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DISCUSSION OF RGA TEST FOR MOISTURE CONTENT FOR ISOLINK OPTOCOUPLERS

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ABSTRACT

Optocouplers are known to have problems with consistently passing RGA (Residual Gas Analysis) requirement for moisture. The nature of most optocoupler construction requires that a lightpipe material be used inside the hermetic package. This material is usually a semiconductor grade silicone compound. When these types of optocouplers were tested for internal moisture content, the moisture content can be very high and inconsistent and can vary widely between different test samples and test laboratories.

Since all the dice in an optocoupler are covered completely with the silicone, RGA testing for moisture does not seem to be a critical test for these types of devices. Tests on units from lots that failed RGA moisture testing using high temperature reverse bias test and steady state life test have shown no significant difference in the performance of the optocoupler. RGA tests also showed that devices without silicone inside have more consistent moisture content results than units with silicone inside.

INTRODUCTION

Optocouplers are hybrid devices consisting of a light emitting diode (LED) and a photodetector that are electrically isolated from each other. The purpose of the optocoupler is to isolate the input side circuitry, the LED side, from the output circuitry, the photodetector side. Information is allowed to pass through this isolation barrier in the form of light pulse from the LED that is detected by the photodetector. In most cases a lightpipe material is used to direct the light from the LED to the photodetector. Semiconductor grade silicone compounds are usually used for this purpose. Silicones are very clean, transparent to light and thermally stable to over 200°C. They are also very good dielectric materials to isolate between the input and output of the optocoupler. Silicones have been used reliably in optocoupler construction since the 1960's. Silicones used for optocouplers have since been improved to be compatible with wire bonds and can withstand thousands of temperature cycles.

Optocouplers have had a problem of consistently passing the moisture requirements of RGA testing. The problem is that the moisture readings can vary widely between test laboratories, test lots and units within the same test lot. This problem appears to affect not just Isolink, but other optocoupler manufacturers as well. Agilent/Avago, a major supplier of hermetic optocouplers, has been granted a waiver by DSCC to eliminate RGA testing for their hermetic optocouplers since August 2002. (See Attachment 1). Their justification was presented in an article in the DSCC Hybrid QML Update on May 2003. (See Attachment 2).

In the present MIL-PRF-19500/548J, Performance Specification Sheet for Optocouplers, dated 30 March 2015, paragraph 3.4.4, the moisture content has been relaxed to 10000ppm. The moisture content requirement had been 5000 ppm maximum as specified in MIL-STD-750 Test Method 1018 and has been increased due to the known issue with moisture in optocouplers.

This specification applies to the 6-pin leadless chip carrier (LCC6) surface mount optocouplers OLS249, and to the 4N49 and Isolink OLH249 phototransistor optocouplers in TO-5 cans. The same LED, photodetector and lightpipe materials are used in both types of package.

BAKING-SEALING PROCESS

The sealer used by Isolink is a Parallel Seam Sealer - Projection Welder housed in a stainless steel glove box with integral vacuum oven. TO-5 cans are welded with the Projection Welder. Packages such as 8-pin ceramic DIP's, flatpack packages, and leadless chip carriers are seam-sealed with the Parallel Seam Sealer. Prior to entering the sealing environment, the devices are cycled through a 12-hour 150°C bake with varying vacuum level. Lowest steady-state pressure is in 10^{-2} torr range. The oven is then purged with dry nitrogen and refilled

with nitrogen to 15 torr and baked at 150°C for 100 minutes. This vacuum bake, nitrogen purge and nitrogen bake cycle is repeated 6 times for a total of 12 hours. After vacuum bake, the units are transferred to the attached dry box through an oven/dry box interlock door. The dry box is constantly filled with dry nitrogen and has an integral moisture monitor. All units from a lot are vacuum baked and sealed as a lot. So all units within the lot should have similar bake and seal conditions and history. The seam sealer and welder are always in the dry box. After the units are sealed they are passed out of the dry box through another interlock door.

OLH249 RELIABILITY STUDY

Isolink has been manufacturing hermetic optocouplers since 1988. The OLS249 was introduced in the early 1990s. Standard products and products to customers' drawing requirements are produced in the same production line. Not all of Isolink's products required RGA lot qualification. Only production lots with RGA testing specified by customers' drawings are tested.

Isolink has performed a long-term reliability test on the OLH249 that failed RGA for moisture >5000PPM. Prior to starting the reliability test, the production lot passed all QCI tests except for the RGA test. Three units were sent to Laboratory X for RGA testing. Two units passed the maximum limit of 10000ppm. The moisture content readings were 9400ppm, and 9100ppm. The one failed unit was at 10800ppm. Two more units were sent to Laboratory X for RGA testing and the results were 12400ppm and 9700ppm. In all cases, the RGA tests showed very normal and typical distributions of other gases.

Three more units from the same production lot were sent to another test laboratory, Laboratory Y for RGA testing to verify Laboratory X's results. The moisture contents for these three units were surprisingly very high, 35228ppm, 43669ppm, and 38806ppm with concentrations and distribution of other gases being very normal. (See Table I).

Discussion with both Laboratory X and Laboratory Y showed that each laboratory used different of equipment, processes and reporting standards. From the inlet pressure data recorded in the test results, one can infer that the test chamber sizes are quite different between laboratories.

Isolink performed life tests on some units from this same production lot to determine the reliability of the units. A high temperature reverse bias (HTRB) test was chosen. The test condition was the same as specified in MIL-PRF-19500/548E, paragraph 4.3.2, TA=125°C, IF=0, VCB=36Vdc. Test duration was extended to 2000 hours instead of 48 hours. The idea of a HTRB test is to accelerate any corrosion mechanisms caused by moisture by providing a bias voltage on the phototransistor and a high ambient temperature. After 2000 hours, there was little significant change in the optocoupler parameters. The units were then placed on steady state operating life test as specified in MIL-PRF-19500/548E, Figure 4: IF=20mA, PT=275±25mW at TA=25±3°C for 168 hours. No significant changes in any of the optocoupler parameters were observed. (See Table II).

RGA TEST RESULTS OF OTHER ISOLINK OPTOCOUPLERS

RGA results of OLH300:

The OLH300 is a photodiode-transistor optocoupler packaged in a TO-5 package similar to the OLH249 phototransistor optocoupler. Three units from one production lot were sent to Laboratory Y for RGA testing and all three units failed at moisture contents of 18288ppm, 20753ppm and 21829ppm. Another three units from the same production lot were then sent to Laboratory X for RGA testing as a comparison. All units passed 10000ppm maximum with moisture contents of 3906ppm, 2777ppm, and 2976ppm. Three more units from the same lot were sent to Lab Y, and all three units failed with moisture contents of 17493ppm, 14645ppm, and 17716ppm. While another three units sent to Lab X and all passed again at moisture contents of 5098ppm, 5860ppm, and 5356ppm. In all cases, distribution and concentrations of other gases were all typical and normal. These series of RGA tests showed that there is a definite difference in moisture content measurements between different test laboratories. (See Table III).

RGA results of optocouplers without silicone lightpipe and empty test packages:

Isolink has tested many units of empty packages, and packages with dice and epoxy die attach, but no silicone lightpipe. In almost all cases, even the small internal volume (< .01cc) 8-pin flatpack packages, (OLFXXX), the moisture contents were below the 10000ppm requirement. However, for units with silicone inside, the moisture readings varied wildly. (See Table IV).

Isolink also manufactures many optocouplers for hybrid assembly. The production volumes of these optocouplers for hybrid assembly are more than 100 times higher than the volume of Isolink hermetic optocouplers. These hybrid optocouplers use similar dice, processes, silicone materials, and die attach epoxies as the hermetic optocouplers. The only difference is that these hybrid optocouplers are used by our customers inside their hermetic hybrids. Our customers' hybrids with Isolink hybrid optocouplers inside have been designed into many critical applications and have not shown any moisture-related problems.

CONCLUSION

Based on the history of Isolink's optocouplers since 1988, there has been no instance of any corrosion failures reported by any of Isolink's customers. RGA test results of Isolink optocouplers have no correlation with their long term reliability.
In addition, there are large variations in RGA test results for moisture content between test laboratories and test samples, especially in optocouplers with silicone inside the hermetic package. Isolink recommends that RGA tests for optocouplers be deleted as a requirement. A long term HTRB test is suggested to test the reliability of the optocouplers instead.

TABLE I: RGA Results OLH249

	Laboratory X					Laboratory Y		
Sample ID	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Pressure (torr)	11.6	12.1	11.4	11.6	11.3	0.183	0.185	0.194
Nitrogen (%)	98.8	98.8	98.7	98.5	98.8	96.2	95.5	96.0
CO2 (ppm)	1504	1826	1584	1435	1291	740	667	988
Moisture (ppm)	9400	9100	10800	12400	9700	35228	43669	38806
Hydrogen (ppm)	121	112	139	104	<100	0	0	0
Helium (ppm)	0	0	0	0	0	0	0	0
Argon (ppm)	<100	<100	<100	<100	<100	67	2	9

TABLE II: OLH249 Long-term HTRB test data

	∆VF (V)	**∆hFE (%)**	**∆CTR (%)**
Post-HTRB 2000 hrs			
AVE	-0.011	2.48%	1.79%
MIN	-0.02	1.78%	0.56%
MAX	-0.01	3.53%	2.98%
STDEV	0.004	0.58%	0.78%
Post-Burn-In 168 hrs			
AVE	-0.004	2.26%	3.08%
MIN	-0.01	0.93%	2.26%
MAX	0.00	3.31%	4.52%
STDEV	0.005	0.70%	0.87%

TABLE III: RGA Results OLH300

	Laboratory X			Laboratory X			Laboratory Y			Laboratory X		
Sample ID	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (torr)	0.202	0.206	206	11.6	10.9	11.3	0.211	0.206	0.211	11.7	11.6	11.6
Nitrogen (%)	98.1	97.8	97.7	99.5	99.6	99.6	98.1	98.4	98.1	99.3	99.2	99.3
CO2 (ppm)	310	329	320	1103	856	897	401	380	374	1400	1619	1330
Moisture (ppm)	18288	20753	21829	3906	2777	2976	17493	14645	17716	5098	5860	5356
Hydrogen (ppm)	0	0	0	<100	105	122	0	0	0	<100	108	<100
Helium (ppm)	1	1	1	0	0	0	2	3	2	0	0	0
Argon (ppm)	2	1	0	<100	<100	<100	0	0	0	<100	<100	<100

TABLE IV: RGA sample results various packages. All tests performed at same lab (empty: no silicone, filled: contains silicone)

	LCC4	LCC4	LCC6	TO-5	TO-5	TO-72	Flatpack 8	Flatpack 8	Flatpack 8	CERDIP 8
Cavity:	empty	filled	filled	empty	filled	filled	empty	filled	filled	empty
Pressure (torr)	1E-5	5.9E-6	1.5	2.2E-5	14.6	6.7	9.3E-6	5.2E-6	5.9E-6	2.8
Nitrogen (%)	99.8	93.5	96.6	99.3	96.1	96.4	99.1	95.6	78.3	99.9
CO2 (ppm)	268	4773	3203	1965	5336	2969	726	7511	23100	417
Moisture (ppm)	502	43400	19200	4155	26969	32200	1833	15400	91900	733
Hydrogen (ppm)	710	2323	1636	1070	145	0	6242	1978	4465	204
Helium (ppm)	0	0	0	0	0	0	0	0	0	0
Argon (ppm)	0	0	0	23	146	83	0	144	450	34