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Accelerated Aging Test of 1310 nm Laser Diodes

APPLICATION NOTE

For application assistance or additional information on our products or services you can contact us at:

ILX Lightwave Corporation
31950 Frontage Road, Bozeman, MT 59715
Phone: 406-556-2481 • 800-459-9459 • Fax: 406-586-9405
Email: sales@ilxlightwave.com

To obtain contact information for our international distributors and product repair centers or for fast access to product information, technical support, LabVIEW® drivers, and our comprehensive library of technical and application information, visit our website at:

www.ilxlightwave.com

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Accelerated Aging Test of 1310 nm Laser Diodes

By: Lawrence A. Johnson

May 31, 2006

This accelerated aging test was performed on telecommunications grade 1310 nm edge emitting laser diodes.

1. OBJECTIVE

Determine the median time to failure at 85°C.

2. DEVICES TESTED

This test was performed on a batch of 18 1310nm edge emitting laser diodes.

3. TEST SETUP

Tests were conducted in an ILX Lightwave LRS-9424 Laser Reliability and Burn-In Test system. Devices were mounted in a standard 32 device fixture with an external InGaAs photodiode array calibrated for 5mW full scale range.

The devices under test were subjected to two sequential 500 hour accelerated aging tests, the first at 60°C and the second at 85°C. Both tests were conducted in constant power (APC) mode at the laser diodes optical output power of 5 mW.

Pre and post LIVs data were collected at 40°C in order to identify any unusual device characteristics.

Control Mode: APC mode at 5mW optical output power.

Data Sampling: 30 minutes
Data Averaging: 30 minutes
Temperature: 60°C, 85°C
Aging Time: 500 hours, each test

Ongoing test results were reviewed periodically during the course of the test. No unusual behavior was observed.

4. DATA ANALYSIS

4.1 Pre and Post Burn-In LIV Results

Pre and post burn-in LIV tests at 40°C produced typical, well behaved parametric curves for output optical power and voltage vs laser drive current. These LIV tests were performed before and after the 85°C burn-in. The results of these tests are shown in Figures 1 and 2 below.

The following publications are available for download at www.ilxlightwave.com.

- Typical Output Stability of the LDC-3742B
- Typical Output Stability of a LDX-3100 Board-Level Current Source
- Typical Pulse Overload of the LDP-3840/03 Precision Pulse Current Source
- Typical Temperature Stability of a LDT-5142 Low-Cost Temperature Controller
- Using Three-Wire RTDs with the LDT-5900 Series Temperature Controllers
- Voltage Drop Across High Current Laser Interconnect Cable
- Voltage Drop Across High Current TEC Interconnect Cable
- Laser diode temperature limit protection of an LDC-3916 Laser Diode Controller
- Wavelength Accuracy of the 79800 DFB Source Module

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Note that the lifetime at which cumulative failures reach 50% is also referred to as the median life or MTTF. The upper and lower bounds reported above correspond to 90% confidence bounds based on the number of samples in this test. The lognormal probability plot for the lasers in this test is shown in Figure 4 below.

The lifetimes reported above correspond to a case temperature of 85°C. Longer lifetimes can be achieved by lowering the operating case temperature of the lasers or designing drive circuitry that can accommodate a larger increase in current than the 20% increase that was used to define end-of-life in this analysis.

Estimation of lifetime at other operating case temperatures can be accomplished by using the Arrhenius equation (see for example the NIST/SEMATECH e-Handbook of Statistical Methods, http://www.itl.nist.gov/div898/handbook/, June 2005). Use of the Arrhenius equation requires a value for the activation energy for the failure mechanism of the lasers. The value of the activation energy may be estimated by collecting and analyzing aging data at two or more temperatures.
4.2 Accelerated Aging Test Results

In this APC mode test the light output of each laser is held at a constant 5mW by increasing the laser diode drive current (Iop) as the device ages. Initial drive currents to achieve 5 mW output ranged from approximately 29.2 mA to 38.2 mA as shown in Figure 3 below. No random (sudden) failures were observed during the test.

![Figure 3 - Aging Trend](image)

This first 500 hour test was performed at 60°C. The devices showed very little aging at this temperature during the short, 500 hour duration of the test. The second 500 hour test was performed at 85°C and a higher rate of aging was observed.

In order to estimate lifetimes it is necessary to establish a definition of end-of-life. For this analysis we have defined end-of-life as a 20% rise in laser diode drive current (Iop) over the initial value. Using this definition the aging trend for each laser was extrapolated to end-of-life. The following table provides a summary of the aging rates and estimated lifetimes based on this analysis.

<table>
<thead>
<tr>
<th>Device #</th>
<th>Aging Rate (%/KHr)</th>
<th>Lifetime (Hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.7</td>
<td>27,297</td>
</tr>
<tr>
<td>2</td>
<td>0.6</td>
<td>31,175</td>
</tr>
<tr>
<td>3</td>
<td>0.4</td>
<td>50,173</td>
</tr>
<tr>
<td>4</td>
<td>1.0</td>
<td>19,664</td>
</tr>
<tr>
<td>5</td>
<td>0.2</td>
<td>82,536</td>
</tr>
<tr>
<td>6</td>
<td>0.5</td>
<td>42,217</td>
</tr>
<tr>
<td>7</td>
<td>0.5</td>
<td>42,127</td>
</tr>
<tr>
<td>8</td>
<td>0.2</td>
<td>84,331</td>
</tr>
<tr>
<td>9</td>
<td>1.4</td>
<td>14,124</td>
</tr>
<tr>
<td>10</td>
<td>0.6</td>
<td>35,920</td>
</tr>
<tr>
<td>11</td>
<td>0.8</td>
<td>26,477</td>
</tr>
<tr>
<td>12</td>
<td>0.7</td>
<td>30,346</td>
</tr>
<tr>
<td>13</td>
<td>0.6</td>
<td>34,668</td>
</tr>
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<td>14</td>
<td>0.8</td>
<td>25,100</td>
</tr>
<tr>
<td>15</td>
<td>0.5</td>
<td>41,239</td>
</tr>
<tr>
<td>16</td>
<td>1.3</td>
<td>14,974</td>
</tr>
<tr>
<td>17</td>
<td>0.2</td>
<td>88,922</td>
</tr>
<tr>
<td>18</td>
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<td>48,815</td>
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5. LIFETIME ANALYSIS

The lifetimes reported above have a lognormal probability distribution as is typical for most laser diodes exhibiting a wear out failure mode. Results of the reliability analysis based on the lifetime data is provided in the table below:

<table>
<thead>
<tr>
<th>Lifetime Results</th>
<th>Lifetime (Hrs)</th>
<th>Upper Bound (Hrs)</th>
<th>Lower Bound (Hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% Cumulative Failures</td>
<td>35,900</td>
<td>44,600</td>
<td>28,900</td>
</tr>
<tr>
<td>2% Cumulative Failures</td>
<td>11,500</td>
<td>17,300</td>
<td>7,802</td>
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Figure 4 Lognormal Probability Plot of Lifetime Data

Figure 1 - Pre Burn-In LIV Test Results

Figure 2 - Post Burn-In LIV Test Results
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**White Papers**
- A Standard for Measuring Transient Suppression of Laser Diode Drivers
- Degree of Polarization vs. Poincaré Sphere Coverage
- Improving Optical Loss Measurement Reproducibility
- Laser Diode Burn-In and Reliability Testing
- Power Supplies: Performance Factors Characterize High Power Laser Diode Drivers
- Reliability Factors for Laser Diodes
- Reducing the Cost of Test in Laser Diode Manufacturing

**Technical Notes**
- Acceleration Accuracy in the 7900 Fiber Optic Test System
- Automatic Wavelength Compensation of Photodiode Power Measurements Using the OMM-6810B Optical Multimeter
- Bandwidth of OMM-6810B Optical Multimeter Analog Output
- Broadband Noise Measurements for Laser Diode Current Sources
- Clamping Limit of a LDX-3724B 5mW Precision Current Source
- Control Capability of the LDC-3916371 Fine Temperature Resolution Module
- Current Draw of the LDC-3926 16-Channel High Power Laser Diode Controller
- Determining the Polarization Dependent Response of the FPM-8210 Power Meter
- Four-Wire TEC Voltage Measurement with the LDT-5900 Series Temperature Controllers
- Guide to Selecting a Bias-T Laser Diode Mount
- High Power Linearity of the OMM-6810B and OMM-6780/6790/6790B Detector Heads
- Large-Signal Frequency Response of the 391633B Current Source Module
- Laser Wavelength Measuring Using a Colored Glass Filter
- Long-Term Output Drift of a LDX-3920 Ultra-Low Noise Laser Diode Current Source
- Long-Term Output Stability of a LDX-3525 Precision Current Source
- Long-Term Stability of an MPS-8033/55 ASE Source
- LRS-9424 Heat Sink Temperature Stability When Chamber Door Opens
- Measurement of 4-Wire Voltage Sense on an LDC-3916 Laser Diode Controller
- Measuring the Power and Wavelength of Pulsed Sources Using the OMM-6810B Optical Multimeter
- Measuring the Sensitivity of the OMM-6709B Optical Measurement Head
- Measuring the Wavelength of Noisy Sources Using the OMM-6810B Optical Multimeter
- Output Current Accuracy of a LDX-3724B 5mW Precision Current Source
- Pin Assignment for CC-305 and CC-905 Cables
- Power and Wavelength Stability of the 79800 DFB Source Module
- Power and Wavelength Stability of the MPS-800 Series Fiber Optic Sources
- Repeatability of Wavelength and Power Measurements Using the OMM-6810B Optical Multimeter
- Stability of the OMM-6810B Optical Multimeter and OMM-6727B InGaAs Power/Wavehead
- Switching Transient of the 79800D Optical Source Shutter
- Temperature Controlled Mini-DIL Mount
- Temperature Stability Using the LDT-5498
- Thermal Performance of an LDX-4516 Laser Diode Mount
- Triboelectric Effects in High Precision Temperature Measurements
- Tuning the LDP-3940 for Optimum Pulse Response
- Typical Long-Term Temperature Stability of a LDT-5412 Low-Cost Temperature Controller
- Typical Long-Term Temperature Stability of a LDT-5525 TEC
- Typical Output Drift of a LDX-3412 Low-Cost Precision Current Source
- Typical Output Noise of a LDX-3412 Precision Current Source

**Application Notes**
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- App Note 2: Selecting and Using Thermistors for Temperature Control
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- App Note 11: Pulsing a Laser Diode
- App Note 12: The Differences between Threshold Calculation Methods
- App Note 14: Optimizing TEC Drive Current
- App Note 17: AD590 and LM335 Sensor Calibration
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- App Note 21: High Performance Temperature Control in Laser Diode Test Applications
- App Note 22: Modulating Laser Diodes
- App Note 23: Laser Diode Reliability and Burn-In Testing
- App Note 25: Novel Power Meter Design Minimizes Fiber Power Measurement Inaccuracies
- App Note 26: Reliabilities LT Threshold Calculations
- App Note 27: Internally Noise Performance of Semiconductor Lasers
- App Note 28: Characterization of High Power Laser Diode Bars
- App Note 29: Accelerated Aging Test of 1310 nm Laser Diodes
- App Note 30: Measuring High Power Laser Diode Junction Temperature and Package Thermal Impedance