TECH NOTE

LRS-9400-4638B Fiber Temperature Stabilized Fixture for Lasers with FBGs

OVERVIEW

This technical note describes the performance of the ILX Lightwave LRS-9400-4638B coolerless butterfly laser diode fixture with a fiber temperature stabilized tray for laser modules which incorporate fiber Bragg gratings (FBGs). The ILX Lightwave LRS-9400-4638B family of fixtures is designed for life testing of coolerless butterfly 980 nm pump laser diodes. These devices frequently incorporate a fiber Bragg grating for wavelength stabilization making them ideal for applications where wavelength stability is critical but temperature stability is difficult to guarantee.

Figure 1: LRS-9400-4638B Fiber Temperature Stabilized Fixture

Inherent in the architecture of this type of device are external fiber Fabry-Perot cavities formed by the rear facet and output facet of the laser and the fiber Bragg grating which is located approximately 2 meters away through single mode fiber. One issue with this architecture is the influence that temperature variations have on the optical and mechanical properties of the fiber cavity. Changes in fiber temperature of less than 0.5°C can cause changes in optical output power of as much as 3%, as measured at the back facet photodiode (PD). While this level of variation is not significant in typical end use applications, it complicates the interpretation of life-test and burn-in aging trend data where results are calculated based on small changes in optical output power over time.

This technical note describes the effectiveness of a proprietary stabilization technique developed by ILX Lightwave to overcome this sensitivity to fiber temperature in long term life-tests, where measurement stability is of primary importance.

BACKGROUND

In order to characterize the effect described above, an experiment was conducted in which laser diode drive parameters were held constant and fiber temperature was varied. A fiber coupled 980nm Fabry-Perot laser with fiber Bragg grating and an external cavity length of 2m was loaded onto an ILX Lightwave LDM-4984 TEC controlled fixture. Laser drive current control, device temperature control, back facet photodiode (PD) current measurement, and fiber coil temperature measurement were performed with an LDC-3744B Laser Diode Controller. Data was logged over GPIB with an external PC. The fiber coil of the device was taped to an optical breadboard with a 10kΩ thermistor at the center of the coil. Fiber temperature was varied by heating the optical breadboard directly.

Figure 2 shows normalized back facet PD current as a function of fiber temperature. The strong periodic behavior is due to the longitudinal translation of the peaks and nulls of the intracavity interference pattern [1, 2] that forms in the single mode fiber plus the effects of the thermal expansion and the temperature dependence of the index of refraction of the fiber, leading to path length changes in the external cavities. As can be seen in Figure 1, a temperature change of only 0.15°C can lead to a change in optical output of more than 1%.

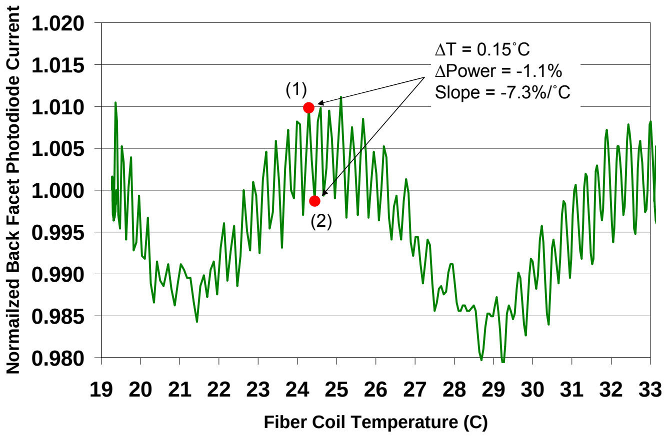

Figure 2: Normalized back facet PD current vs. fiber temperature.

Lifetime of laser diodes is usually defined as the period of time it takes for the light output of the laser to degrade to a predetermined minimum acceptable level. Often this level is defined as a 20% decline in output In aging tests devices are rarely tested to end of life conditions due to the long period of time that would be required to reach end of life under normal operating conditions. Rather they are operated under conditions which accelerate the aging, usually elevated temperature and/or drive current, for a fixed length of time. The aging trend data is then extrapolated to end of life using a linear regression.

The optical output of semiconductor laser diodes often degrades at a rate of only few percent per thousand hours or less, even under accelerated conditions. Because of the use of extrapolation to estimate end of life and the slow aging of the devices, measurement noise must be reduced to a very low level. The effects of small changes in fiber temperature on the stability of the optical output of fiber coupled lasers with external FBGs can lead to changes of several percent, due for example to slight variations in ambient conditions. This increased noise leads to increased errors in estimated device lifetimes. As a result, accurate lifetime estimation for this type of laser requires special control and measurement technology.

One approach would be to carefully control the temperature of the external fiber during the test. However, as noted above, the change in optical output with fiber temperature can be as high as 7%/°C. To reduce the measurement noise due to the intracavity effect to less than ±0.1% would require temperature stability on the order of ±0.01°C. In practice, this level of stability is difficult to achieve over the period of a long-term test.

ILX Lightwave has developed a proprietary control and measurement technology which provides significant reduction in the noise created by the intracavity effects inherent in fiber coupled lasers with external FBGs. The effectiveness of this technique is presented in the following section.

TEST RESULTS

Aging tests were conducted on 96 fiber coupled 980nm Fabry-Perot laser diodes with external FBGs. The devices were aged for approximately 200 hours with the noise reduction control enabled and then another 200 hours with it disabled. Of the 96 devices, 10 showed strong sensitivity to fiber temperature and data from these devices was used in this technical note.

The lasers were aged at a constant case temperature of 65°C and constant forward bias current of 900 mA. The sampling and averaging intervals were 1 hour.

A linear regression was performed on monitor photodiode current versus time, as is typical in lifetime analysis. The residual noise was then calculated as the deviation of each measurement data point from this linear fit.

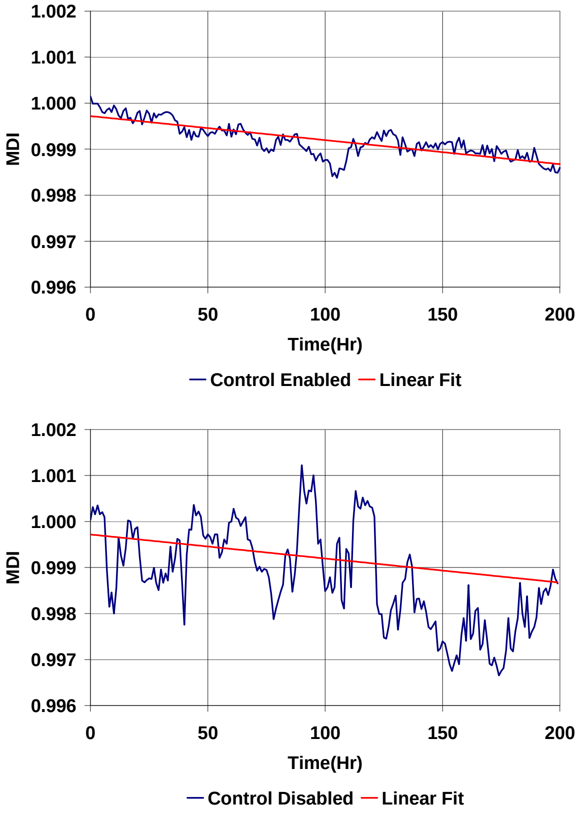

Figure 3: Normalized back facet PD current with and without fiber temperature modulation enabled

Figure 3 shows aging data from one of the ten devices tested. The first graph shows normalized back facet PD current versus time and its linear fit, with noise reduction control enabled. The second graph shows the same parameters from the same device with the noise reduction control disabled.

In comparing the results in Figure 3 it can be easily seen that the noise reduction control substantially reduced the measurement noise during the test. For this particular device, the standard deviation of the residual noise improved from 0.08% to 0.02%. On average, the standard deviation of all ten devices improved from 0.14% to 0.04% as shown in Table 1.

Device	Enabled	Disabled	Ratio
D1	0.02%	0.08%	3.80
D2	0.04%	0.06%	1.76
D3	0.02%	0.06%	2.53
D4	0.02%	0.06%	3.48
D5	0.03%	0.12%	4.15
D6	0.03%	0.11%	3.83
D7	0.07%	0.28%	3.80
D8	0.08%	0.36%	4.53
D9	0.03%	0.08%	2.98
D10	0.04%	0.16%	3.92

Table 1: Standard deviation of residuals with fiber temperature modulation enabled and disabled

CONCLUSION

The proprietary control and measurement circuitry used on ILX Lightwave's LRS-9400-4638 Fiber Temperature Stabilized fixture for laser diodes with external fiber Bragg gratings provides a significant reduction in the noise in optical output associated with this type of laser. The reduced measurement noise offered by this fixture allows more accurate life time estimation compared to conventional fixtures.

TECH NOTE

White Papers

- A Standard for Measuring Transient Suppression of Laser Diode Drivers
- Degree of Polarization vs. Poincaré Sphere Coverage
- Improving Splice Loss Measurement Repeatability
- Laser Diode Burn-In and Reliability Testing
- Power Supplies: Performance Factors Characterize High Power Laser Diode Drivers
- Reliability Counts for Laser Diodes
- Reducing the Cost of Test in Laser Diode Manufacturing

Technical Notes

- Attenuation 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-3525 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 OMH-6780/6790/6795B Detector Heads
- Large-Signal Frequency Response of the 3916338 Current Source Module
- Laser Wavelength Measuring Using a Colored Glass Filter
- Long-Term Output Drift of a LDX-3620 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 OMH-6709B Optical Measurement Head
- Measuring the Wavelength of Noisy Sources Using the OMM-6810B Optical Multimeter
- Output Current Accuracy of a LDX-3525 Precision Current Source
- Pin Assignment for CC-305 and CC-505 Cables
- Power and Wavelength Stability of the 79800 DFB Source Module
- Power and Wavelength Stability of the MPS-8000 Series Fiber Optic Sources
- Repeatability of Wavelength and Power Measurements Using the OMM-6810B Optical Multimeter
- Stability of the OMM-6810B Optical Multimeter and OMH-6727B InGaAs Power/Wavehead
- Switching Transient of the 79800D Optical Source Shutter
- Temperature Controlled Mini-DIL Mount
- Temperature Stability Using the LDT-5948
- Thermal Performance of an LDM-4616 Laser Diode Mount
- Triboelectric Effects in High Precision Temperature Measurements
- Tuning the LDP-3840 for Optimum Pulse Response
- Typical Long-Term Temperature Stability of a LDT-5412 Low-Cost TEC
- 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
- Typical Output Stability of the LDC-3724B
- Typical Output Stability of a LDX-3100 Board-Level Current Source
- Typical Pulse Overshoot of the LDP-3840/03 Precision Pulse Current Source
- Typical Temperature Stability of a LDT-5412 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
- Voltage Limit Protection of an LDC-3916 Laser Diode Controller
- Wavelength Accuracy of the 79800 DFB Source Module

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Laser Diode Instrumentation & Test Systems