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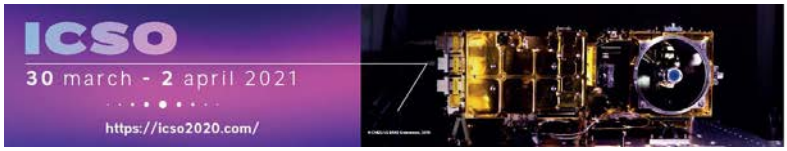

Successful space qualification of DFB laser diodes at 1542 nm wavelength for METOP-SG IASI-NG LASE

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SUCCESSFUL SPACE QUALIFICATION OF DFB LASER DIODES AT 1542 nm WAVELENGTH FOR METOP-SG IASI-NG LASE

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ABSTRACT

Kongsberg Defence & Aerospace (KDA) has developed and qualified the Laser Diode Module (LDM) for the Laser Source Electronics (LASE) for the IASI-NG instrument. The LDMs were Lot Acceptance Tested (LAT), and successfully qualified for use in space. The LASE unit provides a wavelength-stabilized optical source to be injected into the IASI-NG interferometer with a wavelength stability within ± 0.00015 nm throughout the instrument lifetime.

Keywords: IASI-NG, MetOp-SG, space, laser, laser qualification, DFB laser

1. INTRODUCTION

The MetOp-SG satellite program is an EUMETSAT/ESA cooperation with the objective to obtain long-term collection of remotely sensed data of uniform quality for meteorology and climate monitoring state analysis and forecast. A series of three satellite pairs (MetOp-SG-A and MetOp-SG-B) are to be launched, ensuring continuity of data beyond 2045.

The Infrared Atmospheric Sounding Interferometer New Generation (IASI-NG) is a key payload element of the second generation of European meteorological polar-orbit satellites METOP-SG-A, dedicated to operational meteorology, oceanography, atmospheric chemistry, and climate monitoring. The LASE unit was presented[1] at ICSO 2018, this paper focus on the qualification of the LDM.

The core component in a laser system is the Laser Diode Module (LDM). While laser sources in the telecommunication wavelength range near 1550 nm are easily available for terrestrial use as COTS, their suitability for space applications need to be assessed. For the LASE unit, a Furukawa Fitel FRL15DCWD-A82-W19430-B LDM was chosen, and a Lot Acceptance Test (LAT) was performed.

This paper is divided into a description of the qualification campaign and results in chapter 2 and summary and conclusions in chapter 3.

2. LDM QUALIFICATION

The qualification campaign test flow is shown in Figure 2-1. The LAT was divided into sub-groups, mechanical, thermal, endurance and radiation tests, and constructional analysis. Constructional analysis was also performed on some of the devices after environmental tests. The different tests are presented in separate sections.

The Furukawa Fitel FRL15DCWD-A82-W19430-B[2] laser diode is rated for use at 40 mW, a picture is shown in Figure 2-2. To account for derating, the LDMs were qualified at 28 mW.

Furukawa qualify their lasers in accordance with standard Telcordia GR-468-CORE. For the space qualification, all tests were performed by Alter Technology in Spain. A total of 71 LDMs were screened, and 43 of those were included in the LAT.

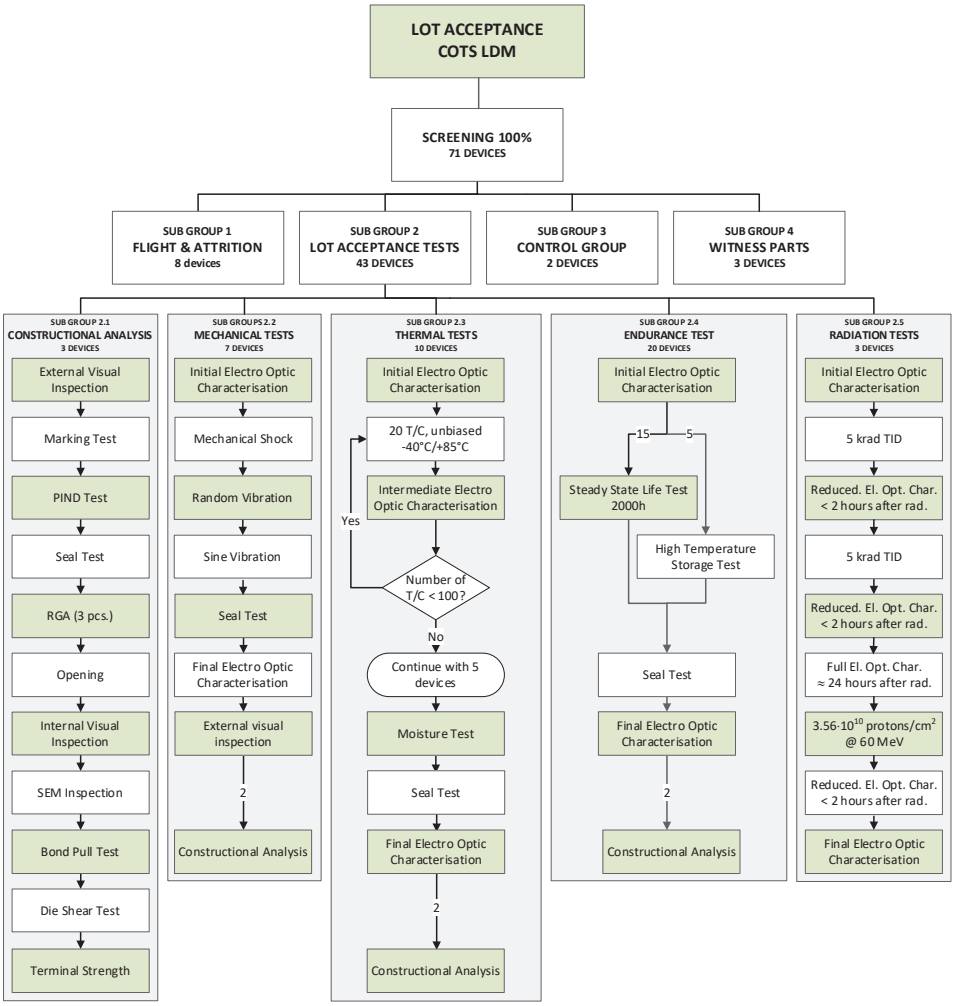

Figure 2-1 LDM LAT Test flow.

The Electro-optic characterization consisted of measurements of the following parameters and their drifts:

- Current draw, Ifwd [mA].
- Laser threshold current, Ith [mA].
- Die temperature, Tdie [°C].
- Electrical resistance, Rtherm [kOhm]
- Diode voltage, Vled [V]
- Optical power slope [mW/mA]
- Wavelength slope [MHz/mA]
- Polarization Extinction Ratio (PER) [dB]

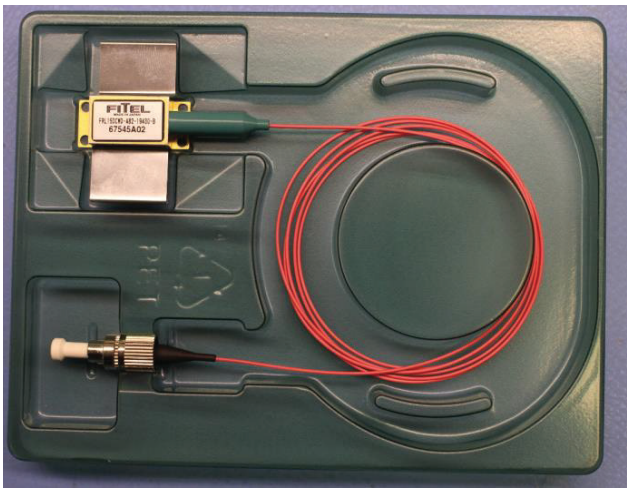

Figure 2-2 The LDM, shown in its packaging.

2.1 Screening

Prior to the tests, all devices were screened, including burn-in and x-ray inspection of the laser diodes. The screening flow is shown in Figure 2-3.

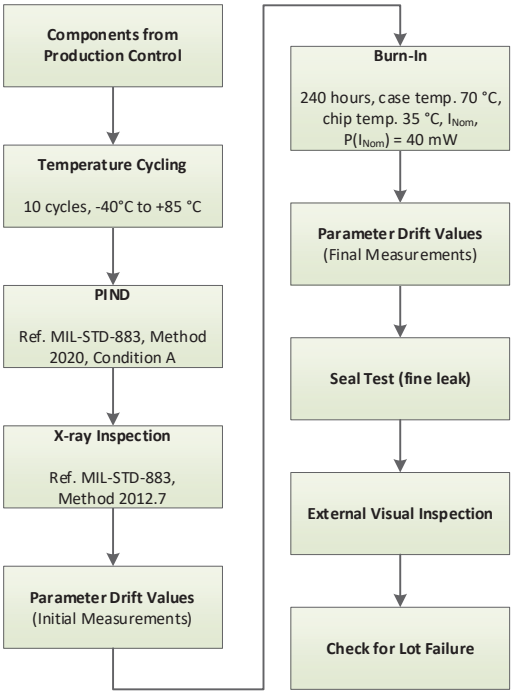

Figure 2-3 Screening flow.

Based on the electro-optical measurements, 7 of the 71 LDMs had anomalies, including too high drifts, operating temperature slightly outside specifications and other minor discrepancies. Where the anomalies had no impact on the test results, the LDMs were included in the LAT.

A representative image from the X-ray inspection is shown in Figure 2-4.

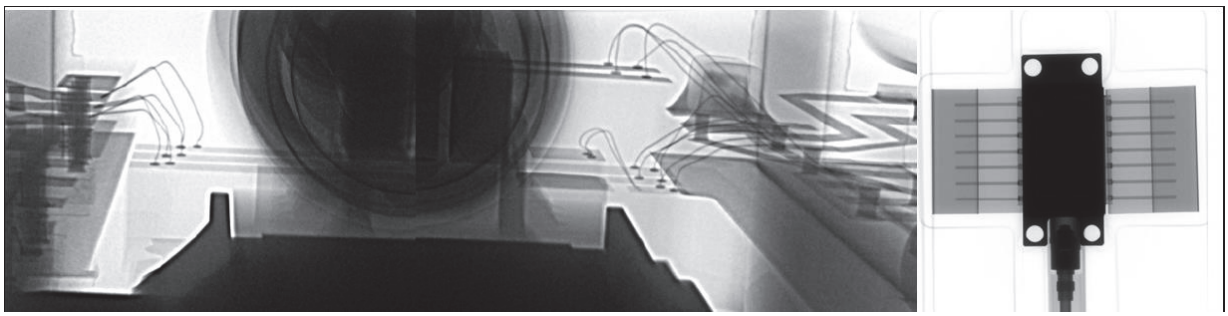

Figure 2-4 Picture from X-ray inspection.

2.2 Mechanical tests

7 LDMs were mechanically tested, see test flow in Figure 2-1. The test levels for the mechanical tests are shown in Table 2-1 - Table 2-3. The test setup is shown in Figure 2-5.

Resonance search and leak tests were performed, which showed no anomalies in the measurements. The leak rates were all below 1E-9 atm·cc/ss.

Table 2-1 Random vibration levels

Frequency [Hz]	ASD [g^2/Hz]	dB	Grms [g]
20	0.0160	*	*
100	0.4000	13.98	3.64
400	0.4000	0.00	11.54
2000	0.0001	-36.02	13.1

Table 2-2 Sine vibration levels

Frequency [Hz]	Levels
5 to 27	10.4 mm amplitude
27 to 110	30 g

Table 2-3 Shock levels

Frequency [Hz]	Shock [g]
100	14
270	72
2000	204
10000	144

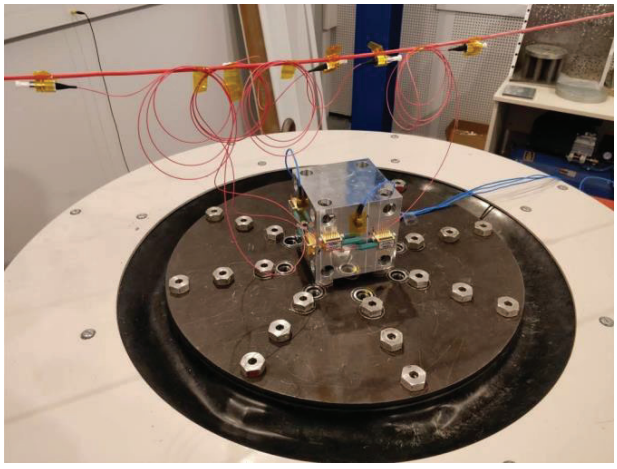

Figure 2-5 Vibration test setup

2.3 Thermal tests

Thermal tests were performed on 10 LDMs, in accordance with the test flow shown in Figure 2-1. 5 of the LDMs were also exposed to a moisture test.

Thermal cycles were performed according MIL-STD-883 TM1010 and customer requirements. A picture of the test setup is shown in Figure 2-6. The following test conditions were applied:

- Total number of cycles: 100
- Tmin = -40°C
- Tmax = +85°C
- Temperature rate = 10°C/min
- Dwell time = 15 mins
- Electro-optical characterization every 20 cycles

Moisture test conditions:

- Duration: 240 hours
- Temperature: +85°C
- Relative humidity: 85%

Figure 2-6 Thermal test chamber

All LDMs passed the tests within required drifts.

2.4 Endurance tests

The endurance test flow is shown in Figure 2-1. A total of 20 lasers were included in this group, 5 were tested for non-operating high temperature storage test, and the other 15 were tested for 2000h in operating conditions. 10 of the 15 LDMs were tested for an additional 1000h.

The following test conditions were used for the Steady State Life Test (Endurance) test:

- Tcase = 70 °C
- Tchip = 35 ° C
- Optical power: 40mW (Ifwd=180mA)
- Test time: 3000h
    - Measurements at 500, 1000, 1500, 2000 and 3000h
    - 15 lasers up to 2000h, 10 lasers up to 3000h

The following test conditions were used for the High Temperature Storage test:

- Non-operational lasers
- Temperature = 85 ° C
- Test time: 2000h (intermediate measurements at 500, 1000, 1500 & 2000h)

Due to a non-conformance in the test equipment, 1 LDM did not complete the tests. The root cause was found to be a TEC controller that failed after 580h operation.

No LDMs failed due to the endurance test level or duration.

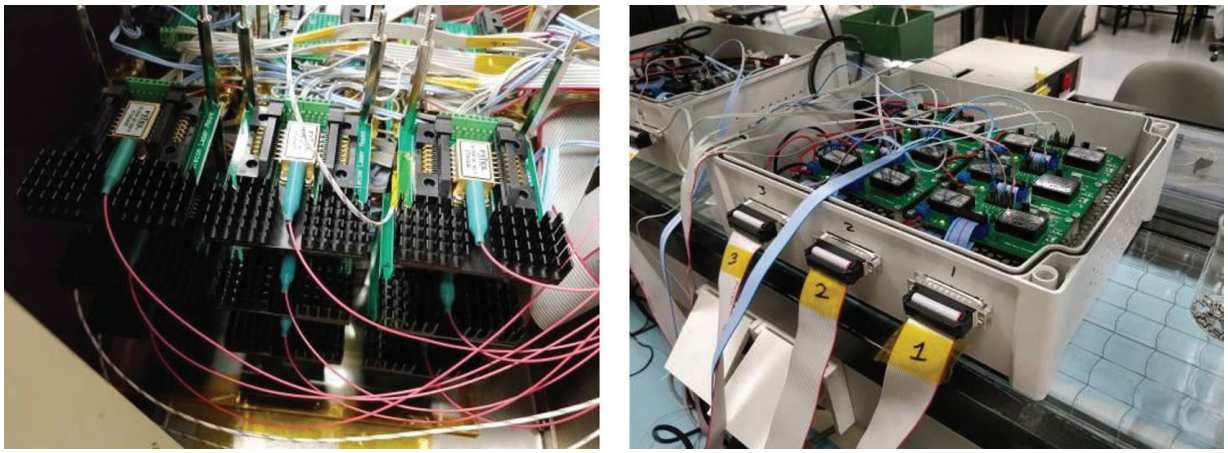

Figure 2-7 Endurance test setup. Left: Lasers mounted in sockets . Right: Thermo-electric controllers.

2.5 Constructional Analysis

The constructional analysis test flow is shown in . It was performed on 3 designated LDMs, and in addition 2 LDMs from each of the following groups were included: Endurance, Thermal and Mechanical.

A minor defect was found on an LDM during SEM inspection, see Figure 2-8. A small piece of the top metallization remained on the laser chip after die cutting. This LDM was from the mechanical testing group. The metal had survived the mechanical tests, and also too small to cause any short-circuits. The anomaly was not cause for rejection.

External visual inspection: No anomalies detected, all samples passed the test.

Marking Test: Good marking legibility after the test, all samples passed the test.

PIND Test: No loose particles were detected, all samples passed the test.

Terminal Strength: No damage was observed in the terminals, all samples passed the test.

Seal-Test: All samples passed the test (leak rate < 1E-9 atm.cc/s).

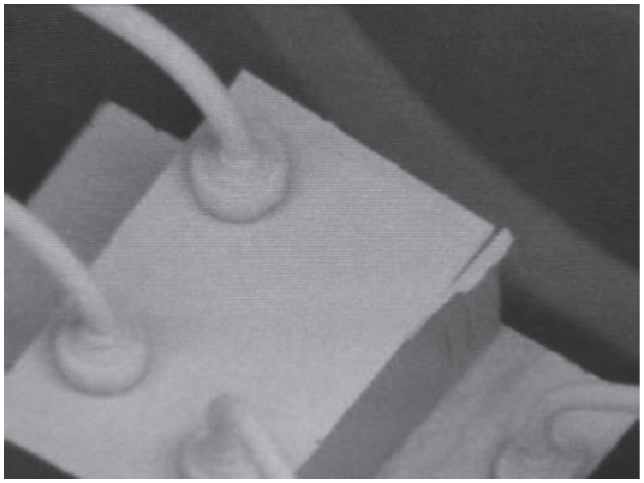

Figure 2-8 SEM picture of laser chip, showing small piece of top metallization remaining after die cutting.

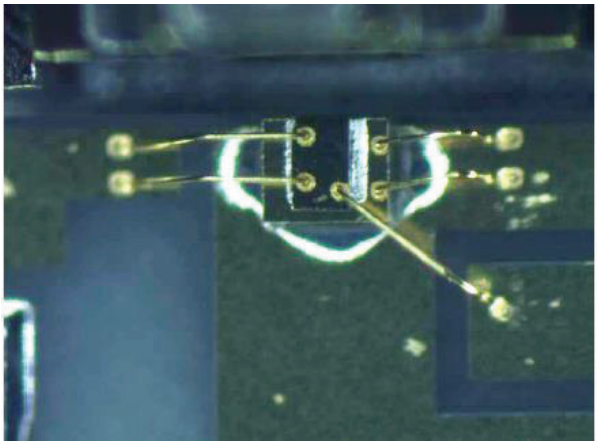

Figure 2-9 Picture from LDM 67536A09 from internal visual inspection.

2.6 Radiation tests

3 LDMs were radiation tested, the test flow is shown in Figure 2-1. Radiation tests were performed using ESCC22900 as a guideline onto a reduced subset of 3 samples.

Total Ionizing Dose test was performed according the following test conditions:

- Number of samples: 3
- Biasing: Terminals short-circuited
- Dose Rate: 210 rad/h
- Total cumulated dose: 10 kRad
- Intermediate measurements: at 5 kRad

Displacement Damage test (Protons radiation) was performed according the following test conditions:

- Number of samples: 3
- Biasing: Terminals short-circuited
- Flux: 10^8 p+/cm2·s
- Fluence: $3.56 \cdot 10^{10}$ p+/cm2
- Beam Energy: 60 MeV

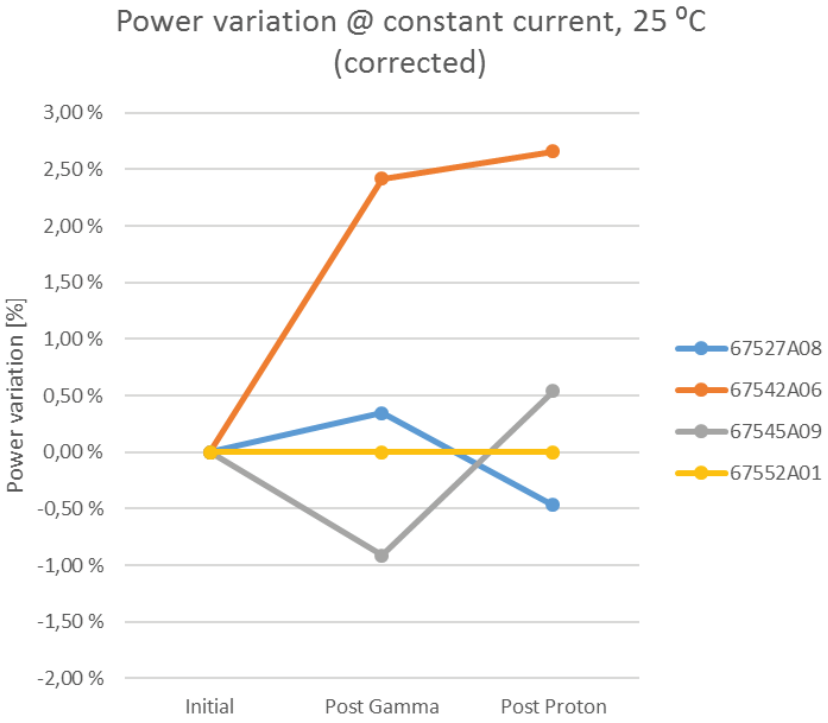

Figure 2-10 The drift in optical power due to radiation environment. The measurements were corrected to account for variation in the test setup. Reference LDM 67552A01, which was not radiation tested, was used for the normalization.

No issues were detected during test.

3. SUMMARY AND CONCLUSION

No LDMs failed due to the LAT. 1 LDM failed due to a non-conformance in endurance test equipment.

The laser qualification was a success. The LDMs in the flight group have been used in the MetOp-SG-A IASI-NG LASE units and will reach flight heritage in the years to come.

4. ACKNOWLEDGEMENTS

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