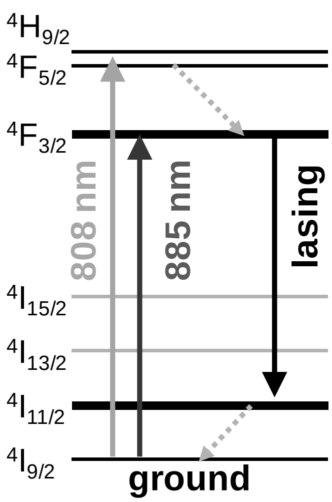
Improvements in Microchannel-Cooled High-Efficiency 885-nm Diode Laser Bars

Paul Leisher, Kirk Price, Ling Bao, Jun Wang, Weimin Dong, Mike Grimshaw, Shiguo Zhang, Mike Bougher, Suhit Das, Aaron Hodges, Mark DeFranza, Chris Ebert, Rob Martinsen Mark DeVito, Jake Bell, and Steve Patterson

nLIGHT Corporation
5408 NE 88th St. Bldg. E
Vancouver, WA 98665

Many solid-state laser systems built today use Nd:YAG crystals which are typically pumped by diode lasers. Most users currently pump at 808-nm, significantly shorter than the emission wavelength of 1064-nm, which leads to excess heat being deposited in the crystal, degrading lifetime and performance. Pumping directly into the upper level with 885-nm sources significantly reduces this effect, as shown in Figure 1, increasing efficiency by > 20% through a reduction in the quantum defect [1]. This results in reduced thermal loading at the facet (in end-pumped configurations) and reduced thermal lensing, allowing for greater TEM_{00} power extraction, improved system efficiency, and a reduction in thermal management requirements. This application has generated significant commercial interest in high-performance 885-nm diode laser pump sources. In this work, we review the development of high-performance, microchannel-cooled diode laser bar arrays operating at 885 nm.



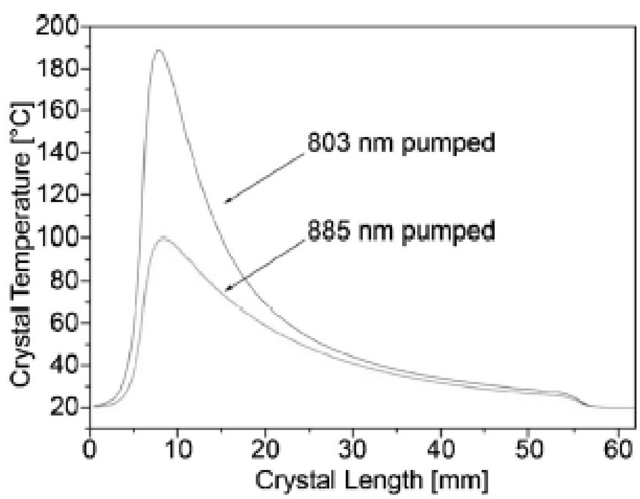


Figure 1. (Left) Nd:YAG systems can be pumped at either 808-nm or 885-nm. (Right) Pumping at 885-nm is predicted to significantly reduce the amount of heat built up in the YAG crystal, enhancing performance and lifetime [1].

Figure 2 illustrates recent results from nLIGHT's new commercial high-efficiency 885-nm laser design [2]. This data is taken from cm bar arrays (50% fill factor, 1.5 mm cavity length) bonded using In solder to Cu microchannel-cooled heatsinks (see left inset). The diodes operate CW at 25 °C, 0.2 lpm water flow. The bars are rated at 100W and operate >60% power conversion efficiency. Also shown is the diode lasing spectrum taken at 100W. Note the laser operates < 2.2 nm FWHM spectral width.

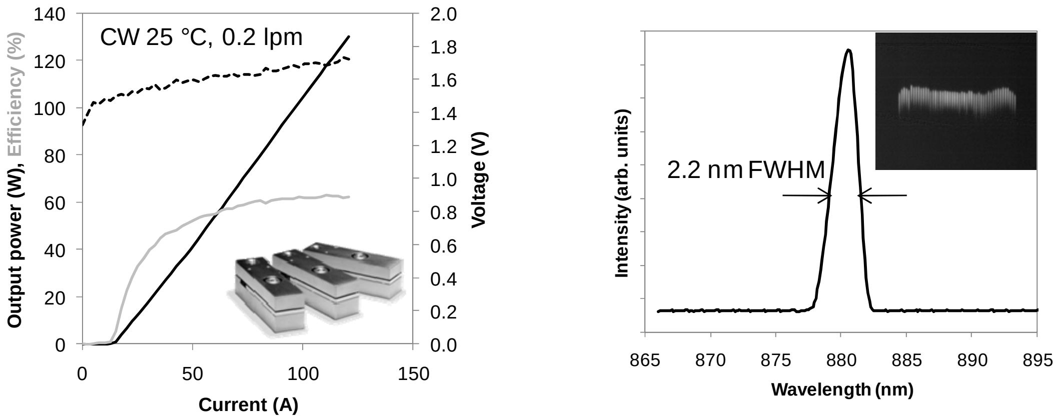


Figure 2. Diode laser characteristics for the high efficiency 885-nm laser design in a 50% fill factor, 1.5 mm cavity length bar. The bar was bonded using In solder to a copper microchannel-cooled heatsink. Testing was done at 25 °C, 0.2 lpm water flow. (Left) LIV curve showing >60% power conversion efficiency at 100 W. (Right) Lasing spectra taken at 100W shows < 2.2 nm FWHM spectral width. The inset shows a spatially-resolved emitter spectrum taken at 100W.

Figure 3 illustrates preliminary lifetime qualification data on the new high efficiency design. A quantity 17 microchannel-cooled laser bar arrays were sampled from three independent epitaxy batches. These diodes were placed on lifetest at 105 A, 40 °C (corresponding to an acceleration factor of ~1.9 relative to the rated operating condition [3]). The observed spike in the data at 48 hours is a measurement artifact (due to the parts having been removed and replaced on the lifetest rack) and can therefore be disregarded. One device is observed to have suddenly degraded (by ~14%) at 165 hours; the other 16 diodes show no signs of sudden or wear-out degradation. To date, >9,900 equivalent accelerated hours of failure-free operation (defined here as >20% reduction in output power) have been recorded. The study is still underway at the time of publication.

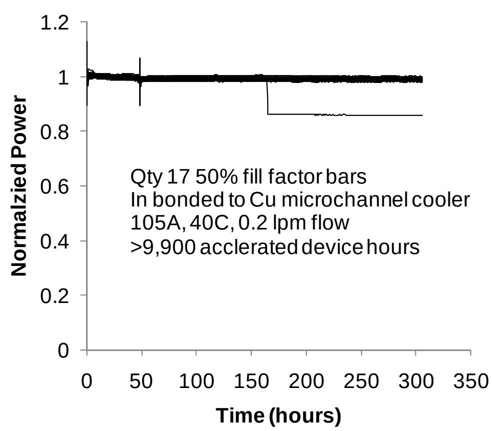


Figure 3. Preliminary reliability qualification data of 17 microchannel-cooled high-efficiency 50% fill factor laser diode cm bar arrays. To date, >9,900 equivalent accelerated hours of operation have been recorded. Reliability testing is still ongoing at the time of publication.

References

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[2] P. Leisher, et al., *Proc. SPIE*, vol. 6952, (2008).

[3] H. Pfeiffer, et al., *OFC Conference*, no. ThN4, (2002).