Blue Laser Diode

Part No. *NUBM47 (V2)*

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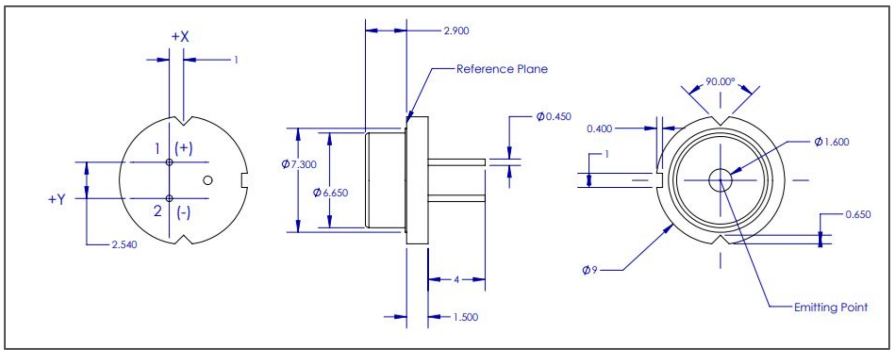
I. Features

Wavelength: 445 nm
Can Type: TO-5 (9 mm)
Output Mode: Multi-Transverse-Mode (MTM)

Outline Dimension



II. Initial Electrical/Optical Characteristics

Item		Value	Unit
Optical Output Power		7	W
Dominant Wavelength		445	nm
Typical Thereshold Currency		350-450	mA
Typical Forward Current		3.7	A
Typical Operating Voltage (at 7W)		3.8	V
Input Electrical Power		14.44	W
Heat Power		7.44	W
Output Power Efficiency		48.5	%
Beam Divergence*	Parallel	14	degC
	Perpindicular	46	degC
Slow Axis Stripe Width		55	um
Slow Axis M^2 Value (Estimate)		23.72	

*Full Angle 1/e^2

III. Other

Item	Value	Unit
Operating Temperature Range	0-60	degC
Storage Temperature Range	-40-85	degC
Typical Lifetime (at 25 degC)	20000	hr

IV. About NUMB44 and NUMB47 Blue Nichia Diodes

NUMB44 (V1) and NUMB47 (V2) blue laser diodes are manufactured by Nichia Corporation in Japan as banks or arrays of diodes to be used in laser-enabled projectors. The NUMB44 (V1) arrays contain 8 blue diodes, and the NUMB47 (V2) 10 diodes per array. Nichia has an exclusive agreement with a projector company to sell these highpower blue diodes. Because of this arrangement, both diodes must be removed from the banks by de-soldering them. Nichia will not sell the diodes directly to users, and the corresponding datasheets are not made available outside the company. This APS datasheet for the NUMB47 diode is our attempt to bring known information into one place. It should be mentioned that 6W NUMB44-XX diodes have been out of production for several years and have been replaced by NUMB-47-XX 7W diodes that have a slightly higher operating efficiency and lower threshold. More detailed information regarding Nichia high-power blue diodes may be found here [1].

V. NUMB47 Spectral Output Data

Here we present Spectral Output data for the NUMB47 7W blue Nichia diode. In Figure 1 we show the output spectral distribution as a function of wavelength for an output power of 7W. The peak wavelength is 446 nm, and the full-width at half-maximum bandwidth is about 1.5 nm. The data were obtained with an Optical Spectrum Analyzer (OSA) with a resolution of 0.05 nm.

VI. Output Power Obtained With APS Heatsinks

At APS we have extensive experience operating high-average-power diode-pumped solid-state lasers, and that experience has proved very useful in designing optimum heatsinks for the NUMB44 and NUMB47 diode lasers. If heat generated in the diode junction is not efficiently removed, the diode junction temperature rises, the slope efficiency decreases, and the threshold current increases. This seems particularly true for high power blue diodes. As a consequence, one must differentiate between transient and true continuous-wave (CW) power measurements. When the heatsinking is not adequate, the diode and heatsink temperature vary with time.

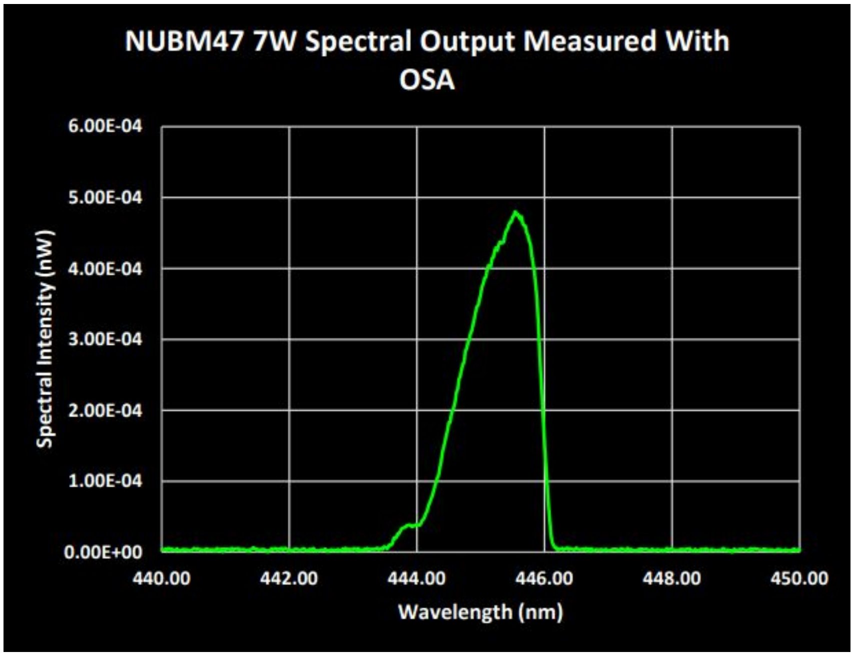


Figure 1. NUBM47 Output Spectral Distribution at an Output Power of 7W

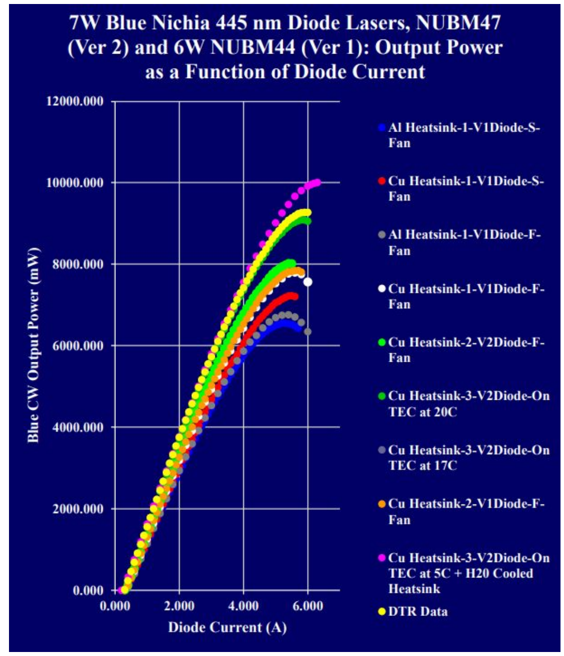


Figure 2. Compendium of Blue Diode Output Power as a Function of Diode Current For Various Heatsink Conditions

Upon turn-on the diode emits its maximum power, which then decreases with time until it comes into a true CW output power, that is always less than the starting power. With sufficient heatsinking, however, the starting diode power is maintained with time, a situation we refer to as "sustained average power", where the starting power and the power at any time after startup are identical. We have found examples in some websites for example, that emphasize the peak starting output power to inflate their blue average power numbers which of course are larger than their true CW values obtained say an hour or two after turn-on, because their heatsinking is inadequate. Only sustained average power, obtained well after turnon should be quoted. In Figure 2, we show a compendium of output power as a function of diode current, for a number of heatsink conditions, including aluminum and copper heatsinks, slow and fast fans (low CFM and high CFM), and with a TEC at different temperatures mounted on a water-cooled heatsink.

For comparison we have included data reported by a commercial source [1]. These tests have confirmed that for fan-cooled heatsinks, the obtained average power is lower than with water-cooled heatsinks, and that a larger air flow increases average power. The best results are achieved with water-cooled heatsinks that may also include a TEC chosen to remove the large heat load. For the V2 diode (NUBM47), rated for 7W output power around room temperature, we have obtained over 10W of output with a water-cooled heatsink and a TEC set at 5 degC. It should be emphasized that our results are all quoted as sustained average power, not peak power. All power measurements were obtained with a calibrated Gentec CW calorimeter.

To illustrate the concept of sustained average power, Figure 3 shows the measured output power (10W) for a two-hour time interval; after a minor power increase in the first 5 minutes of operation, the curve is absolutely straight-line for the rest of the run, indicating that sustained output has been achieved.

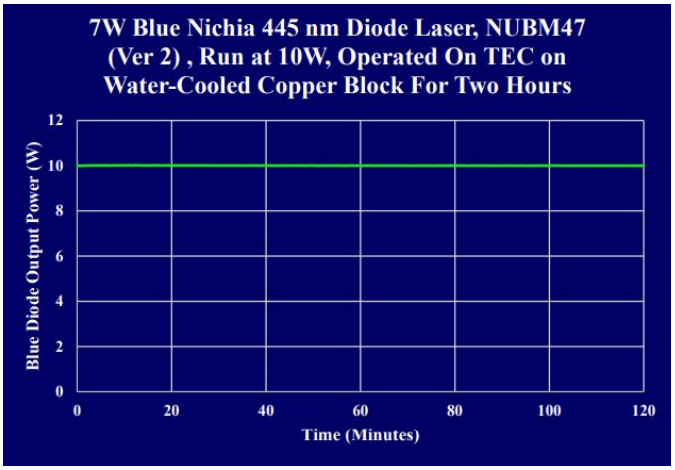


Figure 3. Output Power as a Function of Time for Two Hours, Illustrating The Concept of Sustained CW Output Power

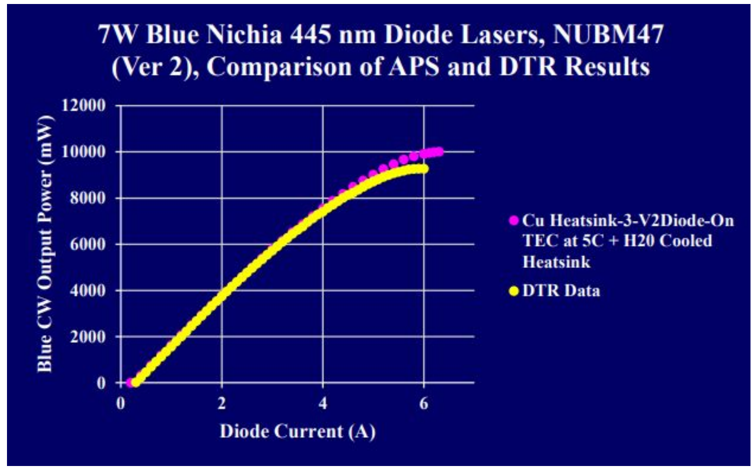


Figure 4. Direct Comparison of APS and DTR High-Power Results

To bring clarity to the similarity of the APS and DTR results shown in Figure 2, we show in Figure 4 a direct comparison of the two results. Both measurements used NUBM47 blue diodes. To discern whether or not the DTR values were peak or sustained, we purchased the largest circular Cu heatsink they offer (35 mm diameter) as well as the holding clamp, as shown in Figure 5. The NUBM47 diode was installed in this unit, which was cooled by convection and some conduction to the optical table.

In Figure 6, data are shown for the two cooling scenarios shown; with no forced air cooling, and with some forced-air convection-cooling. An NUBM47 7W blue diode was installed in the heat sink and operated at 8W; operation was for 2 hours after turn-on. With no forced-air convection, the output power (purple) decayed from 8W to about 5.3W over two hours, a drop of 2.7 W, or a loss of 33.8%. Clearly this is not a case of sustained average power, due to the heatsink thermal impedance being too high.

In the second plot (green), even the addition of some convective cooling using a small fan improved the heatsinking considerably, enough to easily reach a sustained average power of 7.3 W after a short time interval of about ten minutes. The loss of 0.7 W in this case could be minimized further by using more aggressive air-cooling or by the use of water-cooling and TEC cooling.

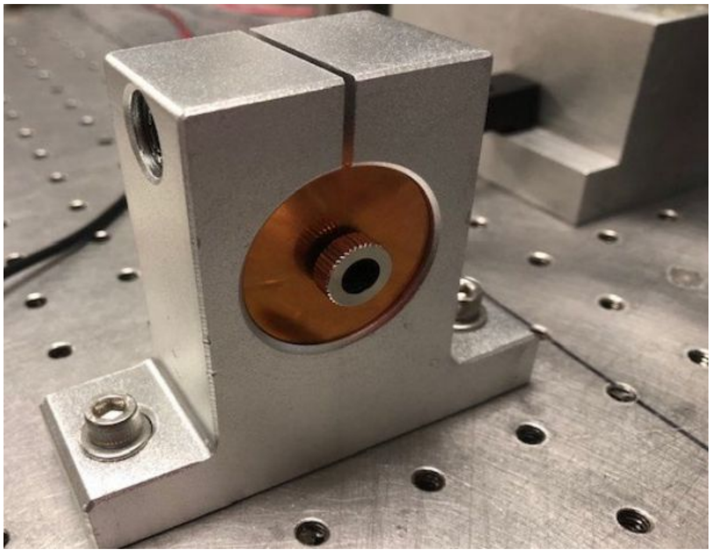


Figure 5. Circular (35 mm) Diameter Copper Heatsink With Aluminum Holding Clamp

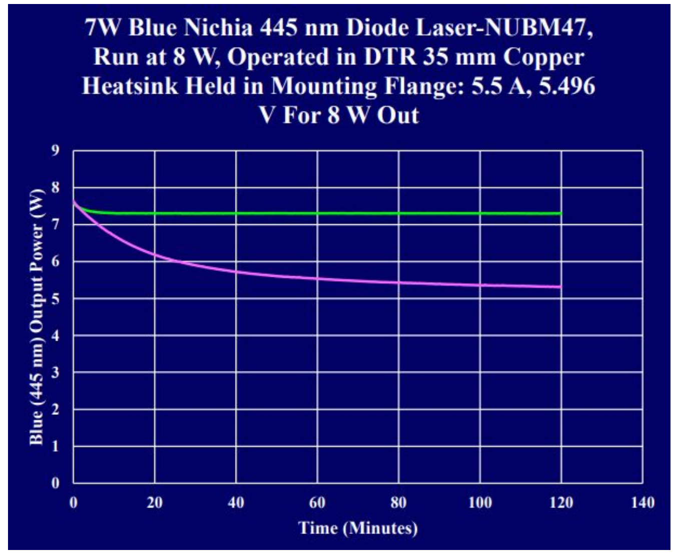


Figure 6. Output Average Power Data Obtained Using Circular (35 mm) Diameter Copper Heatsink With Aluminum Holding Clamp

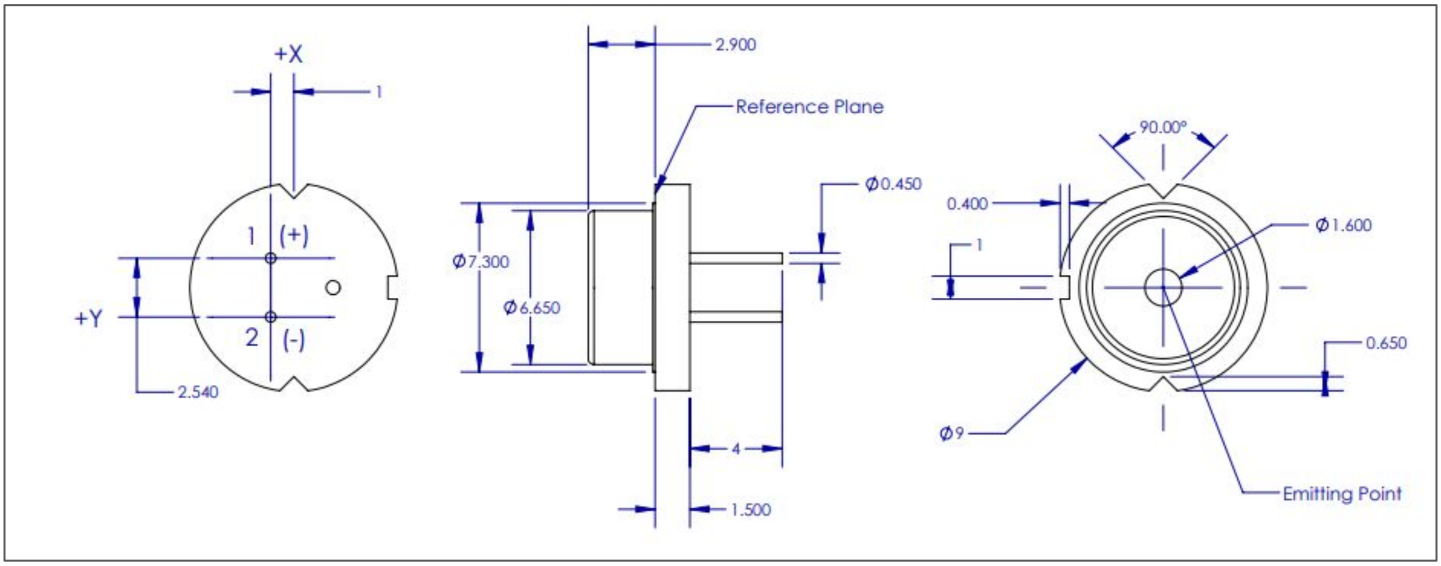
Clearly the most effective cooling scenarios result in not only sustained output power, but no loss of average power. Here, while we do not know for certain that the DTR data are peak and not sustained CW values, the data of Figure 6 strongly suggest they are the former [3]. It should be pointed out that in our experiments, we were unable to achieve 10W of output power using just passive-convectively cooled or forced-air-cooled aluminum or copper heatsinks. Only the addition of water-cooling and a TEC enabled operation above 8W.

VI. Heatsinking The NUBM44 and NUBM47 Blue Diodes

APS offers Cool Photons water-cooled heatsinks to achieve sustained high-average-power operation. One may purchase the integrated heatsink alone, without the mounting block, with provision for watercooling, connection leads, and an aspherical collimator, or with the convenient mounting block. Visit **www.apslasers.com**

Figure 7. APS Developed Cool Photons Module

VII. 9mm Outline Drawing and Pin Outs



VIII. Diode Protection

NUBM47 and NUBM44 blue Nichia laser diodes do not contain a photodiode, or protection circuitry against static electricity or electrical surges. Use wrist strap or anti-static gloves when handling these diodes.

VIV. References

[1]https://sites.google.com/site/dtrslasershop/home/diodes/6wnubm44-445nm-laser-diode

[2] Data measured or calculated at APS.

[3] Confusion between peak and sustained output power can be avoided by simply running all output power measurements until the change in output power disappears. Without agreement between the laser, hobbyist, and maker communities to always quote and publish only true sustained average power results, there will continue to be confusion. It is in the best interests of all sellers and users of such lasers to offer and purchase devices whose output power performance is certified to be sustained average power.