between 1.5 µm - 2.1 µm for the signal beam and between 2.1 µm - 3 µm for the idler beam. The signal will be amplified in the OPAs because the optics and diagnostics is more easily available below 2 µm wavelength. The tunable multi-millijoule source above 2.1 µm will be the idler beam taken from the last amplification stage. High-average output power of 10 W at 1 kHz repetition rate will be unique among 2 – 3 µm tunable systems.

Operation of the amplifiers at high-intensities and high-average powers limits the system performance. The thermal load of crystals caused by the partial beam absorption will be studied. Further, the damage threshold of optical components, transmission range of nonlinear crystals, and amplifiers bandwidths will be addressed.

8780-24, Session 6

The latest developments in switch technology for high energy and RF-operation laser amplifiers in RCLF

Jun Zhang, Jian-gang Zheng, Xiong-jun Zhang, Deng-sheng Wu, Xiao-ling Tian, Kuixing Zheng, China Academy of Engineering Physics (China)

Studies of the design of high energy rf-operation laser amplifiers show that a multipass amplifier architecture offers a significant cost saving and extraction efficiency increasing. An optical switch is very important to control numbers of amplifying passes and to suppress self-excitation oscillation in a multi-pass amplifier, especially in a high stored energy and high saturation fluence gain media amplifier. Unfortunately, the existing switch technologies can't meet the needs of clear aperture and thermal properties at the same time in the case of high energy and rf operation. We manufacture a 10Hz, single-pulse driven, ?30mmx3mm DKDP crystal plasma-electrodes Pockels cell (PEPC). This device, with 4000:1 extinction ratio (ER), 99.8% switching efficiency (SE), and 8.6ns rise time, can be used for injection locking in a regenerative amplifier within 260mW/cm2 laser average power density without drawback of switch performance. Furthermore, we propose and demonstrate a conduction-cooled 10Hz PEPC, which is developed for multi-tens W/cm2 average power density amplifier application. The device, constructed with two plasma chambers providing double-sides electrodes, and longitudinally driven by two ±15kV voltages pulse generators, adopts a piece of 70mmx70mmx7mm white stone to cool two pieces of 50mmx50mmx5mm DKDP crystal. The measured results indicate: the transmission ratio 97.2%, the wave-front distortion PV value 0.3?(?=632.8nm), the ER 2347:1, the SE 99.7%, and the rise time 12ns. With regard to "hot" properties, the simulation results show: if the PEPC was exposed to 50W/cm2 (5J/cm2@10Hz) laser irradiation, the contact thermal resistance between the DKDP and the white stone should be no more than 20cm2K/W to avoid thermal facture on the DKDP surface and to promising the ER greater than 1000:1. To estimate optimistically, the developed conduction-joint technique meets this requirement. We are now preparing a heating source for the later thermal effects studying.

8780-25, Session 7

Preliminary experimental and simulation results of the ESA QOMA project: a new DPSS laser source suitable for space applications

George Tsaknakis, National Technical Univ. of Athens (Greece); Dimitris N. Papadopoulos, Ecole Nationale Supérieure de Techniques Avancées (France); Christos Evagelatos, Paraskevas Bakopoulos, Univ. of Athens (Greece); Georgios K. Avdikos, National Technical Univ. of Athens (Greece); Loïc Deyra, Univ. Paris-Sud 11 (France); François Balembois, Patrick Georges, Lab. Charles Fabry (France); Alexandros D. Papayannis, National Technical Univ. of Athens (Greece); Stavros Boukios, ThyssenKrupp AG (Germany); Georgios D. Tzeremes, European Space Agency (Netherlands)

In the paper, we present preliminary results obtained in the frame of the QOMA project (Q-Switched Master Oscillator based on Multidoping Nd:YAG Technology for Optoelectronics Space Applications) funded by the European Space Agency (ESA). This project is a collaboration between ESA, Raymetrics S.A., and the National Technical University of Athens (NTUA). The main goal of the project is the design, development and manufacture of a new low-weight, high-power diode-pumped laser source for application in future space-borne optoelectronic and lidar systems, dedicated to the study and monitoring of aerosols and the space environment. The system's design is based on new laser engineering technologies combining high power pumping of a multi-segmented crystal rods at 885nm and novel crystal cooling configurations. As active material a multi-segmented Nd:YAG crystal rod (0.1%, 0.23%, 0.6% at Nd) of 54 mm length and 3 mm diameter with 7 mm undoped endcaps on both ends will be used. The use of the specific crystal, as an active material ensures: a high overall efficiency, in combination with excellent beam quality and high average power due to the low thermal effects and mechanical stresses inside the crystal rod. In order to optimize the system's design and performance, laser cavities with uniform rods were first simulated by the LASCAD software. Preliminary experimental results were performed with a uniformly doped 50 mm long, 1 mm diameter, 0.2% at Nd crystal (Taranis module from Fibercryst), end-pumped by a fiber-coupled diode which delivers up to 100 W at 885 nm (nLight) in collaboration with the Laboratoire Charles Fabry. Despite the relatively low doping level of this crystal, absorption reached a satisfactory high efficiency of about 65%. For 65 W absorbed pump power an output of 37 W was obtained at continuous wave operation. The M2 at this level of operation was measured at ~7 indicating a highly multimode operation. To verify the validity of our simulations the specific experimental parameters were used as inputs in the LASCAD which predicted a maximum output power of 38.7 W and an M2 value close to the measured ones. In this paper we will present our experimental results based on an optimized cavity configuration taking advantage of an innovative crystal cooling system in combination to the multi-segmented crystal technology towards a higher beam quality and an efficient laser operation.

8780-26, Session 7

Highly efficient, diode-side-pumped Nd:YLF laser emitting in fundamental mode at 1313 nm, based on the double-beam-mode-controlling (DBMC) technique

Niklaus U. Wetter, Márcio A. P. Aparicio Lopez, Instituto de Pesquisas Energéticas e Nucleares (Brazil); Alessandro M. Deana, UNINOVE (Brazil)

Highly efficient, diode-side-pumped Nd:YLF laser emitting in fundamental mode at 1313 nm, based on the double-beam-mode-controlling (DBMC) technique

Diode-side-pumping technology is the most common choice for solid state laser engineering when high power and scalability is a main issue. However, this design is generally associated with lower beam quality and efficiency. Diode-longitudinal-pumping schemes have demonstrated high beam quality and efficiency, but are rather limited with regard to power scalability because of the low thermal fracture limit of the crystals. Only a few power scalable architectures allow for high efficiency and good beam quality using the side-pumping technique, but they are usually associated with complex configurations that require specially tailored and coated gain media thereby significantly increasing cost and complexity.

In order to develop a versatile laser source capable of delivering watt-level power with high efficiency, diffraction limited beam quality, reduced costs and complexity we present a Nd:YLiF4 diode-side-pumped laser design based on a gain–guided approach that employs a double-beam mode controlling technique, in which the fundamental laser mode makes a double bounce at the crystal's pump surface. This compact folded resonator design uses a simple rectangular slab of gain media at Brewster angle that does not require coatings and therefore is cost-efficient and robust and suited for short pulse Q-switching. The design has demonstrated the highest efficiency ever reported for a diode-pumped Nd:YLF laser emitting at the main 4F3/2?4I11/2 laser transition (Wetter et al., 2009).

Lasers emitting at 1.3 micrometers have important applications in the

fields of fiber-optics, spectroscopy and health care due to diverse characteristics such as high water absorption and low dispersion in quartz. Longitudinal pumping schemes have obtained 30% of optical-to-optical efficiency at the sigma transition of 1313 nm with 3.1 W of output power (Li et al., 2011).

Using standard 1 mol% of neodymium doping, we demonstrate for the first time, to the best of our knowledge, efficient operation of the 4F3/2 ? 4I13/2 laser transition in a diode-side-pumped resonator. By pumping at 797 nm with 19.8 W TE-polarized diode bar that was focused into the crystal (spot size 5 mm x 0.1 mm) using a simple spherical lens of f=2.5cm, 7.8 W of peak output power in fundamental mode were extracted by using a three-mirror cavity comprised by a folding mirror of 8 m radius of curvature, a plane HR end mirror and a plane output coupler with 4% transmission for the emission line at 1313 nm (?-polarization). The measured optical-to-optical efficiency was 31.6% and the slope efficiency was 39.5% operating in the quasi-cw regime. The setup showed losses of 1.5% and a pumping efficiency of 76%.

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8780-27, Session 7

Powerful UV generation in the picosecond pulse trains for the CLIC drive beam photo-injector option

Mikhail Martyanov, CERN (Switzerland); Marta Csatari Divall, Paul Scherrer Institut (Switzerland); Ekaterina Gacheva, Institute of Applied Physics (Russian Federation); Christoph Hessler, Valentin Fedosseev, CERN (Switzerland)

The future Compact Linear Collider (CLIC) is under development at CERN by a collaboration of many institutes worldwide. The goal is to collide electron and positron bunches with a centre-of-mass energy of up to 7 TeV. The CLIC uses a novel two-beam concept: acceleration of a low-current main beam by means of RF power produced during the deceleration of a high-current drive beam. The RF photo-injector is a contemporary electron source for linac-based accelerators which is being considered as the baseline solution for the CLIC main beam and as an option for the drive beam. To deliver high-charge picosecond electron bunches (in case of the CLIC drive beam: 8.4 nC/bunch contained within a 140 us train with 500 MHz repetition rate) the RF photo-injector requires appropriate trains of picosecond laser pulses synchronized with the driving RF pulse in the photo-injector cavity. Given that the quantum efficiency of the Cs2Te photo-cathodes is 1-3%, the laser setup must deliver about 2uJ/pulse at 262 nm or similar, which corresponds to 1 kW of mean power within train and 7 W average UV power for a train repetition rate of 50 Hz. In addition the power requirement, the bunch-to-bunch and train-to-train fluctuations in terms of energy and beam quality must not exceed 0.1% i.e. no train envelope decay or distortion.

The feasibility of such high power UV beam production by 4th harmonic generation (FGH) of the Nd:YLF laser output is being investigated at the CLIC Test Facility 3 (CTF3) at CERN. The laser system consists of a commercial passively mode-locked Nd:YLF oscillator synchronized with the 1.5 GHz RF reference signal, a preamplifier, two diode pumped Nd:YLF amplifier stages and frequency conversion stages for green and UV generation. Our studies focus on the investigation of detrimental UV induced effects in FHG crystals and the search for the optimal geometry and mode of FHG. During the fourth harmonic generation, an accumulation of partly recoverable UV two-photon induced optical defects in a BBO crystal has been observed during the 140us train, even for a relatively low peak pulse power of about 100 MW/cm2. Although the growth of these optical defects is attributed to UV two-photon absorption, the accumulated defects lead to linear absorption of green and UV co-propagating pulses. The peculiarity of this mode of operation is that each pulse itself is very weak and basically it does not induce any considerable optical defects. However, since the train consists of about 70000 pulses and the decay time of induced defects is greater than the train duration, a deterioration of the UV beam and train envelope is clearly observable. Within the scope of these studies, the pulsed 4th harmonic generation has been modelled in detail, taking into account optical defect dynamics (accumulation, relaxation, bleaching etc.). In this work the experimental results, supported by simulations, are presented.

8780-28, Session 7

Generation of 3D ellipsoidal shaped UV laser pulses for the future XFEL low-emittance photo-injector

Anatoly K. Poteomkin, Alexey V. Andrianov, Ekaterina Gacheva, Victor Zelenogorsky, Sergey Y. Mironov, Efim A. Khazanov, Institute of Applied Physics (Russian Federation); Mikhail Martyanov, CERN (Switzerland); Evgeny M. Syresin, Joint Institute for Nuclear Research (Russian Federation); Mikhail Krasilnikov, Frank Stephan, DESY (Germany)

The European X-ray Free Electron Laser (XFEL) will allow unprecedented experiments with atomic resolution on femtosecond time scales with ultra-high peak and average brilliance photon beams of high transverse spatial coherence. Its construction has already started at DESY in Hamburg. The Photo Injector test facility at DESY in Zeuthen (PITZ) develops the electron source for the XFEL. The laser driven RF gun has to fulfill very challenging specifications on electron source performance for linac based FELs, namely it should provide electron bunches with high bunch charge (~1 nC) and extremely low transverse emittance (< 1 mm mrad). Recently the attainability of such low emittance has been experimentally proven at PITZ. But the scientific achievements of the XFEL are expected to extend dramatically with the further improvement of the electron source quality. The RF photo-injector drive laser pulse shaping is a key issue to achieve such a performance. Theoretically shown and proved by beam dynamics simulations that true 3D ellipsoidal pulse shape of the UV pulses driving the photo-injector is the optimal one with respect to Gaussian or flat-top shapes in different spatial-temporal combinations. Currently the 3D-ellipsoidal pulse shape laser is under development in IAPRAS, Russia. Our studies represented in this work are mainly devoted to the following issues:

1) 3D-ellipsoidal 7ps pulse creation by means of two liquid crystal Spatial Light Modulators (SLM) in the mixed spatial-frequency domain out of 200fs pulses;

2) Aamplification of these wide-band pulses in thin-disk Yb:KGW multi-pass amplifier without dramatic distortion of the shape;

3) 2nd and 4th harmonics generation in thin LBO and BBO crystals utilizing the angular chirp technique to achieve high efficiency of conversion without shape degradation.

Home-built two-channel Er/Yb:fiber oscillator and preamplifier delivers chirped 50ps pulses at 1030nm with 1uJ/pulse at 1MHz repetition rate in each channel. The beam from the second channel after compression down to 200fs is used as a probe beam for cross-correlation diagnostics. Fiber part of the second channel is coiled to piezo-disk to produce variable and time-dependent delay for cross-correlation.

The proposed 3D-ellipsoidal pulse shaper consists of two 2D-SLM's (one for amplitude and one for phase masking) installed inside zero-order compressor. Double pass of the setup supplemented with a 90 deg image rotation between passes provides successive access to X-frequency and Y-frequency planes respectively. Since the pulse shaping technique with SLM's is available only on the fundamental wavelength it is necessary to preserve the pulse shape during the amplification and harmonic generation. This can be archived by using wide band thin disk Yb:KGW amplifiers and by introducing a certain angular chirp to the beam before the harmonics crystals.

Theoretical considerations and first experimental results are presented in this paper.