Efficient, high repetition diode pumped picoseconds solid state lasers are important sources of high power radiation for wide range of applications as micromachining, ranging, remote sensing, and microsurgery. Side pumping with CW or QCW diode bars of slab active elements in grazing incidence geometry results in high gain and efficient operation [1]. The pulsed pumping combined with passive mode locking has advantage in generation of submilijoule pulses directly from oscillator. This configuration needs laser crystals with very high absorption coefficients for the pump radiation and therefore Nd:YVO4 and Nd:GdVO4 has challenged Nd:YAG due to their stronger absorption at 808 nm. However advantage of Nd :YAG are better thermal and mechanical properties than vanadates and additionally their higher energy storage capacity due to the longer upper state life-time, which gives potential to generate more energetic pulses pulsed in Q-switched and mode-locked operation. Recently Nd:YAG crystals with Nd concentrations higher than 1% became available which stimulated new interest in using of such crystals in bounce geometry configuration and high efficiency laser operation of 2 % doped Nd:YAG crystals was demonstrated [2].

In this paper we report investigation of pulse shortening by passive negative feedback in mode locked train from 2.4 at.% crystalline Czochralski grown Nd:YAG in a bounce geometry under QCW diode pumping. For passive mode locking we used semiconductor saturable absorber with 33 quantum wells grown on GaAs substrate which acts also as nonlinear element for passive negative feedback by beam defocusing. A high speed digital oscilloscope with bandwith of 9 GHz enabled observation of pulse shortening along extended pulse trains from single laser shot. The pulse duration decreased from 185 ps in the beginning of the train to less than 50 ps for pulses at the end of the extended train containing more than 50 pulses.

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7354-27, Session 6

Efficient generation of 488 nm radiation by using a diode laser and a PPLN crystal in a monolithic ring resonator

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In recent years a V-shaped external resonator design for improving the spectral and spatial beam quality of gain guided broad area diode lasers (BAL) was presented [1]. The external cavity enhanced BAL was used for single pass second harmonic generation (SHG) using periodically poled lithium niobate (PPLN) bulk and waveguide crystals [2]. However, the blue output power is limited whether by the rather low efficiency of the bulk crystal or by the damage threshold of the waveguide crystal due to the photorefractive effect.

In this work we focus on the enhancement of the power density for increasing the SHG efficiency. Therefore a new setup was developed consisting of two optically coupled resonators. The first resonator is based on a BAL in a Littrow configuration providing 450 mW single mode emission at 976 nm with excellent beam quality. The second resonator is a monolithic high finesse ring cavity containing the bulk PPLN crystal. This ring resonator consists of four mirrors with appropriate reflectivities, two GRIN lenses for stability reasons, and the 10 mm PPLN crystal for efficient SHG. All parts are mounted monolithically on a glass substrate. The resonator is designed as small as possible with the PPLN crystal as the limiting part and thus it provides high stability and simple adjustment. The coupling of both resonators is purely optically and no active controls are applied. A maximum output power of 115 mW blue light at 488 nm could be achieved with 450 mW infrared light. This results in a conversion efficiency of more than 25%. [1] A. Jechow, et al. Opt. Com. 277, 161 165, 2007; [2] A. Jechow and R. Menzel, Appl. Phys. B 89, 507-511, 2007.

7354-28, Session 6

Optical pulse frequency shift with mismatched three-wave interaction

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We discuss the principally new effects of optical pulse frequency tuning and time delay (advancing) caused by two-pulse collision in a medium with cascaded quadratic nonlinearity. This phenomenon is a temporal analog of the cascade beam refraction and reflection. In quadratic medium the weak signal pulse interacts with the power pump pulse at another frequency, and they generate the sum-frequency wave which in return changes the refractive index at the signal frequency. The total internal reflection of signal pulse from moving pump pulse can occur only in defocusing case. As a result of collision the signal frequency and group velocity change. In other words the signal pulse obtains a push, after which it moves away from the pump pulse with another velocity. If pump intensity is insufficient for switching the signal pulse passes through the pump pulse, and its frequency doesn’t vary. We obtained the signal pulse reflection conditions and shown the critical value of group velocity mismatch is similar to the critical angle for the parametric total internal reflection. We derived the expression for the frequency shift of the reflected signal pulse according to which tuning is proportional to the ratio of the group velocity mismatch to the group velocity dispersion coefficient. Thus with the help of cascade three-wave interaction it is possible to achieve the total internal reflection of the signal pulse from the pump pulse. While two-pulse collision occurs, the optical pulse can be slowed down or accelerated and its frequency can be tuned.

7354-29, Session 6

The unified theory of chirped-pulse oscillators

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A completely analytical and unified approach to the theory of chirped-pulse oscillators is presented. The developed approach is based on the approximate integration of the generalized nonlinear complex Ginzburg-Landau equation and demonstrates that a chirped-pulse oscillator is controlled by only two parameters, which are i) energy, and ii) ratio of the squared inverse bandwidth to the dispersion multiplied by ratio of the self-phase modulation coefficient to the inverse saturation power of self-amplitude modulator. Such a simple structure of the parametrical space allows tracing easily a spread of the real-world characteristics of both solid-state and fiber oscillators operating in the positive dispersion regime. The work was supported by the Austrian Fonds zur Foerderung der wissenschaftlichen Forschung (Project P20293).

Summary

In the last decade, femtosecond pulse technology has allowed achieving a few-optical-cycle pulse generation directly from an oscillator. Applications of such pulses range from medicine and micro-machining to fundamental physics of light-matter interaction. To achieve these regimes, the over-microjoule pulse energies are required. Critical milestones on this path has been achieved for the solid-state oscillators operating both in the negative- (NDR) and positive-dispersion regimes (PDR), and the fiber oscillators operating in the all-normal dispersion (ANDi) regime. The fundamental difference between the NDR and the PDR is that, in the PDR, the energy scaling is provided by large pulse chirp allowing the linear pulse compressibility. The issue is that there is no uniform description of the chirped solitary pulse (CSP) properties and dynamics.

In this work, the analytical theory of PDR has been developed. The theory treats the CSP as the solitary pulse solution of the generalized nonlinear complex Ginzburg-Landau equation (CGLE). The main advantage of the developed theory is possibility to represent the chirped-pulse oscillator (CPO) parametrical space in the form of two-dimensional master diagram. As a result, the CSP characteristics become easily traceable. It has been demonstrated, that both ANDi fiber and chirped-pulse solid-state oscillators can be described from a uniform standpoint and represented on the unified master diagram. The main difference between them is that they realize mainly two different branches of the CSP solution. Such branches differ in the energy and dispersion scaling rules as well as in the behavior of CSP parameters.

Comparison with the results of numerical simulations has shown that the analytical solution provides a good approximation for the spectrum shape, which is truncated and has a flat or parabolic top. The approximation is quite precise even in the case, when the net-gainband is narrow, that the squared inverse bandwidth verges towards the group-delay dispersion (GDD) coefficient. This provides an adequate description of both ANDi fiber and thin-disk narrowband solid-state chirped-pulse oscillators. Thus, the theory allows optimizing the CPO characteristics.

Simultaneously, comparison with the numerical results demonstrates the phenomena, which are beyond the scope of the validity of analytical approach: i) when the squared inverse bandwidth is close to or exceeds the GDD, the spectrum edges are smoothed (not truncated); ii) when the spectrum is too broad, its top becomes concave. The last spectra exist even as the solutions of the cubic nonlinear CGLE and this issue requires a further study.

7354-38, Poster Session

Cd1−xHgxTe system for optoelectronic application: photo-electrical properties and composition dependent deep level energies

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Cd1-xHgxTe (1>x>0) is very important material for the production of photonic detectors in infrared range, including multicolor ones, THz emitters and detectors. This material also possesses good nonlinear and photorefractive characteristics. It is expected that undoped as well as Ti, V-doped CdHgTe crystals can be used for these purposes. In order to achieve a more realistic interpretation of the deep level energies in CdHgTe, we implemented a composition-dependent representation of the band-edge energies with respect to an independent reference level into the modeling of photo-physical effects. The various relations between the energy levels of defects of different nature and the band states are discussed. The effect of composition dependences of defect ionization energies on electrical compensation, photosensitivity, photorefraction, and sensitivity to THz radiation has been investigated in the ternary Cd1−xHgxTe system. We demonstrated the dramatic effect of the actual defect nature and composition on electrical bulk resistivity, photocurrent, etc., obtained from experimental measurements. The potential impact of composition-dependent ionization energies on compensation and electrical characteristics has been pointed out. The implementation of various compositions of Cd1−xHgxTe for optoelectronic application has been discussed.

7354-42, Poster Session

Pr:YAP generation in blue spectral region

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The radiation from the blue part of spectrum is suitable in basic physics experiments as well as in many applications like spectroscopy, medicine, etc. Therefore, reliable laser sources operated in 400 nm spectral region are required. In the presented study, the possibility of second harmonic generation from the Pr:YAP laser working at 747 nm was investigated.

The laboratory built flash-lamp pumped Pr:YAP laser was operated in Q-switched pulsed regime with repetition rate of 0.5 Hz at room temperature. A 321 mm long laser resonator was formed by a highly reflecting spherical mirror (radius of curvature 5 m) and a flat output mirror with the optimal 90% output coupler reflectance. The active medium used was a Pr:YAP crystal grown by the Czochralski method having 4 mm in diameter, 60 mm in length, and 1 at. % Pr3+ ion concentration. For the purpose of second harmonic generation, the laser was operated in Q-switched regime. The Q-switching was ensured by the LiNbO3 Pockels cell working in a lambda/4 setting. Position of this electro-optical modulator inside the laser resonator was close to the rear mirror. As polarizer, one sapphire plate placed in the resonator between the Pockels cell and Pr:YAP crystal under Brewster angle was employed. The maximal output energy reached in one giant pulse was 5 mJ. The corresponding pulse length was 50 ns, yielding in 100 kW peak power.

As second harmonic converter, extracavity positioned BBO crystal with dimensions of 6 x 6 x 10 mm3 and antireflection coating at 747 and 373.5 nm was utilized. The stable output pulses with the energy of 30 uJ and the length of 35 ns at 373.5 nm wavelength were generated. It presents ~ 0.9 kW peak power in the blue spectral region.

7354-43, Poster Session

Parabolic pulse propagation in mean-zero, dispersion-managed transmission systems and mode-locked laser cavities

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Self-similarity is a ubiquitous concept in the physical sciences used to explain a wide range of spatial- or temporal-structures observed in a broad range of applications and natural phenomena. Indeed, they have been predicted or observed in the context of Raman scattering, spatial soliton fractals, propagation in the normal dispersion regime with strong nonlinearity, optical ampliers, and mode-locked lasers. These self-similar structures are typically long-time transients formed by the interplay, often nonlinear, of the underlying dominant physical effects in the system. A theoretical model shows that in the context of the universal Ginzburg-Landau equation with rapidly-varying, mean-zero dispersion, stable and attracting self-similar pulses are formed with parabolic proles: the zero-dispersion similariton. The zero-dispersion similariton is the final solution state of the system, not a long-time, intermediate asymptotic behavior. An averaging analysis shows the self-similarity to be governed by a nonlinear diffusion equation with a rapidly-varying, mean-zero diusion coeffcient. Indeed, the leading-order behavior is shown to be governed by the porous media (nonlinear diusion) equation whose solution is the well-known Barenblatt similarity solution which has a parabolic, self-similar profile. The alternating sign of the diffusion coeffcient, which is driven by the dispersion uctuations, is critical to supporting the zero-dispersion similariton which is, to leading-order, of the Barenblatt form. This is the first analytic model proposing a mechanism for generating physically realizable temporal parabolic pulses in the Ginzburg-Landau model. Although the results are of restricted analytic validity, the findings are suggestive of the underlying physical mechanism responsible for parabolic (self-similar) pulse formation in lightwave transmission and observed in mode-locked laser cavities.

7354-44, Poster Session

Solvents effects on NLO properties of ethyl eosin dye

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We report the nonlinear optical properties of Ethyl Eosin Dye in four solvents by (SHG) of Nd-YAG CW laser at (532 nm).The third-order nonlinear susceptibility [3], nonlinear refractive index and nonlinear absorption is measured by Z-scan technique, and optical limiting response by the transmission technique. The mechanism for the third-order optical nonlinearities and the optical limiting properties are discussed. The optical power limiting behavior of Ethyl Eosin Dye in four solvents and concentrations was also investigated. The third order nonlinearity of this dye is dominated by nonlinear absorption which leads to strong optical limiting of CW laser beam. The strength of the optical limiting is dramatically influenced by the solvent used, with limiting decreasing in the order Methanol, Ethanol, DMSO and Water. The results show that all these solvents have effect on the optical limiting performance of the Ethyl Eosin Dye suggesting that the observed limiting responses are likely dominated by a nonlinear absorption mechanism.

7354-45, Poster Session

Photophysics of organic and inorganic media treated with nanoobjects

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