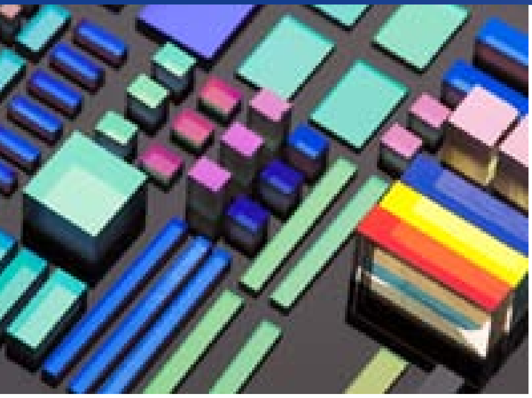
PowerLocker®

Wavelength Stabilization Gratings



Ondax's PowerLocker® wavelength stabilization gratings are volume holographic gratings (VHGs) that "lock" a laser diode's emission wavelength into a narrowed optical spectrum. This increases the spectral brightness and delivers highly stablized optical performance over extended temperature ranges. PowerLockers® typically reduce the spectral output of a laser by an order of magnitude. The short external cavity configurations enabled by the PowerLocker® design deliver better mode selection than systems based on Littrow or Littman cavities, at a fraction of the size and cost.

All Ondax VHGs are bulk "solid-state" diffractive holographic filters, which unlike thin films or gels, can deliver ultra-stable, degradation-free performance for the lifetime of the filter. Capable of very tight wavelength, efficiency, bandwidth, and diffraction angle control, Ondax VHGs can be precisely and reproducibly engineered to meet even the most demanding spectral and temporal specifications.

Proprietary materials, manufacturing and test processes ensure consistent, repeatable performance from every single filter, every time, guaranteed.

Features:

- Increases spectral brightness of lasers
- Reduces thermal dependence of lasers
- Reduces unwanted spectral components
- Narrow bandwidth
- Low loss
- Highly stable and reliable with over 12,000 hours of testing at 150°C
- No degradation under high power illumination conditions

Applications:

- Diode Pumped Solid State Lasers (DPSSL)
- Raman Spectroscopy
- RGB Sources
- Frequency Doubling
- Gas Sensing
- Bio-instrumentation
- Rb Lasers
- Lung Imaging
- LIDAR
- Beam Combining
- Metrology
- Graphic Arts (Printing & Digital Imaging)
- Photodynamic Therapy
- Visible Lasers

Specifications:

Parameter	Unit	Min	Typical	Max
Center Wavelength	nm	375	405, 658, 780, 785, 794.7, 808, 885, 920, 938, 976, 981, 1064, 1532, C-band	2700+
Wavelength Tolerance[1]	nm	-0.5		+0.5
Wavelength Variation (within filter)	nm			0.2
Bandwidth[2] (FWHM)	nm	0.03		1
Temperature Dependence	nm/°C		0.01	
Bragg mirror Reflectivity	%	5	10-98	>99.9
Reflectivity Tolerance[1]	%	-5		+5
Grating Slant Angle	Degrees		<1 custom available	
Standard Dimensions (X,Y)	mm	0.5		25
Thickness	mm	0.3	0.6-3	30

[1] Standard tolerances. Tighter tolerances available upon request
[2] Grating bandwidth is a function of wavelength and thickness

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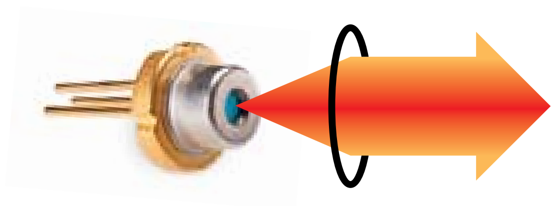
Wavelength Stabilization Gratings

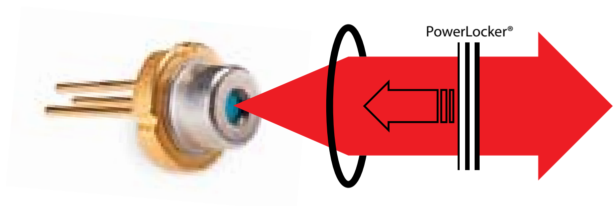
Laser Wavelength Stabilization with PowerLocker®

Adding a PowerLocker® to an external cavity laser system enables wavelength stabilization of the output, increasing the power in the desired mode and reducing unwanted spectral components.

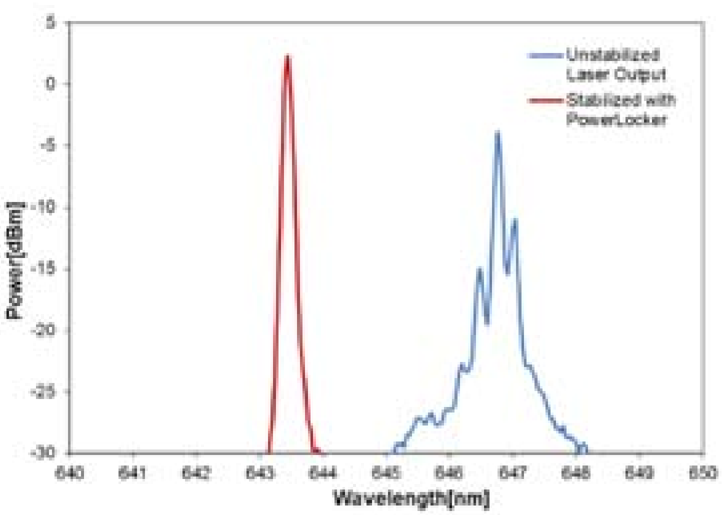
Unstabilized without PowerLocker®



Wavelength Stabilized with PowerLocker®



Measured Performance with and without PowerLocker®



Model Number System:

PLRλλλ.λ - RR - XX - YY - TT

- λ: Wavelength (nm)
- R: Reflectivity (%)
- X: Length (mm)
- Y: Width (mm)
- T: Thickness (mm)

Ondax PowerLocker® wavelength stabilization gratings are produced in a proprietary glass designed for long lifetime, high efficiency and low loss. Ondax's fabrication process is highly stabilized to ensure excellent part-to-part repeatability.

ONDAX

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626-513-7494 (Sales Fax)

For more information about Ondax products and the name of a local representative or distributor, visit www.ondax.com, email sales@ondax.com, or call (626) 357-9600. Specifications subject to change without notice.

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Explanation of Filter Specifications

1 Wavelength ($_{spec}$)

The specified filter wavelength, in nanometers.

2 Wavelength Tolerance ($_{tol}$)

The allowed wavelength tolerance of the part, in nanometers, such that the following is true for all positions on the filter:

$$\lambda_{max} < \lambda_{spec} + \lambda_{tol}$$
$$\lambda_{min} > \lambda_{spec} - \lambda_{tol}$$

3 Maximum Wavelength Variation (

The maximum allowed spatial variation of wavelength, in nanometers, within a single filter defined as $\Delta\lambda = \lambda_{max} - \lambda_{min}$.

4 External Diffraction Efficiency (E_{spec})

The specified external diffraction efficiency, in percent.

5 External Diffraction Efficiency Tolerance (E_{tol})

The allowed external diffraction efficiency tolerance of the part, in percent, such that the following is true for all positions on the filter:

$$E_{max} < E_{spec} + E_{tol}$$
$$E_{min} > E_{spec} - E_{tol}$$

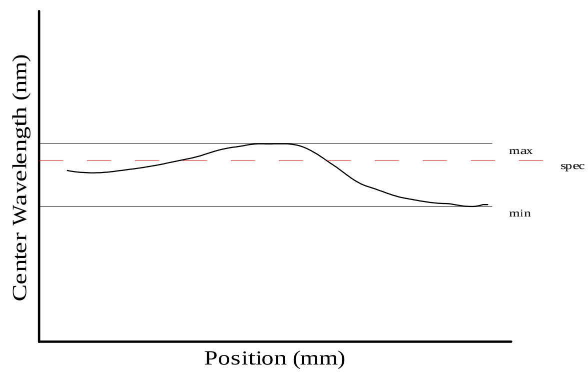

Figure 1: A representative plot of filter center wavelength for normal incidence versus position within a filter.

6 Maximum External Diffraction Efficiency Variation (E)

The maximum allowed spatial variation of external diffraction efficiency within a single filter, in percent, defined as $\Delta E = E_{max} - E_{min}$.

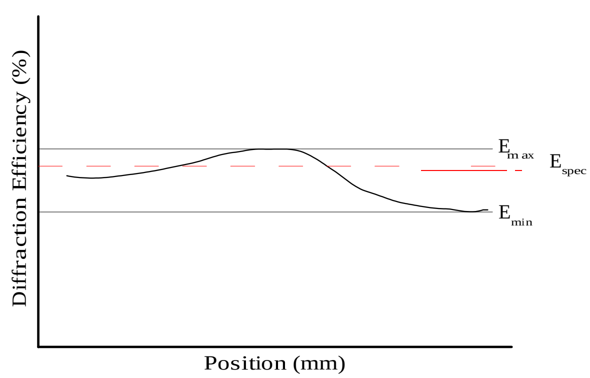

Figure 2: A representative plot of diffraction efficiency versus position within a filter.

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Filter Handling

1 Handling

Preferred handling is with plastic or teflon-coated tweezers. If handling by hand, wear gloves or finger cots. Filters are AR coated on both optical surfaces - avoid touching or contacting these coated surfaces.

2 Cleaning

If necessary, clean filters using optical-grade acetone (99.5% pure) or optical-grade Isopropyl Alcohol (99.9% pure), filtered to 0.2µm. Drag a clean optical tissue soaked in solvent across surface. Avoid abrasion of optical surfaces.

3 UV Exposure

VHG filter glass is sensitive to UV light, including sunlight and UV curing sources.

Avoid exposure to sunlight. If using a UV curing source, we strongly recommend physical shielding of the filters to limit exposure to UV. We also recommend spectral shielding of the filters from UV emissions below 350nm. If using a broadband source (e.g. mercury lamp) you may use a bandpass filter to attenuate all wavelengths below 350nm. Alternatively, you may use a narrow-band LED source that operates above 350nm (e.g. 365nm). Please contact Ondax if you need more details.

Filters exposed to UV may become discolored. If this occurs, please contact Ondax for technical assistance.

4 Operating Temperature

Recommended filter operating temperature is <200°C. Please contact Ondax for technical assistance, if you wish to operate filters above 200°C.

5 Traceability

Individual filters are not generally marked (unless specified on the PO), but filter lots are shipped in containers labeled with the part number and lot code. Ondax maintains complete traceability on all filters by lot code.

6 Filter Orientation

Some filters are orientation-sensitive – orientation must be determined by comparing filter dimensions against mechanical drawing. Some large filters may have a chamfered corner for orientation – see data sheet for more information.

7 AR Coating Specification

Filter Anti-Reflection Coating meets the criteria of MIL-C-675C.

Summary of Holographic Glass Properties

1 Scope

This document provides information on the properties and characteristics of the Ondax holographic glass when in the state of a final product.

2 Optical

2.1 Index of Refraction

The index at wavelength **l** (in micrometers) is given by the formula:

$n=\sqrt{(2.21776-5.34442\times10^{-3}\cdot\lambda^{2}+1.18996\times10^{-2}\cdot\lambda^{-2}+1.54366\times10^{-4}\cdot\lambda^{-4})}$ · This formula is accurate to within 10^{-3} in the wavelength range of 405 nm to 1570 nm.

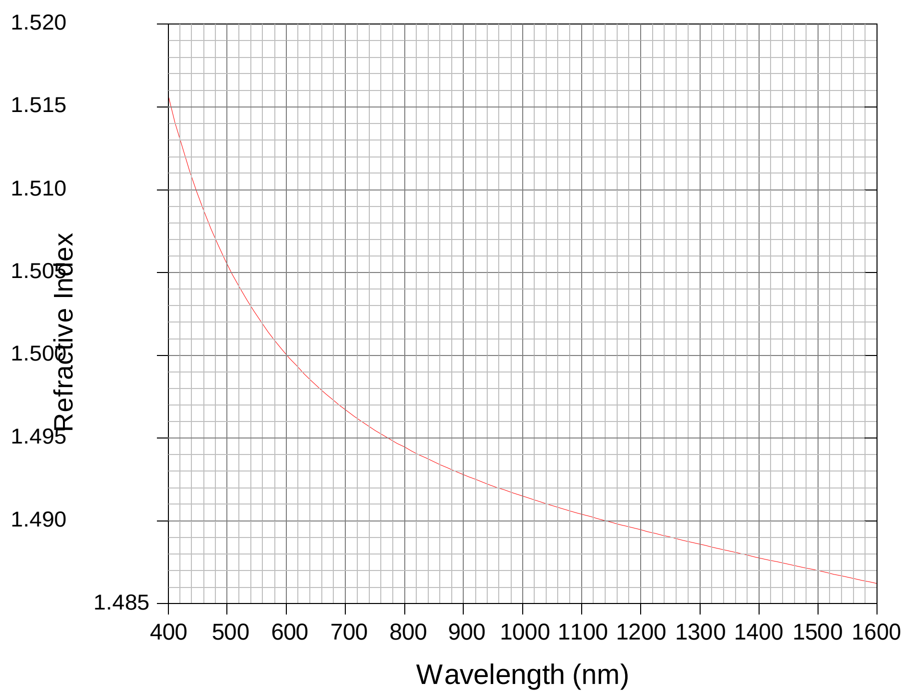


Figure 1

ONDAX

3 Reliability

3.1 Accelerated Aging

Two physical parameters impact the center wavelength and efficiency (strength) of a volume holographic grating: refractive index and modulation depth. A strong 14 mm long grating was recorded in the Telecom Cband (nominal 1550 nm) using an e-beam fabricated phase mask. The extremely high precision of the e-beam fabrication process provides exact knowledge of the grating period recorded into the material, which is independent of refractive index and recording laser wavelength.

The refractive index can be calculated by measurement of the filter's center wavelength using the equation $\lambda = 2n\Lambda$ where **l** is the measured center wavelength, n is the refractive index, and L is the known grating period.

The refractive index modulation depth, Dn, is calculated from measurement of the bandwidth of the grating. For strong gratings, the -0.5 dB bandwidth of the filter response is approximately linear with Dn, as determined through simulation.

Accelerated aging was performed at 150^{o} C.

Figure 2 shows the measurement of refractive index after time spent at 150^{o} C. The error is composed of

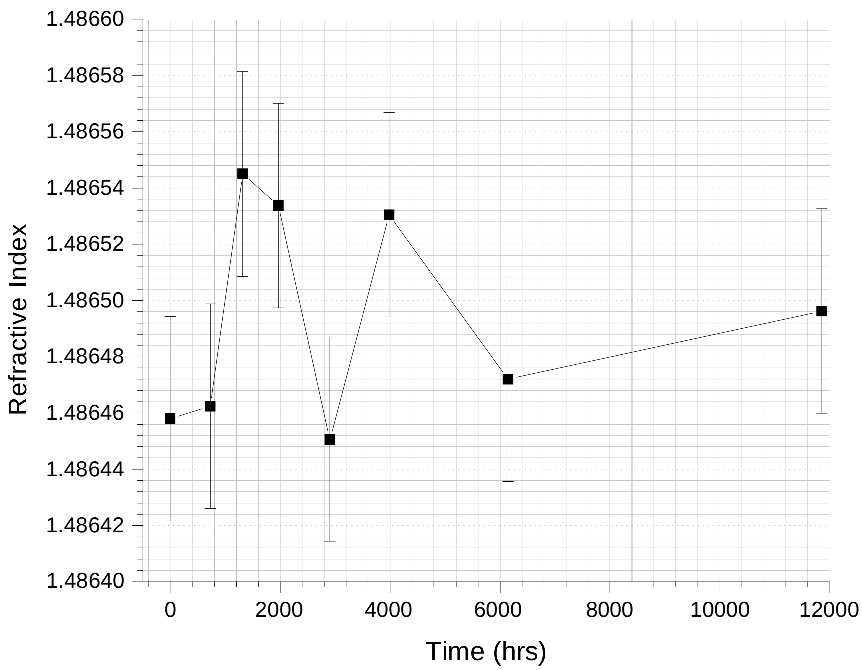


Figure 2

a +/-2^{o} C temperature uncertainty plus the 10 pm accuracy of the laser used to read out the filter.

Figure 3 shows the refractive index modulation depth after time spent at 150° C. The error is computed

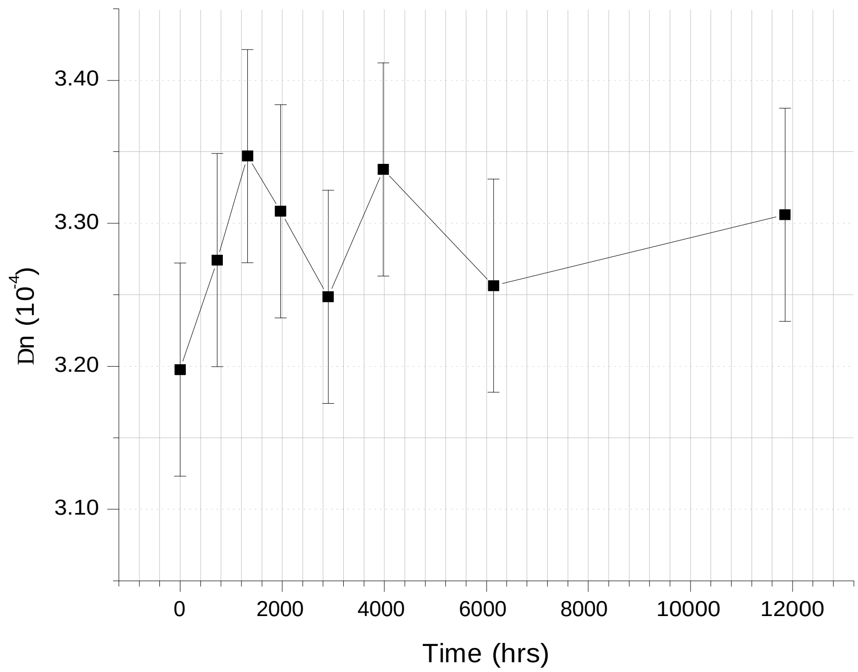
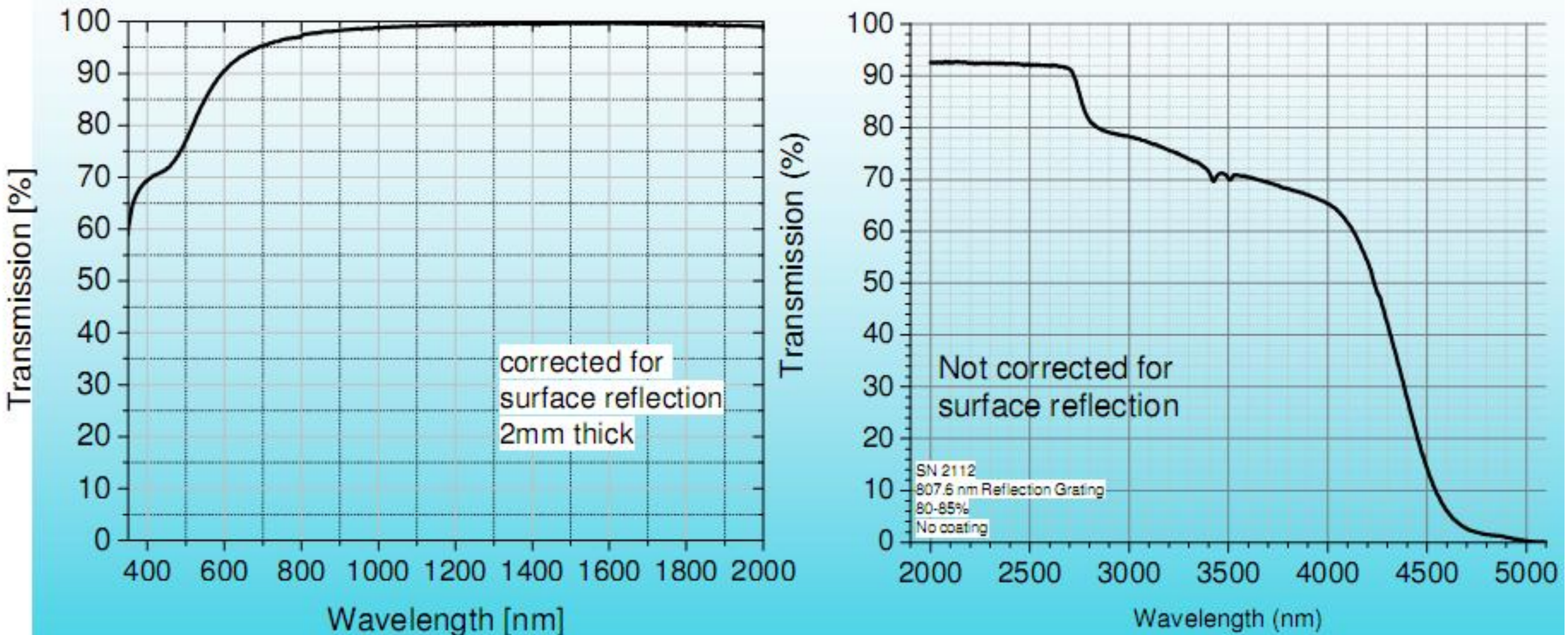


Figure 3

from the 10 pm accuracy of the laser used to read out the filter.

In both cases a lifetime or decay time constant cannot be determined because there is no observable change within the measurement resolution.

High Efficiency VHG Transmission



RoHS Compliance Statement

The below products conform to the European Union's directive 2002/95/EC, Restrictions of Hazardous Substances (RoHS). This directive prohibits or limits the content of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE) in finished electronic goods. Exemption 5 allows for lead in glass of electronic components. The six restricted components are not constituents in the below products and are not intentionally added to the products except where permitted by exemption 5.

114-80000-xxx Powerlocker Filters - Standard	114-ERxxx-xxx Powerlocker Filters - Custom

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Document History

Rev	Date	Responsible	Description of Change
-	05/02/10	E.Maye	Released

Alignment Procedure for Volume Holographic Gratings in External Cavity Lasers

Volume Holographic Gratings (VHG's) can be categorized by two different types, transmission and reflection. This document assumes that the VHG's are of reflection type, i.e. the diffracted beam is on the same side as the incident beam.

The grating structure of VHG's is within the bulk material. VHG's have similar properties to BK7. They can be handled similar to optical components such as lenses. Ondax generally manufactures VHG's with an anti-reflection coating. Use vacuum pickup tools or soft-tip tweezers to prevent damaging the coating or scratching optical surfaces.

Acetone and isopropyl alcohol can be used to clean the VHG's facets.

VHG's manufactured by Ondax have a small controlled slant angle. As a result, the angle between the diffracted beam and the surface normal is typically 0.45 degrees (See Figure 1). The slant angle avoids the specularly reflected light from the surface to co-propagate with the diffracted beam.

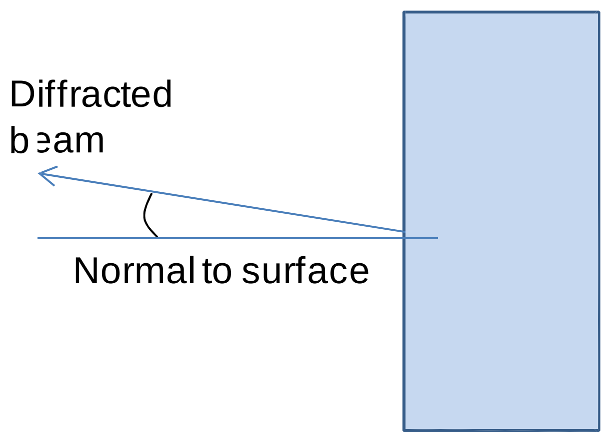

Figure 1: Angle between Surface Normal and diffracted beam

Alignment Procedure:

The basic principle in locking the wavelength of the laser diode is to orient the VHG so that the diffracted beam (filtered beam) is propagating in a direction opposite to the collimated beam. The alignment sensitivity of the VHG depends on the size of the emitter and the collimating optics. Because the emitter is smaller in the fast axis direction (emitter dimension typically 1 µm), the rotation in the fast axis is more sensitive than the slow axis (emitter size vary from 50 µm to 200 µm for high power lasers).

The alignment procedure is valid for single emitters or an array of single emitters (bars).

Figure 2 shows a side view laser diode with a fast axis collimator (FAC) to collimate the fast axis of the laser.

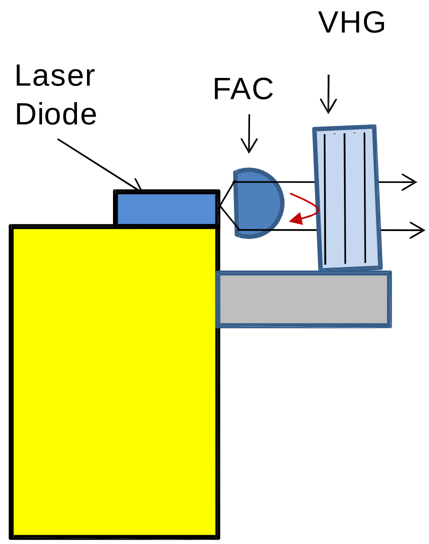

Figure 2: Side view: Laser Diode Collimated with Fast Axis Lens

The slow axis is freely diverging as figure 3 illustrates. A spherical lens is used to capture the light from all the emitters to direct it inside an integrating sphere or on the surface of a diffuser. The fiber from an Optical Spectrum Analyzer collects the light from all emitters.

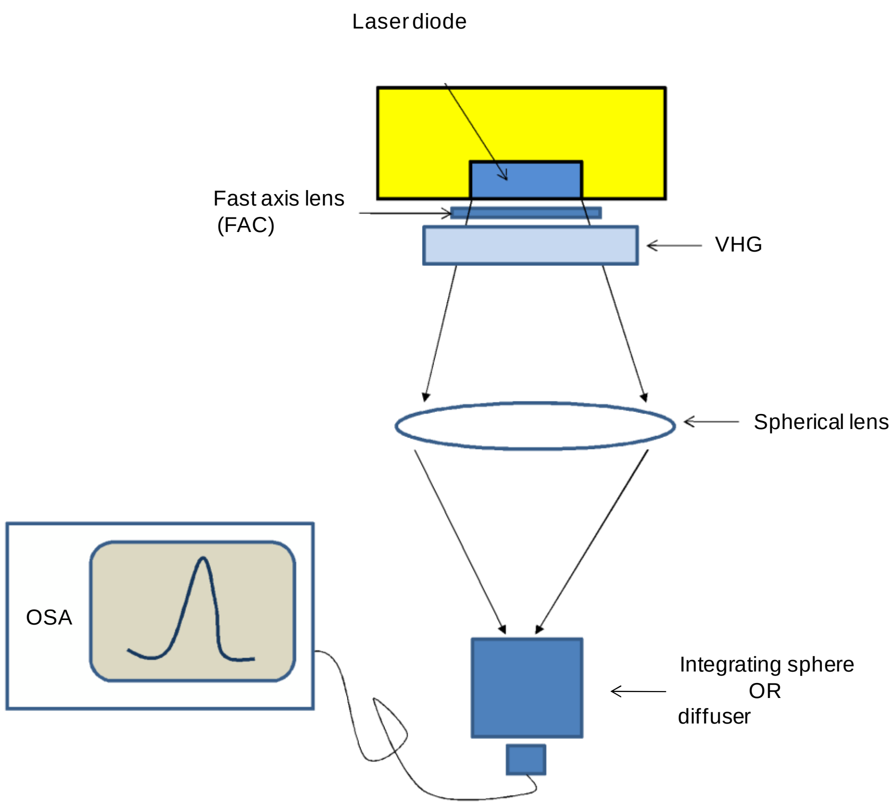

Figure 3: Top view: Laser Diode Collimated with Fast Axis Lens

- The spectrum of the laser diode should be within a few nanometers of the specified VHG wavelength.
- Mount a VHG onto a glass submount.
- Place epoxy on the surface of the VHG glass mount. This epoxy will be used to fix the VHG alignment. Do not place too much epoxy otherwise it may wet onto laser diode facet. Providing a notch on the submount will help prevent the epoxy from flowing.
- Place the VHG mounted on submount on a 6 axis stage (3 axis XYZ and 3 angles). For example use http://www.thorlabs.com/NewGroupPage9.cfm?ObjectGroup_ID=1100
- The gap between the VHG and the fast axis lens is not critical. Use a couple of mm to ensure that the VHG is not in contact with the FAC.
- Referring to figure 3, adjust the long facet of the VHG to be approximately parallel to the long side of the lens.
- Turn on the laser diode to low power (~1/10th of full power).
- Adjust the height of the VHG so that the collimated light is not clipped by the VHG.
- Observe the optical spectrum on the OSA while adjusting the angle of the VHG around the fast axis (the axis with the most angular sensitivity). A narrow peak at the wavelength of the VHG should appear once it is close to optimum alignment. At this point, light is being diffracted back into the laser cavity. Fine tuned both the slow axis and fast axis angle to optimize the locking.
- Turn the laser to full power and re-align slightly if necessary.
- Turn off the laser diode and illuminate the VHG submount with UV source to cure the epoxy.

The broad spectrum of a free running laser bar is shown in figure 4 along with the narrowband spectrum after wavelength stabilization (black curve).

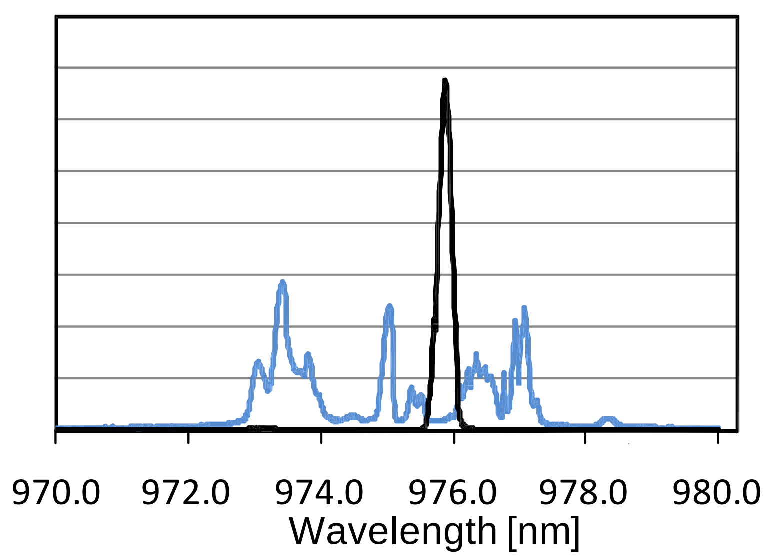

Figure 4: board spectrum of the free running laser superimposed with the narrow band spectrum after wavelength stabilization (black curve).

Once aligned properly, the stabilized wavelength is fixed by the VHG. Due to thermal expansion of the VHG material, changing the temperature of the VHG could vary the wavelength. The temperature dependence of the wavelength is typically 10pm/deg. C.