High brightness semiconductor lasers at 1300-1600 nm

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ABSTRACT

We present recent advances in high power semiconductor laser bars and arrays at eye-safe wavelengths including increased spectral brightness with internal gratings to narrow and stabilize the spectrum. These devices have the potential to dramatically improve diode pumped Er:YAG systems and enable new direct diode applications.

Keywords: Diode laser, semiconductor laser, eye-safe

1. Introduction

Diode lasers in the 1300 nm to 1600 nm regime are used in a variety of applications including pumping Er:YAG lasers, range finding, materials processing, and aesthetic medical treatments. In addition to the compact size, efficiency, and low cost advantages of traditional diode lasers, high power semiconductor lasers in the eye-safe regime are becoming widely used in an effort to minimize the unintended impact of potentially hazardous scattered optical radiation from the laser source, the optical delivery system, or the target itself.

2. High power fiber coupled modules

QPC has developed high power multimode semiconductor laser bars at 1320nm and has integrated them into high brightness fiber coupled modules. The modules produce >15W at 1320nm at an operating current of 50A and a voltage <1.25V. The fiber output is 400 micron with a numerical aperture of 0.22. This Fabry-Perot laser design exhibits a spectral width of ~8nm FWHM.

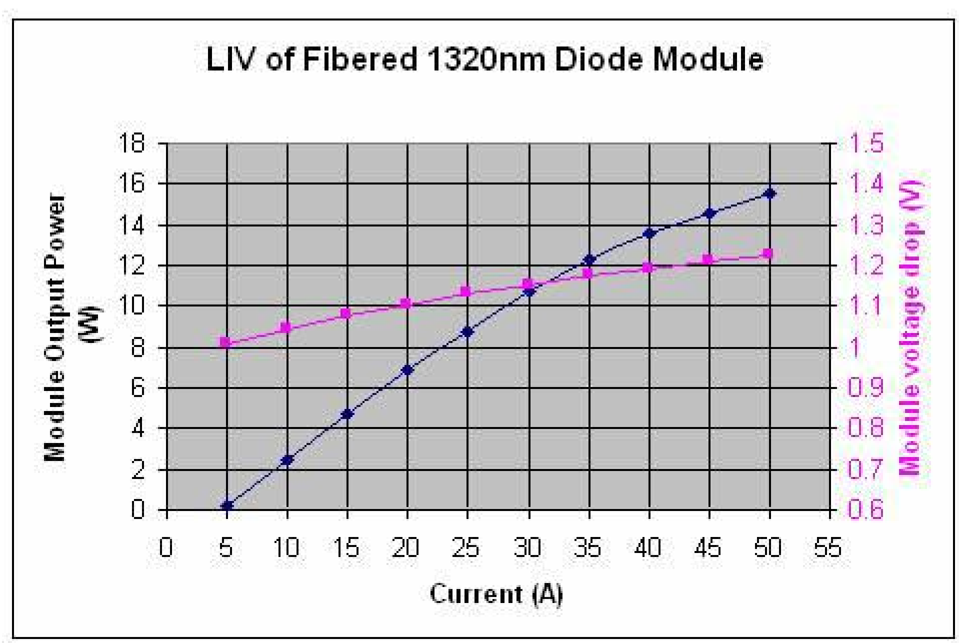

Fig. 1. 1320 nm fiber coupled module, 400 micron, 0.22NA.

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3. High power modules with Internal Gratings

High power diode lasers are conventionally formed by inserting a gain-producing active stripe into a resonant cavity formed by reflective facets at each end of the laser. Aside from defining the periodic “comb” of resonant frequencies, this Fabry-Perot cavity provides essentially no wavelength control. Wavelength of emission is instead controlled by the gain spectrum of the semiconductor used as the active layer. Unfortunately, this gain spectrum is “flat” (with width ~ 20 nm), and strongly temperature dependent. As a result, the output spectrum is broad, particularly at high power fluxes, and highly dependent on the operating temperature, typically changing by 0.3 – 0.4 nm per ºC.

For high power devices, external methods have been demonstrated such as the use of using seed lasers in MOPA designs[1], the use of external lenses and bulk gratings[2], or volume Bragg gratings[3]. These external approaches require sensitive alignment techniques, costly additional lasers and or optics, and specially designed coatings. Internal DFB gratings similar to those used in telecom lasers would offer an on-chip solution, but, unfortunately, it is not trivial to adopt this approach for high power diode lasers since they are multi-mode and more difficult to lock.

To address this need, QPC has developed high power multimode semiconductor laser bars at 1532 nm with internal “on-chip” gratings. Figures 2 and 3 show the power versus current and output spectrum of a 1532 nm bar operating at 20 Watts at 65 A on a conduction cooled mount. The output spectrum exhibits a spectral width less than 1.6 nm wide, roughly 5-10 times narrower than a similar Fabry-Perot without an internal grating.

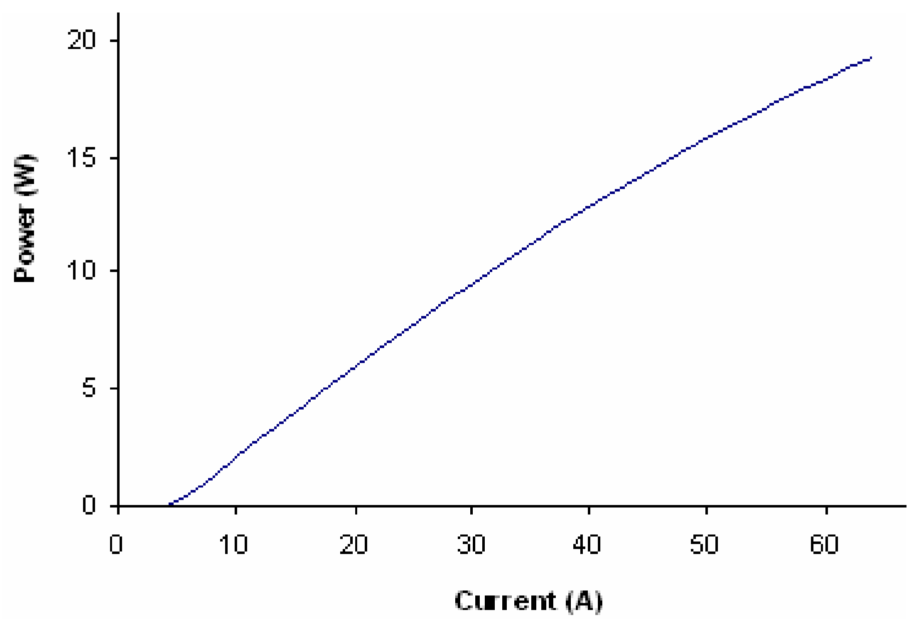

Fig. 2. 1532 nm bar with internal grating stabilization, power versus current performance

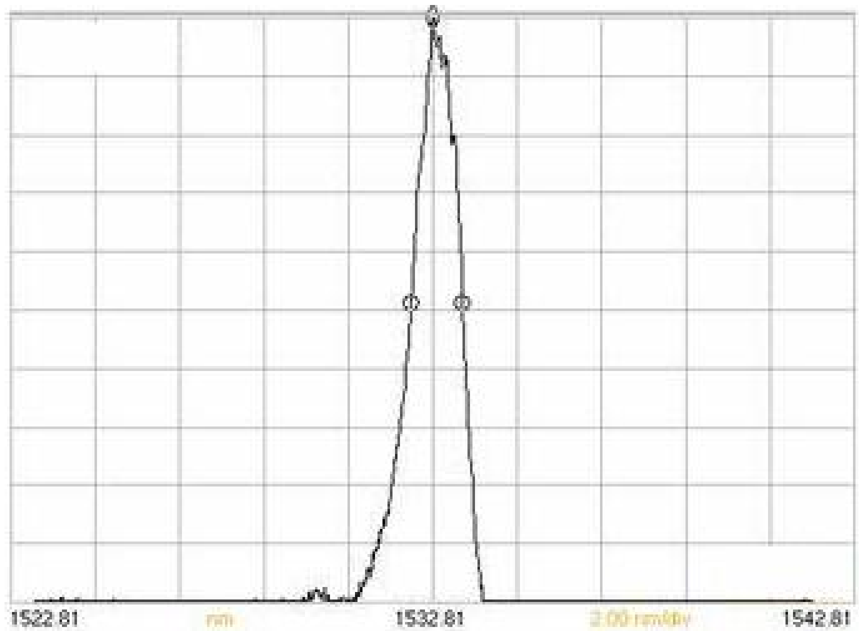

Fig. 3. 1532 nm bar with internal grating stabilization, output spectrum at 20 W, showing <1.6 nm FWHM.

QPC has developed high power coupled laser modules with internal gratings at 1532 nm. The modules produce 13W at 1532 nm at an operating current of 60A and a voltage <1.5V. The fiber output is 400 micron with a numerical aperture of 0.22. This module with internal grating design exhibits a spectral width of ~1.22 nm FWHM.

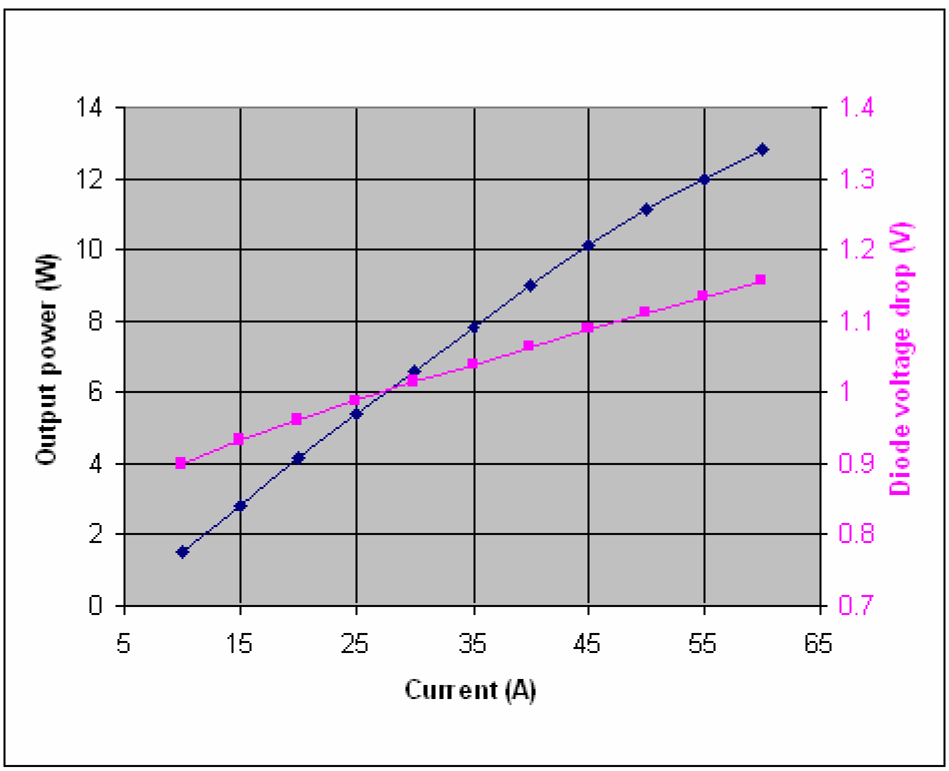

Fig. 4. 1532 nm bar with internal grating stabilization, output power and voltage versus current.

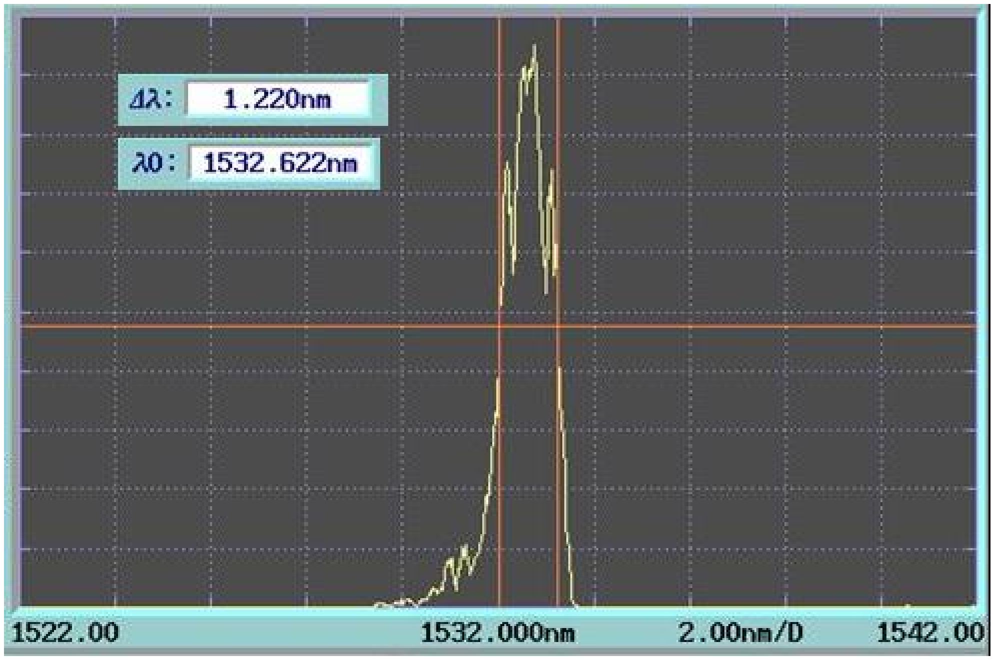

Fig. 5. 1532 nm bar with internal grating stabilization, output spectrum at 13 W, showing 1.22 nm FWHM.

QPC has also developed high power water cooled bars and stacked arrays based on the internal grating lasers at 1532nm. Figures 6 and 7 show the power versus current and output spectrum of a 1532 nm water cooled stack operating at 175 Watts at 95 A on a conduction cooled mount. The output spectrum exhibits a spectral width less than 2 nm wide, roughly 5-10 times narrower than a similar Fabry-Perot without an internal grating.

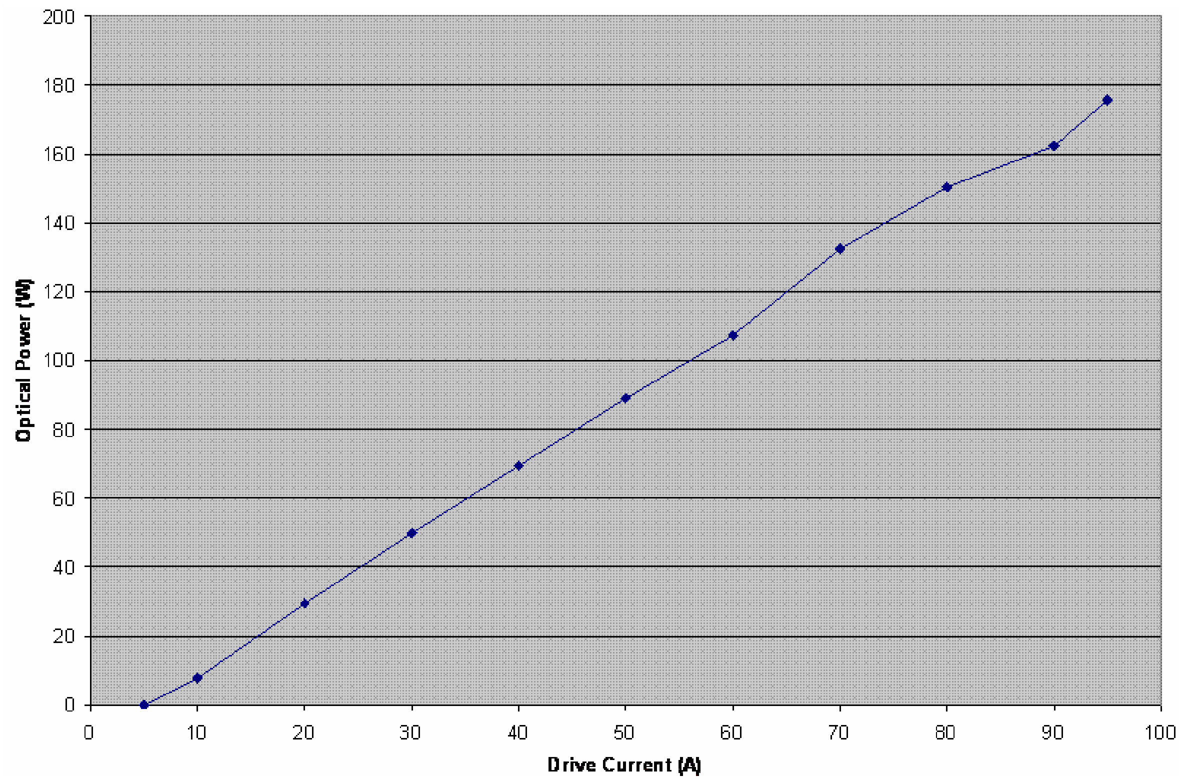

Fig. 6. 1532 nm water cooled stack with internal grating stabilization, power versus current performance

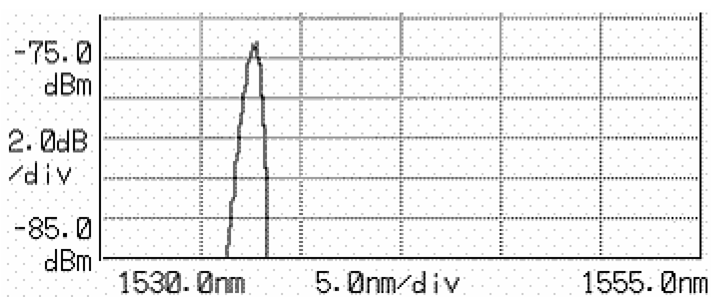

Fig. 7. 1532 nm stack with internal grating stabilization, output spectrum at 175 W, showing <2 nm FWHM.

QPC has also developed devices at 1470 nm with internal grating and achieved >1.4 W at <5 A from 100 µm wide stripe lasers on a conduction cooled mount. The output spectrum at 20 ºC and exhibits a spectral width < 1 nm wide, roughly 10 times narrower than a similar Fabry-Perot without an internal grating. The wavelength dependence on temperature of the 1470 nm and 1532 nm devices is <0.1 nm/ºC, >3 times smaller than a F-P laser.

4. Conclusions

The recent advances in high brightness, high power semiconductor laser technology include 20W 1320nm bar performance with 8 nm FWHM spectral width, 13W 1532nm fiber coupled module performance with <1.25 nm FWHM from 400 micron 0.22NA, and < 2nm FWHM spectral with from 175W 1532nm high power stacks with internal gratings.

ACKNOWLEDGEMENTS

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