High efficiency high brightness diode lasers at 1470 nm/1550 nm for medical and defense applications

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ABSTRACT

Diode lasers in the 1400 nm to 1600 nm regime are used in a variety of applications including pumping Er:YAG lasers, range finding, materials processing, aesthetic medical treatments and surgery. 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.

In this article we describe the performance of high efficiency high brightness InP laser bars at 1470nm and 1550nm developed at QPC Lasers for applications ranging from surgery to rangefinding.

Keywords: Eyesafe, rangefinder, InP, surgery, diode, laser, semiconductor, LIDAR, brightness

Figure 1: QPC Lasers Ultra-500

At present, 1470nm lasers are used to treat benign prostatic hyperplasia (enlarged prostate), for chest surgery, for varicose vein treatments as well as aesthetic medical treatments. For example, traditional laser treatment for varicose veins targets the lining of the blood vessel to cause blood coagulation and destruction of the vein which is painful and leads to a long recovery period. Typically, these surgical lasers are based on power-hungry, high maintenance, laser platforms that are expensive and bulky.

However, high power direct diode solutions based on precise wavelength control at the peak of water absorption in the wavelength regime around 1440nm enable fast ablation rate and efficient blood coagulation at a fraction of the cost and size of existing laser systems. For example, the 1470nm diode laser targets the water in the vein walls to collapse the walls for complete vein closure [1]. Another advantage is that lasers in this eye-safe regime minimize the unintended impact of potentially hazardous scattered optical radiation from the laser source, the optical delivery system, or the target itself. This is also important in defense applications including use in illumination, covert operation and eyesafe rangefinding.

By solving fundamental material problems, such as improvements in epitaxial design, growth process control and waveguide structure in the indium phosphide (InP) laser diode semiconductor materials, we have developed lasers that are significantly more efficient and brighter at long wavelengths, and that can operate at higher temperatures. This means that the diodes can operate warm and under higher power density with lower power consumption. We have demonstrated efficiency of 20% at 80C and slope efficiencies of >1W/A. (see figure 2, 3)

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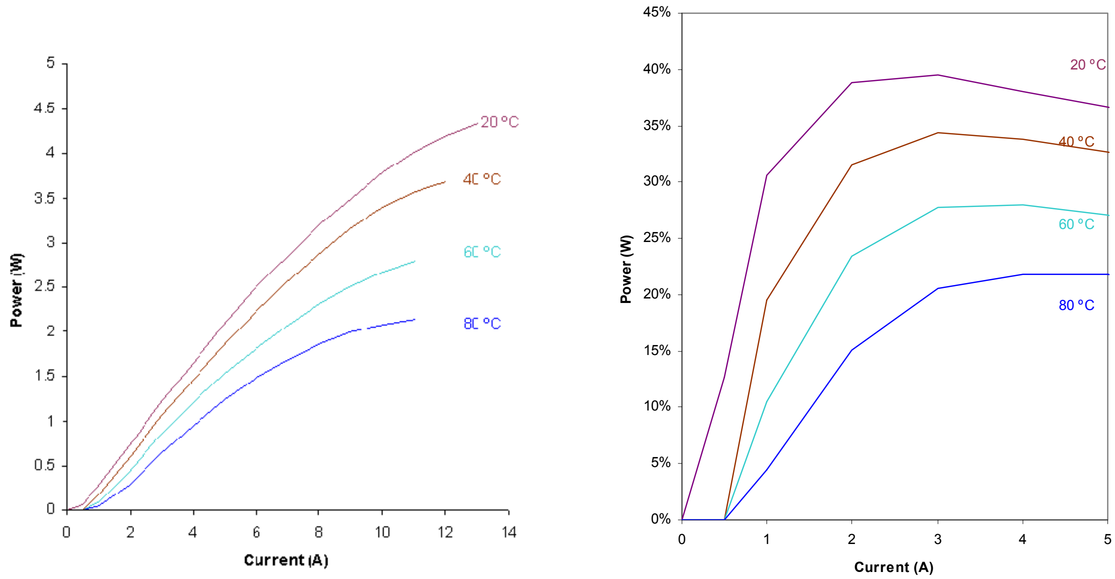

Figure 2: Power and Efficiency Over Wide Temperature Range (85um Emitter)

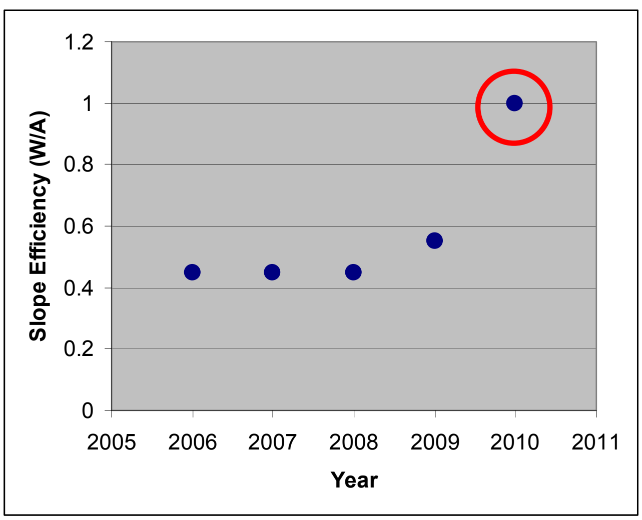

Figure 3: Highest W/A Commercially Available (1470nm Bar)

These advances allowed us to achieve >15W of eyesafe power at 1550nm from a 100um stripe width single emitter in a standard TO-18 package. (see figure 4) 30W peak power using a pulse width of 150nsec and a duty cycle of 0.1%. Running the diode using 20A current and <7V to obtain peak powers in excess of 15W gives a typical conversion efficiency of >10%. (see figure 5)

These wavelengths are ideal when directing weapons at a live target as they cannot be seen without the use of infrared glasses. This level of brightness with a compact, efficient direct diode module facilitates deployment of applications such as light detection and ranging (LIDAR) at 1550nm where lower Rayleigh scattering is observed.

Figure 4: 1550nm in TO Package

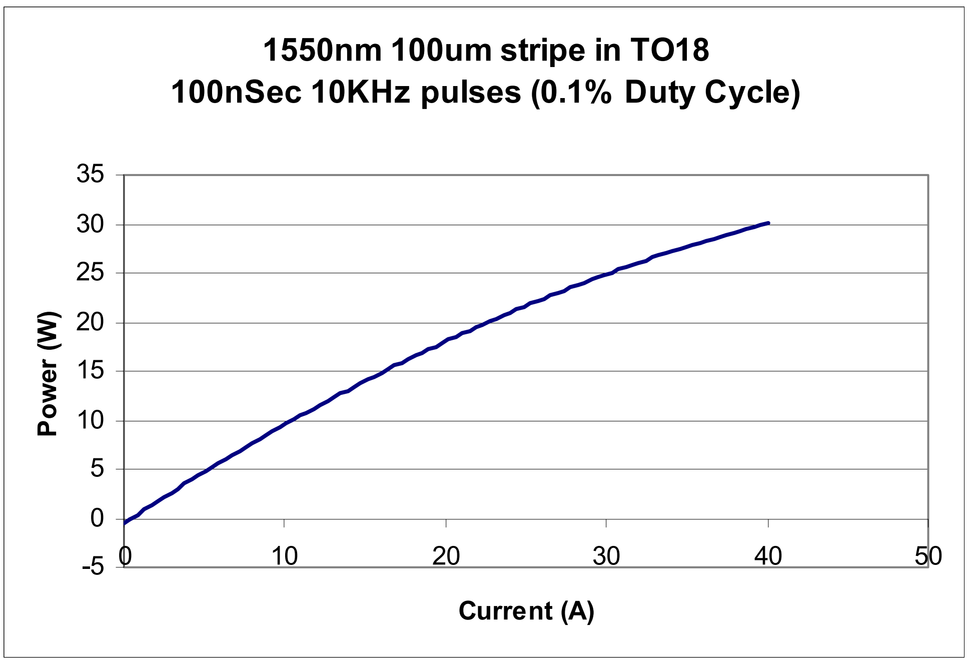

Figure 5: 10kHz, 0.1% Duty Cycle

We have combined these advances in chip technology with state of the art beam combining techniques based on micro-lens beam shaping and polarization optics to build a novel laser for therapeutic use. By combining high water absorption at 1470nm for fast cutting with high continuous wave power for large coagulation depth, the Ultra-500 200W laser (see figure 1) has the potential to improve surgical procedures such as Benign Prostatic Hyperplasia, thoracic surgery, or ENT [2]. The diode laser flexibility also enables fast pulsing of the laser for high peak power applications such as stone treatments (lithotripsy). The small laptop-size and low power consumption of the diode laser module enables a three- to five-fold reduction in size and cost of ownership compared to existing laser systems.

In summary, the advances in chip technology have allowed us to develop two state of the art products. The Ultra-500 is the only laser of its class capable of delivering 200W CW from a medical-grade surgical delivery fiber at 'eyesafe' wavelengths. It is also the first laser to reach >25% efficiency above 100W, a 40% improvement over the nearest competitor. See figures 6 and 7. The single emitter at 1550nm can produce >30W peak power and can run at elevated temperatures in a standard TO package making it ideal for defense applications.

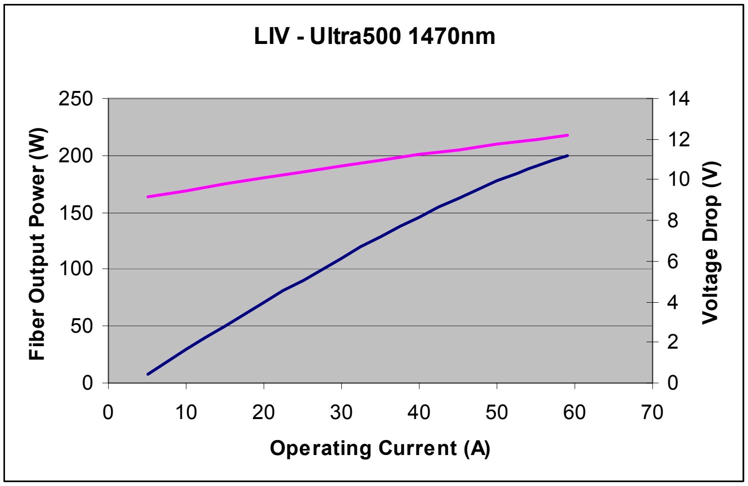

Figure 6: LIV Curve with 600um Core Fiber Delivery

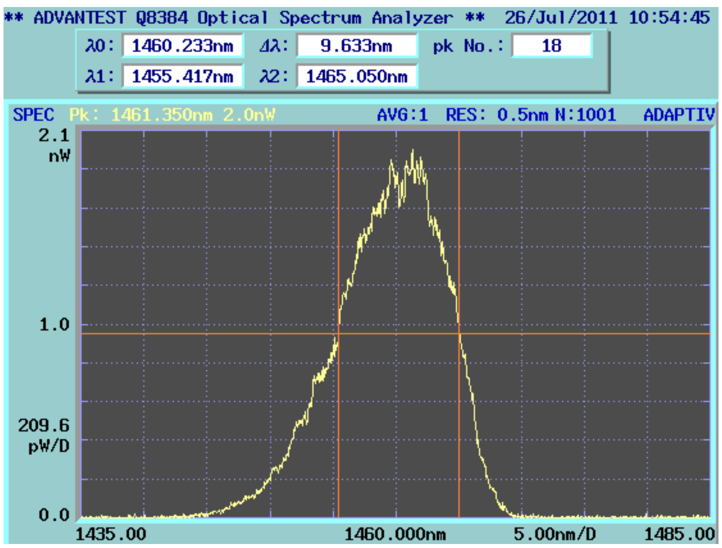

Figure 7: Spectrum with 600um Core Fiber Delivery

References:

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[2] “New alternatives for laser vaporization of the prostate: experimental evaluation of a 980-, 1,318- and 1,470-nm diode laser device” Felix Wezel · Gunnar Wendt-Nordahl · Nina Huck · Thorsten Bach · Christel Weiss · Maurice Stephan Michel · Axel Häcker