Diode Pumped Solid State Lasers Mit Lincoln Laboratory

This volume contains the lectures and seminars presented at the NATO Ad vanced Study Institute on "Solid State Lasers: New Developments and Appli cations" the fifteenth course of the Europhysics School of Quantum Electronics, held under the supervision of the Quantum Electronics Division of the European Physical Society. The Institute was held at Elba International Physics Center, Marciana Marina, Elba Island, Tuscany, Italy, August 31 -September 11, 1992. The Europhysics School of Quantum Electronics was started in 1970 with the aim of providing instruction for young researchers and advanced students al ready engaged in the area of quantum electronics or wishing to switch to this area from a different background. Presently the school is under the direction of Professors F.T. Arecchi and M. Inguscio, University of Florence, and Prof. H. Walther, University of Munich, and has its headquarters at the National Insti tute of Optics (INO), Florence, Italy. Each time the directors choose a subject of particular interest, alternating fundamental topics with technological ones, and ask colleagues specifically competent in a given area to take the scientific responsibility for that course. Diode pumping of solid state media offers the opportunity for very low maintenance, high efficiency, and compact laser systems. For remote sensing, such lasers may be used to pump tunable non-linear sources, or if tunable themselves, act directly or through harmonic crystals as the probe. The needs of long range remote sensing missions require laser performance in the several watts to kilowatts range. At these power performance levels, more advanced thermal management technologies are required for the diode pumps. The solid state laser design must now address a variety of issues arising from the thermal loads, including fracture limits, induced lensing and aberrations, induced birefringence, and laser cavity optical component performance degradation with average power loading. In order to highlight the design trade-offs involved in addressing the above issues, a variety of existing average power laser systems are briefly described. Included are two systems based on Spectra Diode Laboratory's water impingement cooled diode packages: a two times diffraction limited, 200 watt average power, 200 Hz multi-rod laser/amplifier by Fibertek, and TRW's 100 watt, 100 Hz, phase conjugated amplifier. The authors also present two laser systems built at Lawrence Livermore National Laboratory (LLNL) based on their more aggressive diode bar cooling package, which uses microchannel cooler technology capable of 100% duty factor operation. They then present the design of LLNL's first generation OPO pump laser for remote sensing. This system is specified to run at 100 Hz, 20 nsec pulses each with 300 mJ, less than two times diffraction limited, and with a stable single longitudinal mode. The performance of the first testbed version will be presented. The authors conclude with directions their group is pursuing to advance average power lasers. This includes average power electro-optics, low heat load lasing media, and heat capacity lasers.

Comprehensive yet concise, The Physics and Technology of Laser Resonators presents both the fundamentals and latest developments in laser resonator technology, including specific case studies. The book covers various types of resonators, including unstable, ring laser, and multifold laser. It also discusses numerical resonator calculations and laser beam analysis. This reference will be of value and interest both to newcomers to the field and to professional engineers wishing to update their knowledge.

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 were purchased, along with six power supplies and a controller. 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 were purchased, along with four power supplies, four temperature controller units and a controller. 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.

Although solid-state lasers have been the primary means by which the physics of inertial confinement fusion (ICF) have been investigated, it was previously thought that solid-state laser technology could not offer adequate efficiencies for an inertial fusion energy (IFE) power plant. Orth and co-workers have recently designed a conceptual IFE power plant, however, with a high efficiency diode-pumped solid-state laser (DPSSL) driver that utilized several recent innovations in laser technology. It was concluded that DPSSLs could offer adequate performance for IFE with reasonable assumptions. This system was based on a novel diode pumped Yb-doped Sr[sub 5](PO[sub 4])[sub 3]F (Yb:S-FAP) amplifier. Because this is a relatively new gain medium, a project was established to experimentally validate the diode-pumping and extraction dynamics of this system at the smallest reasonable scale. This paper reports on the initial experimental results of this study. We found the pumping dynamics and extraction cross-sections of Yb:S-FAP crystals to be similar to those previously inferred by purely spectroscopic techniques. The saturation fluence for pumping was measured to be 2.2 J/cm[sup 2] using three different methods based on either the spatial, temporal, or energy transmission properties of a Yb:S-FAP rod. The small signal gain implies an emission cross section of 6.0[times]10[sup[minus]20] cm[sup 2]. Up to 1.7 J/cm[sup 3] of stored energy density was achieved in a 6[times]6[times]44 mm[sup 3] Yb:S-FAP amplifier rod. In a free running configuration diode-pumped slope efficiencies up to 43% were observed with output energies up to[approximately]0.5 J per 1 ms pulse from a 3[times]3[times]30 mm[sup 3] rod. When the rod was mounted in a copper block for cooling, 13 W of average power was produced with power supply limited operation at 70 Hz with 500[mu]s pulses.

We have begun building the "Mercury" laser system as the first in a series of new generation diode-pumped solid-state lasers for inertial fusion research. Mercury will integrate three key technologies: diodes, crystals, and gas cooling, within a unique laser architecture that is scalable to kilojoule and megajoule energy levels for fusion energy applications. The primary near-term performance goals include 10% electrical efficiencies at 10 Hz and 100J with a 2-10 ns pulse length at 1.047 mm wavelength. When completed, Mercury will allow rep-rated target experiments with multiple chambers for high energy density physics research.

Invention of the solid-state laser has initiated the beginning of the laser era. Performance of solid-state lasers improved amazingly during five decades. Nowadays, solid-state lasers remain one of the most rapidly developing branches of laser science and become an increasingly important tool for modern technology. This book represents a selection of chapters exhibiting various investigation directions in the field of solid-state lasers and the cutting edge of related applications. The materials are contributed by leading researchers and each chapter represents a comprehensive study reflecting advances in modern laser physics. Considered topics are intended to meet the needs of both specialists in laser system design and those who use laser techniques in fundamental science and applied research. This book is the result of efforts of experts from different countries. I would like to acknowledge the authors for their contribution to the book. I also wish to acknowledge Vedran Kordic for indispensable technical assistance in the book preparation and publishing.

This text covers a wide range of material, from the basics of laser resonators to advanced topics in laser diode pumping. The subject matter is presented in descriptive terms that are understandable by the technical professional who does not have a strong foundation in fundamental laser topics.

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Solid-state lasers which offer multiple desirable qualities, including enhanced reliability, robustness, efficiency and wavelength diversity, are absolutely indispensable for many applications. The Handbook of solid-state lasers reviews the key materials, processes and applications of solid-state lasers across a wide range of fields. Part one begins by reviewing solid-state laser materials. Fluoride laser crystals, oxide laser ceramics, crystals and fluoride laser ceramics doped by rare earth and transition metal ions are discussed alongside neodymium, erbium and ytterbium laser glasses, and nonlinear crystals for solid-state lasers. Part two then goes on to explore solid-state laser systems and their applications, beginning with a discussion of the principles, powering and operation regimes for solid-state lasers. The use of neodymium-doped materials is considered, followed by system sizing issues with diode-pumped quasi-three level materials, erbium glass lasers, and microchip, fiber, Raman and cryogenic lasers. Laser mid-infrared systems, laser induced breakdown spectroscope and the clinical applications of surgical solid-state lasers are also explored. The use of solid-state lasers in defense programs is then reviewed, before the book concludes by presenting some environmental applications of solid-state lasers. With its distinguished editors and international team of expert contributors, the Handbook of solid-state lasers is an authoritative guide for all those involved in the design and application of this technology, including laser and materials scientists and engineers, medical and military professionals, environmental researchers, and academics working in this field. Reviews the materials used in solid-state lasers Explores the principles of solid-state laser systems and their applications Considers defence and environmental applications

This text explains the mutual influences between the physical and dynamic processes in solids and their lasing properties. It provides insight into the physics and engineering of solid state lasers by integrating information from several disciplines, including solid state physics, materials science, photophysics, and dynamic processes in solids. The text discusses approaches to developing new laser materials and includes data tables of basic parameters that can be applied to laser design. Novel materials and techniques used in recent developments are also covered.

Progress at LLNL in the development high-average-power diode-pumped solid state lasers is summarized, including the development of enabling technologies.

Since it s resurgent in 1990s, the field of diode pumped solid state (DPSS) lasers grew exponentially over the last two decades. With the availability of new materials, components and devices the importance of DPSS lasers in our society is increasing by the day and they are finding applications in almost every field of science and technology. However, to create an optimum solution for specific applications, it is necessary to understand the functional possibilities and the methods to control the lasing regimes of modern DPSS lasers. This book, therefore, provides the physical basis and the state of the art of building diode-pumped solid-state lasers in the light of the new developments and describes with experimental details the issues related with various modes of operation of these lasers at the fundamental as well as intracavity frequency doubled configuration. The book should help the students and researchers in the field of lasers to understand the basics, scopes and limitations of DPSS lasers and should help shed some light on the new developments and trends in this exciting field.

The largest commercial application of high power lasers is for cutting and welding. Their ability to increase productivity by introducing processing flexibility and integrated automation into the fabrication process is well demonstrated. This paper addresses the potential importance of recent developments in laser technology to further impact their use within the automotive industry. The laser technology we will concentrate upon is diode laser technology and diode-pumped solid-state laser technology. We will review present device performance and cost and make projections for the future in these areas. Semiconductor laser arrays have matured dramatically over the last several years. They are lasers of unparalleled efficiency (greater than 50%), reliability (greater than 10,000 hours of continuous operation), and offer the potential of dramatic cost reductions (less than a dollar per watt). They can be used directly in many applications or can be used to pump solid-state lasers. When used as solid-state laser pump arrays, they simultaneously improve overall laser efficiency, reduce size, and improve reliability.

The general objective of the study was an evaluation of the state-of- the-art of diode array fabrication; identification of potential solid state laser candidates suitable for diode pumping; evaluation of different pump configurations; investigation of different cooling techniques and resonator designs; and a conceptual design of a cost-effective laser system.

This paper reviews work on flashlamp-pumped solid state lasers and discusses diode-pumped solid state lasers, the Mercury laser in particular. It also discusses ICF lasers beyond Mercury.

Koechner's well-known ‘bible’ on solid-state laser engineering is now available in an accessible format at the graduate level. Numerous exercises with hints for solution, new text and updated material where needed make this text very accessible.

Recent years have witnessed rapid advances in the development of solid state, fiber, semiconductor, and parametric sources of coherent radiation, which are opening up new opportunities for laser applications. Laser Sources and Applications provides a tutorial introduction to the basic principles of these developments at a level suitable for postgraduate research students and others with a basic knowledge of lasers and nonlinear optics. Encompassing both the physics and engineering aspects of the field, the book covers the nature of nonlinear optical interactions; solid state, fiber, and semiconductor lasers; optical parametric oscillators; and ultrashort pulse generation and applications. It also explores applications of current interest, such as electromagnetically induced transparency, atomic trapping, and soliton optical communications.

The primary objective of this program involved the development of diode pumpable sources which could serve as the driver for a mid IR optical parametric amplifier. The present state-of-the-art is the diode-pumped Q- switched Nd:YAG at 1.06 microns. The development of longer wavelength drivers was mandated by the need for improved efficiency in mid IR OPO's. The most promising candidate laser appeared to be the Er:YAG room temperature laser at 1. 64 microns. The development of diodes operating at the required pump wavelength for this laser indicated that diode pumping was feasible. The work performed utilized an Er:glass laser at 1.53 micron as a pump source. Characterization of Er:YAG laser action with this pump source can be used to model the diode pumped version of this laser.

The authors recent developments in high powered diode pumped solid state lasers at Lawrence Livermore National Laboratory. Over the past year the authors have made continued improvements to semiconductor pump array technology which includes the development of higher average power and lower cost pump modules. They report the performance of high power AlGaAs, InGaAs, and AlGaInP arrays. They also report on improvement to the integrated micro-optics designs in conjunction with lensing duct technology which gives rise to very high performance end pumping designs for solid state lasers which have major advantages which they detail. Substantial progress on beam quality improvements to near the diffraction limit at very high power have also been made and will be reported. They also will discuss recent experiments on high power non-linear materials for q-switches, harmonic converters, and parametric oscillators. Advances in diode pumped devices at LLNL which include tunable Cr:LiSrAlF6, mid-IR Er:YAG, holmium based lasers and other developments will also be outlined. Concepts for delivering up to 30 kilowatts of average power from a DPSSL oscillator will be described.

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