High power picosecond laser with adjustable pulse duration and repetition rate

Julie Siv, Julien Bour, Marc Zetek, Jerôme Lhermite, Giorgio Santarelli, Romain Dubrasquet, Romain Royon
Irisiome SAS, 1 rue François Mitterrand 33400 Talence
Author e-mail address:siv@irisiome.com

Abstract: We demonstrate a fiber based laser that generate picosecond pulses with adjustable pulse duration down to 35 ps and adjustable repetition rate up to 1.2 GHz. The average power can be amplified up to 35 W and the pulse generation method have been implemented at 1030 nm, 1064 nm, 1550nm and after frequency conversion at 775 nm and 532 nm. The pulses are gated thanks to an intensity optical modulator through a CW seeder then they are amplified by a multi-stage Erbium doped fiber amplifier (EDFA) or Ytterbium doped fiber amplifier (YDFA) depending on the wavelength.

OCIS codes: (140.0140) Laser and laser optics

1. Introduction

Nowadays, picosecond lasers can be found in many fields of applications from research to industry. These lasers are very common in bio-photonics, non-linear-optics, chemistry or machining and even a very conservative market, such as dermatology is becoming aware of the benefits of picosecond pulses for laser treatments.

For laser-matter applications and for instance fluorescence applications [1,2], the fine tuning and setting of the energy, the peak power and the pulse duration can be essential to study the dependence of the interaction with each laser parameter. So far, the most common ultrafast pulse generation technique, the mode locking does not allow a large flexibility of the pulse parameters because they depends on the design of the cavity and the nature of the gain medium. Moreover the change of one design parameter, not influence only one pulse parameter but several, since there are complex interactions of many effects to take into account[3].

In this conference, we demonstrate an ultrafast pulse generation based on pulse sampling in continuous wave laser signal. It allows the independent and fine tuning of many pulse parameters on a wide range such as the pulse duration, the repetition rate, the peak power and the pulse energy.

2. Experimental setup

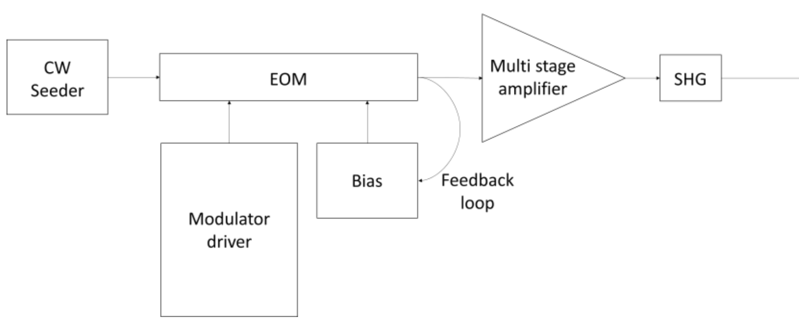

Fig. 1 Diagram of the laser system; CW, continuous wave; EOM, electro-optics modulator; SHG, second harmonic generator

Figure 1 shows a diagram of the laser system. The system is composed of a CW laser seeder. It is usually a narrow bandwidth laser diode but we also experimented a commercial integrated tunable laser assembly (ITLA) from 1535 nm to 1565 nm wavelength or a tunable fiber seeder from 1020 nm to 1080 nm developed at Irisiome[4]. The CW seeder is then injected into a Mach-Zehnder (MZ) intensity electro-optical modulator (EOM). The EOM is connected by a driver designed by Irisiome with two inputs to control the repetition rate and the pulse duration. The repetition rate is driven by an external a 0-5V TTL RF electrical signal and the pulse duration is driven by an external electrical voltage.

The purpose of the intensity modulator module is to sample pulses within the CW signal with a repetition rate and a pulse duration set by external controls. At the output of the intensity modulator, the resulting average power depends on the repetition rate and the pulse duration. The challenge of such a laser system is to be able to amplify correctly the signal for any pulse parameter within the adjustability range of pulse duration and repetition rate. To be able to do so, we have developed a specific architecture of multi stage fiber amplifier based on Ytterbium or Erbium doped fiber.

We have also demonstrated 775 nm and 532 nm operation with setups including a built-in second harmonic generator.

3. Results and measurements

The minimum pulse duration we managed to obtain is 35 ps. At this pulse duration, the temporal pulse profile is Gaussian. If one widen the pulse duration, the temporal pulse profile is flat top with a raising and falling edge of around 15 ps.

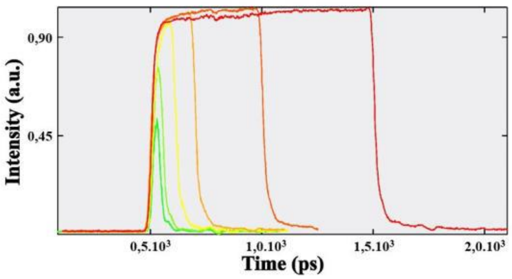

Fig. 2. Temporal pulse profiles measured between 35 ps and 1 ns with a fast response photodiode

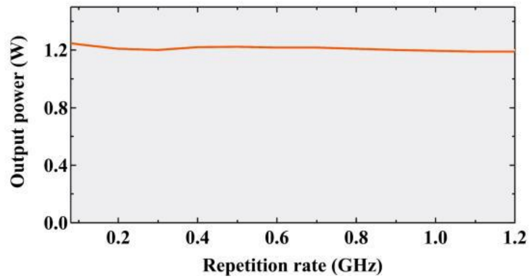

Fig. 3. Output power vs repetition rate measured at 15 different repetition rates

We demonstrate repetition rate adjustability from 5 MHz up to 1.2 GHz at 1030nm and 1.2 W. The measurements shows that the average power of the laser system after amplification does not depends on the repetition rate. Therefore, at a constant pulse duration, the fine tuning of the repetition rate allows a fine tuning of the pulse energy and peak power.

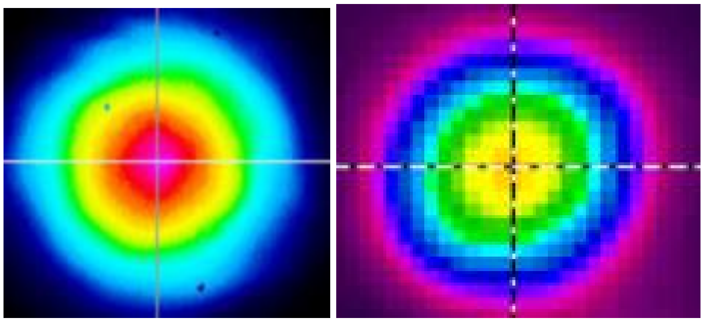

Fig. 4 Spatial profile at 1064 nm, 16 W (left) and 1550 nm, 10 W (right)

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