



SOT-23 Reliability

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Introduction

Diodes Incorporated has offered high-quality SOT-23 products since 1990. When the demand for SOT-23 packages significantly increased during 1995, Diodes, Inc. responded. In March 1996, Diodes, Inc. formed Shanghai KaiHong Electronic Company (now called Diodes-China) and has made major investments in it since that time. Using state-of-the-art die- and wire-bonding equipment, all SOT-23 devices manufactured at the QS-9000 registered KaiHong facility are subjected to extensive on-site high-reliability testing. Today, all SOT-23 devices manufactured at the facility are the highest-quality, most reliable products on the market.

Quality Control

Quality control at the KaiHong facility begins at the incoming material level. The Incoming Quality Control (IQC) group carefully inspects all incoming materials. The factory purchases its raw materials from only world-class suppliers. The IQC team at KaiHong audits its raw material suppliers on a regular basis and carefully monitors the incoming quality levels.

The quality control continues in the assembly line where mechanical and electrical parameters are monitored using highly-automated In-Process Quality Control (IPQC) methods. Die placement is optically checked to very tight tolerances. The electrical parameters of every device are tested twice on the assembly line before the product is loaded into the carrier tape. The data collected at these stations is compiled and reviewed by the IPQC team using advanced statistical process control methods.



Quality Control Conducted at the Diodes-China Facility

Sample lots are randomly selected from the die-bond station output and subjected to die-shear testing, or from wire-bond station output and subjected to wire-bond pull testing. Next, an Outgoing Quality Control (OQC) team of specially trained inspectors sample outgoing products, performing additional visual-mechanical inspection and electrical testing these samples. The OQC team works closely with manufacturing engineers to continually improve the manufacturing methods as part of an ongoing effort to achieve high quality.

High-Reliability Tests

Quality control methods effectively verify that manufacturing processes are under strict control, but the actual reliability of a device cannot be accurately determined with standard visual and electrical measurement techniques. Using the U.S. Military Standards as a reference, Diodes, Inc. has equipped and trained the factory personnel with the capability to perform a variety of high-reliability tests. The reliability of all SOT-23 products manufactured there are continually monitored by subjecting randomly selected 45-piece sample lots to selected tests discussed below. The high-reliability tests performed are highly effective at inducing failure in relatively short periods of time in samples which are affected by manufacturing anomalies.

Solderability: Solderability testing monitors the solder-adhesion capability of the device terminals. Solderability can be negatively impacted by several factors including insufficient plating thickness, mold flashing, and surface oxide. The test is performed by immersing the sample into a solder bath and checking the amount of solder coverage on the leads.

Solder Heat Resistance: Solder heat resistance testing is designed to check the thermal integrity of the package at withstanding a high temperature solder bath. This test simulates a “worst-case” wave solder process where the parts are not preheated prior to entering the wave. The test is performed by immersing the sample into a solder bath. The temperature is higher and the duration is longer than for the solderability test.

Thermal Shock (Liquid-to-Liquid): Thermal shock checks the ability of the sample to withstand rapid temperature changes. The sample is immersed in boiling water for five minutes, and is then rapidly transferred into freezing water.



Thermal Shock Chamber

High-Reliability Tests (continued)

Humidity: This test checks the ability of the package to resist moisture penetration. The sample is loaded into an environmental chamber. The relative humidity is then increased to 85% and the temperature is also elevated. The conditions are more severe than would be normally encountered.



Humidity Chamber

Autoclave: This test checks the ability of the package to withstand the mechanical stress that is generated by high pressure. By subjecting the samples to high humidity, it also checks the package's resistance to environmental conditions. Loaded into a pressure cooker, the samples are tested under extreme conditions.



Autoclave Chamber

High Temperature Storage Life: This test checks the ability of the parts to withstand high temperatures without the application of any electrical bias. Loaded into an oven, the samples are subjected to excessive heat.

Low Temperature Storage Life: This test checks the ability of the parts to withstand low temperatures without the application of any electrical bias. The samples are loaded into a freezer and subjected to extremely low temperatures.

High-Reliability Tests (continued)

Operating Life: This test checks the ability of the parts to operate with an electrical bias applied for long periods of time. An electrical current equal to the maximum average forward current rating of the device is applied.

High Temperature Reverse Bias (HTRB): This test checks the ability of the samples to withstand a reverse bias while being subjected to the maximum ambient temperature that the parts are rated to withstand.



Operating Life Chambers



HTRB Chambers

Salt Spray: This test monitors the effects of saline mist applications onto the parts. Although it is not considered to be an accurate standalone corrosion test, it is a qualitative test to check the effects of applying corrosive substances onto the parts.

Temperature Cycling: The temperature cycling test checks the ability of parts to withstand extreme temperature changes for long periods of time. Two chamber environmental units are used to perform this test.



Salt Spray Chamber



Temperature Cycling Chambers

High-Reliability Test Standard

At the KaiHong facility, SOT-23 products are tested to the following standards:

Test	Acronym	Conditions	Standard
Solderability	SA	$T=235\pm 5^{\circ}\text{C}$, $t=5\text{s}$	Mil Std 202F, method 208G
Solder Heat Resistance	SHR	$T=260\pm 5^{\circ}\text{C}/-0^{\circ}\text{C}$, $t=10\text{s}$	Mil Std 750D, method 2031.2
Thermal Shock (Liquid-to-Liquid)	TS	$T_H=100^{\circ}\text{C}/5\text{min}$ $T_L=0^{\circ}\text{C}/5\text{min}$ Transfer time < 3s $t=100$ cycles	Mil Std 750D, method 1056.7
Humidity	HUM	$T=85\pm 2^{\circ}\text{C}$ R.H.=85±2%	Mil Std 202F, method 103B
Autoclave/Pressure Cooker	PC	15PSIG/121°C steam $t=96\text{hrs}$	JEDEC Standard JESD22-A102-B
High Temperature Storage Life	HTSL	$T=150^{\circ}\text{C}$	Mil Std 750D, method 1031.5
Low Temperature Storage Life	LTSL	$T=-55\pm 2^{\circ}\text{C}$	IEC 68-2-1, test A
Operating Life	OPL	$I_O=100\%$, $T_A=25^{\circ}\text{C}$	Mil Std 750D, method 1027.3
High Temperature Reverse Bias	HTRB	$T_A=150^{\circ}\text{C}$ $V_R=80\%$ of $V_{R(\text{MAX})}$	Mil Std 750D, method 1038.3
Salt Spray	SS	$T_{\text{SPRAY}}=35^{\circ}\text{C}$, 5%NaCl	Mil Std 202F, method 101D

High-Reliability Test Results

Using the standard tests described above, extensive high-reliability testing has been completed on representative products from the different product types that we offer. The following matrix shows the results of our testing.

Note: If you need high-reliability test reports for any SOT-23 type number which is not shown on this matrix, please contact your local Diodes, Inc. Sales Representative or select *Technical Support* at our website: www.diodes.com.

Test	Switching Diode BAV99		Schottky Diode BAT54S		Zener Diode BZX84C5V1		Bipolar Transistor MMBT3904	
	# of failures	time	# of failures	time	# of failures	time	# of failures	time
SA	0/45	5s	0/45	5s	0/45	5s	0/45	5s
SHR	0/45	10s	0/45	10s	0/45	10s	0/45	10s
TS	0/45	100 cycles	0/45	100 cycles	0/45	100 cycles	0/45	100 cycles
HUM	0/45	1000hrs	0/45	1000hrs	0/45	1000hrs	0/45	1000hrs
PC	0/45	96hrs	0/45	96hrs	0/45	96hrs	0/45	96hrs
HTSL	0/45	1000hrs	0/45	1000hrs	0/45	1000hrs	0/45	1000hrs
LTSL	0/45	1000hrs	0/45	1000hrs	0/45	1000hrs	0/45	1000hrs
OPL	0/45	1000hrs	0/45	1000hrs	0/45	1000hrs	0/45	1000hrs
HTRB	0/45	1000hrs	0/45	1000hrs	0/45	1000hrs	0/45	1000hrs

Customer-Specific High-Reliability Testing

In addition to the standard high-reliability tests described in the previous sections, Diodes Incorporated has performed specialized, customer-specific high-reliability tests. The following matrix of tests is an example of those performed to satisfy customer-specific requirements:

Test	Conditions	Most Similar Mil Standard	Failure Rate (# of failures)
Electrostatic Discharge Sensitivity	0-2kV, 100V steps, 5 reps at each voltage forward and negative pulses	Mil Std 750D, method 1020.2	N/A ¹
Thermal Impedance	Junction-terminal & junction-ambient	Mil Std 750D, method 3101.2	N/A ²
Power & Temperature Cycling (Air-to-Air)	T _H =70°C/45min, T _L =0°C/45min Transfer time<15min, t=1,000 hrs	Mil Std 750D, method 1055.1	0/45
Reverse Bias Humidity	T=85+/-5°C, R.H.=85+/-5%, t=1,000 hrs V _R sufficient to assure reverse bias condition	Mil Std 750D, method 1021.2	0/45
High Temperature Operating Life	T=100°C, I _F =100mA, t=1,000 hrs	Mil Std 202F, method 108A	0/45
Temperature Cycling (Air-to-Air)	T _L =-40°C/25min T _H =125°C/25min Transfer time<5min, duration=100 cycles	Mil Std 750D, method 1051.5	0/45

Notes: (1): The ESD test is intended to determine the point of secondary breakdown in diodes. It can be considered a destructive test and the failure rate is therefore not relevant.

(2): The thermal impedance test was performed to prove the validity of our specification for thermal resistance, j-a. It is a test to measure performance rather than reliability. The term 'failure rate' is not applicable to this test.

If your qualification requirements include specialized high-reliability testing, please contact us and we would be happy to review your requirements.

Conclusion

Diodes Incorporated offers the highest quality, most reliable SOT-23 products available from a commercial product manufacturer. Our major investment as well as our continuing investments and commitment in our KaiHong facility over the last two years has allowed us to equip it with the most modern, state-of-the-art manufacturing equipment available in the world. Our KaiHong facility is now operating at a capacity of sixty million devices per month. We are installing more equipment to increase our capacity to one billion devices per year by the end of 1998. Recently, the breadth of our product line at our KaiHong facility has increased with the addition of the SOD-123 package. Other package types will also be available soon.

Diodes Incorporated is well equipped to meet all of your requirements for SOT-23 devices. Our commitment to quality, reliability, and superior service sets us above other manufacturers. Please give us a call today to discuss your sampling needs.

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