

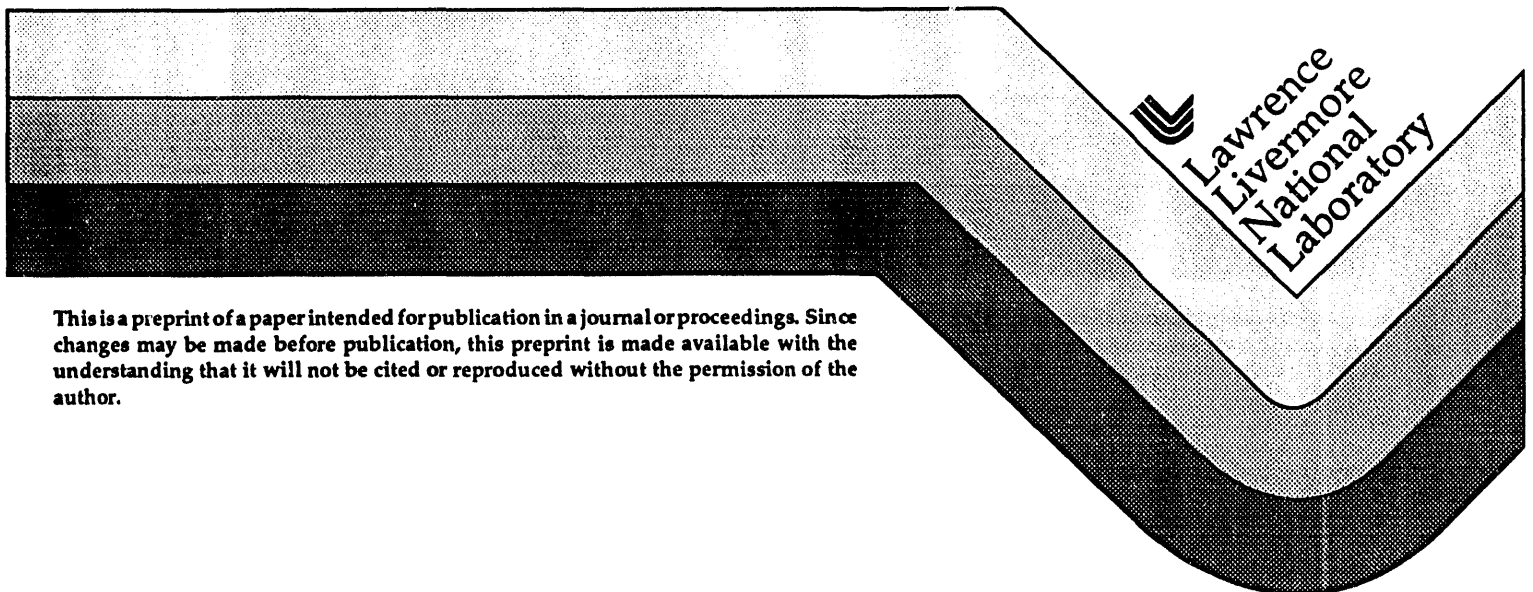
UCRL-JC-115945  
PREPRINT

## High-Power CW Operation of AlGaInP Diode-Laser Arrays

M. A. Emanuel, R. J. Beach, J. A. Skidmore,  
D. Hudson, W. J. Bennett, B. L. Freitas,  
N. W. Carlson

This paper was prepared for submittal to the  
CLEO '94  
Anaheim, CA  
May 8-13, 1994

January 1994



This is a preprint of a paper intended for publication in a journal or proceedings. Since changes may be made before publication, this preprint is made available with the understanding that it will not be cited or reproduced without the permission of the author.

MASTER

*ds*  
DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

#### DISCLAIMER

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

## **High-Power CW Operation of AlGaInP Diode-Laser Arrays\***

**M. A. Emanuel, R. J. Beach, J. A. Skidmore, D. Hudson, W. J. Benett,**

**B. L. Freitas, and N. W. Carlson**

**Lawrence Livermore National Laboratory**

**P.O. Box 808, L-250, Livermore, CA 94550**

**(510) 423-7645**

### **Abstract**

We report 40 W cw power output with 40% power conversion efficiency from an AlGaInP diode laser array mounted on a microchannel cooled heatsink.

---

\* This work was performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under contract W-7405-Eng-48.

## High-Power CW Operation of AlGaInP Diode-Laser Arrays

M. A. Emanuel, R. J. Beach, J. A. Skidmore, D. Hudson, W. J. Benett,

B. L. Freitas, and N. W. Carlson

Lawrence Livermore National Laboratory

P.O. Box 808, L-250, Livermore, CA 94550

(510) 423-7645

High-power visible diode lasers in the 630-690 nm wavelength range are important for applications in photodynamic therapy, and are required for pumping single-frequency, tunable Cr:LiSAF solid-state, laser sources which are planned for the DIAL laser-radar systems that are to be used for monitoring global climate change. Silicon microchannel cooled heatsinks have been shown to be a superior technology for meeting the requirements for high-average power pump arrays.<sup>1</sup> To assess the high-power potential of AlGaInP diode-laser arrays for such applications, we have fabricated and mounted 1 cm wide AlGaInP diode bars on silicon microchannel coolers. Under cw operating conditions at a wavelength of 684 nm, these arrays have typically demonstrated 40 W power output with 40% power conversion efficiency, as illustrated in Figure 1. Although, one array with a lower power-conversion efficiency of 25% was successfully operated at 60 W cw power output. These performance characteristics represent the highest cw power output and conversion efficiency reported, to date, for a visible AlGaInP diode-laser array.

The laser structure, grown on a GaAs substrate, was comprised of a 1  $\mu\text{m}$  thick  $\text{Al}_{0.5}\text{In}_{0.5}\text{P}$  n-clad layer, a 0.14  $\mu\text{m}$  thick  $\text{Al}_{0.6}\text{GaIn}_{0.5}\text{P}$  undoped confinement layer, an 80 Å thick  $\text{GaIn}_{0.57}\text{P}$  quantum well, a 0.14  $\mu\text{m}$  thick  $\text{Al}_{0.6}\text{GaIn}_{0.5}\text{P}$  undoped confinement layer, a 1  $\mu\text{m}$  thick  $\text{Al}_{0.5}\text{In}_{0.5}\text{P}$  p-clad layer, a 0.05  $\mu\text{m}$  thick  $\text{GaIn}_{0.5}\text{P}$  cap barrier layer, and a 0.2  $\mu\text{m}$  GaAs cap

layer. The array elements were defined by 100  $\mu\text{m}$  wide openings in  $\text{SiO}_2$  and were placed on 140  $\mu\text{m}$  centers. Isolation trenches were etched between each element of the array. The wafer was cleaved to give 1 cm wide bars with cavity lengths of 800 and 500  $\mu\text{m}$  long cavity. A reflectivity coating of  $> 95\%$  was used for the high-reflect facet and a 10% reflectivity was used for the output facet. The cw operating characteristics of an array with an 800  $\mu\text{m}$  cavity length appear in Figure 1. At an inlet coolant temperature of 15  $^{\circ}\text{C}$ , the spectral output under cw operation of this device was 685.4 nm with a bandwidth at full-width half-maximum of 1.5 nm. At the same coolant temperature, for low-duty pulsed operation with a 1 Hz rep rate and 5  $\mu\text{sec}$  pulse lengths, the device operated at a wavelength of 676.4 nm. Under high-repetition rate pulsed operation at a 10% duty cycle with 100  $\mu\text{sec}$  pulse lengths, peak power outputs in excess of 70 W were observed from 500  $\mu\text{m}$  long cavity arrays. The power-current characteristic for pulsed operation is shown in Figure 2 and the corresponding power conversion efficiency curve is presented in Figure 3. The maximum power output is over 70 W and the corresponding power conversion efficiency is 42%. Reliability and lifetime issues will be discussed and results will also be presented on the performance characteristics of two-dimensional arrays of AlGaInP diode lasers.

The record cw and pulsed performance characteristics displayed by the AlGaInP diode-laser arrays mounted on silicon microchannel heat sinks meet the requirements for applications in photodynamic therapy and pump sources for single-frequency, tunable Cr:LiSAF solid-state, laser systems.

### References

1. R. J. Beach, W. J. Benett, B. L. Freitas, D. Mundinger, B. J. Comaskey, R. W. Solarz, M. A. Emanuel, "Modular microchannel cooled heatsinks for high average power laser diode arrays," IEEE J. Quantum Electron. 28, 966-975, (1992).

## **Acknowledgment**

This work was performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under contract W-7405-Eng-48.

Figure 1. The cw power-current characteristic of a 1 cm wide by 800  $\mu\text{m}$  long cavity AlGaInP diode-laser array under cw operation.

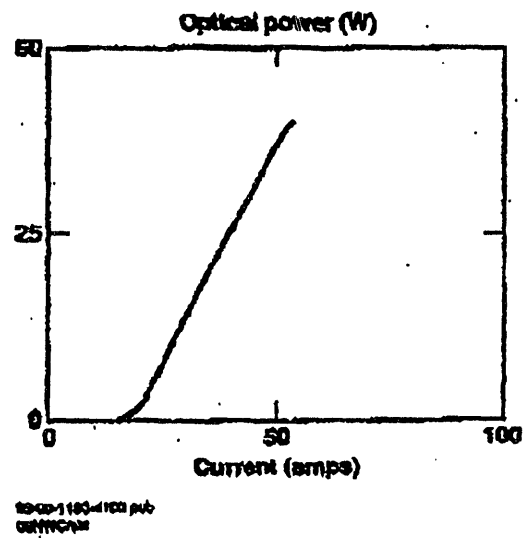
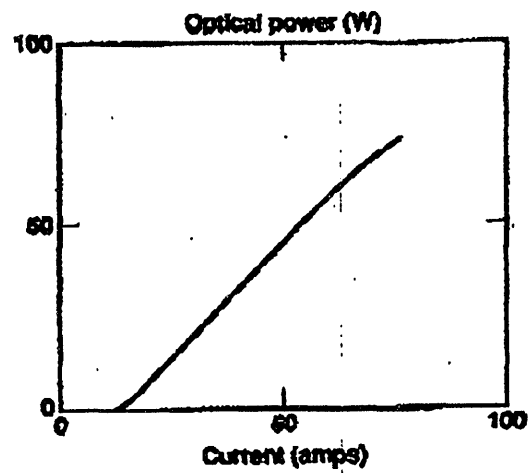


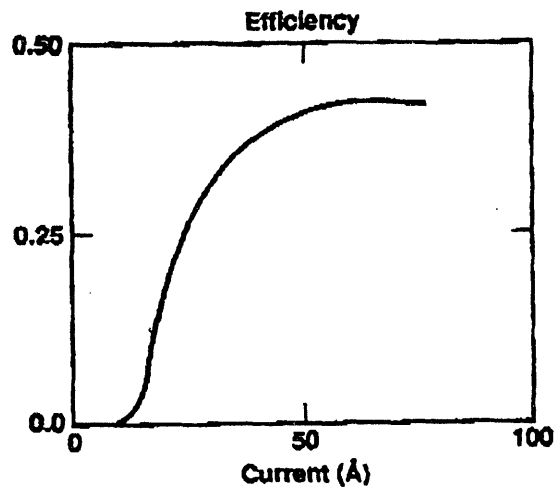
Figure 2. The cw power-current characteristic of a 1 cm wide by 800  $\mu\text{m}$  long cavity AlGaInP diode-laser array under cw operation.



88-00-1193-4101 pub  
88MTCM



Figure 3. The power conversion efficiency versus current curve of a 1 cm wide AlGaInP diode-laser array under cw operation.



99-00-1193-4102.pdf  
08/11/93

**DATE**

**FILMED**

*6 / 2 / 94*

**END**

