주기적으로 분극반전된 stoichiometric $LiTaO_3$을 이용한 OPCPA 연구

Application of periodically poled stoichiometric $LiTaO_3$ for OPCPA

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Optical parametric chirped pulse amplification (OPCPA) is an attractive amplification method, in which chirped pulse amplification (CPA) concept is combined with optical parametric amplification (OPA). The high pulse energy from powerful nano- or picosecond lasers/amplifiers can be efficiently transferred to temporally stretched femtosecond pulses. Compared to the widespread conventional regenerative/multi-pass femtosecond amplifier systems, OPCPA exhibits larger gain bandwidth, higher gain achievable without the use of gated electro-optic modulators and multi-pass amplification, lack of cumulative spectral narrowing, low nonlinear phase distortion and B-integral accumulation,high contrast ratio, low heat deposition and larger wavelength flexibility.

An overview of the progress in OPCPA in the last decade can be found in Ref. 1. The first trend observed is directed towards extremely high-power pulses (TW peak levels) at low repetition rates (< 10 Hz) with schemes operated collinearly at degeneracy and birefringent crystals of LBO, BBO and KDP having the highest damage thresholds. The second trend, towards ultimately short and tunable pulses, is related to the concept of noncollinear parametric amplification and pumping with shorter, typically 150fs long, pulses. The third trend is related to the development of more compact and reliable systems operating at kHz repetition rates, having both power and pulse duration at the intermediate level. Such systems are designed as all-diode-pumped and/or fiber based alternatives of commercially available Ti:sapphire based regenerative amplifiers but operate at different wavelengths. Periodically poled (PP) ferroelectric crystals seem predestined for this application since they ensure through their superior effective nonlinearity substantial improvement of the parametric gain but their limited thickness sets an upper limit for the pulse energy in order to avoid optical damage.

Stoichiometric $LiTaO_3$ (SLT) exhibits an order of magnitude lower coercive field than LiNbO3 or congruent $LiTaO_3$ (CLT) which is essential for the fabrication of thick quasi-phase-matched devices for high-power applications. Additional advantages of SLT include high damage threshold, low thermo-optic coefficients, wide transmission, and anonlinear coefficient larger than that of CLT.

In this work, We report the first application of PPSLT in a 1kHz OPCPA scheme (Fig. 1). The damage threshold is estimated with ns pump pulses. The amplified, in a single stage, signal pulse energy of 39.5 μJ corresponds to a parametric gain of $1.93*10^6$ which is roughly 6 times higher than previously achieved with PPKTP.[2] The spectral and temporal characteristics of amplified pulses are shown in Fig 2. The pulse duration at the wavelength of 1.57 μm amounts to 315 fs after recompression.

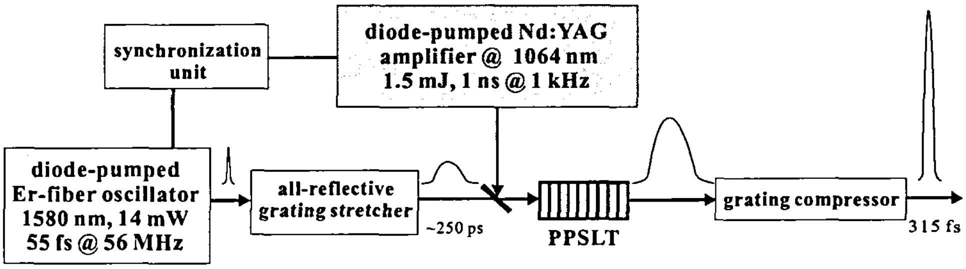

Fig. 1. Experimental setup of the single-stage PPSLT OPCPA

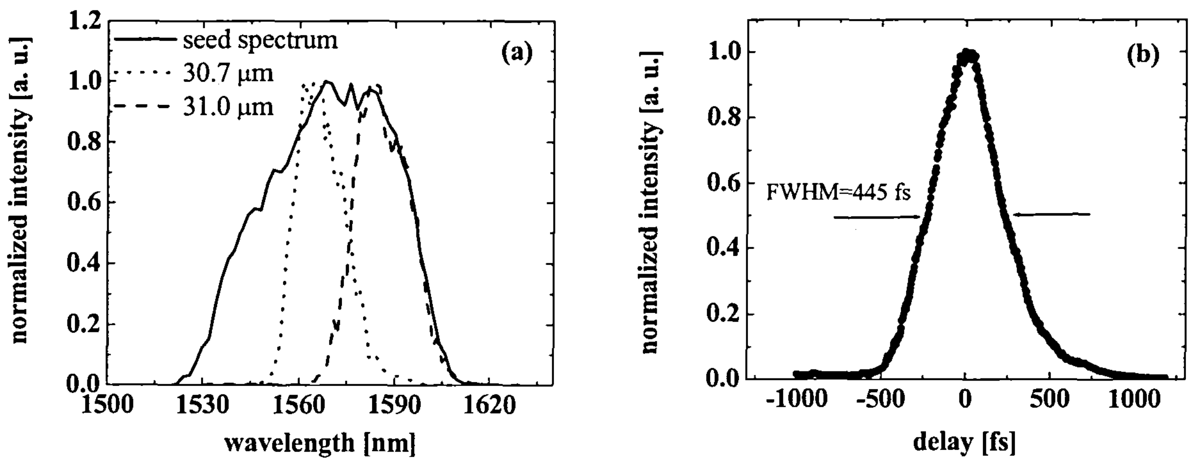

Fig. 2. (a) Seed spectrum measured behind the stretcher (solid line) and amplified signal spectra obtained with the 30.7 μm (dotted line) and the 31.0 μm (dashed line) QPM period, 7-mm long PPSLT samples, (b) autocorrelation trace of the amplified signal pulses after recompression.

References

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