Pulse control and pulse jitter stabilization in Cr:ZnSe-passively Q-switched Ho:YAG lasers

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Abstract—We report on experimental investigation of various methods for pulse control and pulse jitter stabilization in Cr:ZnSe passively Q-switched Ho:YAG lasers. We explore methods of synchronous pump power modulation and application of dual passive/active Q-switch. Pulse jitter <0.1% and precise pulse control of PQS Ho:YAG laser has been achieved.

Keywords— Passive Q-switch, pulse jitter, Cr:ZnSe, Ho:YAG laser, Tm-fiber laser

I. INTRODUCTION

High-power fiber lasers have found numerous applications in industry for material processing as the most versatile tools featuring reliable maintenance-free operation. Direct quasi-resonant pumping of Q-switched Ho:YAG lasers by 1.9 um Tm-fiber lasers transforms its CW radiation in time- and frequency domains resulting in high energy nanosecond pulsed output radiation at 2.1 um at pulse repetition rates ranging from tens of Hz to tens of kHz [1]. Using of high-quality polycrystalline Cr:ZnSe saturable absorbers allows for building very simple and robust passively Q-switched (PQS) single frequency high-power 2.1 um pulsed laser systems operating at high repetition rates [2]. One of the inherent drawbacks of passive Q-switching techniques is a relatively high pulse jitter, undesirable for precise micromachining applications [3]. In this work we explore several techniques for significant reduction of the pulse jitter and precise control of the pulse train in PQS Ho:YAG systems.

II. EXPERIMENTAL SETUP AND RESULTS

The experimental laser cavity utilizes simple linear scheme and consists of two plane mirrors, 40 mm long 0.5% Ho:YAG gain crystal, dichroic polarizer/pump filter, and Cr:ZnSe saturable absorber at the Brewster angle. Transmission of Cr:ZnSe crystal and OC reflection were accurately selected for work at high pulse repetition rates (f>=10 kHz).

We investigated 2 methods for pulse control and jitter suppression: (a) synchronous pump power modulation at the natural repetition rate of the PQS laser; (b) addition of low-power AOM into the laser cavity. The first method could be used to perform up to 3 kHz pulse repetition rates and resulted in jitter suppression of an order of magnitude (down to ~1% of pulse period). The second method allows for arbitrary pulse repetition rates (10 kHz and above) and results in pulse jitter suppression down to 0.1% of pulse period. Additional significant advantage of dual Q-switch approach is complete and precise pulse train control (Fig. 1), critical for material processing applications. Addition of single-pass power amplifier allows for significant increase (up to 10 dB) of the output pulse energy. MOPA performance is depicted below.

Fig. 1. Waveforms of control electric signal (Ch1), optical pulse train (Ch2), and pulse profile of the dual Q-switch master oscillator.

Fig. 2. MO average power and pulse frequency.

Fig. 3. MOPA average output power and pulse energy at 52 W pump.

REFERENCES
