Performance of Nonlinear Ultra-Short Pulse Fiber CPA System Using Power Amplifiers with Core Diameter from 12 to 33 μm

J. Želudevičius, R. Danilevičius, K. Viskontas, N. Rusteika, K. Regelskis
Department of Laser Technology
Center for Physical Sciences & Technology
Vilnius, Lithuania
j.zeludevicius@ar.fi.lt

Abstract—In this work nonlinear fiber CPA system is investigated, in which self-phase modulation is utilized both in stretcher fiber and power amplifier in order to achieve femtosecond output pulses. System performance using different power amplifier designs with core diameters ranging from 12 to 33 μm is experimentally investigated. Achieved results are compared and analyzed.

Keywords—Fiber laser; doped fiber amplifiers; fiber nonlinear optics; ultrafast optics.

I. INTRODUCTION

Fiber laser systems are attractive for many industrial and scientific applications because of compact size, robust design and easily achievable high average power output. However, achieving high-energy ultra-short pulses from fiber source is much more challenging because of nonlinear pulse distortions, which are caused by high peak intensities in the fiber core and large interaction lengths. Usually two main strategies are implemented to mitigate this: increasing of the mode area in the fiber and stretching pulses in time before amplification - chirped pulse amplification (CPA). Using conventional CPA method dispersion of the stretcher is matched to dispersion of the compressor and efforts are made to minimize nonlinear phase shift. However, fiber CPA (F CPA) can operate at high level self-phase modulation (SPM) and still provide high peak power pulses as it was recently demonstrated [1], [2].

In this contribution we investigate FCPA system, in which SPM is utilized both in stretcher fiber and power amplifier in order to achieve femtosecond pulses. Few power amplifier designs based on different active fiber are experimentally tested and results are compared.

II. EXPERIMENTAL SYSTEM AND RESULTS

Our experimental setup consisted of a passively mode-locked all-in-fiber picosecond oscillator (1064.7 nm center wavelength), the first pre-amplifier, an acousto-optic down-counter to reduce pulse repetition rate to 100 kHz, a polarization-maintaining single-mode fiber stretcher, the second preamplifier, a power amplifier and a bulk diffraction grating (1000 1/mm) compressor. Performance of the system was investigated using three different kinds of Yb-doped fibers for power amplifier: 12-μm core diameter polarization-maintaining (PM) large-mode-area (LMA), 25-μm core diameter PM LMA and 33-μm core diameter chirally-coupled-core (CCC) fiber [3]. Parameters (seed power and gain) for each power amplifier case were optimized for highest achievable peak power of the output pulses. Because of combined effects of gain shaping and SPM in power amplifier, third-order dispersion mismatch between fiber stretcher and bulk grating compressor was reduced and output pulse durations of around 400 fs (FWHM, assuming deconvolution factor 0.705) were achievable for all three power amplifier designs (Fig. 1). Pulse contrast was improved by introducing spectral filtering in the compressor. Achieved output pulse energy (before significant pulse distortion occurred), depending on fiber used in power amplifier, varied from 17 to 50 μJ. Output beam quality was nearly diffraction limited with M2 not higher than 1.2 for all three power amplifier designs.

![Fig. 1. Output pulse autocorrelation traces for three power amplifier designs. Fiber core diameter and achieved pulse energy are provided above corresponding graphs.](image)

REFERENCES


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