High-Energy Yb:KYW Ultrafast Laser

C.Y. Ramirez Corral*, C.G. Leburn and D.T. Reid

*correspondence author - cyr2@hw.ac.uk

ABSTRACT

We describe the characterization of a diode-pumped Yb:KYW (ytterbium-doped potassium yttrium tungstate) femtosecond laser that is soon to be incorporated in a Master Oscillator Power Amplifier. To date this laser has generated over 4.1 W of average power at λ=1030 nm with a slope efficiency of 30%. Pulses as short at 500 fs have been generated at a pulse repetition frequency of 56 MHz.

INTRODUCTION

This work is part of a project that aims to deliver new laser device technology based on ytterbium materials along with short-pulse generation techniques to develop a family of industrial ultra-fast picosecond and femtosecond MOPA systems with average power levels up to 300W, to service a range of new applications in precision materials processing.

Femtosecond laser technology has lead to new laser materials such as highly efficient Yb-doped crystals. This project utilised Yb:KYW which allows for the generation higher power and energy at 1µm. Due to ability to vary the doping concentration of Yb:KYW this material can be used for several applications [1, 2, 3]. Some configurations using Yb:KYW crystals have demonstrated output powers > 10 W [4, 5]. Other advantages of these crystals include their absorption band at 981nm where high brightness diodes can be implemented to pump the gain system [6].

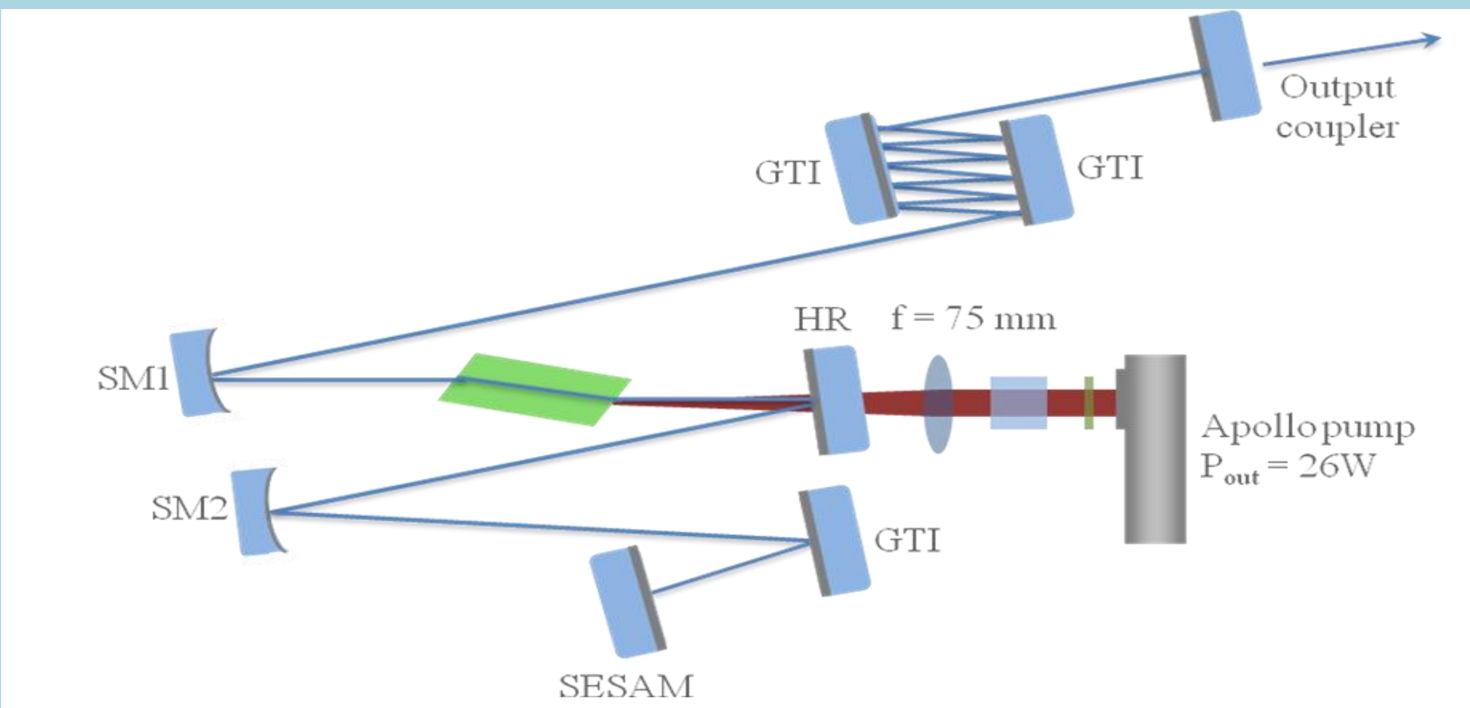

Figure 1: Schematic of laser geometry.

EXPERIMENTAL SETUP

In this configuration (Figure 1) the oscillator is pumped by a laser diode (*Apollo C32-981-0*) linearly polarized output, tunable to 981nm, with a pump power of 26 W, and a M²=16.

The pump beam is focused by a 75-mm lens into the Yb:KYW crystal with a Brewster angle cut, it has a doping of 1.5.% at. and is 10 mm in length.

The cavity was designed so the spot radius in the crystal is 160 µm. One arm of the cavity is terminated by a SESAM, and the other arm by an output coupler. Two GTI mirrors are used in the long arm of the cavity for dispersion compensation. The crystal and the pump laser are mounted on water cooled plates at 20°C.

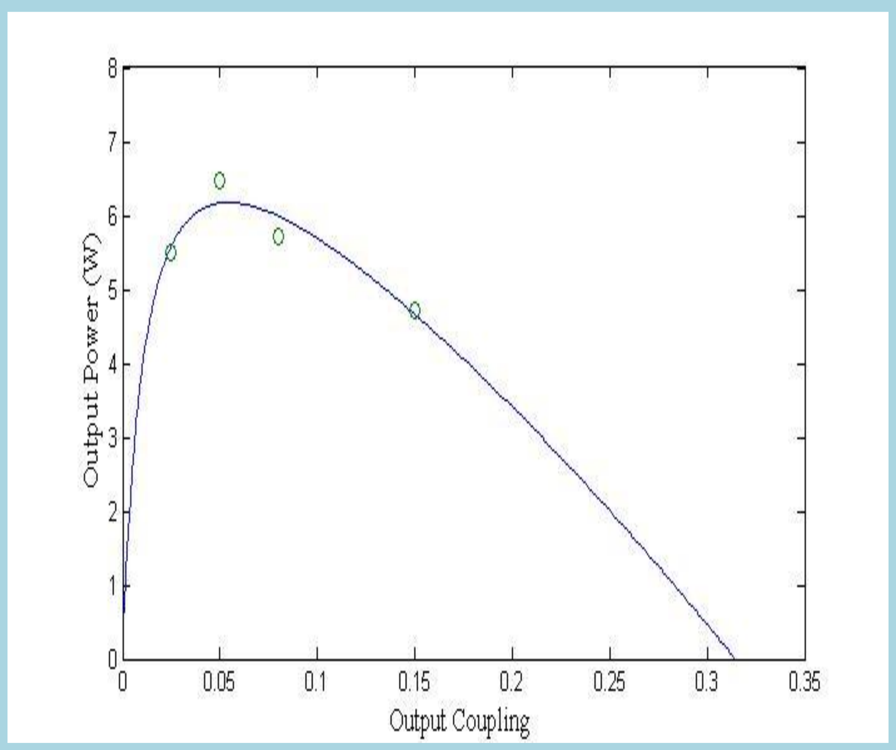

Figure 2: Rigrod analysis

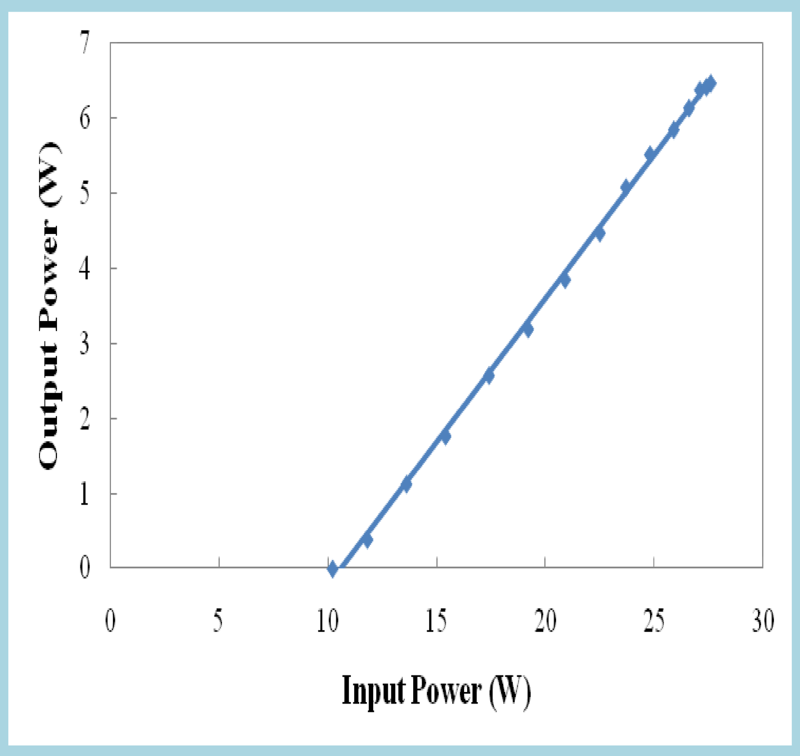

Figure 3: Slope efficiency

CW Operation

- 4 output couplers (2.5%, 5%, 8% and 15%), were used to perform a Rigrod analysis (Figure 2)[7]. This yielded parasitic losses of 0.86%
- Using the optimal output coupler of 0.5%, 5.5 W output power were generated, with a 30% slope efficiency (Figure 3).
- The output beam was measured to be M²=1.1
- A tunability between 1020-1057 nm was obtained for three different output couplers (Figure 4).

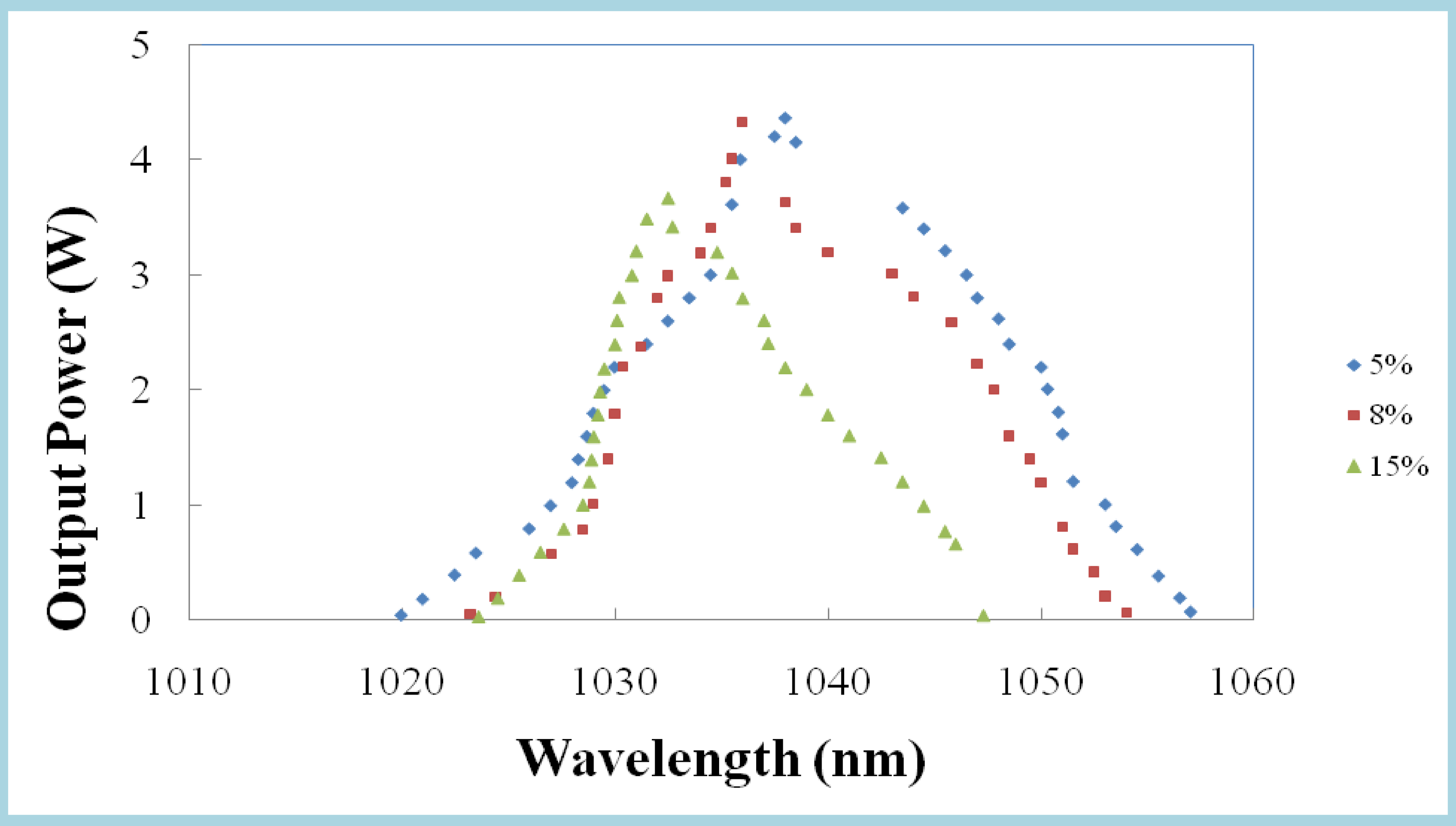

Figure 4: Spectral tunability

Pulsed Mode

- The cavity was mode locked with a selection of different SESAMs. Average output powers = 4 W could be generated with with A=2%, 1% and 1.5% *BATOP* SESAM.
- A GTI mirror pair in the long arm with 5 bounces of the beam between them, and one more in the short arm was used to compensate intracavity dispersion and stabilise the the mode locking, but this lead to a reduced output power of 3.6 W.
- Autocorrelation of the pulses is shown in Figure 6 for a sech² pulse shape, with a p.r.f.=56 MHz at 1030 nm.

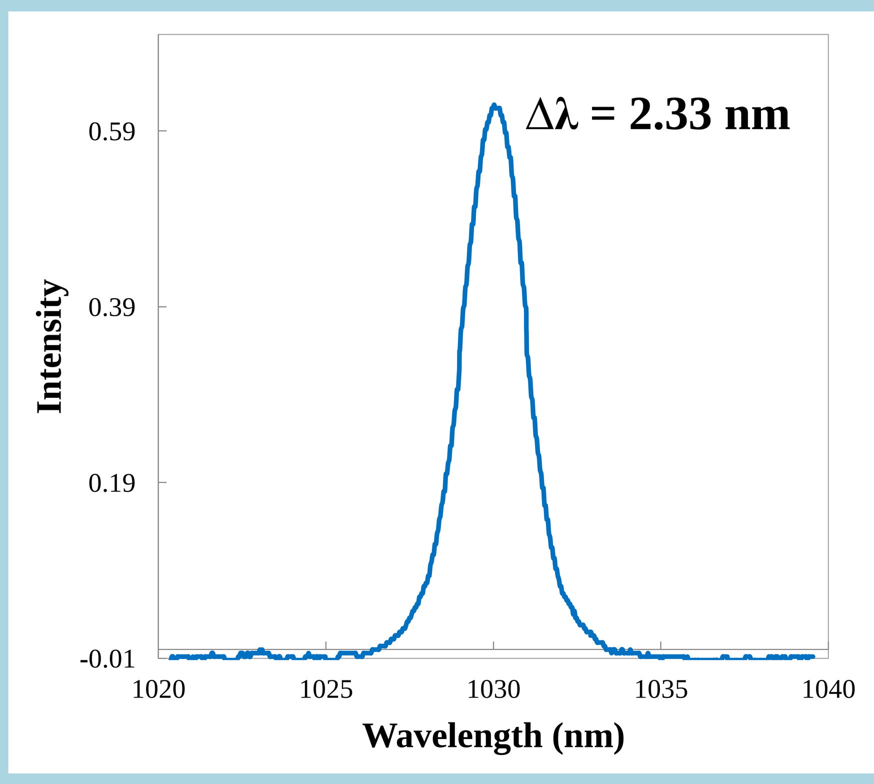

Figure 5: Spectral output.

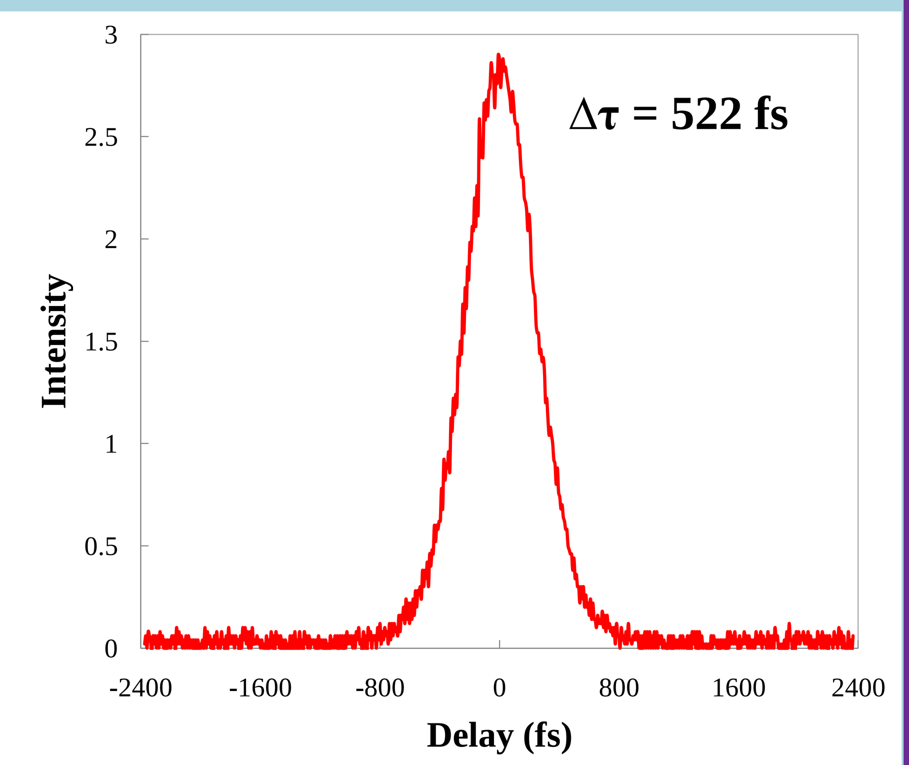

Figure 6: Autocorrelation.

FUTURE WORK

- Build a pulse picking system.
- Build a new cavity configuration with different doping of the crystal, to reduce the number of elements in the cavity and improve the results.

REFERENCES

[1] – Yehoshua Kalisky, et. al., IEEE Quant. Elec., 13, 502-510 (2007).
[2] – A.A. Demidovich, et. al., J. of Alloys and Comp. 300–301, 238–241, (2000).
[3] – A.A. Lagatsky, N.V. Kuleshov, V.P. Mikhailov, Optics Com. 165, 71–75 (1999).
[4] – Gary R. Holtom, Opt. Lett. 31, 2719-2721 (2006).
[5] – A.-L. Calendron, K. S. Wentsch, M. J. Lederer, Opt. Exp. 16, 18838-18843 (2008).
[6] – A. Lagatsky, et. al., *Electron. Lett.*, vol. 39, pp. 1108–1110, (2003).
[7] – W. W. Rigrod, IEEE 14, 377 (1978).