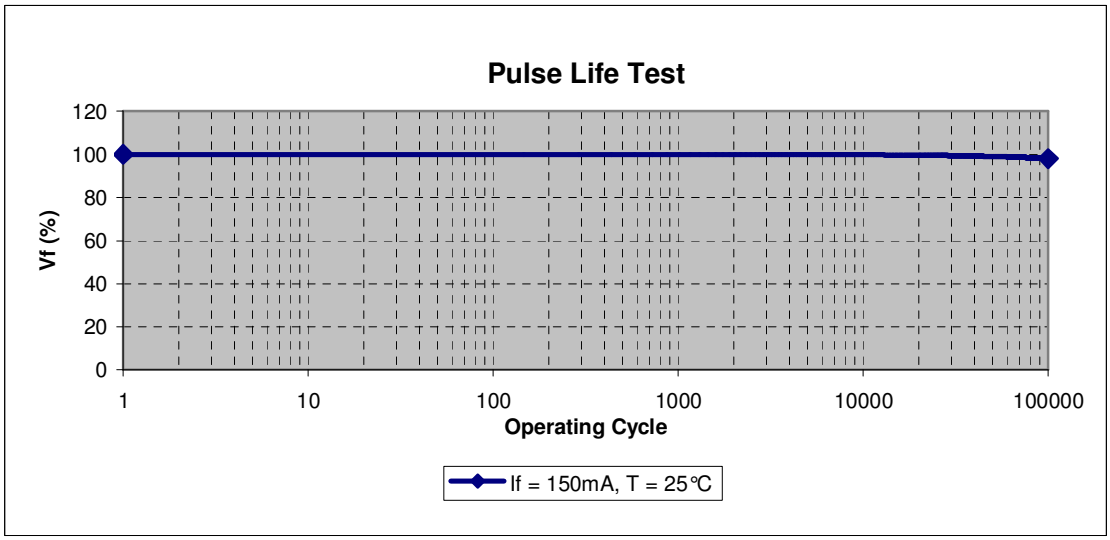


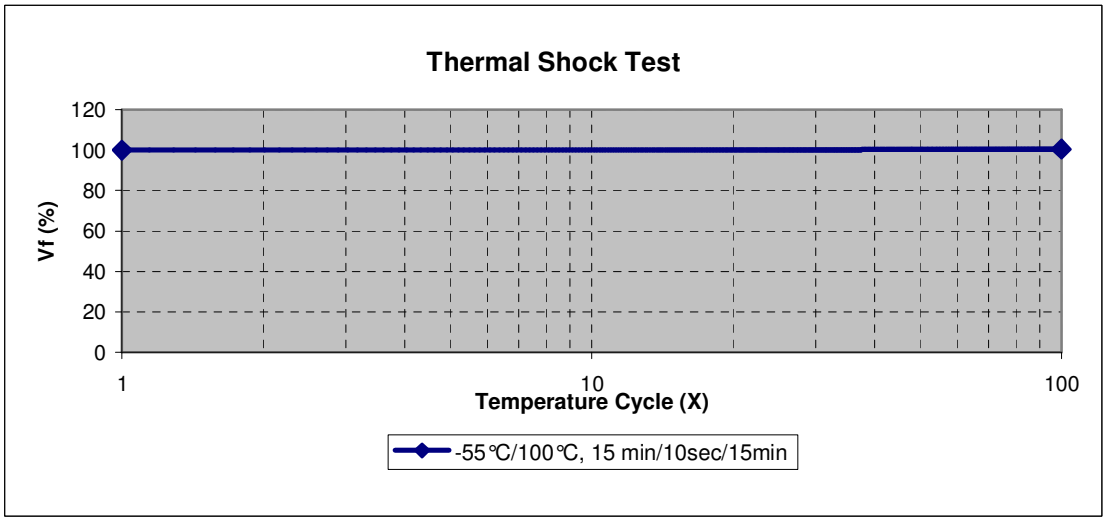




Vf Shift Graph







Solid-State Light. Done Right.

Reliability Test Data

Ambient Life Test. T = 25°C, If = 90 mA.

	VF(v)			IV(mcd)			Cx		Cy	
Unit no:	0 hrs	168 hrs	%	0 hrs	168 hrs	%	0 hrs	168 hrs	0 hrs	168 hrs
1	3.801	3.722	-2.08%	3705	2774	-25.1%	0.303	0.299	0.304	0.298
2	3.907	3.877	-0.77%	3832	2985	-22.1%	0.303	0.301	0.304	0.299
3	3.779	3.801	0.58%	4045	3151	-22.1%	0.313	0.302	0.32	0.311
4	3.756	3.665	-2.42%	3863	2920	-24.4%	0.305	0.297	0.305	0.295
5	3.823	3.786	-0.97%	3930	3111	-20.8%	0.308	0.3	0.313	0.299
6	3.893	3.777	-2.98%	3980	3121	-21.6%	0.312	0.301	0.319	0.303
7	3.759	3.821	1.65%	3913	3148	-19.6%	0.302	0.297	0.303	0.297
8	3.78	3.778	-0.05%	3861	3011	-22.0%	0.299	0.288	0.296	0.287
9	3.757	3.672	-2.26%	3932	3144	-20.0%	0.307	0.298	0.313	0.304
10	3.829	3.671	-4.13%	4047	3130	-22.7%	0.313	0.301	0.319	0.302
11	3.771	3.598	-4.59%	4012	3022	-24.7%	0.307	0.297	0.31	0.299
12	3.778	3.632	-3.86%	3865	3091	-20.0%	0.303	0.296	0.304	0.295
13	3.791	3.621	-4.48%	3963	3000	-24.3%	0.306	0.299	0.308	0.297
14	3.782	3.681	-2.67%	3992	2912	-27.1%	0.307	0.298	0.312	0.303
15	3.813	3.679	-3.51%	3746	2987	-20.3%	0.305	0.295	0.31	0.299
16	3.771	3.699	-1.91%	3992	3109	-22.1%	0.305	0.297	0.306	0.295
17	3.757	3.598	-4.23%	4010	3076	-23.3%	0.306	0.296	0.309	0.298
18	3.805	3.717	-2.31%	3967	3091	-22.1%	0.311	0.302	0.317	0.303
19	3.773	3.669	-2.76%	4006	3016	-24.7%	0.307	0.298	0.312	0.301
20	3.786	3.811	0.66%	3958	2899	-26.8%	0.302	0.296	0.302	0.296
Min			-4.59%			-27.1%				
Max			1.65%			-19.6%				
Average			-2.15%			-22.8%				

Solid-State Light. Done Right.

Pulse Life Test.

T_a = 25°C, I_f = 150 mA (total)
2 sec ON, 5 sec OFF

	VF(v)			IV(mcd)			Cx		Cy	
Unit no:	0x	100kx	%	0kx	100kx	%	0x	100kx	0kx	100kx
1	4.342	4.242	-2.30%	5593	4556.4	-18.5%	0.283	0.279	0.26	0.253
2	4.334	4.174	-3.69%	5649.3	4606.8	-18.5%	0.283	0.278	0.259	0.252
3	4.319	4.122	-4.56%	5383.8	4242.1	-21.2%	0.276	0.271	0.249	0.241
4	4.344	4.26	-1.93%	5645.2	4408.5	-21.9%	0.284	0.279	0.26	0.252
5	4.386	4.14	-5.61%	5592.9	4449.7	-20.4%	0.281	0.276	0.257	0.25
6	4.385	4.184	-4.58%	5637	4551.9	-19.2%	0.283	0.277	0.26	0.252
7	4.334	4.275	-1.36%	5484	4418.4	-19.4%	0.279	0.273	0.252	0.244
8	4.323	4.311	-0.28%	5532.8	4381.3	-20.8%	0.286	0.281	0.265	0.257
9	4.402	4.363	-0.89%	5572.7	4627.1	-17.0%	0.284	0.278	0.261	0.253
10	4.384	4.412	0.64%	5480.3	4395.9	-19.8%	0.28	0.276	0.253	0.247
11	4.307	4.373	1.53%	5503.7	4205.5	-23.6%	0.281	0.275	0.266	0.258
12	4.279	4.153	-2.94%	5615.9	4201.1	-25.2%	0.281	0.314	0.262	0.299
13	4.321	4.412	2.11%	5239.1	4053.9	-22.6%	0.281	0.276	0.262	0.254
14	4.269	4.222	-1.10%	5444.5	4164.8	-23.5%	0.28	0.275	0.261	0.254
15	4.264	4.253	-0.26%	5689.2	4175	-26.6%	0.282	0.276	0.266	0.256
16	4.284	4.094	-4.44%	5752.1	4261.3	-25.9%	0.284	0.278	0.268	0.257
17	4.29	4.322	0.75%	5678.8	4257.9	-25.0%	0.281	0.273	0.262	0.249
18	4.299	4.154	-3.37%	5787.4	4568.3	-21.1%	0.283	0.276	0.267	0.256
19	4.301	4.154	-3.42%	5509	4271.4	-22.5%	0.281	0.275	0.263	0.254
20	4.27	4.199	-1.66%	5749	4560.7	-20.7%	0.284	0.279	0.271	0.263
Min			-5.61%			-26.6%				
Max			2.11%			-17.0%				
Average			-1.87%			-21.7%				

Solid-State Light. Done Right.

Thermal Shock Test. Liquid-to-liquid, -55°C to 100°C, 15 min dwell, < 10 sec transfer.

	VF(v)			IV(mcd)			Cx		Cy	
Unit no:	0x	100x	%	0kx	100x	%	0x	100x	0kx	100x
1	3.859	3.853	-0.16%	3897	3674	-5.72%	0.302	0.298	0.302	0.299
2	3.767	3.762	-0.13%	3795	3559	-6.22%	0.303	0.299	0.304	0.297
3	3.855	3.85	-0.13%	3825	3678	-3.84%	0.303	0.296	0.304	0.299
4	3.783	3.78	-0.08%	3764	3643	-3.21%	0.303	0.297	0.305	0.298
5	3.847	3.846	-0.03%	3811	3685	-3.31%	0.303	0.292	0.303	0.298
6	3.803	3.822	0.50%	3607	3453	-4.27%	0.303	0.294	0.305	0.299
7	3.811	3.814	0.08%	3617	3465	-4.20%	0.303	0.296	0.303	0.297
8	3.815	3.841	0.68%	3914	3741	-4.42%	0.305	0.298	0.310	0.302
9	3.842	3.845	0.08%	3952	3735	-5.49%	0.305	0.299	0.309	0.299
10	3.838	3.84	0.05%	3755	3650	-2.80%	0.303	0.297	0.304	0.297
11	3.855	3.855	0.00%	3574	3419	-4.34%	0.303	0.297	0.304	0.298
12	3.809	3.816	0.18%	3826	3695	-3.42%	0.313	0.302	0.320	0.307
13	3.814	3.818	0.10%	3715	3532	-4.93%	0.305	0.295	0.305	0.296
14	3.787	3.791	0.11%	3608	3413	-5.40%	0.305	0.297	0.305	0.297
15	3.793	3.794	0.03%	3765	3581	-4.89%	0.308	0.299	0.313	0.301
16	3.779	3.784	0.13%	3788	3698	-2.38%	0.312	0.302	0.319	0.299
17	3.774	3.893	3.15%	3617	3518	-2.74%	0.300	0.292	0.297	0.289
18	3.772	3.89	3.13%	3657	3533	-3.39%	0.307	0.298	0.313	0.307
19	3.82	3.822	0.05%	3644	3485	-4.36%	0.307	0.297	0.312	0.302
20	3.783	3.785	0.05%	3804	3698	-2.79%	0.310	0.299	0.316	0.302
21	3.758	3.794	0.96%	3770	3704	-1.75%	0.310	0.301	0.315	0.303
22	3.786	3.815	0.77%	3752	3595	-4.18%	0.303	0.296	0.303	0.297
23	3.807	3.809	0.05%	3825	3662	-4.26%	0.308	0.298	0.312	0.302
24	3.795	3.911	3.06%	3625	3560	-1.79%	0.308	0.298	0.313	0.300
25	3.776	3.784	0.21%	3690	3625	-1.76%	0.306	0.297	0.310	0.298
Min			-0.16%			-6.2%				
Max			3.15%			-1.8%				
Average			0.51%			-3.8%				

Solid-State Light. Done Right.

ESD-HBM Test

Product	: AOT-3228MINI-0452BZ-H
Testing Item	: ESD-HBM
Test Method	: MIL-STD-883D Method 3015.7
Failure Criteria	: FOR V CHANGE AT 1μA ±30%
Test Voltage	: 500V ~ 8000V, Step：500V

Test Equipment:

KEYTEK ZAPMASTER

Environmental Condition of Laboratory:

Temperature: 25ºC±5ºC

Humidity: 55%±10% RH

Test Result:

Sample	1	2	3	4	5
Failure Voltage	Pass	Pass	Pass	Pass	Pass

Sample	6	7	8	9	10
Failure Voltage	Pass	Pass	Pass	Pass	Pass

MODEL: HBM	ESD SENSITIVITY PASS: **-50V**		V CLASS: **3**
PIN COMBINATION	SAMPLE SIZE	PASSED VOLTS	**NOTE:** FOR MIL-STD CLASS1: 0V-1999V CLASS2: 2000V-3999V CLASS3: 4000V-TO ABOVE
VDD (+) vs. VSS	5	≥ +6000V	
VDD (-) vs. VSS	5	≥ I -6000V I	

Conclusions:

The reliability tests were designed to evaluate both package integrity as well as workability of product performance over time.

All sample has done well by completed the test required for ALT, PLT and TSK test.

The result shows that all sample passed the qualification criteria with ZERO failure.

From design standpoint, the package is robust enough to meets its datasheet conditions.

Solid-State Light. Done Right.

Cautions:

1. After open the package, the LED should be kept at 30°C, 60%RH or less. The LED should be soldered within 168 hours (7 days) after opening the package.
2. Heat generation must be taken into design consideration when using the LED.
3. Power must be applied resistors for protection, over current would be caused the optic damage to the devices and wavelength shift.
4. Manual tip solder may cause the damage to Chip devices, so advised that heat of iron should be lower than 15W with temperature control under 5 seconds at 230-260 ℃. (The device would be got damage in re working process, recommended under 5 seconds at 230-260 ℃)
5. All equipment and machinery must be properly grounded. It is recommended to use a wristband or anti-electrostatic glove when handing the LED, or should be installed the ionizer if need the risk of generation area would be high.
6. Use IPA as a solvent for cleaning the LED. The other solvent may dissolve the LED package and the epoxy, Ultrasonic cleaning should not be done.
7. Damaged LED will show unusual characteristics such as leak current remarkably increase, turn-on voltage becomes lower and the LED get unlight at low current.

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