REPORT DOCUMENT PAGE

AFRL-SR-BL-TR-01-

0106

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	15 January 2001	Final technical report 15 Mar. 1999 through 14 June 2000

4. TITLE AND SUBTITLE
Pump Module for High Average Power Diode-Pumped Solid-State Lasers - DURIP99/BMDO equipment only

5. FUNDING NUMBERS
Grant F49620-99-1-0200

6. AUTHORS
T. Rutherford, R. K. Route, R. L. Byer

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESSES
Edward L. Ginzton Laboratory
Stanford University
Stanford, CA 94305-4085

8. PERFORMING ORGANIZATION REPORT NUMBER
SPO No. 20541

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AFOSR
801 North Randolph Street, Room 732
Arlington, VA 22203-1977

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
The view, opinions and/or findings contained herein are those of the author(s) and should not be construed as necessarily representing the official policies or endorsements, either expressed or implied, of the Air Force Office of Scientific Research or the U.S. Government.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

The objective of this DURIP-99 University Research Instrumentation Program, F49620-99-1-0200, was to acquire laser diode pump modules to enable research on high average power, scalable DPSS lasers, nonlinear optical materials, and the continued education of Ph.D.students in this field.

Twelve 940 nm fiber-coupled 55 W laser diode units (Opto-Power H01-U055-940FB) were purchased, along with six power supplies (Newport Model 5501) and a controller (Newport Model 8000). This system is currently in use to pump a zigzag slab laser using Yb:YAG as the active medium. Numerical modeling predicts that Yb:YAG slab lasers can be scaled to the 100kW level.

Twenty-four 808 nm fiber-coupled 30 W laser diode units (Coherent FAP/B-808-30C) were purchased, along with four power supplies (Newport Model 5501), four temperature controller units (Newport Model 9008) and a controller (Newport Model 8000). This system has been used to demonstrate phased array output from a zigzag Nd:YAG slab laser. This advance opens the engineering path toward scaling slab lasers to 100kW power levels.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Solid-state lasers, laser-diode-pumped solid-state lasers, zig-zag slab lasers, Nd:YAG lasers, Yb:YAG lasers	5
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

Pump Module for High Power Diode-Pumped Solid-State Lasers

Final Technical Report
for the period
15 March 1999 through 14 June 2000

Principal Investigator
Professor Robert L. Byer
Applied Physics Department
and
Center for Nonlinear Optical Materials
Stanford University
Stanford, California 94305-4085

E. L. Ginzton Laboratory
SPO No. 20541

Report date
January 2001

Prepared for
AFOSR

Grant Number F49620-99-1-0200

TABLE OF CONTENTS

II. Final Technical Report

A. Introduction

The objective of this DURIP-99 University Research Instrumentation Program, F49620-99-1-0200, was to acquire laser diode pump modules to enable research on high average power, scalable DPSS lasers, nonlinear optical materials, and the continued education of Ph.D.students in this field.

Background - High average power laser diode-pumped solid-state (DPSS) lasers are compact, efficient, robust laser sources that are ideal candidates for DOD applications such as free space coherent communications, coherent laser radar, laser remote sensing, laser rangefinders, infrared countermeasures, and target designators. Additionally, these DPSS lasers provide the pump laser for nonlinear optical devices. DPSS slab lasers provide the ability to scale to kW power levels with diffraction-limited beam quality as required by these applications.

In 1998 we demonstrated a 100 W multi-mode DPSS slab laser in a conduction-cooled, transverse-pumped laser geometry. This novel design represented the next step in slab laser research: it takes advantage of the traditional thermal benefits of the zig-zag slab laser with improved pump absorption efficiency in a simple compact laser head design. In order to continue the development of high average power DPSS lasers we requested a laser diode pump module to replace our aged 360 W system which was 5-7 years old, and which had suffered an average 20% drop in output power per diode.

Our proposal request was for $311,670 to acquire a 450 watt fiber-coupled diode laser pump power module to develop a 100 W TEMoo laser. However, by aggressively negotiating deep Stanford (CNOM) discounts and committing additional Stanford (CNOM) funds as cost-sharing contributions, we were able to acquire two pump modules, one with 600 W of 940 nm output for pumping Yb:YAG slab lasers and one with 720 W of 808 nm output for pumping Nd:YAG slab lasers. The combined total value of this package was $474,362.

Stanford has the only university lab in the country where high average power, high coherence DPSS laser research is underway. As such, it presented a unique opportunity for students to study high power solid-state lasers with good spatial and spectral coherence properties. Additionally, high power DPSS lasers provide the laser source for numerous nonlinear optical device demonstrations, and are a critical tool for advancing the study of nonlinear optical materials. Laser diode pump modules are essential for this research. The instrumentation requested enabled continued research in these areas.

B. Equipment purchased and research facilitated under this program

The equipment purchased under this grant can be divided into two catagories:

1. Laser diodes and power supplies for pumping Yb:YAG

Twelve 940 nm fiber-coupled 55 W laser diode units (Opto-Power H01-U055-940FB) were purchased, along with six power supplies (Newport Model 5501) and a controller (Newport Model 8000). This system is currently in use to pump a zigzag slab laser using Yb:YAG as the active medium.

In preliminary experiments, this laser produced 50 W of output power at 25% slope efficiency. Quasi-three-level transparency was achieved at 80 W of pump power. Experiments at higher pump power levels have been delayed by failures in the fibers and fiber couplers that transmit the pump light to the Yb:YAG slab. We are working with the manufacturer to resolve this problem. However, even this preliminary result served to validate our models which predict that Yb:YAG slab lasers can be scaled to the 100kW level.

2. Laser diodes and power supplies for pumping Nd:YAG

Twenty-four 808 nm fiber-coupled 30 W laser diode units (Coherent FAP/B-808-30C) were purchased, along with four power supplies (Newport Model 5501), four temperature controller units (Newport Model 9008) and a controller (Newport Model 8000).

This system has been used to demonstrate phased array output from a zigzag Nd:YAG slab laser. Six parallel beams were locked in phase, creating a brightness enhancement in the far field. This result is important for future attempts to scale the power of edge-pumped slab lasers. Cooling is most efficient in these lasers when the slab aperture has a large aspect ratio. However, extraction of laser energy from this type of aperture can be difficult using conventional resonators or amplifiers. Use of parallel beams with mutual phase coherence solves this problem and opens an engineering path toward scaling slab lasers to 100kW power levels.

C. Educational benefits of instrumentation

The laser diode pump packages provide a unique opportunity for students to study high power solid-state lasers with good spatial and spectral coherence properties. The laser diode pump modules will enable continued university research on high average power, scalable DPSS lasers, nonlinear optical materials, and the continued education of Ph.D.students in this field.

III. References:

1. T. S. Rutherford, W. M. Tulloch, E. K. Gustafson and R. L. Byer, "Demonstration and power-scaling of edge-pumped zig-ag slab lasers," in *OSA Trends in Optics and Photonics, Vol. 34, Advanced Solid-State Lasers*, H. Injeyan, U. Keller and L. Marshall, eds. (Optical Society of America, Washington, D.C., 2000), pp. 16-20.

IV. List of Equipment Purchased

Newport Corporation				
1	#990325-CBG-101, 36 device laser diode driver system	1 ea	$ 43,675	$ 43,675
2	#990325-CBG-202, 12 device laser diode driver system with independent TEC control	2 ea	$ 43,565	$ 87,130
3	less Stanford (CNOM) discount	1 ea	($ 30,855)	($ 30,855)
4	sales tax (8.25%)	1 ea	$ 8,246	$ 8,246
5	less Stanford (CNOM) cost-sharing	1 ea	($ 11,677)	($ 11,677)
		line items subtotal:		$ 96,428
Opto-Power Corporation				
1	#H01-U055-940-FB, 55-watt cw fiber coupled diode laser	12 ea	$ 4,167	$ 50,000
2	#OPC-conv-02, 2:1 optical converter	12 ea	$ 4,167	$ 50,000
3	#OPC-FJ-422, 400 micron, 0.22 NA single core optical fiber jumper, 8 meter	12 ea	$ 4,167	$ 50,000
4	less Stanford (CNOM) discount	1 ea	($ 50,000)	($ 50,000)
5	sales tax (8.25%)	1 ea	$ 8,250	$ 8,250
		line items subtotal:		$ 108,250
Coherent Laser Group				
1	#FAP/B -808 +/-, 2.5-30C-800; FAP-B, basic fiber-array packaged bar 30 W, 808 nm +/- 2.5nm	26 ea	$ 6,500	$ 169,000
2	less Stanford (CNOM) discount	1 ea	($ 70,200)	($ 70,200)
3	sales tax	1 ea	$ 8,151	$ 8,151
		line items subtotal:		$ 106,951
		Total cost of equipment received		**$ 474,362**
		Total cost to AF F49620-99-1-0200		**$ 311,630**
		Total Stanford (CNOM) discounts		$ 151,055
		Total Stanford cost-sharing		$ 11,677