7197-19, Session 4

Monolithic ring resonator with PPLN crystal for efficient cw SHG of 976 nm emitted by an diode laser

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In recent years external resonator designs for improving the spectral and spatial beam quality of broad area diode lasers (BAL) were presented [1]. These lasers were applied to single pass second harmonic generation (SHG) using periodically poled lithium niobate (PPLN) crystals [2]. To improve the efficiency waveguide crystals can be used [3], however, the blue output power is limited by the damage threshold of the 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 500 mW single mode emission at 976 nm. The second resonator is a monolithic high finesse ring cavity containing the SHG 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. First experiments showed good matching of both cavities resulting in an output of 70 mW blue light at 488 nm.

[1] A. Jechow et al. Opt. Com. 277, 161-165, 2007

[2] A. Jechow et al. Appl. Opt. 46, 943-946 2007

7197-20, Session 5

Wideband parametric engineering by localized four-photon mixing

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In contrast to conventional parametric devices based on crystals, fiber parametric amplifiers rely on phase matching over long fiber sections. While longer device means higher conversion efficiency, it also introduces stringent requirements on fiber geometry compatible with wide-band operation. In addition to high order dispersion engineering, longitudinal dispersion fluctuation has to be controlled over the entire pump-signal interaction length. Precise phase matching over many hundreds of meters also means nanometer-scale control of fiber transverse geometry and was identified as the fundamental obstacle on a path to engineering of arbitrary-bandwidth response. This barrier can be, at least in principle, overcome by requiring a molecular scale transverse control of fiber draw process. Unfortunately, such fabrication is neither physical nor practical. In an alternative approach, one could synthesize arbitrary parametric response by solving the inverse phase matching problem defined by the fiber dispersive fluctuation. We describe a new class of such techniques that allow, for the first time, exact dispersive mapping of nearly dispersionless fibers. The new technique is based on localization of four-photon mixing in a long optical waveguides. The new approach uses countercolliding power delivery and offers more than two orders of magnitude increase in spatial resolution and sensitivity over conventional methods. The approach breaks away from common treatment of highly nonlinear fibers as stochastic waveguide and allows for deterministic bandwidth engineering for the first time. The prospects that the new technology opens in communication, sensing and signal processing are discussed in detail.

7197-21, Session 5

The nonlinear coefficient d36 of CdSiP2

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The new nonlinear crystal for the mid-IR $CdSiP_2$ was discovered only very recently but the interest in this chalcopyrite is enormous because it possesses most of the attractive properties of the related $ZnGeP_2$ but allows in addition pumping at 1064 nm without two-photon absorption and uncritical phase-matching for 6 µm generation with maximized effective nonlinearity. The last feature is due to the fact that this crystal is negative uniaxial in contrast to $ZnGeP_2$ which shows positive birefringence. We now measured its nonlinear coefficient using SHG near 4.6 µm and femtosecond pulses generated from a seeded $KNbO_3$ optical parametric amplifier. The SHG efficiency was compared for uncoated samples of $CdSiP_2$ and $ZnGeP_2$, both 0.5 mm thick, in the low conversion limit (<10% internal conversion efficiency) which justifies the use of the plane wave approximation. Since for both crystals absorption losses could be neglected, the spectral and angular acceptances are extremely large and the birefringence walk-off very low, the result had to be corrected only for the slightly different Fresnel losses and index of refraction. Taking into account the experimentally determined phase-matching angles for type-I SHG (oo-e type in $CdSiP_2$ and ee-o type in $ZnGeP_2$), which were in good agreement with the existing Sellmeier approximations, we arrived at $d_{36}(CdSiP_2)$-$d_{36}(ZnGeP_2)$ which is rather unexpected having in mind the larger band-gap of $CdSiP_2$. The reliability of the measurement was tested at the same wavelength by comparing $ZnGeP_2$ with $HgGa_2S_4$ which led to the result $d_{36}(ZnGeP_2)$-$3d_{36}(HgGa_2S_4)$, in very good agreement with previous estimations.

7197-22, Session 5

Second-harmonic generation in CdSiP2

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A new nonlinear optical crystal, $CdSiP_2$, has been developed and is an excellent candidate for infrared generation applications because of its thermal properties and ability to phase-match over a large range of wavelengths. Large, high quality, single crystalline samples have recently been grown with transparency from 0.56 to beyond 9.5 µm. $CdSiP_2$ has the potential to be pumped at near IR wavelengths to generate output in the mid and long wave infrared.

Second harmonic generation (SHG) experiments on an uncoated $CdSiP_2$ crystal have recently been completed. The sample used was an uncoated crystal with dimensions of 3.7 x 7.0 x 11.7 mm^3 and was cut at an angle of 42.5° with respect to the c-axis. The initial set of experiments used the frequency doubled output of a TEA CO_2 laser at a wavelength of 4.78 µm. The laser pulsewidth was 64 nsec (HW1/eM) with longitudinal mode beating present in the pulse. In $CdSiP_2$, SHG of 4.78 to 2.9 µm is a Type 1 process, e <-> o + o with the 4.78 µm pump polarized along the ordinary axis. Phase matching is predicted at an angle of 42.31°, which equates to an angle of 0.58° in air with this sample. Experimental results showed peak SHG at an external angle of 0.26° off normal, in agreement with theory. Accounting for Fresnel losses, internal conversion efficiency was over 55% at an incident irradiance of 56 MW/cm^2.