产品存储时间可靠性评估报告

Product Storage Time Reliability Assessment Report

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1. 简介 Introduction

This paper details the study results of the quality, reliability, and usability of semiconductor products after long-term storage in a controlled environment.

本文详细介绍了在受控环境中经过长期存储后半导体产品的质量、可靠性和可用性的研究结果。

To better understand long-term storage viability, additional data was collected to further comprehend the time that products can be stored before the reliability can be compromised.

为了更好地了解长期存储的可行性，收集了额外的数据以进一步了解产品在可靠性受到影响之前的存储时间。

2. 程序 Procedure

10 lots of product from different package types(such as QFN, DFN, WLCSP and contact finishes NiPdAu, Sn, or SnAgCu solder balls) were evaluated in this study. The age of the products studied ranged from more than 5 years and up to around 8 years of storage in a controlled environment (<30°C and <80% RH). The acronym LTS (long term storage) is used to identify this aged material.

本研究从不同封装类型中挑选了十批产品进行评估(例如 QFN, DFN 和 WLCSP，端子类型如镍钯金，锡或者锡银铜材质的锡球)。所研究的产品在受控环境(<30°C 和<80%相对湿度)中的存储时间从 5 年以上到 8 年左右不等。缩写词 LTS(长期储存)用于识别这种老化材料。

The product packaging was carefully examined when the samples were received and the Humidity Indicator Card (HIC) was recorded for each lot at the first time opening of the sealed Moisture Barrier Bag (MBB). The labels on the bags and boxes were evaluated for legibility and adhesion. MBB and cover tape were assessed for any deterioration in ESD protection through Tribocharging testing. A cover tape peel test was performed to ensure there was no adhesion deterioration for long term storage.

在收到样品时我们仔细检查了产品包装，并在首次打开密封的防潮袋(MBB)时记录每个批次湿度指示卡(HIC)的状态。对包装袋和包装盒上标签的可识别性和粘性也进行了评估。通过摩擦电压测试，对 MBB 和盖带的 ESD 性能是否恶化进行了评估。通过盖带剥离测试以确保粘性不会因为长期存储而出现恶化。

The products were carefully examined for any evidence of deterioration on the lead or package body. Solderability, which can be the most significant concern with long term storage, was performed on all lots to determine if there were any detrimental effects.

这些产品经过了仔细检查以确认引脚或者塑封体是否有任何劣化迹象。可焊性是长期存储产品最令人担忧的问题，因此安排了可焊性测试以确认是否有任何负面影响。

3. 风险评估 Risk Assessment

The reliability risk to semiconductor products that have been stored for longer period of time is low. No failure mechanisms have been identified that would compromise the electrical performance or circuit reliability of LTS devices. HTOL and HTSL assessment data provides the best estimate of parametric performance over time, which was two fixed items during product qualification.

长期存储半导体产品的可靠性风险较低。尚未发现会影响长期存储产品的电性能或电路可靠性的故障机制。HTOL 和 HTSL 的评估数据提供了对参数性能随时间变化的最佳估计，这是产品认证阶段的两个固定项目。

Devices are biased during HTOL testing, this is the worst case compared to unbiased storage. FIT rates have been in the single digit or low level two digits based on Awinic reliability assessment data. This assures that biased and unbiased devices would remain within data sheet limits far beyond the design and storage life of the device.

产品在 HTOL 测试时会进行偏置，相对常规存储已经是最严苛的场景。依据艾为可靠性评估数据，产品的 FIT 率一直保持在个位数或者低水平的两位数，这确保了偏置和无偏置的产品满足产品手册的时间将远超出产品的设计和存储寿命。

In addition to the studies performed on the long term storage products, package qualifications include humidity testing to evaluate the effect of moisture on die metallization (galvanic corrosion). Devices routinely pass high temperature and high humidity testing. All products are stored in a properly controlled environment prior to being shipped. Moisture sensitive products are packaged with appropriate MBB and desiccant based on Awinic internal specification for moisture sensitivity which aligns with JEDEC J-STD-033D. Packaging material and cover tape was evaluated using Tribocharge testing and showed no issues. Any failure of the MBB would be detected immediately by the HIC discolorations upon opening the package.

除了对长期存储产品的研究外，封装认证时已经包括耐湿测试，以评估湿气对金属层(电化学腐蚀)的影响。且产品通过了常规的高温和高湿测试。所有产品在发货前都会存放在合适受控的环境中。基于 Awinic 内部规范，对湿气敏感产品会使用适当的 MBB 和干燥剂进行包装，也符合 JEDEC J-STD-033D 标准。通过摩擦电压测试对包装材料和盖带进行了评估，结果正常。一旦 MBB 出现任何问题，在打开真空包装查看湿度指示卡是否有变色时就能及时发现。

4. 评估产品清单 Products Samples Included in the Evaluation

表格 4-1 列出了评估的产品清单。
Table 4-1 Lists the evaluated device samples.

Sample Batch	Part Number	Date Code	Shelf Storage Age (Years)	Package Type	Pin Count	MSL	Terminal Finish
1#	AW87319CSR	1627	7.5	WLCSP	19	MSL1	SnAgCu solder ball
2#	AW9666QNR	1631	7.4	WBQFN	16	MSL3	Sn
3#	AW8737FCR	1640	7.2	FCQFN	16	MSL3	Sn
4#	AW9119QNR	1738	6.3	WBQFN	20	MSL3	Sn
5#	AW9233CSR	1742	6.2	WLCSP	16	MSL1	SnAgCu solder ball
6#	AW5027ECR	1819	5.6	ECP	6	MSL1	SnAgCu solder ball
7#	AW5008L2FDR	1844	5.2	FCDFN	6	MSL1	NiPdAu
8#	AW36429FCR	1845	5.1	FCQFN	10	MSL1	Sn
9#	AW5105DNR	1813	5.3	WBDFN	6	MSL1	NiPdAu
10#	AW5017DNR	1837	5.7	WBDFN	6	MSL3	Sn
11#	AW8899QNR	1828	5.5	WBQFN	24	MSL3	Sn
12#	AW87317CSR	1812	5.8	WLCSP	14	MSL1	SnAgCu solder ball

Table 4-1

5. 包装材料评估 Packing Materials Evaluation

Device information labels continued to properly adhesive after 5 years of warehouse storage and were readable. The HIC had been checked immediately after opening the MBB. No HIC samples showed a change in the color dots.

经过五年期的存储，标签粘性无异常且可识别，打开铝箔袋后立即检查湿度指示卡，未发现湿度指示卡色点有变化。

图 5-1 样品 10#打开内盒，MSL3 包装
Figure 5-1. Sample 10# Opened Box, MSL3 Packing

图 5-2 样品 10# MBB 上的标签
Figure 5-2. Sample 10# Label on MBB

图 5-3 样品 10# 湿度指示卡
Figure 5-3. Sample 10# HIC after opening MBB

6. 包装材料 ESD 测试 Packing Material ESD Testing

The measurement for the originally used tape and MBB packing material was made and all meet requirement.

对原始包装的载盖带和铝箔袋进行了 ESD 测试，全部符合要求。

图 6-1. 样品 4# 载带表面电阻测试

Figure 6-1. Carrier Tape Resistivity Measurement

图 6-2. 样品 4# 盖带表面电阻测试

Figure 6-2. Cover Tape Resistivity Measurement

图 6-3. 样品 4# MBB 表面电阻测试

Figure 6-3. MBB Resistivity Measurement

图 6-4. 样品 4# MBB 摩擦电压测试

Figure 6-4. MBB Voltage Test

表 6-1 ESD 测试结果汇总

Table 6-1 ESD test result summary

Sample Batch	Date Code	Part Number	MSL	MBB inner surface resistance (1.0E4~1.0E11 Ω)	MBB outer surface resistance (1.0E4~1.0E11 Ω)	MBB voltage <100v	Carrier tape surface resistance (1.0E4~1.0E11 Ω)	Carrier tape voltage <100v	Cover tape surface resistance (1.0E4~1.0E11 Ω)	Cover tape voltage <100v
1#	1627	AW87319CSR	MSL1	$3.59\times10^{9}\Omega$	$2.64\times10^{9}\Omega$	0V	$6.32\times10^{10}\Omega$	0V	2.12×10^{10}	0V
2#	1631	AW9666QNR	MSL3	$4.37\times10^{9}\Omega$	$5.23\times10^{9}\Omega$	0V	$5.75\times10^{10}\Omega$	0V	1.54×10^{10}	0V
3#	1640	AW8737FCR	MSL3	$1.27\times10^{9}\Omega$	$7.14\times10^{9}\Omega$	0V	$2.33\times10^{10}\Omega$	0V	1.98×10^{10}	0V
4#	1738	AW9119QNR	MSL3	$3.17\times10^{8}\Omega$	$3.96\times10^{9}\Omega$	0V	$8.85\times10^{10}\Omega$	0V	2.24×10^{10}	0V
5#	1742	AW9233CSR	MSL1	$1.54\times10^{10}\Omega$	$8.04\times10^{8}\Omega$	0V	$2.43\times10^{10}\Omega$	0V	1.47×10^{10}	0V
6#	1819	AW5027ECR	MSL1	$9.34\times10^{9}\Omega$	$8.28\times10^{8}\Omega$	0V	$1.35\times10^{10}\Omega$	0V	1.44×10^{10}	0V
7#	1844	AW5008L2FDR	MSL1	$8.90\times10^{9}\Omega$	$2.77\times10^{9}\Omega$	0V	$1.75\times10^{10}\Omega$	0V	1.61×10^{10}	0V
8#	1845	AW36429FCR	MSL1	$1.34\times10^{10}\Omega$	$1.08\times10^{9}\Omega$	0V	$8.66\times10^{9}\Omega$	0V	2.04×10^{10}	0V
9#	1813	AW5105DNR	MSL1	$2.30\times10^{10}\Omega$	$1.51\times10^{9}\Omega$	0V	$2.26\times10^{10}\Omega$	0V	1.25×10^{10}	0V
10#	1837	AW5017DNR	MSL3	$1.37\times10^{9}\Omega$	$2.12\times10^{10}\Omega$	0V	$3.07\times10^{10}\Omega$	0V	3.04×10^{10}	0V
11#	1828	AW8899QNR	MSL3	$4.99\times10^{9}\Omega$	$2.37\times10^{10}\Omega$	0V	$9.21\times10^{9}\Omega$	0V	2.02×10^{10}	0V
12#	1812	AW87317CSR	MSL1	$2.49\times10^{10}\Omega$	$1.41\times10^{9}\Omega$	0V	$4.17\times10^{10}\Omega$	0V	1.55×10^{10}	0V

Table 6-1

7. 编带拉力评估 Cover Tape Peel Strength Evaluation

The test is done to confirm that the cover tape adhesion did not change over the long-term storage of the reel. The peel force of the cover tape was measured within the 10gram minimum force and 100gram maximum limit according industry standard EIA 481. The peeling speed of the cover tape was set to 300mm per minute.

编带拉力测试确认了盖带粘性在经过长时间存储后没有明显变化，依据 EIA 481 标准，剥离力最小 10 克，最大 100 克，剥离速度设置为每分钟 300 毫米。

图 7-1. 编带拉力测试设置
Figure 7-1. Cover Tape Peel Strength Test Setup

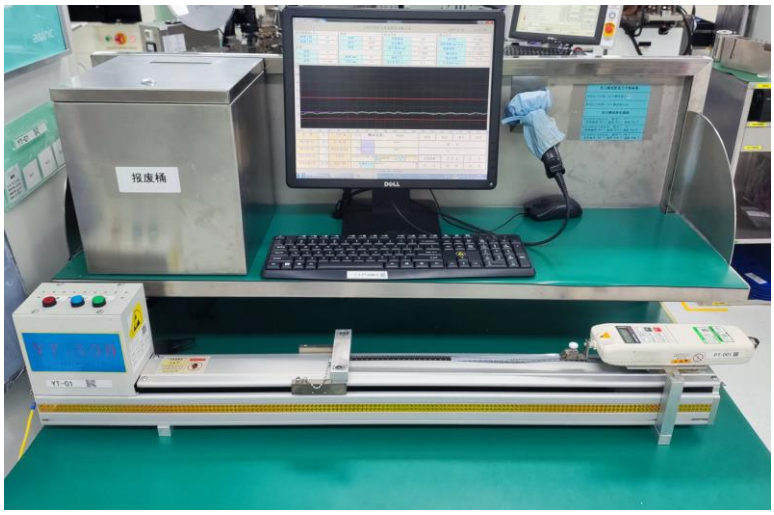


Figure 7-1.

图 7-2. 样品 8#, 8mm 载带拉力测试结果(内控 30-80g)
Figure 7-2. Cover Tape Peel Strength Test Result for 8mm Tape.

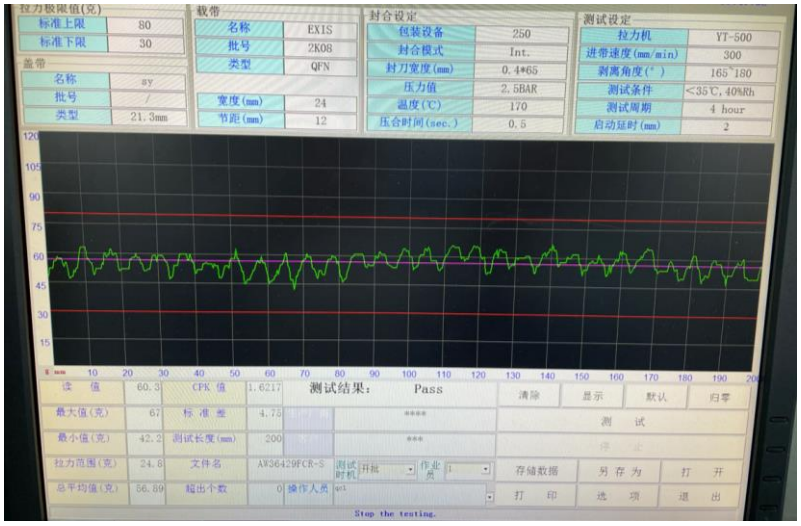


Figure 7-2.

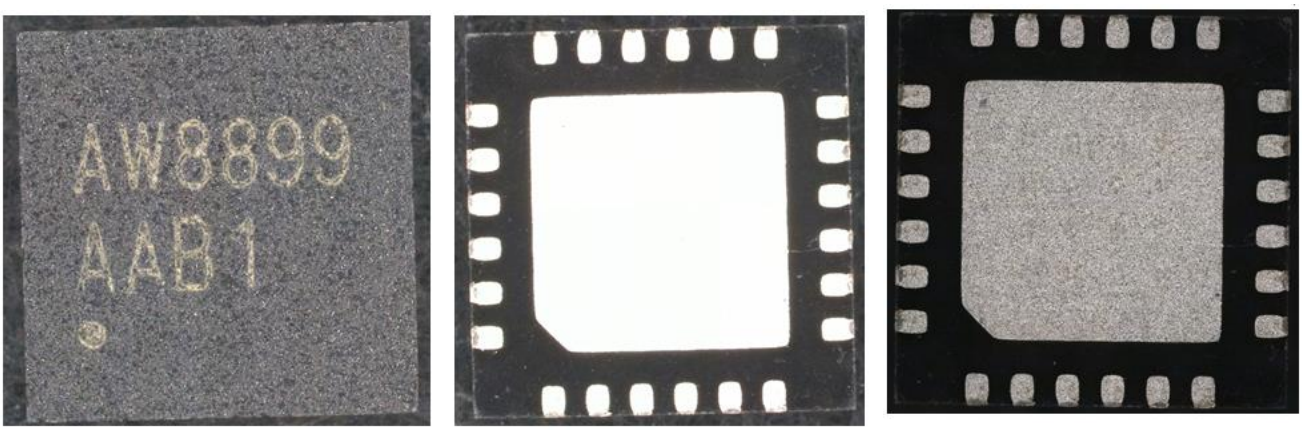
8. 芯片评估 Package Evaluation

- 芯片外观 Appearance Check

Appearance is checked after taking out from carrier pocket, no abnormality was found on the terminal, like corrosion, oxidation, etc.

从编带中取出芯片检查外观，确认端子无腐蚀、氧化等异常，具体如下：

图 8-1 样品 11#，外观检查
Figure 8-1. Sample 11# appearance



正面
Topside

背面-聚焦塑封料
(Backside-focus on compound)

背面-聚焦焊盘
(Backside-focus on pad)

图 8-2 样品 9#，外观检查
Figure 8-2. Sample 9# appearance

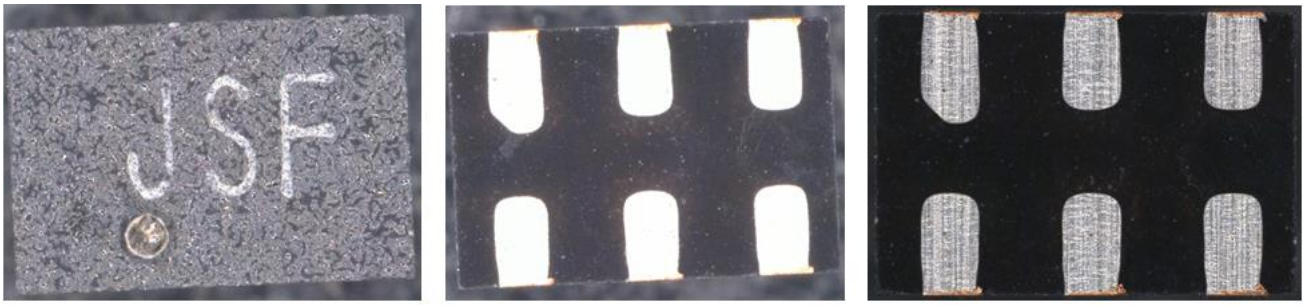


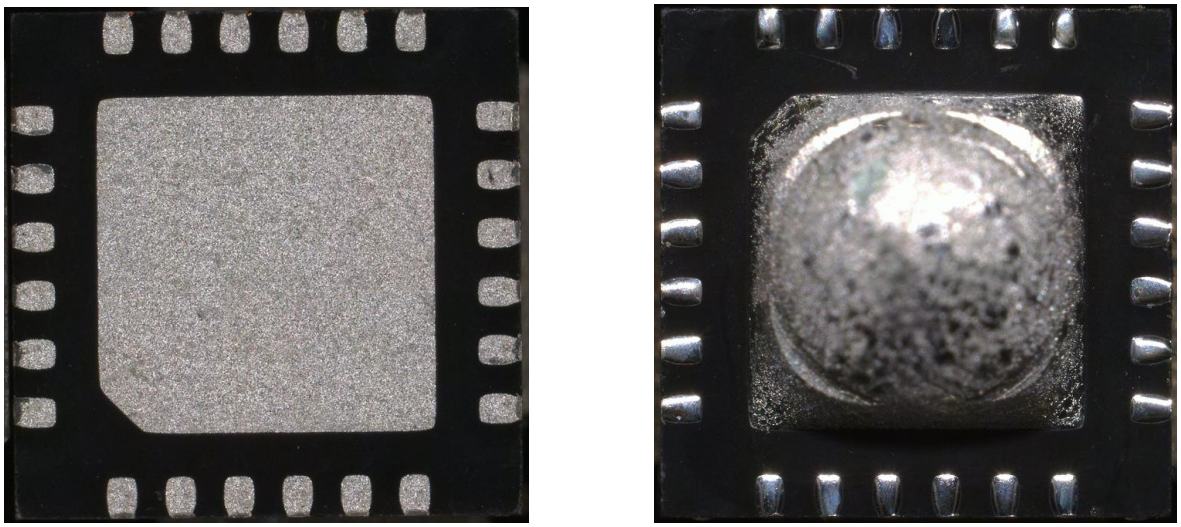
图 8-3 样品 5#，外观检查
Figure 8-3. Sample 5# appearance

- 芯片可焊性 Solderability Test

Samples from each of the selected lots were tested for solderability follow JEDEC standard (J-STD-002) and were all pass.

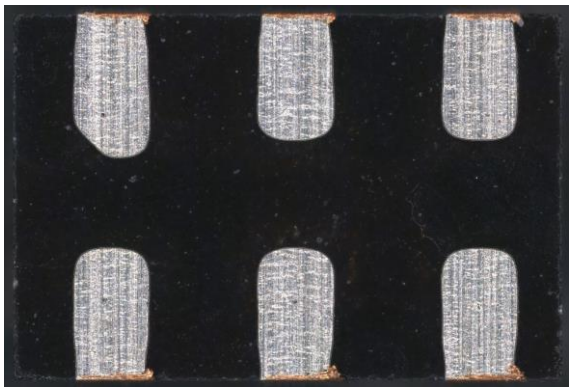
依据 J-STD-002 标准对每个选定批次的样品进行了可焊性测试，结果全部合格。

图 8-4 样品 11#，可焊性结果
Figure 8-4. Sample 11# solderability result

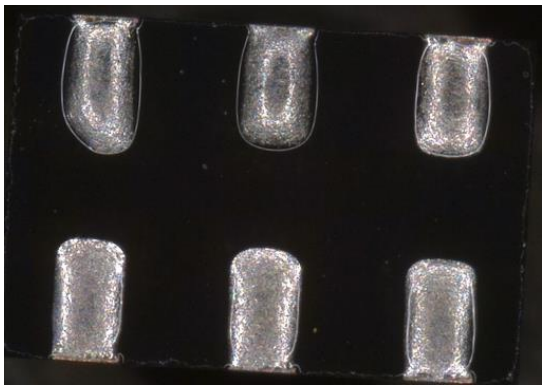


Before Solderability　　After Solderability

图 8-5 样品 9#，可焊性结果
Figure 8-5. Sample 9# solderability result

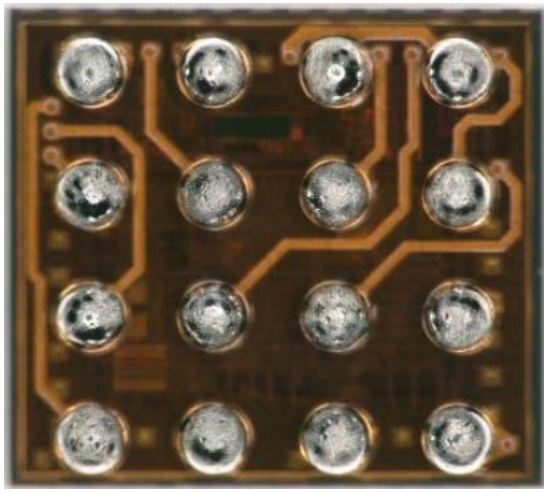


Before Solderability

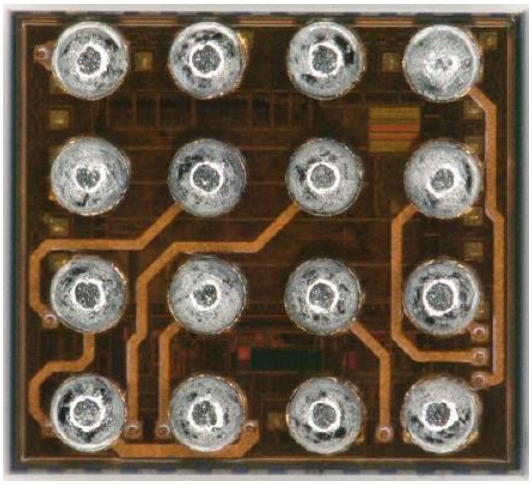


After Solderability

图 8-6 样品 5#，可焊性结果
Figure 8-6. Sample 5# solderability result



Before Solderability



After Solderability

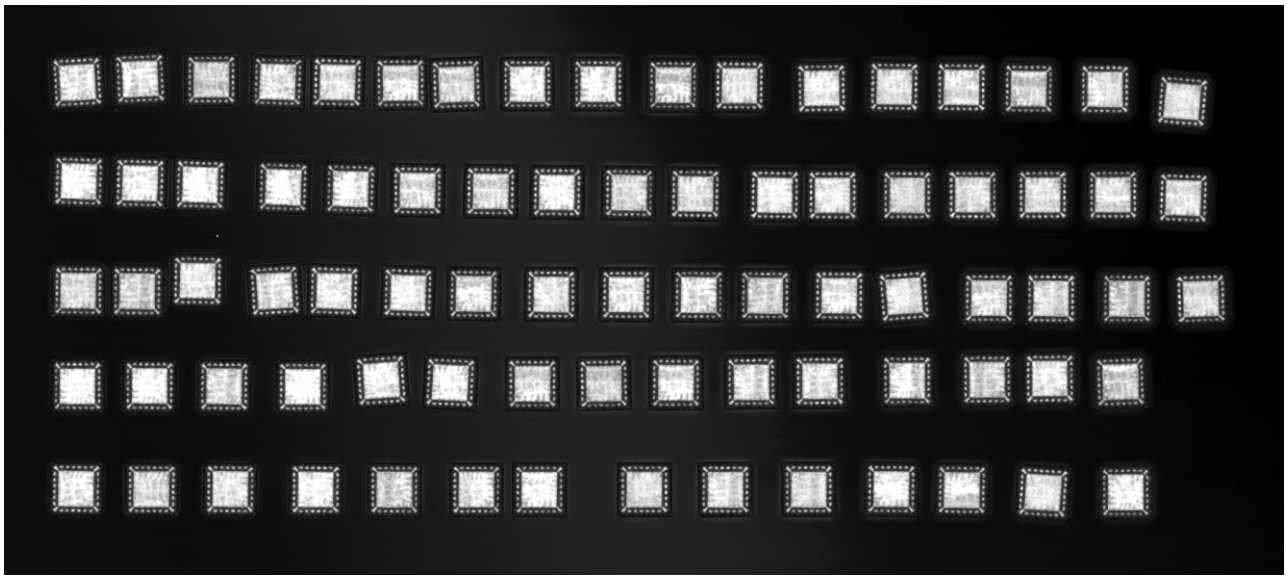
- 三次回流焊后扫描 SAT Results After 3X Reflow

The package samples from each of the selected lots were picked out of the reel baked for 24 hours at 125°C and then 3X reflow(Follow J-STD-020) to check SAT result and no any delamination was found.

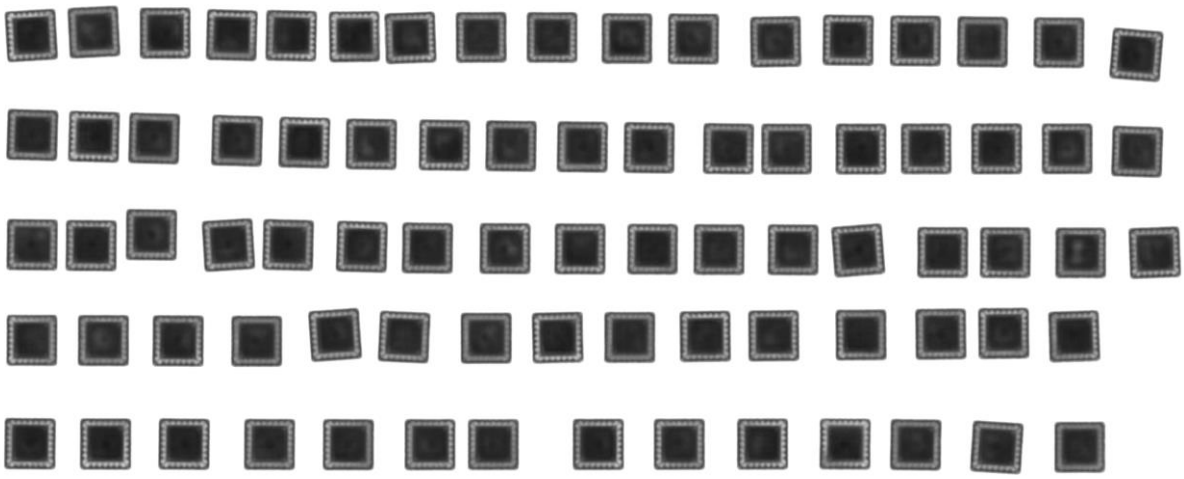
从每个选定批次中取出样品，在 125 度下烘烤 24 小时，然后进行 3 次回流焊(参考 J-STD-020)，检查 SAT 结果，没有发现任何分层现象。

图 8-7 样品 11#，回流焊后 C-SCAN&T-SCAN 结果

Figure 8-7. Sample 11# C-SCAN&T-SCAN result after reflow

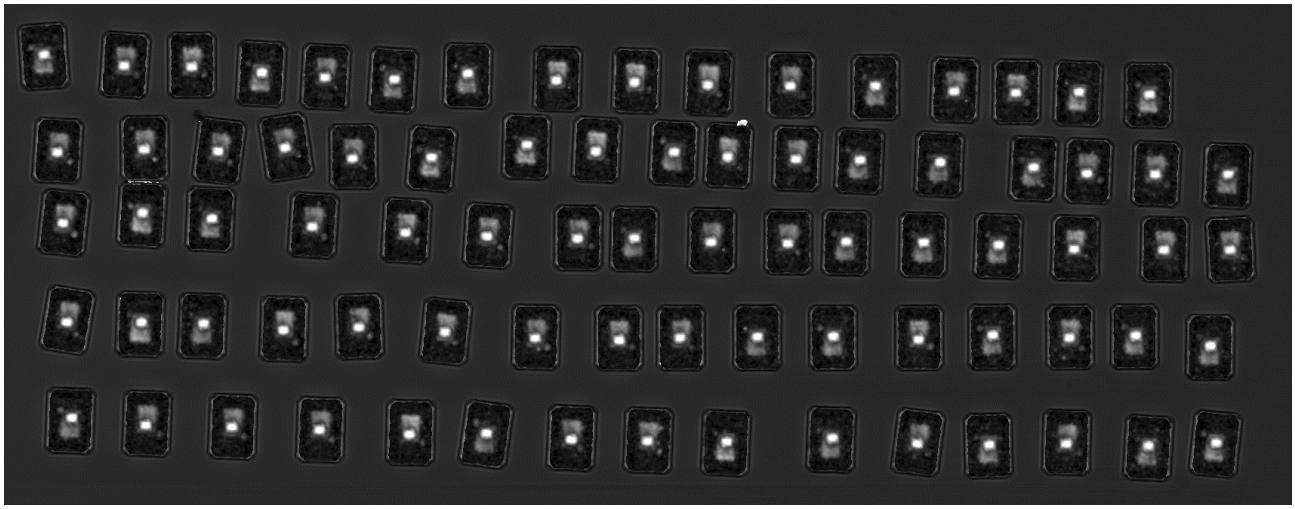


C-SCAN after reflow

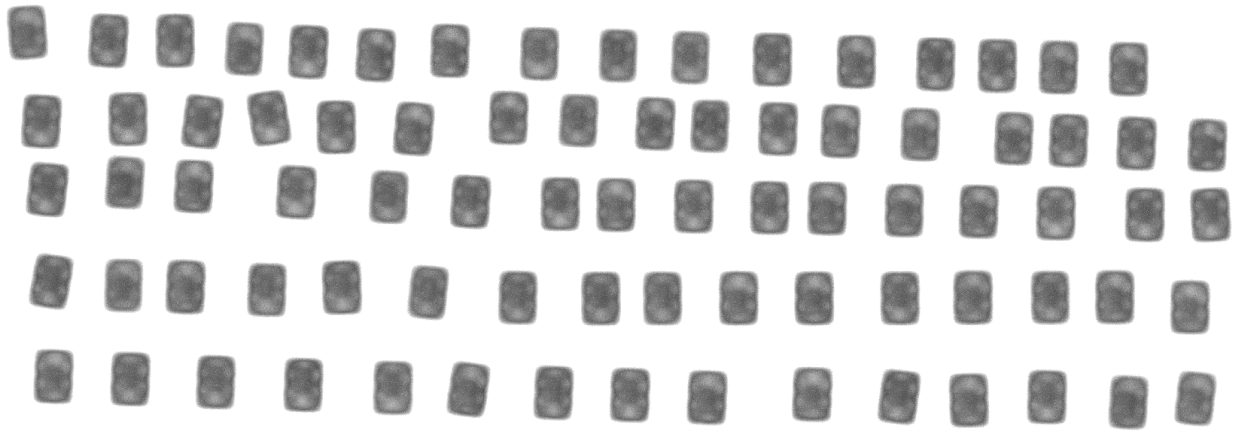


T-SCAN after reflow

图 8-8 样品 9#，回流焊后 C-SCAN&T-SCAN 结果
Figure 8-8. Sample 9# C-SCAN&T-SCAN result after reflow



C-SCAN after reflow



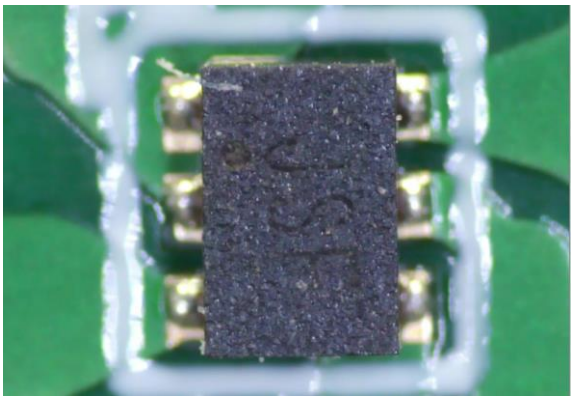
T-SCAN after reflow

- **板级可焊性测试 Board Level Solderability**

Some of the selected lots were soldered to the PCB for simulating SMT process, X-ray and OS test was checked to valid the result.

选取部分批次焊接到印刷电路板上以模拟 SMT 过程，通过 X-ray 和 OS 测试来验证结果。

图 8-9 样品 9#, X-ray 和 OS 测试 OK，可焊性正常
Figure 8-9. Sample 9# X-ray and OS test was OK, solderability was pass



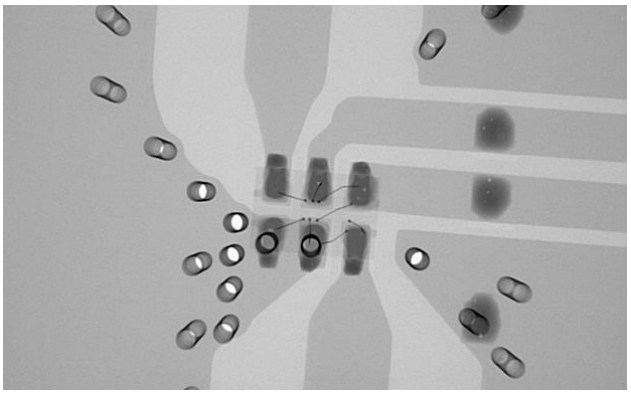
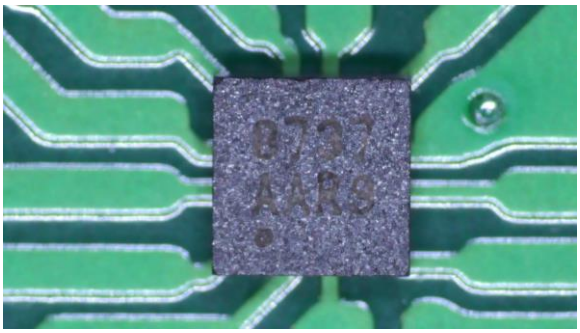


图 8-10 样品 3#, X-ray 和 OS 测试 OK，可焊性正常
Figure 8-10. Sample 3# X-ray and OS test was OK, solderability was pass



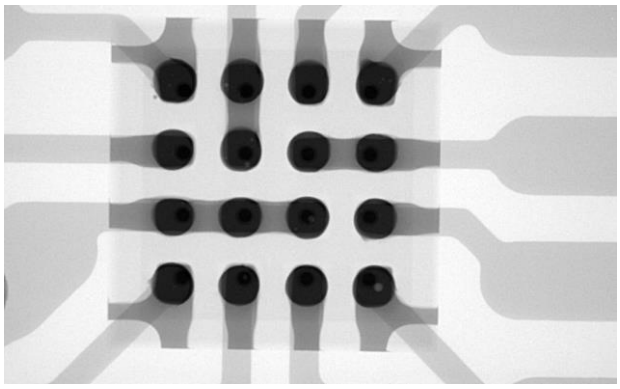
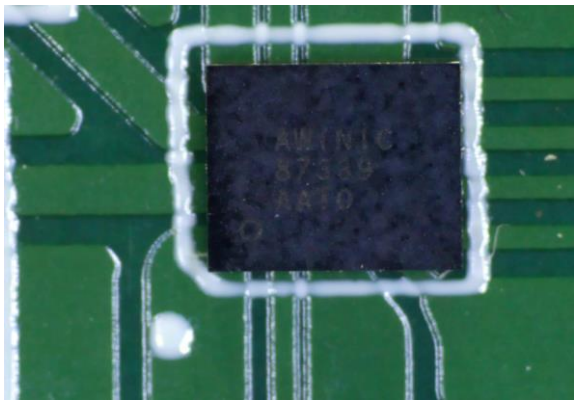


图 8-11 样品 13#, X-ray 和 OS 测试 OK，可焊性正常
Figure 8-11. Sample 13# X-ray and OS test was OK, solderability was pass



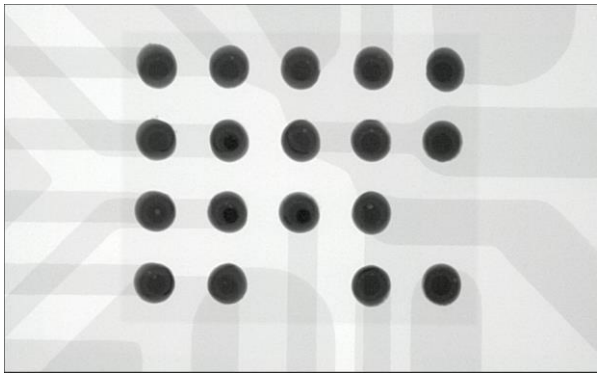


表 8-1 可焊性测试结果汇总
Table 8-1 Solderability test result summary

Sample Batch	Date Code	Part Number	Package Type	MSL	Appearance check (10pcs)	SAT (3x reflow) (>77pcs)	Solderability (22pcs)	Board Level Solderability (22pcs)
1#	1627	AW87319CSR	WLCSP	MSL1	Pass	Pass	Pass	Pass
2#	1631	AW9666QNR	WBQFN	MSL3	Pass	Pass	Pass	/
3#	1640	AW8737FCR	FCQFN	MSL3	Pass	Pass	Pass	Pass
4#	1738	AW9119QNR	WBQFN	MSL3	Pass	Pass	Pass	/
5#	1742	AW9233CSR	WLCSP	MSL1	Pass	/	Pass	/
6#	1819	AW5027ECR	ECP	MSL1	Pass	/	Pass	/
7#	1844	AW5008L2FDR	FCDFN	MSL1	Pass	Pass	Pass	/
8#	1845	AW36429FCR	FCQFN	MSL1	Pass	Pass	Pass	/
9#	1813	AW5105DNR	WBDFN	MSL1	Pass	Pass	Pass	Pass
10#	1837	AW5017DNR	WBDFN	MSL3	Pass	Pass	Pass	/
11#	1828	AW8899QNR	WBQFN	MSL3	Pass	Pass	Pass	/
12#	1812	AW87317CSR	WLCSP	MSL1	Pass	/	Pass	/
13#	1830	AW87339CSR	WLCSP	MSL1	Pass	/	/	Pass

Table 8-1

9. 结果汇总 Summary of Results

- Reliability of the semiconductor devices stored in an environmentally controlled warehouse for an extended period of time up to around 8 years was assessed. No failure mechanisms were identified;
- ESD performance of tape and reel samples was comparable to new tape and pocket samples;
- The HIC were confirmed to be functional with no color change;
- No degradation in ESD performance or moisture ingress was observed on the MBB when stored in a controlled environment;
- Solderability of the package pins met all expectations and is comparable with the solderability performance of current devices.

- 对在环境受控仓库中存放长达 8 年左右的半导体器件可靠性进行了评估，未发现失效；
- 载盖和盖带的 ESD 性能与新的材料相当；
- 湿度指示卡功能正常，没有颜色变化；
- 存放在受控环境的 MBB 的 ESD 性能没有衰退或者有湿气进入；
- 封装引脚的可焊性符合预期且与现有产品的可焊性能相当。

10. 结论 Conclusion

Advancements in lead-frame technology, packing materials and inventory logistics have made it possible to further extend the time between manufacturing semiconductor products and delivering to customers.

由于在引线框技术，包装材料和库存物流方面的进步，使得半导体从生产到出货至客户的时间延伸成为了可能。

Based on above studies, this extended storage time to 5 years does not impact product performance or the customers product shelf life. Awinic will continue to collect data on more samples and continue to adjust the storage conditions and duration for various products.

依据以上研究，存储时间延展至五年不会影响产品的性能或者客户产品的保质期。艾为将持续收集更多样品数据以继续调整产品的储存条件和储存时间。

11. 术语表 Glossary of Terms

Humidity Indicator Card	(HIC)–a card printed with a moisture sensitive chemical(cobalt chloride) that changes from blue to pink in the presence of water vapor.
Long Term Storage	(LTS)-storage of devices in an uncontrolled indoor environment for more than two years.
Moisture Barrier Bag	(MBB)-storage bag manufactured with a flexible laminated vapor barrier film that restricts transmission of water vapor (also called Dry Pack Back).
Nickel, Palladium, Gold	(NiPdAu)-metal layers that are pre-plated on lead frames to enable solderability.
SAC/SnAgCu	Solder paste metal composition, tin, silver, copper content.
Shelf Life	The time that moisture sensitive devices may be stored in MBB with desiccant and HIC or MSL 1 devices stored at room ambient.
WLCSP	Wafer Level Chip Scale Package.