Near-infrared Femtosecond Laser Pulse Amplification in Photorefractive Two-wave Mixing

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Abstract

Grating formation and its use through nonlinear two-wave mixing amplification (TWMA) technique in $Fe:LiNbO_3$ and $BaTiO_3$ photorefractive (PR) crystals for the processing of ultrashort laser pulses and other applications so far have been limited in the visible and ultraviolet regions of optical spectrum due to their low sensitivity in the near-infrared region. In this study, grating formation and TWMA of femtosecond laser pulses in $Fe:LiNbO_3$ and $Rh:BaTiO_3$ have been investigated at a wavelength of 800 nm.

Chapter 1 provides a background of photorefractive effects in electro-optic crystals and a brief sketch of its extended applications to cw laser and previous works on TWM with ultrashort laser pulses along with the motivation and objective of the present work.

Chapter 2 describes the theory of grating formation and TWMA in PR crystals for ultrashort laser pulses and basic PR properties of $LiNbO_3$ and $BaTiO_3$ crystals.

Chapter 3 describes the experimental methods and results of light absorption measurement and grating formation by low-energy 76 MHz and high-energy 1 kHz femtosecond laser pulses in 0.05 mol% $Fe:LiNbO_3$. One-photon absorption (~ 0.11 /cm) is dominant in this crystal up to 70 GW/cm^2. The dependence of diffraction efficiency and amplification on chirping of one of the writing pulses was investigated. The performance of grating formation at various laser intensities was compared. At high writing laser peak intensities of ~100 GW/cm^2, the diffraction efficiencies ranging in 13~17 % were obtained after the irradiation time of 600-1000 s even at a relatively low repetition rate of 1 kHz.

Chapter 4 describes experimental method and results of TWMA gain in $Rh:BaTiO_3$ (400 ppm Rh concentration in the melt) for 76 MHz femtosecond laser pulses at 800 nm. The measured one-photon absorption in this crystal is high (~ 1.1 /cm) at 800 nm. The role of geometric factor concerning grating width and beam overlapping width in producing gain was investigated. This crystal exhibits high TWMA gain, fast response time and sufficient bandwidth for femtosecond laser amplification. The effect of electron-hole competition in the observed TWMA gain due to two-photon absorption was also investigated. It was observed that beam fanning for femtosecond laser pulses is less pronounced than for cw laser.

Chapter 5 summarizes major findings, conclusions and future work.