NORTHROP GRUMMAN

Improved Laser Stability for Industrial Applications

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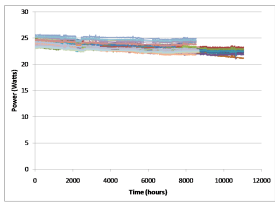
Industrial micromachining applications such as diamond jewelry cutting require high reliability and precise beam control.
High reliability and stability high finesse lasers are dependant on the gain module design.
Gain module design begins with robust pump sources.

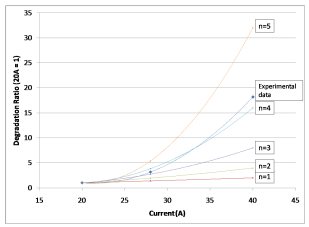
High Reliability Laser Diodes → SilentLight™ Gain Module → Patara™ High Finesse Laser

- NGAS-CEO fabricates all diode bars used with their industrial high finesse lasers systems.
- Every diode bar lot is tested for long term degradation at currents 1.5 to 2 times higher than the normal operating current.
- Every diode array is tested before it is installed in a gain module or sold to a customer.



- Twenty nine diode bar samples were tested for over 10,000 hours with no failures.
- Degradation was on average 0.55%/khr.

Degradation Rate as Function of Drive Current



- Drive current plays an important role in the degradation rate.
  - Degradation rate equation. $\frac{R_1}{R_2} = \left(\frac{I_1}{I_2}\right)^n$
  - Typical literature values are n=3 to 4.
  - N=4 closely matches data illustrated above.

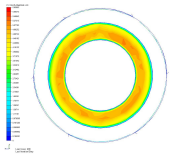
Expected Diode Lifetime at 28A and 22A

Drive Current (A)	Scale Factor	Case	Degradation Rate (per khr)	Method	Expected Lifetime (khrs)
28	1	Average	0.55%	Measured	36
28	1	Worst-Case	1.27%	Measured	16
22	0.38	Average	0.21%	Calculated	95
22	0.38	Worst-Case	0.48%	Calculated	41

- Lower drive current can significantly increase the life time of the system and lowers the worst-case failure rate.

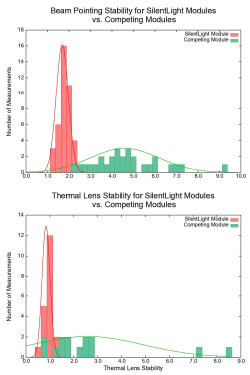
- NGAS-CEO's SilentLight™ gain module is specifically designed to increase the stability of lasers.
- Module incorporates the high reliability diodes manufactured at NGAS-CEO

Improved Flow Uniformity



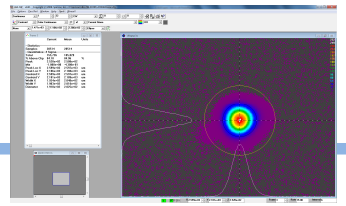
- The SilentLight™ gain module was designed to have uniform, steady flow around the rod.
- CFD flow analysis was used to confirm design changes.
- Beam pointing and thermal lens stability was measured to confirm improvements made to the gain module design.

Significant improvement in Beam Pointing and Thermal Lens Stability



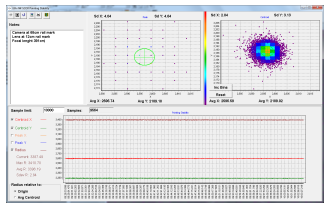
- Single mode Patara™ lasers incorporate the SilentLight™ gain module.
- Patara™ lasers are used for precision micromachining of diamonds for the jewelry industry.
- These high stability lasers result in lower weight loss after cutting.
- The normal operating current of 22 Amperes or less greatly increases the expected lifetime.

Beam Profile at Waist



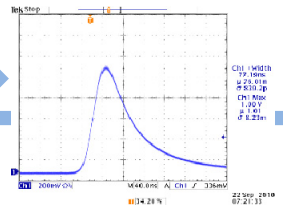
- Careful testing and selection of gain modules results in round beam profiles.
- Round profiles result in uniform, smooth cuts, reducing the amount of post cut finishing needed.

Laser Beam Pointing Stability (<6 µrad)



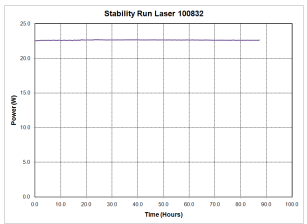
- Steady fluid flow and low degradation diode bars result in excellent beam pointing stability.
- Good beam pointing allows for more precise diamond machining.

Pulse-to-Pulse Stability (<1% rms)



- Steady fluid flow results in excellent pulse to pulse stability.
- Uniform peak powers result in higher quality cuts.

Long Term Output Power Stability



- No measureable power change in 80 hours
- Low degradation rate laser diodes and careful design of the optical components of the laser result in long term power stability.

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