ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

Final Presentation

ESA No. 4000133320/20/NL/FE

17th December 2024

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

PRESENTATION OVERVIEW

1. Context and background
2. Project objectives
3. Work planning
4. Description of the tasks performed
5. Main results
6. Conclusions
7. Future work and recommendations

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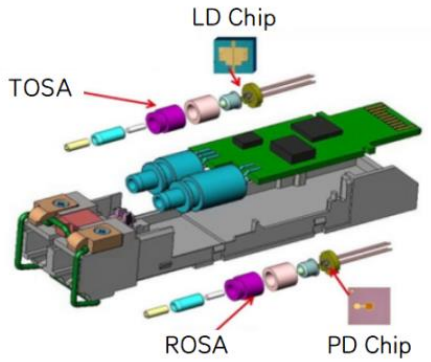
CONTEXT AND BACKGROUND

Historically, space missions required the use of hermetically sealed components.

Current trends show an increased use of commercial, non-hermetic components.



Optical transceivers are increasingly used in space applications due to their high-speed, multi-gigabit data communication capabilities.

The main advantages over conventionally used copper-based RF systems:

- significant mass/size reduction
- no interference issues between adjacent cables
- no need for heavy RF shielding.
- They are electrically isolated from the environment due to their non-metallic assemblies, preventing potential on-board ground-loops.

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CONTEXT AND BACKGROUND

ESA previously attempted the development of a **hermetic optical transceiver,** which did not result in a flight model. This study highlighted that manufacturing and qualifying sealed optical transceivers is challenging, time-consuming and with a high cost associated.

ESA participated in the ARTES programme with the successful space qualification of a non-hermetic optical transceiver.

For space applications, **non-hermetic packaged devices** present higher risk, and hermetic packaging is recommended. However, non-hermetic packaging can significantly reduce costs if the reliability of such devices can be demonstrated.

The current activity evaluates the selection of commercially available non-hermetically packaged transceivers to assess their usefulness and limitations when exposed to clean room and space environments.

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PROJECT OBJECTIVES

The main objective of the project is to **assess the reliability of non-hermetic optical transceivers** through rigorous testing, identify potential failures and provide recommendations for improving their design and manufacture.

During this project, a study has focused on the reliability testing of non-hermetic packaging susceptible to moisture ingress.

The key concepts considered are :

- **Commercial parts** - to focus the analysis on existing parts on the market, without considering new developments.
- **Non- Hermetic reliability test** - to define the proposed test campaign on those environmental factors that may affect parts performance degradation due to lack of hermeticity.
- Maximise use of **European Suppliers** as main selection factors of potential candidates in the frame of European Independence on this technology.

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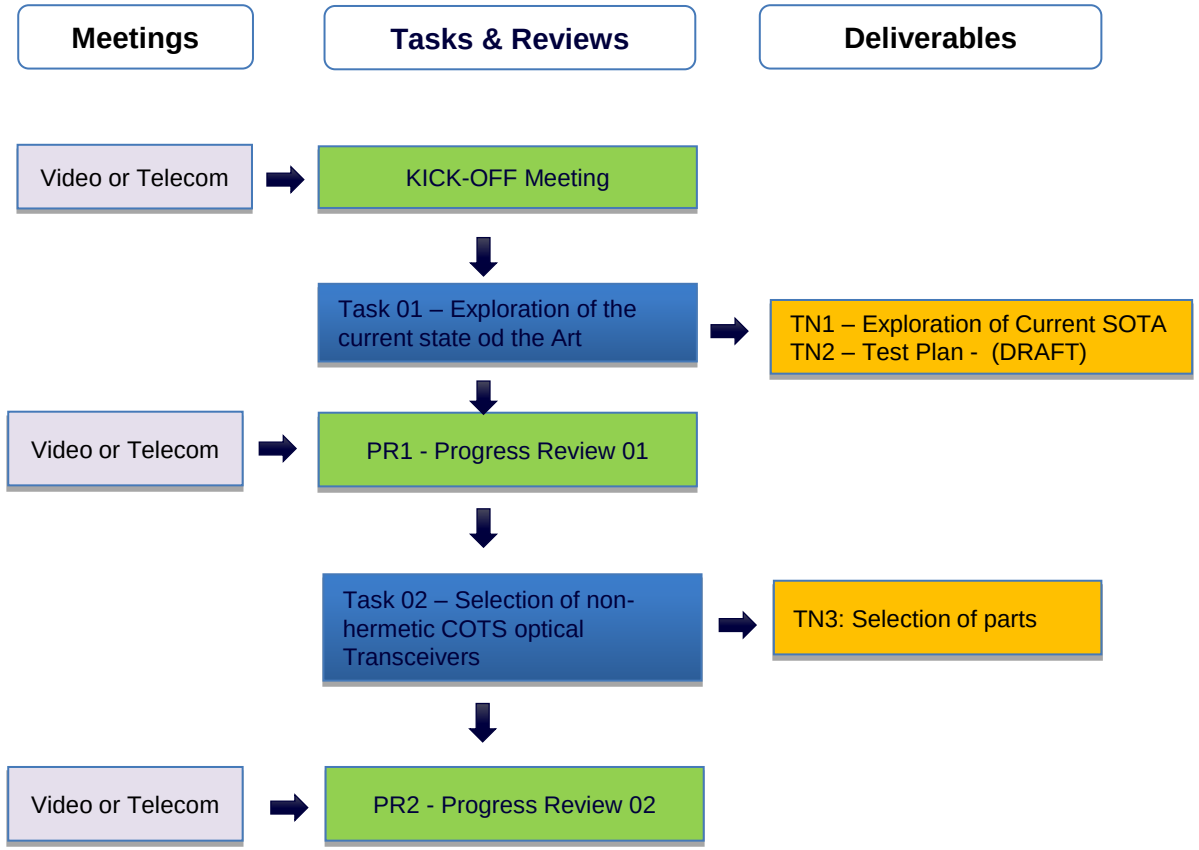
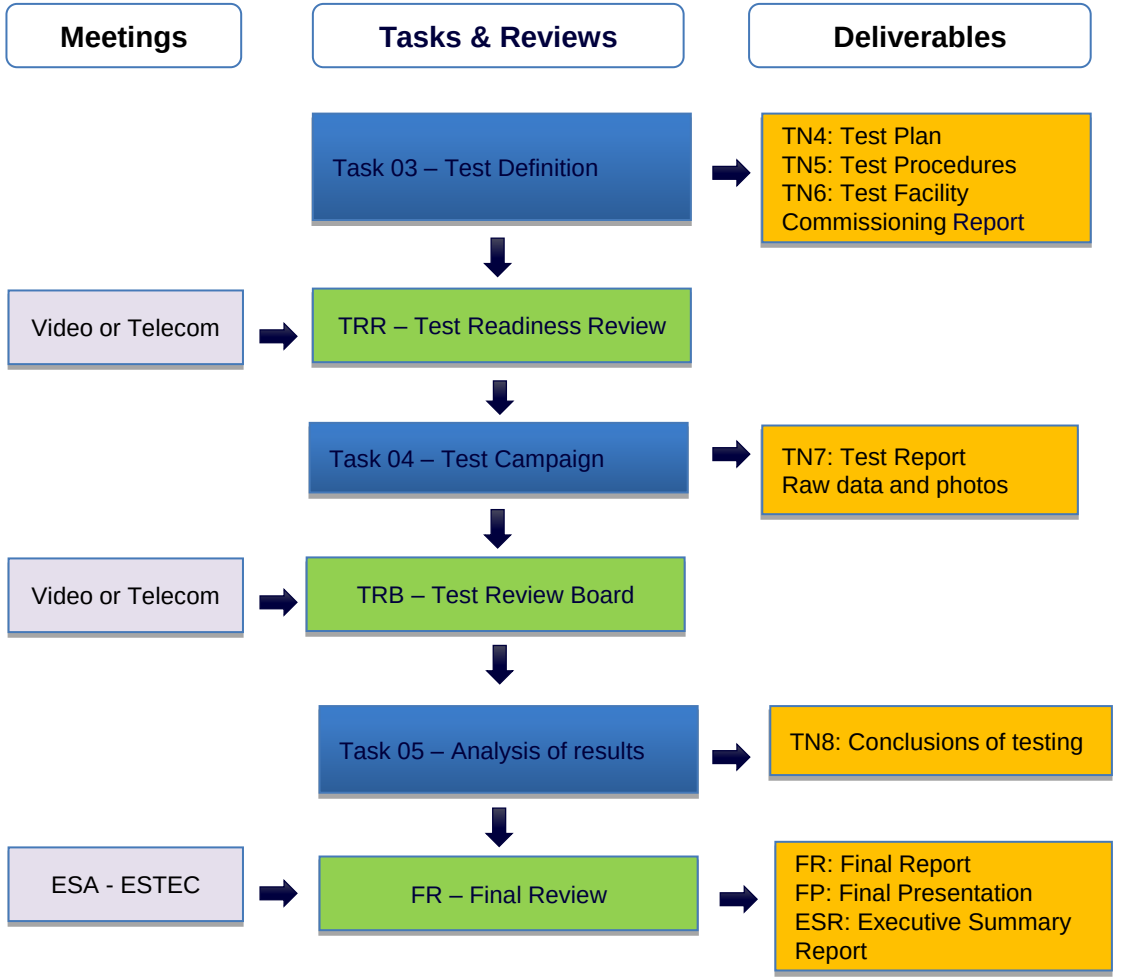
WORK PLANNING





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TASK 1 - Exploration of the Current State of the Art

The present study is focused on reliability tests on non-hermetic packaging susceptible to moisture ingress. The state-of-the-art exploration considered the following three key concepts:

- the use of **commercial parts**
- **non-hermetic reliability tests**
- prioritization of the use of **European Suppliers**

With such criteria a **market analysis** was performed giving an overview of the terrestrial OT market, the aerospace and space market, the available OT technologies, the datacom OT package types and the highest OT single channel data rate.

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TASK 2 - Selection of non-hermetic COTS optical transceivers

The following selection criteria were used to choose three different devices:

- Non hermetic optical transceiver
- Commercial optical transceiver is already available from at least two European manufacturers without export licenses involved.
- Fulfilment of the General specification of the transceivers given in Annex B of the SoW
- Targeting High reliability applications
- Willingness of the manufacturer to collaborate within space projects.
- Devices are not already tested for ESA projects.

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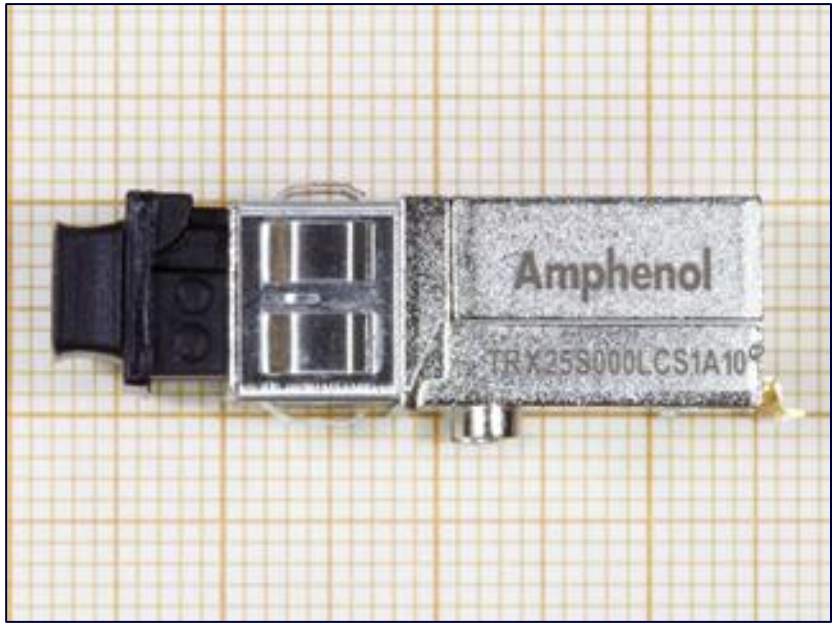
TASK 2 - Selection of non-hermetic COTS optical transceivers

- **25Gbps SCFF** (PN TRX25S000LCS1A10)**:** Rugged SCFF optical transceiver (1TRx) @ 850nm, from Amphenol.

TECHNICAL INFORMATION	
Power Supply Voltage	3.3V
Data Rate	1.25 Gbps to 28.05 Gbps
Bit Error Rate @25.78125 Gbps, PRBS31	$<10^{-12}$
Bit Error Rate @10.3125 Gbps, PRBS31	$<10^{-12}$
Lanes per device	1 Transmit and 1 Receive
Low Power Consumption	<1W @25G
Transmitter Type	850 nm (VCSEL Laser)
Receiver Type	PIN Photodiode
Case Operating Temperature	-40ºC to 85ºC



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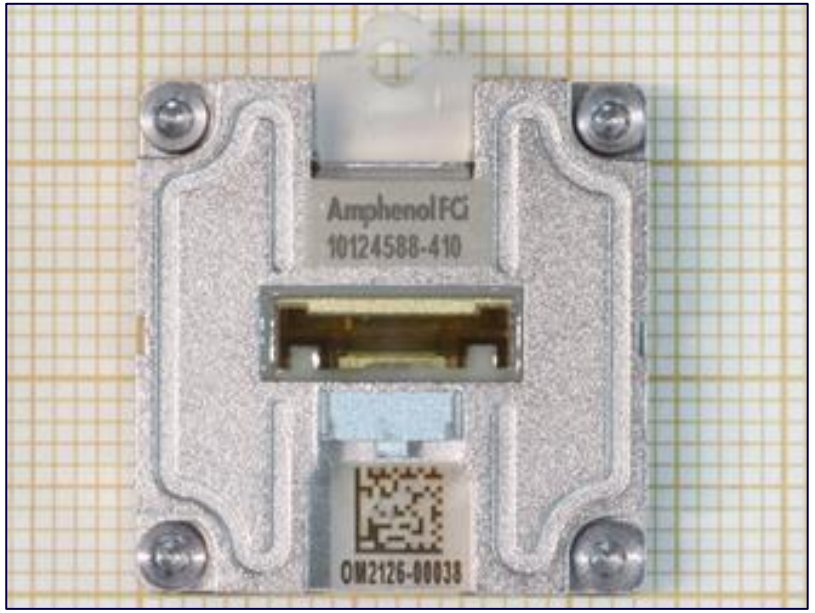
TASK 2 - Selection of non-hermetic COTS optical transceivers

- **12x25 Gbps OBT** (PN 10124588-410)**:** 12 channel Transmit & 12 channel Receive @ 850nm, from Amphenol.

TECHNICAL INFORMATION	
VDDTx, VDDRx Supply Voltage	3.3 V
Data Rate	300 Mb/s to 25.8 Gb/s
Maximum Bit Error Rate @ 25.78125 Gb/s, PRBS31	10^{-12}
Lanes per device	12 Transmit and 12 Receive
Power consumption (typ.)	5.4 W
Transmitter Type	850 nm VCSEL Laser
Receiver Type	PIN Photodiode
Case Operating Temperature	0ºC to 70ºC



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TASK 2 - Selection of non-hermetic COTS optical transceivers

- **4-Channel 10Gbps Optical Transceiver** (PN 16009): 4 channel Transmit & 4 channel Receive @850nm Multi-mode, from Spectrum Control (formerly Api Technologies)

TECHNICAL INFORMATION	
VCCTx, VCCRx Supply Voltage	3.3 V
VDDRx Supply Voltage	1.5 V
Optical Wavelength	850 nm
Data Rate over multi-mode fibre	20 Mbps to 10 Gbps
Lanes per device	4 Transmit and 4 Receive
Ultra Low Power Consumption	100mW/channel @+3.3V
Case Operating Temperature	-40ºC to +85ºC

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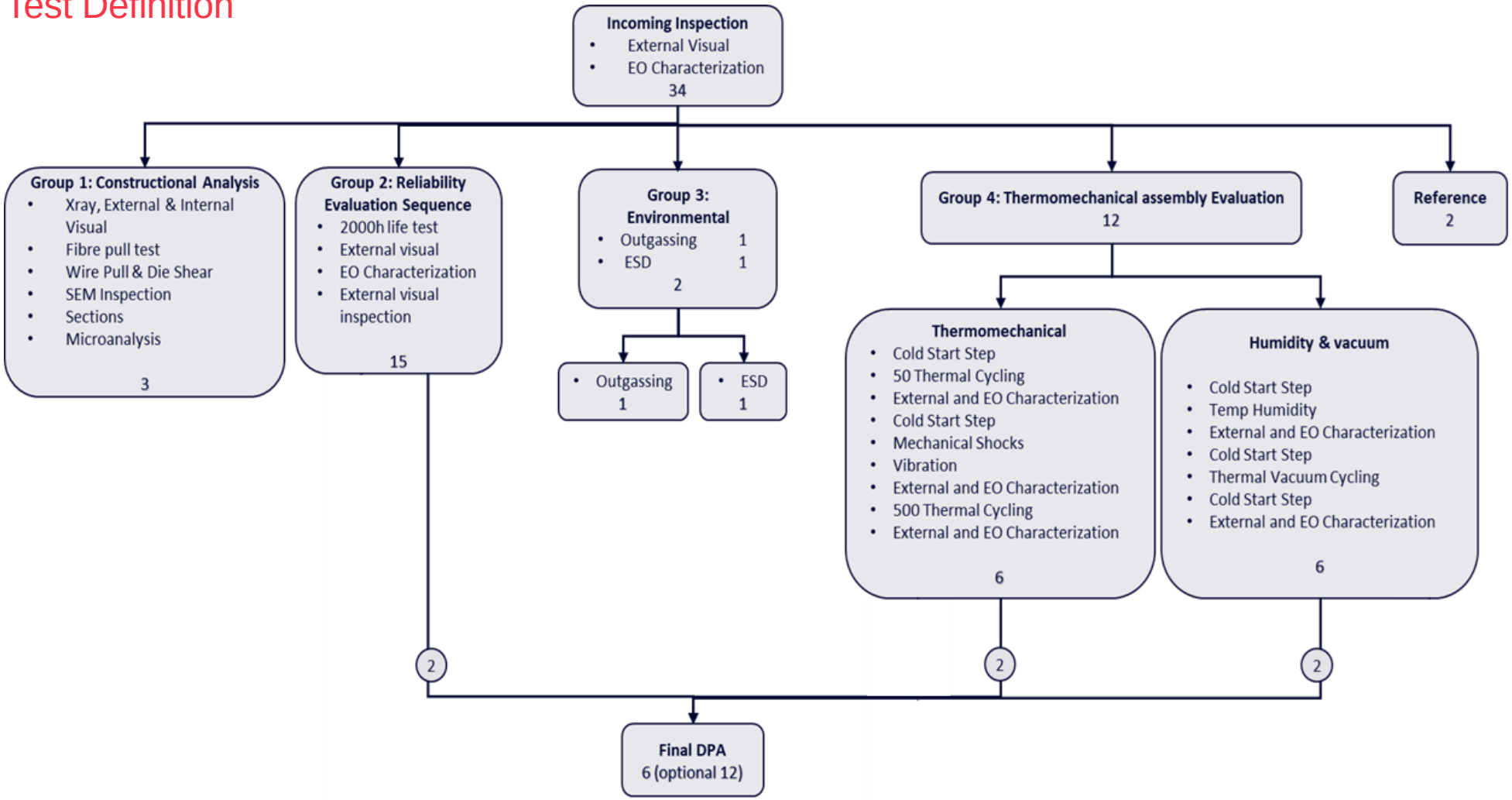
TASK 3 - Test Definition



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TASK 4 - Test Campaign

The aim of this task was to carry out the test campaign of the three different devices.

- Several test beds were developed.
- The manufacturer's evaluation kits were used for characterization purposes. Also, those evaluation kits were the baseline design for the development of specific test boards to carry out all biased tests.
- Life test was done in active configuration with the optical transceiver in operation at maximum operating temperature. A board with the corresponding sockets was developed for this purpose.
- They were all customized for each part type.

The test campaign took place between October'21 and March'24.

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TASK 5 - Analysis of results, conclusions and recommendations

- The final task comprises the analysis of the results obtained during the test campaign in Task 4.
- Conclusions and recommendations were extracted in order to identify also future work to be undertaken after closure of the project. A summary of these conclusions and recommendations will follow.
- Potential future work is also proposed as part of this study

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 1: Amphenol's 25 Gbps SCFF

Incoming Inspection

Group 1: Constructional analysis

Group 2: Reliability evaluation

Group 3: Environmental

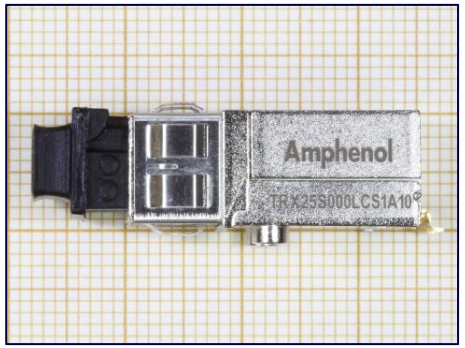
Group 4a: Thermomechanical

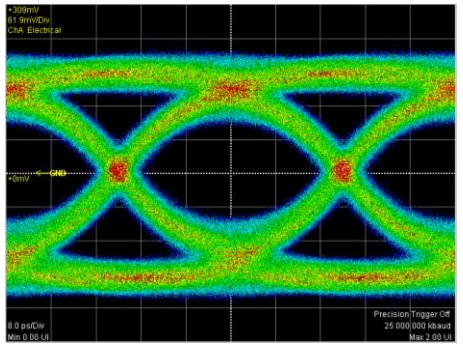
Group 4b: Humidity and vacuum

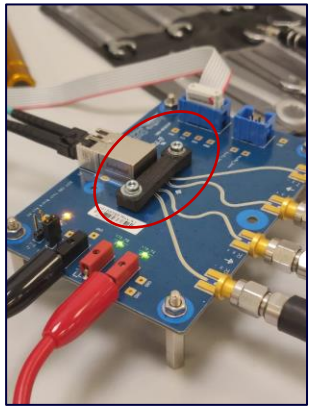
Final DPA

Qty: 34 + 12 extra samples

- A visual inspection and an electro-optical characterization were performed during incoming inspection.
- BER and eye diagram were measured in each characterization step.
- Three samples could not be measured and were sent back to the manufacturer. As replacement, a second batch was delivered with 12 extra samples to be used for Group 4 testing.
- No anomalies were observed during the incoming inspection of the second batch.







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- Incoming Inspection
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- Group 3: Environmental
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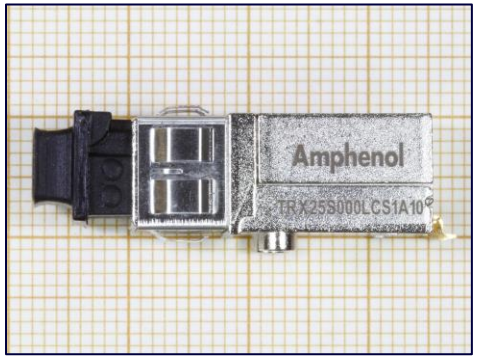
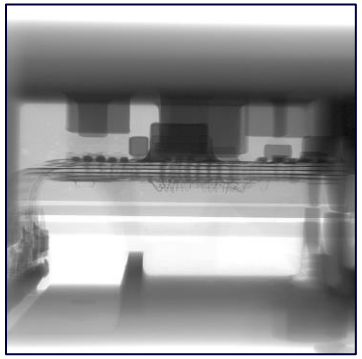
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 3 samples

- Device construction is based on multi-layer PCB, flex-PCB and SMT technology.
- X ray revealed apparently wire crossing each other. Visual inspection showed they were acceptable since they were located within the same connection pad.
- Good internal structure was observed. No foreign particles, broken or damaged dice, scratches in the metallizations or any other deviations were observed.
- Wire pull and die shear tests were successful on all wires of two samples.





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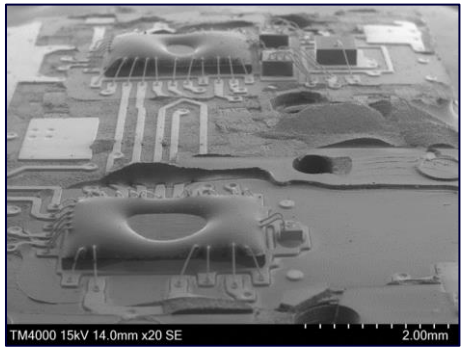
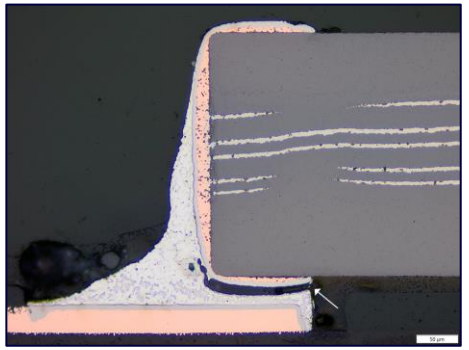
- Final DPA

Qty: 3 samples

- SEM inspection of the internal construction was performed with successful results.
- Pure tin was first identified at the surface of the solder joints (under a conformal coating). However, during the cross-section, the bulk material of the solder joint was found to be SAC.
- Different planes were inspected during microsection analysis. A void in the solder joint of a capacitor was found, exceeding the acceptable limit of ECSS-Q-ST-70-61C standard.





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- Final DPA

Qty: 3 samples

- A summary of the complete sequence:

TEST	METHOD	S/N		
		2134-11	2134-14	2134-15
EXTERNAL VISUAL INSPECTION	MIL-STD-883. Method 2009.14 2	C	C	C
RADIOGRAPHIC INSPECTION	MIL-STD-883. 2012.11 2	C	C	C
FIBER PULL TEST	MIL-STD-202. Method 211 H	C	C	-
INTERNAL VISUAL INSPECTION	MIL-STD-883. Method 2010.14 2	C	C	-
SEM INSPECTION	MIL-STD-883. Method 2018.6 2	C	C	-
WIRE PULL TEST	MIL-STD-883. Method 2011.10 2	C	C	-
DIE SHEAR TEST	MIL-STD-883. Method 2019.10 2	C	C	-
RADIOGRAPHIC INSPECTION	CUSTOMER REQUIREMENTS	-	-	C
MATERIAL ANALYSIS	MANUFACTURER DATASHEET	C	C	-
MATERIAL ANALYSIS - XRF	MANUFACTURER DATASHEET	-	-	C
CROSS SECTION	ECSS-Q-ST-70-61 C	-	-	NC
MATERIAL ANALYSIS (PLANE 1)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 2)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 3)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 4)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 5)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 6)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 7)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 8)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 9)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 10)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 11)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 12)	MIL-STD-1580. Req. 9 C	-	-	C

C Compliant, no anomalies detected
C* Compliant, acceptable anomalies detected
NC Not compliant, unacceptable anomalies detected
CD Customer disposition required
- Serial number not tested

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Group 4a: Thermomechanical

Group 4b: Humidity and vacuum

Final DPA

Qty: 15 samples

- Life testing of 2000 h was carried out at maximum operating temperature (+85°C) under nominal bias configuration and an input signal of 2 GHz.
- All samples met electrical specifications during all the sequence.
- BER values were below 10^{-12} during all testing process.
- VCSEL current is on the order of 7mA.
- Maximum drift on the eye diagram is around 20% for the eye height parameter. This is also the most sensitive parameter in repeatability tests due to the tightening of the pins against the test board.
- Performance at high (+85°C) and low (-40°C) temperatures was also verified after 2000h. All samples met specifications at both extreme operating temperatures. Eye height and eye width were the most sensitive parameters to temperatures.

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Final DPA

Qty: 1 + 1 samples

- Outgassing test was performed on one sample. Results were within the acceptance criteria for:
  - TML (Total Mass Loss) < 1.0%
  - RML (Recovered Mass Loss) < 1.0%
  - CVCM (Collected Volatile Condensable Material) < 0.1%.
- ESD test was carried out at a single voltage level of 2 kV following test method 3015 of MIL-STD-883 Electrostatic Discharge Sensitivity Test Method.
- The sample was functional after the discharge, but a reduction was observed in the signal levels of the eye diagram (one and zero level). Consequently, eye height was also reduced with a variation of around 30%.

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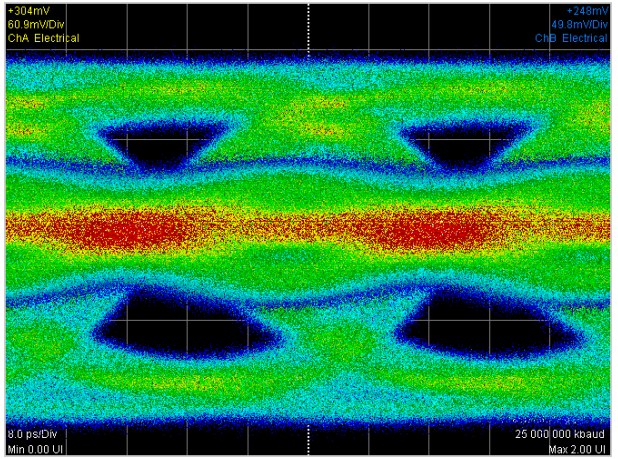
- Final DPA

Qty: 6 samples

- Testing in this subgroup includes thermal cycling, mechanical shock, vibration test, and final extended thermal cycling. Additionally, cold start at -35°C was performed before and after each thermal cycling.
- Four samples passed all the test flow successfully.
- One sample showed no output in one of the differential signals after vibration test. Failure was identified on RX side testing it using a different device as transmitter.
- One sample failed during the final extended thermal cycling. A reduction was observed in the eye height after the first 100 cycles. After 200 cycles the samples was not functional and showed much lower current consumption than expected (approx. 60 mA lower than usual).
- Both samples were opened and inspected but no root cause could be found.



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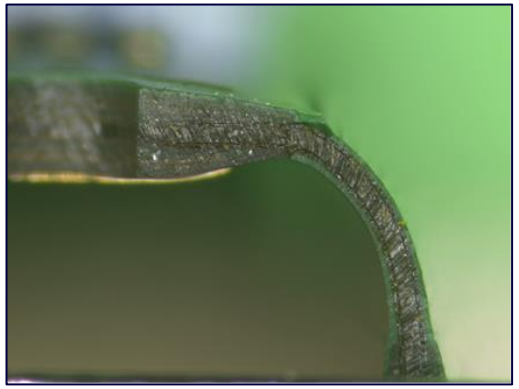
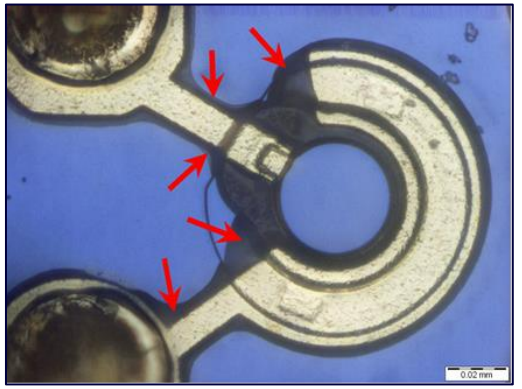
Qty: 6 samples

- Testing in this subgroup includes temperature humidity test and thermal vacuum cycling, and cold start at -35°C before and after each test.
- Three samples passed all tests. However, the three remaining failed humidity test. The samples were not functional and could not be measured.
- One of the samples was further inspected. It showed a low Tx power warning alarm in the SW, and the current consumption was much lower than expected. Tx and Rx side were tested separately and none of them worked.
- Sample was opened for inspection, revealing:
  - A crack in the flexiboard affecting only the soldermask.
  - Residual moisture on Rx side.





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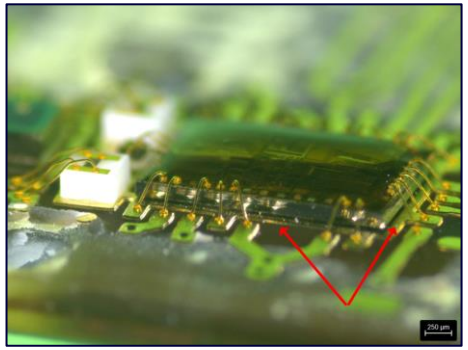
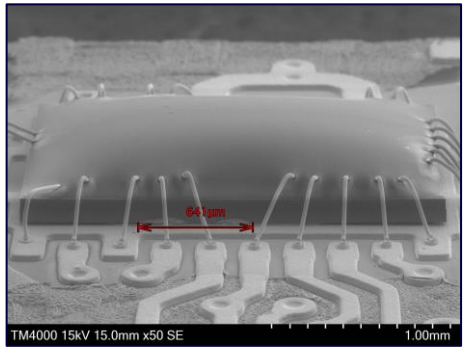
Final DPA

Qty: 3 + 3 samples

- Internal visual inspection showed non-acceptable lack of die attach (on IC6 VCSEL driver, IC7 TIA, and D2 monitoring diode) on three samples. Die attach medium is Ag 100%.
- The anomalies were also verified during SEM inspection on the three opened samples.
- Die shear test failed on IC6 (on all three samples), IC7 (on two samples) and R12 (on one sample).





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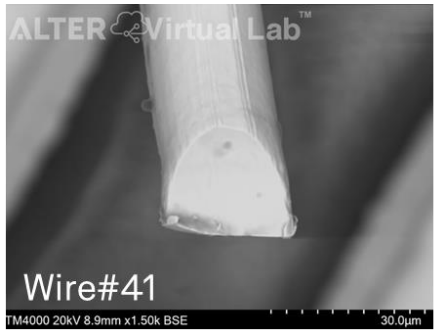
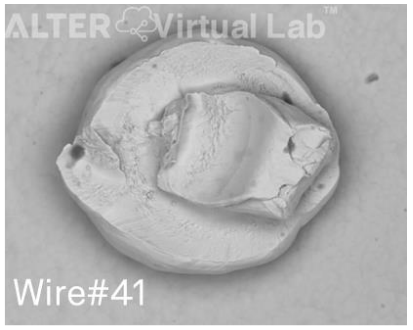
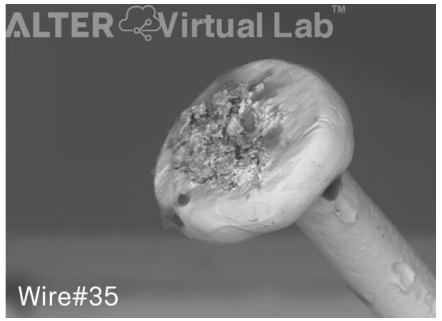
Qty: 3 + 3 samples

- Two samples failed wire pull test, two wires on each sample. SEM inspection was performed on the failed wires after the test.
- Different breaking modes were observed: at neckdown point and at the bonding pads.
- Sample from Group 4b was the one failing after humidity test. It should be highlighted that wire #14 is the one connecting VCSEL driver and VCSEL, while wire #35 bonds the monitoring diode D2. Wire #14 was lifted from VCSEL, and wire #35 from D2. This deviation may be linked to the observed functional failure showing a low Tx power warning alarm.





Wires on sample taken from Group 2.



Wires on sample taken from Group 4b.

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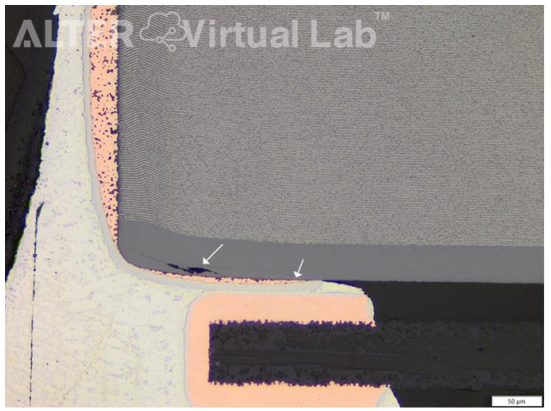
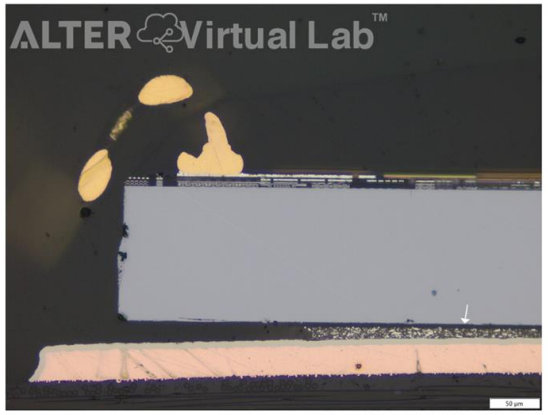
Qty: 3 + 3 samples

- Remaining three samples were used for microsection analysis and material analysis.
- Microsection analysis on the sample taken from Group 4a revealed:
  - Non-acceptable crack in the ceramic of the component C11
  - Non-acceptable separation of adhesive from the contact surface of component IC7 (TIA).
- All the internal elements showed no prohibited or foreign materials.





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- Final DPA

Qty: 3 + 3 samples

- Summary of the final DPA

TEST	METHOD	S/N					
		2134-19	2134-24	2227-01	2227-02	2227-08	2227-10
EXTERNAL VISUAL INSPECTION	MIL-STD-883. Method 2009.15 2 (w/Change1)	C	C	C	C	C	C
RADIOGRAPHIC INSPECTION	MIL-STD-883. Method 2012.11 2 (w/Change 1)	C	C	C	C	C	C
FIBER PULL TEST	MIL-STD-202. Method 211 H	C	-	C	-	C	-
INTERNAL VISUAL INSPECTION	MIL-STD-883. Method 2010.14 2 (w/Change1), MIL-STD-883. Method 2017.14 2 (w/Change1)	NC	-	NC	-	NC	-
SEM INSPECTION	MIL-STD-883. Method 2018.6 2 (w/Change1)	NC	-	NC	-	NC	-
WIRE PULL TEST (D/C: 2134)	MIL-STD-883. Method 2011.10 2 (w/Change 1)	NC	-	-	-	-	-
WIRE PULL TEST (D/C:2227)	MIL-STD-883. Method 2011.10 2 (w/Change 1)	-	-	C	-	NC	-
SEM I INSPECTION	MIL-STD-883. Method 2018.6 2 (w/Change1)	C	-	-	-	C	-
DIE SHEAR TEST	MIL-STD-883. Method 2019.11 2 (w/Change 1)	NC	-	NC	-	NC	-
CROSS SECTION	ECSS-Q-ST-70-61 C	-	C	-	NC	-	C
MATERIAL ANALYSIS (PLANE 1)	MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 2)	MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 3)	MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 4)	MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 5)	MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 6)	MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 7)	MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 8)	MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 9)	MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 10)	MIL-STD-1580. Req. 9 C	-	C	-	C	-	C

C Compliant, no anomalies detected
C* Compliant, acceptable anomalies detected
NC Not compliant, unacceptable anomalies detected
CD Customer disposition required
- Serial number not tested

ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

CONCLUSIONS – Device 1: Amphenol's 25 Gbps SCFF

- Samples showed **good electro-optical performance** since the beginning of the tests, meeting the manufacturer's specifications.

- The reliability of the device shows **no concern at the nominal operating conditions at maximum operating temperature**. Moreover, **no outgassing issue** was identified.

- The **internal construction** of the device was also expected to show **no major issues** after the constructional analysis results. Even if the device construction is quite complex (based on PCB and flexPCB), only a void at the solder joint of a capacitor was found. However, the **expectations could not be met during the final DPA**, where the inspected samples showed fabrication issues on several samples such as lack of die attach. Other defects (wire pull or die shear) are not necessarily fabrication issues.

- These are COTS components that are not subjected to space requirement inspections. It would be **advisable for Amphenol to review the manufacturing processes** in order to avoid these fabrication defects.

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

CONCLUSIONS – Device 1: Amphenol's 25 Gbps SCFF

- More relevant deviations were observed in the **thermomechanical** evaluation subgroup where two failures were identified (one in vibration test and another during thermal cycling), and specially, on the humidity subgroup where three of the six parts tested failed.

- The **observed failures are all functional** but not the same in all cases.

- The sample that failed after vibration lost one of the different signals in RX. The one that failed after thermal cycling was not functional and showed an anomalous power consumption. Finally, for the three samples tested in humidity, nor BER or eye diagram could be measured but no anomaly was observed in power consumption. Unfortunately, the root cause of the failures could not be identified and linked to the actual tests.

- **No conclusion can be extracted about the relation of the non-hermeticity of the sample and the observed failures.**

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 2: Amphenol's 12x25Gbps OBT

Incoming Inspection

Group 1: Constructional analysis

Group 2: Reliability evaluation

Group 3: Environmental

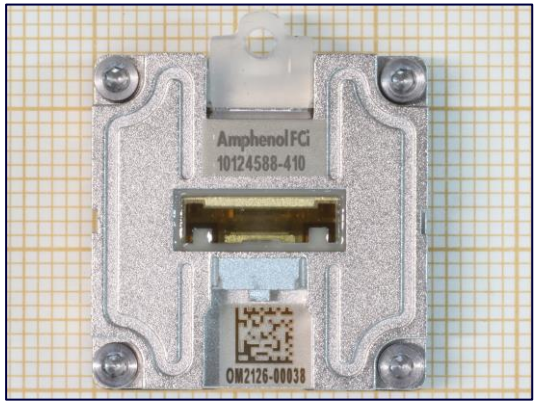
Group 4a: Thermomechanical

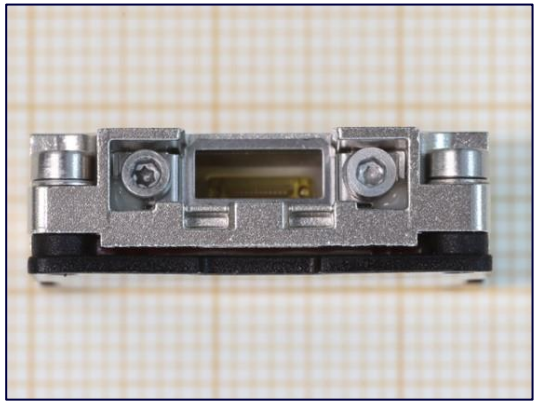
Group 4b: Humidity and vacuum

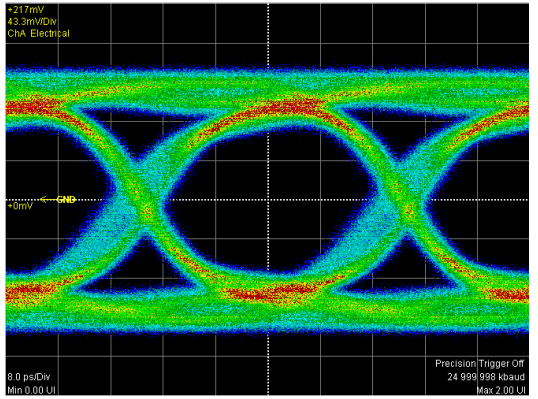
Final DPA

Qty: 34 samples

- A visual inspection and an electro-optical characterization were performed during incoming inspection.
- BER and eye diagram were measured in loopback configuration in each characterization step.
- No anomalies were observed.







ALTER

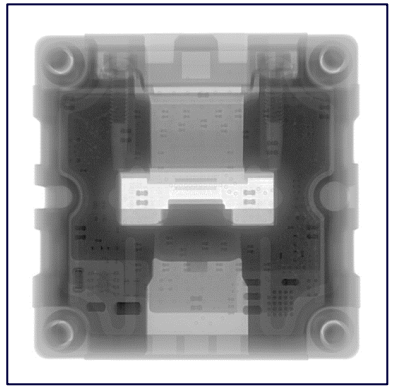
RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

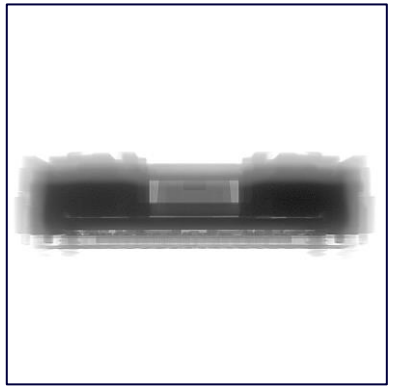
MAIN RESULTS – Device 2: Amphenol's 12x25Gbps OBT

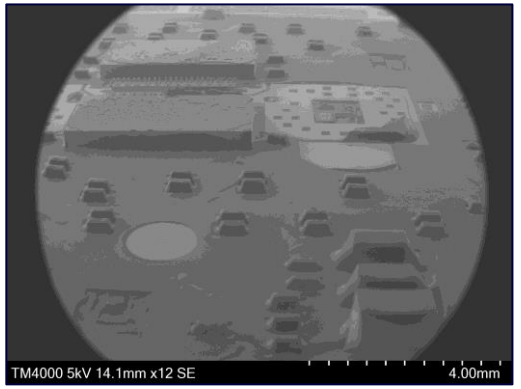
- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 3 samples

- Constructional analysis showed a construction based on multilayer PCB and SMT technology but not as complex as SCFF.
- X-ray inspection revealed the same internal structure on all samples and no anomalies.
- Good internal structure was observed once opened, although some elements were detached during opening.







ALTER

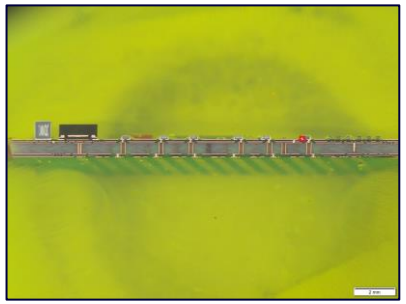
RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

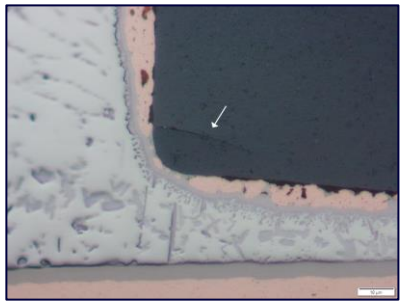
MAIN RESULTS – Device 2: Amphenol's 12x25Gbps OBT

- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 3 samples

- Wire pull and die shear tests were successful.
- X-ray inspection was carried out on an opened sample to help determine the PCB stack-up and select planes for microsection analysis.
- Material analysis of the surface of solder joints revealed pure tin (Sn 100%), which was covered by conformal coating.
- Microsection analysis revealed a non-acceptable crack according to the standard ECSS-Q-ST-70-61C, Table 14-6, in the ceramic body of C10 capacitor.
- Material analysis showed no prohibited or foreign materials. In fact, composition of the bulk solder material was detected to be SAC.





ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 2: Amphenol's 12x25Gbps OBT

- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 3 samples

- A summary of the complete constructional analysis is shown below:

TEST	METHOD	S/N		
		37	38	39
EXTERNAL VISUAL INSPECTION	MIL-STD-883. Method 2009.14 2	C	C	C
RADIOGRAPHIC INSPECTION	MIL-STD-883. 2012.11 2	C	C	C
FIBER PULL TEST	MIL-STD-202. Method 211 H	C	C	-
INTERNAL VISUAL INSPECTION	MIL-STD-883. Method 2010.14 2	C	C	-
SEM INSPECTION	MIL-STD-883. Method 2018.6 2	C	C	-
WIRE PULL TEST	MIL-STD-883. Method 2011.10 2	C	C	-
DIE SHEAR TEST	MIL-STD-883. Method 2019.10 2	C	C	-
RADIOGRAPHIC INSPECTION	CUSTOMER REQUIREMENTS	-	-	C
MATERIAL ANALYSIS	MANUFACTURER DATASHEET	C	C	-
MATERIAL ANALYSIS - XRF	MANUFACTURER DATASHEET	-	-	C
CROSS SECTION	ECSS-Q-ST-70-61 C	-	-	NC
MATERIAL ANALYSIS (PLANE 1)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 2)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 3)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 4)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 5)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 6)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 7)	MIL-STD-1580. Req. 9 C	-	-	C
MATERIAL ANALYSIS (PLANE 8)	MIL-STD-1580. Req. 9 C	-	-	C

C Compliant, no anomalies detected
C* Compliant, acceptable anomalies detected
NC Not compliant, unacceptable anomalies detected
CD Customer disposition required
- Serial number not tested

ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 2: Amphenol's 12x25Gbps OBT

- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 15 samples

- Life testing of 2000 h was carried out at maximum operating temperature (+70°C) under nominal bias configuration and an input signal of 2 GHz.
- All samples met electrical specifications during all the sequence.
- BER values were below 10^{-12} during all testing process.
- VCSEL current is on the order of 7mA.
- Maximum drift on the eye diagram is less than 10% for all parameters.
- Performance at high (+85°C) and low temperatures (-40°C) was also checked at life test completion.
- Higher BER values than at room were measured on the samples (~$5 \cdot 10^{-12}$), but still much lower than the limit of 10^{-9}.
- Eye diagram was also slightly impacted by temperature, showing a mean value of eye height about 9.5% lower at high temperature.

ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 2: Amphenol's 12x25Gbps OBT

- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 1 + 1 samples

- Outgassing test was performed on one sample. Results were within the acceptance criteria for:
  - TML (Total Mass Loss) < 1.0%
  - RML (Recovered Mass Loss) < 1.0%
- However, it was on the limit for:
  - CVCM (Collected Volatile Condensable Material) < 0.1%.
- ESD test was carried out at a single voltage level of 2 kV following test method 3015 of MIL-STD-883 Electrostatic Discharge Sensitivity Test Method.
- No anomalies were detected during discharge as well as during the E/O characterization performed after the test.

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 2: Amphenol's 12x25Gbps OBT

- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 6 samples

- Testing in this subgroup includes:
  - Initial thermal cycling
  - Mechanical shock
  - Vibration test
  - Final extended thermal cycling
- Additionally, cold start at -35°C was performed before and after each thermal cycling.
- All six samples passed all the test flow successfully showing great robustness against thermomechanical stress.

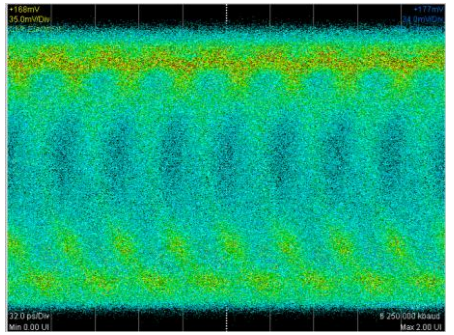
RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 2: Amphenol's 12x25Gbps OBT

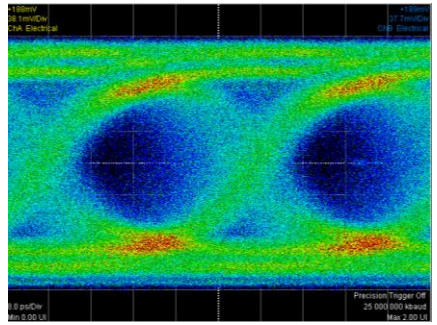
- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 6 samples

- Testing in this subgroup includes temperature humidity test and thermal vacuum cycling, and cold start at -35°C before and after each test.
- Four samples passed all the tests successfully.
- One sample showed deviations in its performance in one channel during humidity test. First showing measurable BER values below the limit (after 250h), then failing to pass the BER parameter limit (after 500h), and finally stopped working (after 750h). Same result was obtained for the Tx side and for the sample in loopback configuration. No anomaly was found after opening the sample.



- One last sample failed to pass E/O characterization after thermal vacuum test. No BER or eye diagram could be measured in one of its channels. This sample was chosen to be used for final DPA, but no deviations were observed.



ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 2: Amphenol's 12x25Gbps OBT

Incoming Inspection

Group 1: Constructional analysis

Group 2: Reliability evaluation

Group 3: Environmental

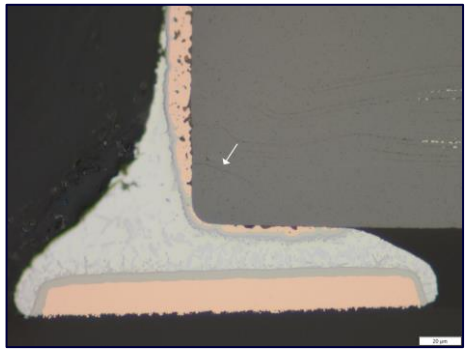
Group 4a: Thermomechanical

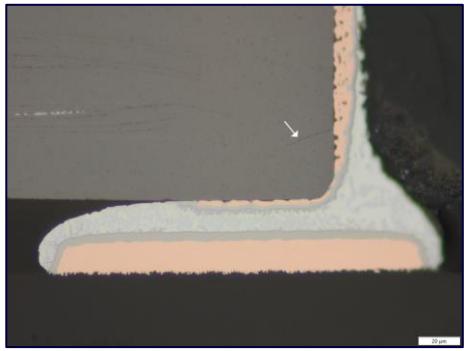
Group 4b: Humidity and vacuum

Final DPA

Qty: 3 + 3 samples

- During final DPA, all tests but the microsection were successful.
- Microsection revealed a non-acceptable crack in the ceramic body of capacitor C10, on one sample taken from Group 4a. That is, the same deviation that was found during constructional analysis.
  - This deviation seems to be related to the capacitor itself or its mounting process, and not to the applied stress.





RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 2: Amphenol's 12x25Gbps OBT

- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 3 + 3 samples

- A summary of the complete final DPA is shown below:

TEST	METHOD	S/N					
		3	4	22	24	27	29
EXTERNAL VISUAL INSPECTION	METHOD: MIL-STD-883. Method 2009.14 2	C	C	C	C	C	C
RADIOGRAPHIC INSPECTION	METHOD: MIL-STD-883. Method 2012.11 2	C	C	C	C	C	C
FIBER PULL TEST	METHOD: MIL-STD-202. Method 211 H	C	-	C	-	C	-
INTERNAL VISUAL INSPECTION	METHOD: MIL-STD-883. Method 2010.14 2	C	-	C	-	C	-
SEM INSPECTION	METHOD: MIL-STD-883. Method 2018.6 2	C	-	C	-	C	-
WIRE PULL TEST	METHOD: MIL-STD-883. Method 2011.10 2	C	-	C	-	C	-
DIE SHEAR TEST	METHOD: MIL-STD-883. Method 2019.10 2	C	-	C	-	C	-
CROSS SECTION	METHOD: ECSS-Q-ST-70-61 C	-	C	-	C	-	NC
MATERIAL ANALYSIS (PLANE 1)	METHOD: MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 3)	METHOD: MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 4)	METHOD: MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 5)	METHOD: MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 6)	METHOD: MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 7)	METHOD: MIL-STD-1580. Req. 9 C	-	C	-	C	-	C
MATERIAL ANALYSIS (PLANE 8)	METHOD: MIL-STD-1580. Req. 9 C	-	C	-	C	-	C

C Compliant, no anomalies detected
C* Compliant, acceptable anomalies detected
NC Not compliant, unacceptable anomalies detected
CD Customer disposition required
- Serial number not tested

ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

CONCLUSIONS – Device 2: Amphenol's 12x25Gbps OBT

- This device shows **good internal construction**, with the only defect found in a capacitor. This defect was also observed in a sample inspected during the final DPA. The placement of the **crack** at the area of the cover plates of the capacitor and the fact that the crack was detected during the reference constructional analysis, leads to the **hypothesis of an issue related to the component itself and not the applied stress**.

- **Endurance test has been successfully completed**, meaning that reliability of the device should not be a concern. At completion of the endurance test, the **characterization of the samples at low and high temperatures showed slight deviations** with respect to that achieved at room temperature. Unfortunately, no measurement was performed at three temperatures at the beginning of the endurance test, so that it **cannot be confirmed if the deviation is caused by the temperature or by the life test**.

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

CONCLUSIONS – Device 2: Amphenol's 12x25Gbps OBT

- The device has also shown to be **robust against thermomechanical tests after mechanical shock, vibration test and extended thermal cycling**. It showed also robustness in terms **of outgassing and ESD sensitivity**.

- Possible **weak points** of the device may be found in the **humidity and vacuum subgroups**, where one sample failed in each of the tests. However, the root cause of the failure was not identified, and no confirmed correlation has been reported between the failure and the test.

- Generally, **OBT has been found to be very robust to the tests and conditions subjected** with an electro-optical performance that has been very stable and repetitive in all the test campaign.

- In terms of performance, it should be also mentioned that it is **the most complex device** with 12 transmit/receive channels and requires an overall power consumption that is much higher than the other two tested devices.

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

Incoming Inspection

Group 1: Constructional analysis

Group 2: Reliability evaluation

Group 3: Environmental

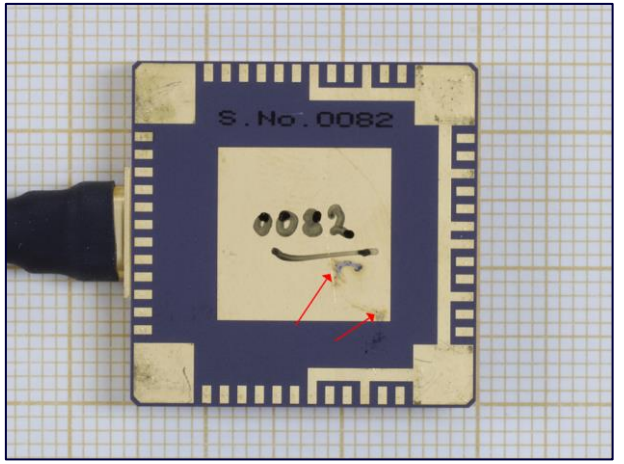
Group 4a: Thermomechanical

Group 4b: Humidity and vacuum

Final DPA

Qty: 34 samples

- Delivery of the samples was performed in seven different batches along seven months.
- During the visual inspection, two samples are rejected due to the presence of foreign material in pads.
- All samples show evidence of manipulation (scratches, fingerprints) and socket marks that are considered cosmetic defects.



ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

Incoming Inspection

Group 1: Constructional analysis

Group 2: Reliability evaluation

Group 3: Environmental

Group 4a: Thermomechanical

Group 4b: Humidity and vacuum

Final DPA

Qty: 34 samples

- During initial characterization of all samples, we faced repeatability issues in the BER parameter.
- After checking with the Manufacturer, we got the following guidelines:
  - Changing PRBS value from PRBS31 to PRBS7 in the measurement conditions.
  - Using one reference sample and testing both Rx and Tx sides against that reference instead of doing it in loopback.
- Even following those guidelines, two samples failed to pass BER test with BER values above the limit (10^{-9}).
- No correlation was found between BER errors and D/C, batch number or receiving date of the samples.

ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

Incoming Inspection

Group 1: Constructional analysis

Group 2: Reliability evaluation

Group 3: Environmental

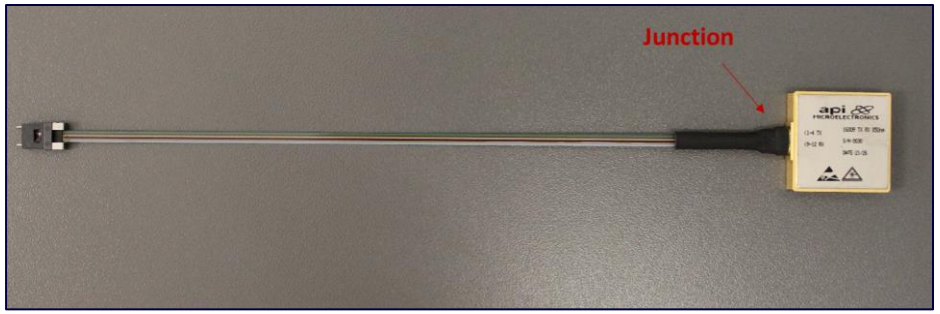
Group 4a: Thermomechanical

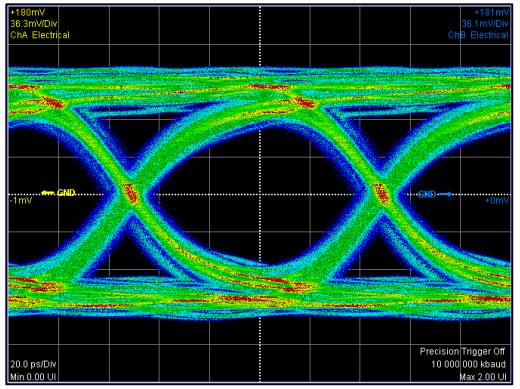
Group 4b: Humidity and vacuum

Final DPA

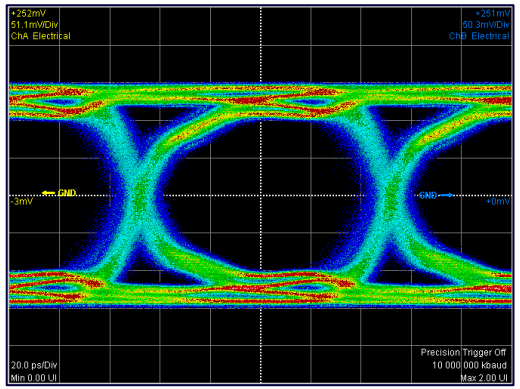
- Repeatability tests were performed on several samples, and it was found that some samples showed no communication error (BER < 10^{-12}), while some others were much more sensitive and not that repeatable.
- It was observed that those showing communication errors were sensitive to the position and movement of the fiber attached on the sample.
- Additionally, since Tx and Rx sides were tested separately, it could be observed that eye diagram on Rx side was closer than Tx side.

Qty: 34 samples





Eye diagram on Rx side



Eye diagram on Tx side

ALTER

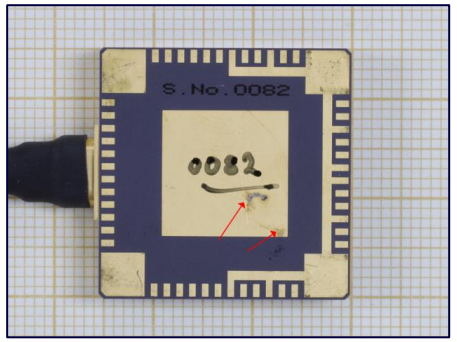
RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

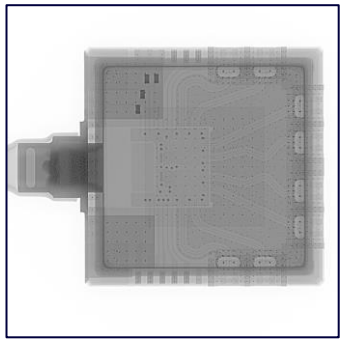
MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 3 samples

- One sample showing foreign material was chosen, so this deviation was again reported at initial external visual inspection.
- The device shows a very different construction compared to previous devices, based on ceramic packaging, alumina and a much lower component count on the assembly.
- X-ray inspection showed same internal structure for dice location and wires clearance.
- Fiber pull test was also carried out satisfactorily.





ALTER

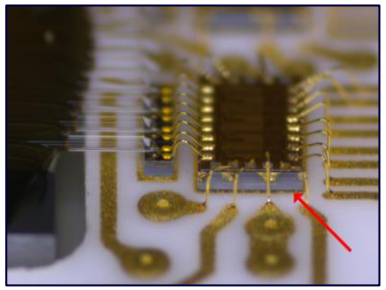
RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

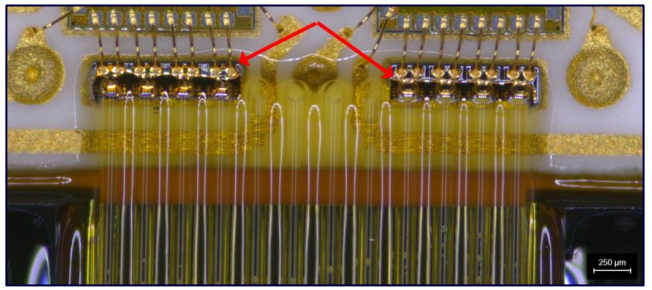
MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 3 samples

- In the internal visual inspection, samples showed a lack of die attach on the assembled dice.
- In addition, the material used for fixing the optical fiber has different coverage in different samples. In some of them, the material covers TX and RX diodes.
- SEM inspection, confirmed the previously observed anomalies of lack of die attach and material excess covering TX an RX diodes.





ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

- Incoming Inspection
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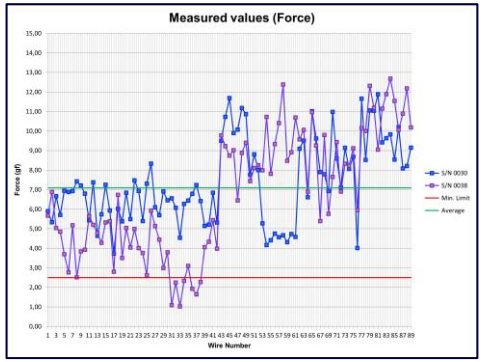
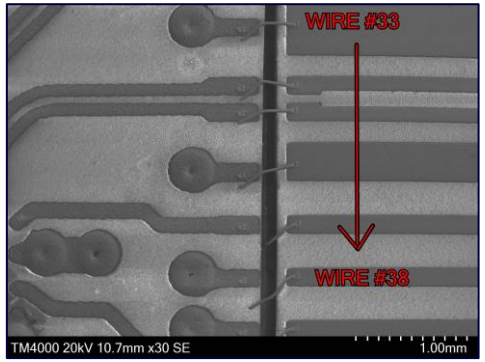
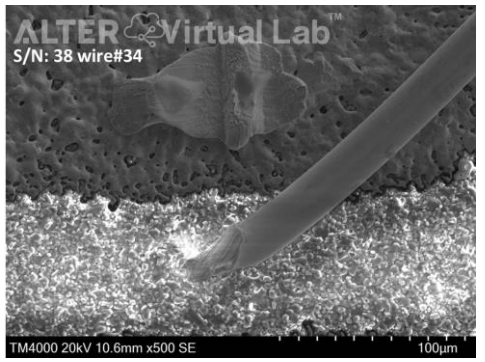
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 3 samples

- All the wires of one sample passed wire pull test, while seven wires failed in the second sample. The failure occurred at neckdown point.
- SEM inspection did not reveal any anomaly on the failed wires. No differences were observed either between the wires that passed the test and the ones that failed.
- Both samples passed die shear test on all elements.







ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

Incoming Inspection

Group 1: Constructional analysis

Group 2: Reliability evaluation

Group 3: Environmental

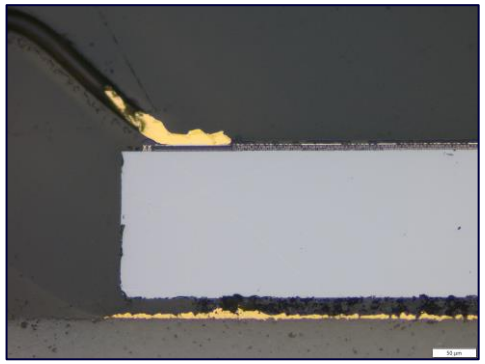
Group 4a: Thermomechanical

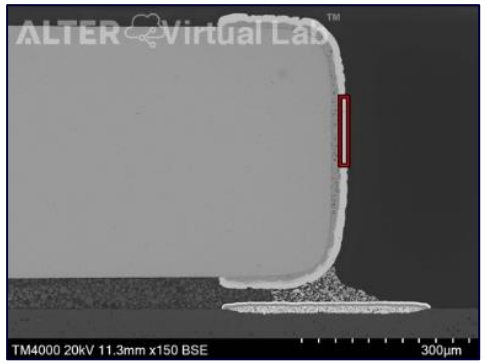
Group 4b: Humidity and vacuum

Final DPA

Qty: 3 samples

- One sample was cross sectioned at package level. No issues were detected.
- Material inspection revealed pure tin in the capacitors contact finish.
- Other internal elements showed material composition in line with the expected for this kind of device. Metallizations have ENIG finish, and silver is detected on solder joints of passive elements.





RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 3 samples

- Summary of the complete sequence

TEST	METHOD	S/N		
		30	38	82
EXTERNAL VISUAL INSPECTION	MIL-STD-883. Method 2009.14 2	C	C	NC
RADIOGRAPHIC INSPECTION	MIL-STD-883. Method 2012.11 2	C	C	C
FIBER PULL TEST	MIL-STD-202. Method 211 H	C	C	-
INTERNAL VISUAL INSPECTION	MIL-STD-883. Method 2017.13 2	NC	NC	-
SEM INSPECTION	MIL-STD-883. Method 2018.6 2	NC	NC	-
WIRE PULL TEST	MIL-STD-883. Method 2011.10 2	C	NC	-
SEM INSPECTION	MIL-STD-883. Method 2018.6 2	-	C	-
DIE SHEAR TEST	MIL-STD-883. Method 2019.10 2	C	C	-
MATERIAL ANALYSIS - XRF	MANUFACTURER DATASHEET	-	-	C
INTERNAL VISUAL INSPECTION	MIL-STD-883. Method 2017.13 2	-	-	NC
CONFOCAL TEST	-	C	-	-
CROSS SECTION	MANUFACTURER DATASHEET, ECSS-Q-ST-70-61 C	-	-	C
MICROANALYSIS	MIL-STD-1580. Req. 9 C	-	-	NC

C Compliant, no anomalies detected
C* Compliant, acceptable anomalies detected
NC Not compliant, unacceptable anomalies detected
CD Customer disposition required
- Serial number not tested

ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 15 samples

- Life testing of 2000 h was carried out at maximum operating temperature (+85°C) under nominal bias configuration and an input signal of 2 GHz.
- Two samples failed to pass BER parameter test in @Ch01 of Tx side, showing BER values over 10^{-9} after 240h and 500h respectively which continued until life test completion
- The remaining thirteen samples passed the tests. However, nine of them, showed measurable BER values below the limit at different channels.
- Performance at high (+85°C) and low temperatures (-40°C) was also checked at life test completion. The two samples failing BER parameter still failed at high temperature but passed the test at low temperature.
- The number of communications errors was increasing as the test was going on. However, it is not clear if this is caused by wear out or if the repetitive handling of the sample may have an impact.

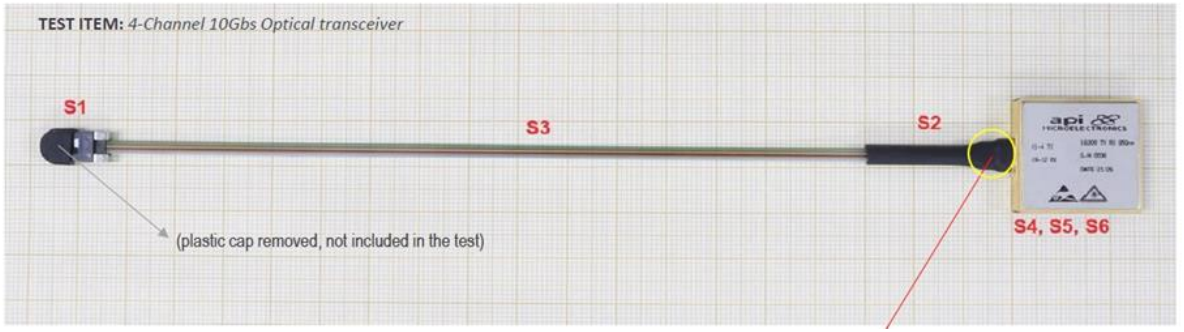
RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 1 + 1 samples

- For outgassing test, one sample was divided into six different items to be tested separately. Samples from CA were used to complement the required weight for some of the items.
- Items S4, S5, and S6 passed the outgassing test according to all criteria (TML, RML, CVCM).
- Items S1, S2, and S3 passed the test according to TML and RML, but failed according CVCM criteria.



RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

Incoming Inspection

Group 1: Constructional analysis

Group 2: Reliability evaluation

Group 3: Environmental

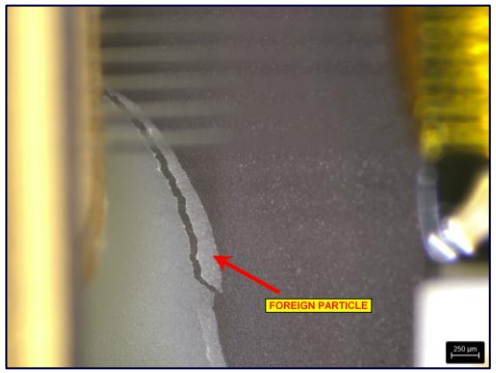
Group 4a: Thermomechanical

Group 4b: Humidity and vacuum

Final DPA

Qty: 1 + 1 samples

- ESD test was carried out at a single voltage level of 2 kV following test method 3015 of MIL-STD-883 Electrostatic Discharge Sensitivity Test Method.
- Two channels of the sample failed the following E/O characterization. In one channel the eye diagram could get some signal, but no synchronization was possible. The second channel showed no live signal.
- Sample was inspected using X-ray with no deviation observed. PIND detected some loose particle which was later identified during internal visual inspection as part of the connector's glue.



ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

Incoming Inspection

Group 1: Constructional analysis

Group 2: Reliability evaluation

Group 3: Environmental

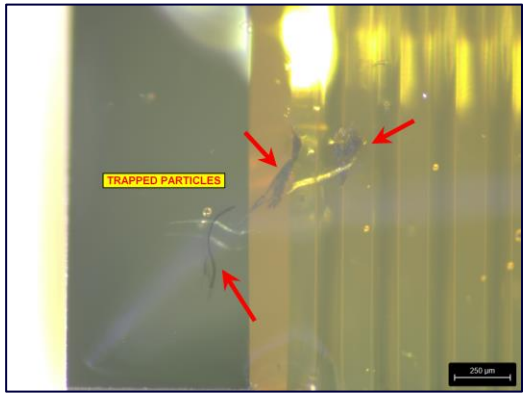
Group 4a: Thermomechanical

Group 4b: Humidity and vacuum

Final DPA

Qty: 1 + 1 samples

- Trapped foreign material is also observed trapped in the glue to used to fix the fiber optics.
- None of these deviations seem to be related to the defective behaviour.



ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 6 samples

- Testing in this subgroup includes thermal cycling, mechanical shock, vibration test, and final extended thermal cycling. Additionally, cold start at -35°C was performed before and after each thermal cycling.
- Five samples passed the test, although random communication errors were detected with BER values lower than the limit in all samples but one.
- Last sample showed communication errors with BER values higher than 10^{-9} in one channel after the first cold start. Samples was subjected to mechanical shock and vibration and then removed for further analysis.
- Sample was opened for visual inspection. A slight misalignment was observed in the fibers over the diodes as well as a scratch on the fiber pigtail. But non was affecting the failed channel, so there cannot be related to the failure.

ALTER

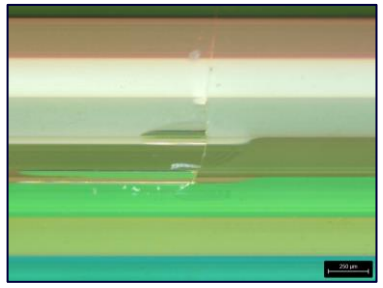
RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

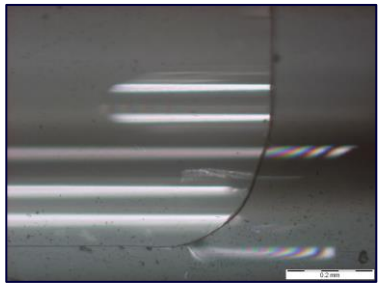
MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 6 samples

- Testing in this subgroup includes temperature humidity test and thermal vacuum cycling, and cold start at -35°C before and after each test.
- Five samples passed all the tests successfully, although three showed random communication errors with BER values below 10-9.
- One last sample failed E/O characterization in one channel after thermal vacuum test. A crack was detected at the fiber optics which seems to be caused by mishandling during thermal vacuum test.
- It cannot be determined if the crack affects the fiber or only the coating. However, it occurs at the exact channel failing the E/O test.





ALTER

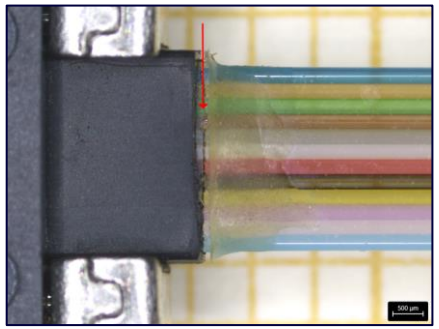
RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 3 + 3 samples

- One sample taken from Group 4a showed a crack onto the sleeve of the fiber located at the input of the MT-Ferrule connector.
- Radiographic inspection and fiber pull tests were successful on all tested samples.
- During internal visual inspection, all samples showed a lack of die attach on the assembled dice. In addition, an excess of the material fixing the optical fiber was also observed in only one of the samples.



ALTER

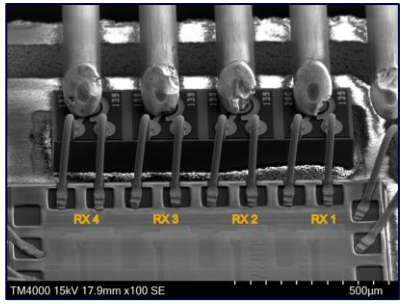
RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

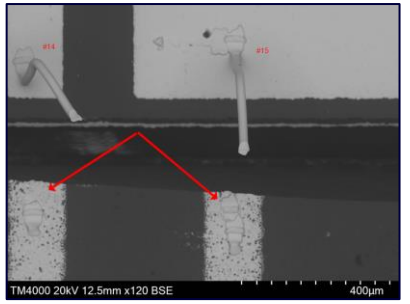
MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

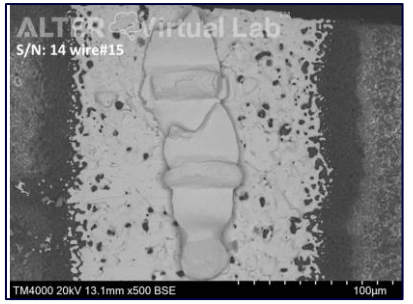
- Incoming Inspection
- Group 1: Constructional analysis
- Group 2: Reliability evaluation
- Group 3: Environmental
- Group 4a: Thermomechanical
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 3 + 3 samples

- The same observation as in the visual inspection were confirmed during SEM inspection. Additionally, one of the samples showed damage at the end of the optical fiber located at the RX diode. This sample was one failing in Group 2. However, no correlation is found between this deviation and the failure.
- Two samples passed wire pull test on all wires, while one wire failed in the third tested sample, failing at neckdown point.
- SEM inspection showed a rebonding in the failed wire bond pad, being the only bonding pad showing a rebonding.







ALTER

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- Group 3: Environmental
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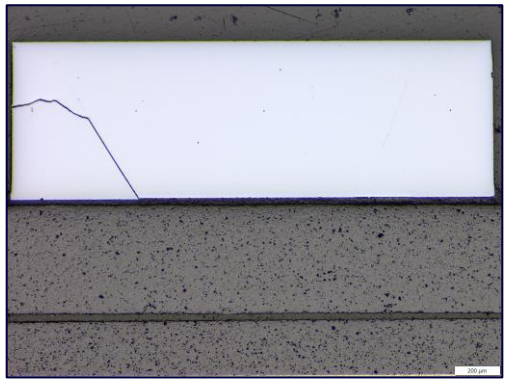
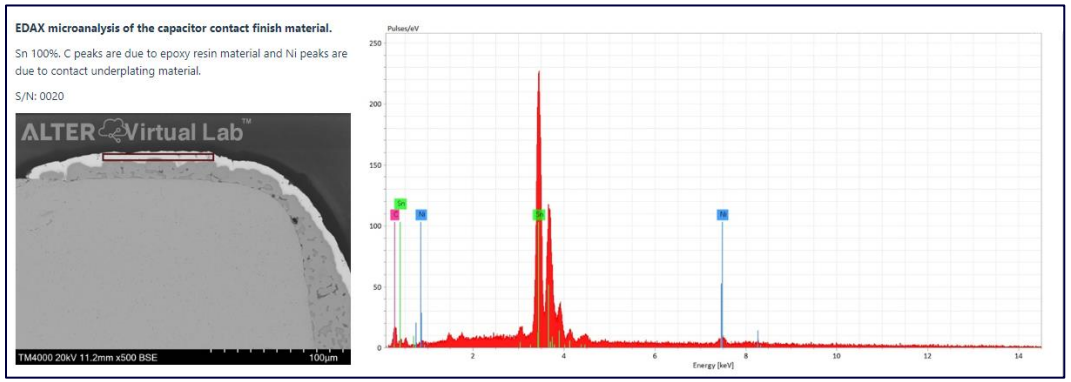
- Group 4b: Humidity and vacuum
- Final DPA

Qty: 3 + 3 samples

- During die shear all elements were sheared with a force greater than the minimum, even if lack of die attach material was observed before.
- Microsection inspection showed an unacceptable crack in the die (TIA).
- Material analysis showed the same deviation as the one observed during the constructional analysis, pure tin in the capacitors contact finish





ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

MAIN RESULTS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

Incoming Inspection

Group 1: Constructional analysis

Group 2: Reliability evaluation

Group 3: Environmental

Group 4a: Thermomechanical

Group 4b: Humidity and vacuum

Final DPA

Qty: 3 + 3 samples

- Summary of final DPA

TEST	METHOD	S/N						
		14	20	32	37	41	45	12
EXTERNAL VISUAL INSPECTION	MIL-STD-883. Method 2009.14 2	NC	C	C	C	C	C	-
RADIOGRAPHIC INSPECTION	MIL-STD-883. Method 2012.11 2	C	C	C	C	C	C	-
FIBER PULL TEST	MIL-STD-202. Method 211 H	C	-	C	C	-	-	-
INTERNAL VISUAL INSPECTION	MIL-STD-883. Method 2017.13 2	NC	-	NC	NC	-	-	NC
SEM INSPECTION	MIL-STD-883. Method 2018.6 2 (w/Change1)	NC	-	NC	NC	-	-	-
WIRE PULL TEST	MIL-STD-883. Method 2011.10 2	NC	-	C	C	-	-	-
SEM I INSPECTION	MIL-STD-883. Method 2018.6 2 (w/Change1)	C	-	-	-	-	-	-
DIE SHEAR TEST	MIL-STD-883. Method 2019.10 2	C	-	C	C	-	-	-
CROSS SECTION	ECSS-Q-ST-70-61 C	-	C	-	-	NC	NC	-
MICROANALYSIS (PLANE 1)	MIL-STD-1580. Req. 9 C	-	NC	-	-	-	-	-
MICROANALYSIS (PLANE 2)	MIL-STD-1580. Req. 9 C	-	-	-	-	NC	-	-
MICROANALYSIS (PLANE 3)	MIL-STD-1580. Req. 9 C	-	-	-	-	-	NC	-

C Compliant, no anomalies detected
C* Compliant, acceptable anomalies detected
NC Not compliant, unacceptable anomalies detected
CD Customer disposition required
- Serial number not tested

ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

CONCLUSIONS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

- SC parts have been **particularly sensitive** since the beginning of the test flow.
- Before starting the evaluation, the **repeatability and stability** of these parts in electrical measurement was studied using different setup configurations.
- Parts showed **random BER errors** (below the maximum limit) from the initial incoming inspection and later on during the testing. Several **hypotheses** have been considered as the cause although none of them has been fully confirmed:
    - *This part type has a pigtail, and it was observed that failing samples were sensitive to the position and movement of the fibre attached on the sample.*
    - *The resin used to fix the fibers is not uniformly distributed and repetitive in all samples.*
    - *Throughout the test flow, the number of channels and samples with BER errors has increased, which may be due to both the tests themselves but also to the increased handling of the parts.*
- Based on the gathered experience, the **pigtail may be one weakness of this device**. On the one hand, it has is identified as the possible root cause of the random BER errors. On the other hand, the pigtail is the reason for the outgassing failure. Hence, it would be **advisable for SC to offer the product without fiber pigtail or when planned to be used for space, to offer the option to incorporate space grade fibers.**

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

CONCLUSIONS – Device 3: SC's 4-Channel 10Gbps Optical transceiver

- **Differences** have been observed in the **construction between the samples**, although they could not be correlated to the different shipments or batches. For example, the material used to fix the fibers to the sample does not present the same quantity or distribution in all samples, as can be seen in internal visual inspections made. The **non-homogeneity of the construction of the samples is a risk that may jeopardize the outcome of the whole test campaign.**

- **Failures** have been detected **throughout the evaluation** of this part type. As opposed to other devices, **most of the failures are parametric failures** in the BER parameter. **The only functional failures were found after ESD test**, and the one caused by the crack in the optical fiber which was due to mishandling.

- Nevertheless, this part type shows **greater robustness to the humidity and vacuum tests**. All samples passed successfully humidity tests, and the failure detected after vacuum test was really caused by mishandling. This may be clearly caused by the construction of the device itself which makes also feasible a hermetic version (in fact available from the manufacturer under PN 16003).

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

GENERAL CONCLUSIONS

- All devices seem to be **good candidates** for qualification, but each of them has **its own strengths and weaknesses which require design or process adjustments**.

- **No correlation** has been proved between the non-hermeticity of the samples and the possible reliability issues found during the testing.

ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

FUTURE WORK AND RECOMMENDATIONS

1) The **tests** conducted during the campaign **did not reveal the root cause of the failures**. As a result, we cannot confirm whether the applied stress conditions—such as temperature, thermal cycling, humidity, and life tests—were responsible for the observed issues. **Further investigation is necessary**, either by analyzing the study samples or through additional testing. One approach could involve step stress tests to better assess the devices' limitations.

2) **Radiation testing is crucial for space applications**; however, this ITT did not consider this to be studied during the project. It would be essential to **extend the testing activities to include radiation hardness assurance** at the assembly or subcomponent level to ensure the transceivers can be effectively used in space.

ALTER

RELIABILITY OF NON-HERMETIC OPTICAL TRANSCEIVERS

FUTURE WORK AND RECOMMENDATIONS

3) Given the insights gained, there is potential to **enhance the testing program with new activities**. These could involve designing tests with different bias conditions or testing newly commercialized transceivers.

4) Careful attention is needed during the procurement process to **guarantee sample homogeneity.** Transceivers involve complex assembly and may require reworking, making it more challenging to maintain consistency compared to simpler electronic components. **Testing non-homogeneous samples could compromise the validity of the results.**

5) Some deviations are **manufacturing issues** that may be solved with **better process controls** at the manufacturer.

Thank you!

ALTER