Advanced Optical Technology Ltd

Technical Note (10)

Further into the Picosecond Pulse-Length Regime

Introduction

Advanced Optical Technology (AOT) has been developing short-pulse, high rep-rate E-O Q-switched solid-state lasers since 1999. The lasers are all diode pumped, very efficient and have found use for a wide range of applications from scientific (academic and commercial) research through to precision micro-machining. In 2002, the company was the first to offer the option of subnanosecod pulse duration at high repetition rate from an actively Q-switched laser. The SP Models were introduced for applications such as optical ranging and 'excite and probe' type measurements where the short pulses brought greater accuracy or temporal resolution. These SP lasers have been very attractive and economical sources for users.

Figure (1) Oscilloscope record showing the relative timing of the voltage waveform (yellow) applied to open the Q-switch and the laser output pulse (green) in a miniature laser experiment. For these traces the temporal resolution is limited by the finite bandwidth of the diagnostic system.

Subnanosecond Laser Pulses

Since 2002, Stuart Pearce at AOT has been supported under an Engineering Fellowship from the Royal Commission for the Exhibition of 1851 and, with the guidance of Prof Pete Dyer at Hull University, has been studying the parameters controlling the laser output (especially pulse duration) in actively Q-switched miniature lasers ie lasers of the type offered by AOT. The study has included analytical and numerical models and trials with modified experimental resonators. The company's goal has been to reliably produce pulses of < 500ps without sacrificing either laser beam quality or power. It has been found that the main factors controlling performance in this subnanosecond time domain are laser gain and Q-switch optical risetime. The optimum arrangement for generating short pulses occurs when the pulse build-up time and Q-switch opening time are comparable and pulses are emitted when the switch transmission reaches it's peak, as indicated by the timing in Figure (1).

New Picosecond Laser Model

1064nm Performance

As a result of this work, AOT can announce that it is now able to offer customers performance in this sub-500ps regime. Results at 1064nm with a demonstrator system operating at constant pump power are shown in Figure (2). It can be seen that pulse length falls below 500ps in the 0-10kHz pulse repetition rate range and pulse peak power exceeds 50kW.

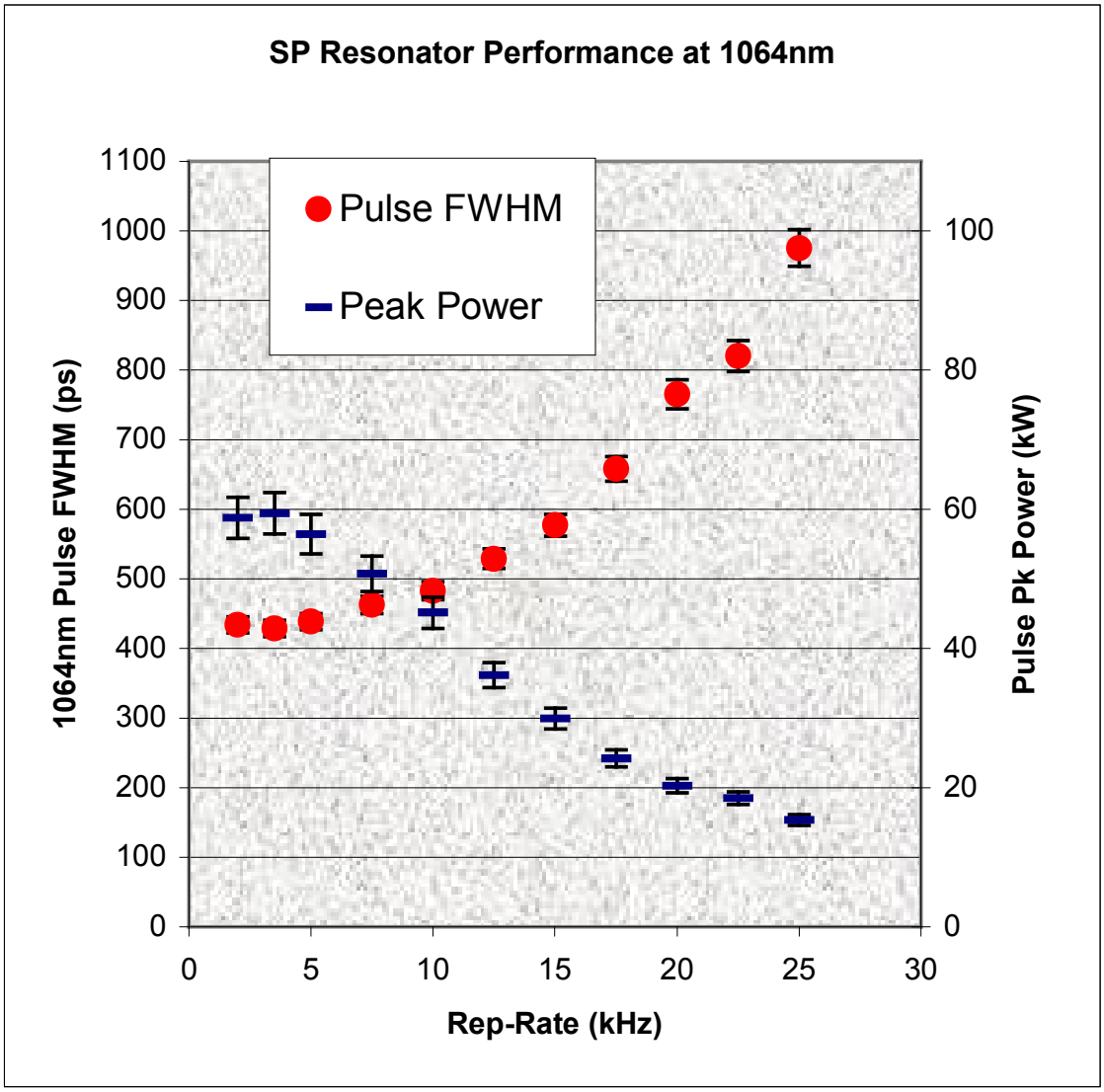

Figure (2) Pulse duration and peak power performance of the new AOT-YVO-20QSPX demonstrator as a function of repetition-rate. The bars indicate standard deviation: (i) For pulse length ~ 2.5% at low repetition rates rising to ~ 7% at 20kHz. (ii) For peak power ~ 4% at low repetition rates rising to ~ 6% at 20kHz.

As with previous SP oscillators from AOT, the laser is capable of 25µJ/pulse at low repetition rates and up to 300mW average power at 20kHz. ie the new SP laser achieves sub-500ps TEMoo performance without sacrificing efficiency or the ability to externally trigger and synchronise the pulses (jitter down to < 200ps). Figure (3) below indicates how the pulse parameters change with diode pump power.

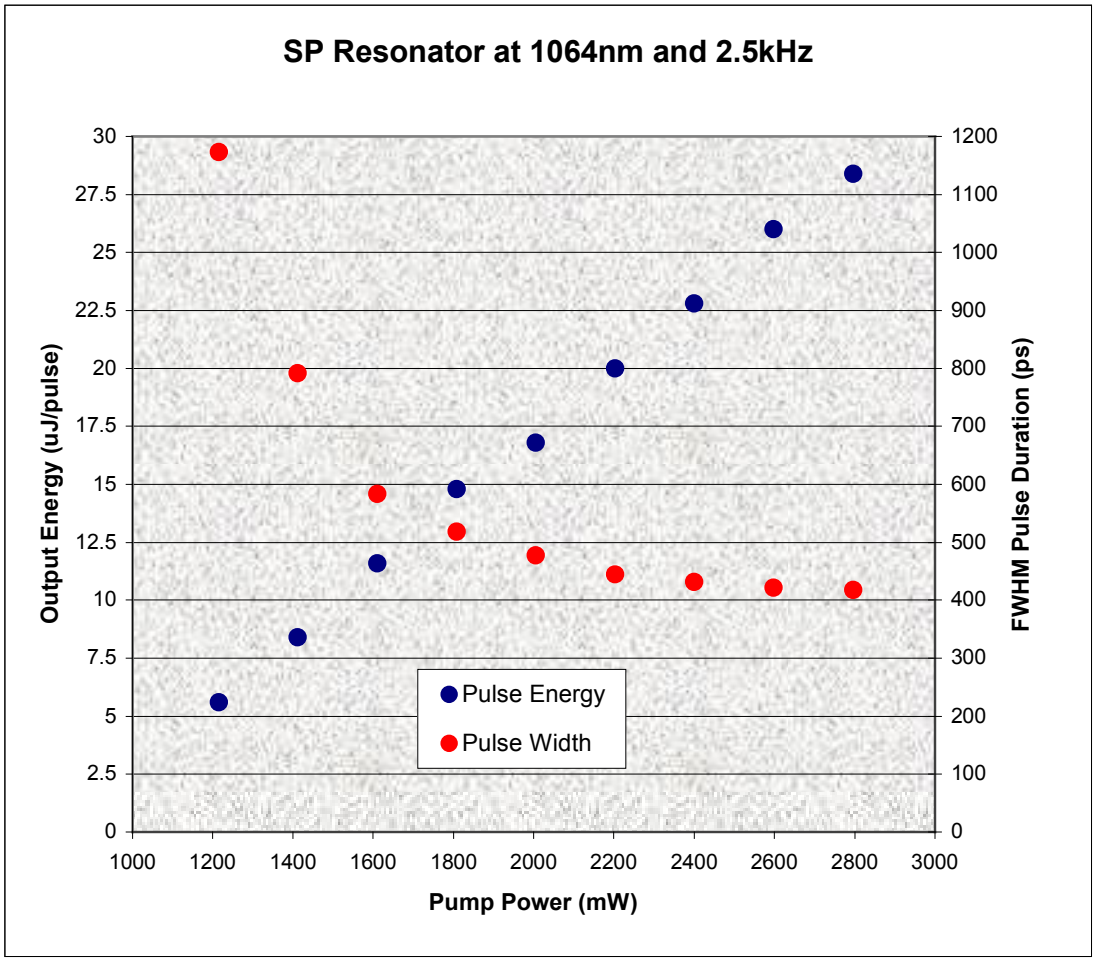

Figure (3) Effect of 808nm pump power on SP oscillator pulse energy and duration under low rep-rate operation.

Harmonic Performance

For a number of applications, average power in the laser beam rather than pulse energy is a more important parameter for users, and this is a maximium at harmonic wavelengths in the 10-20kHz repetition rate range for the SP laser – eg see Figure (4) below. The nature of the non-linear process means that the pulse durations are further shortened at the harmonic wavelengths. For example, at 12.5kHz, the demonstrator laser produced 513ps pulses at 1064nm, which shortened to 407ps at 532nm, 397ps at 355nm, and 354ps at 266nm.

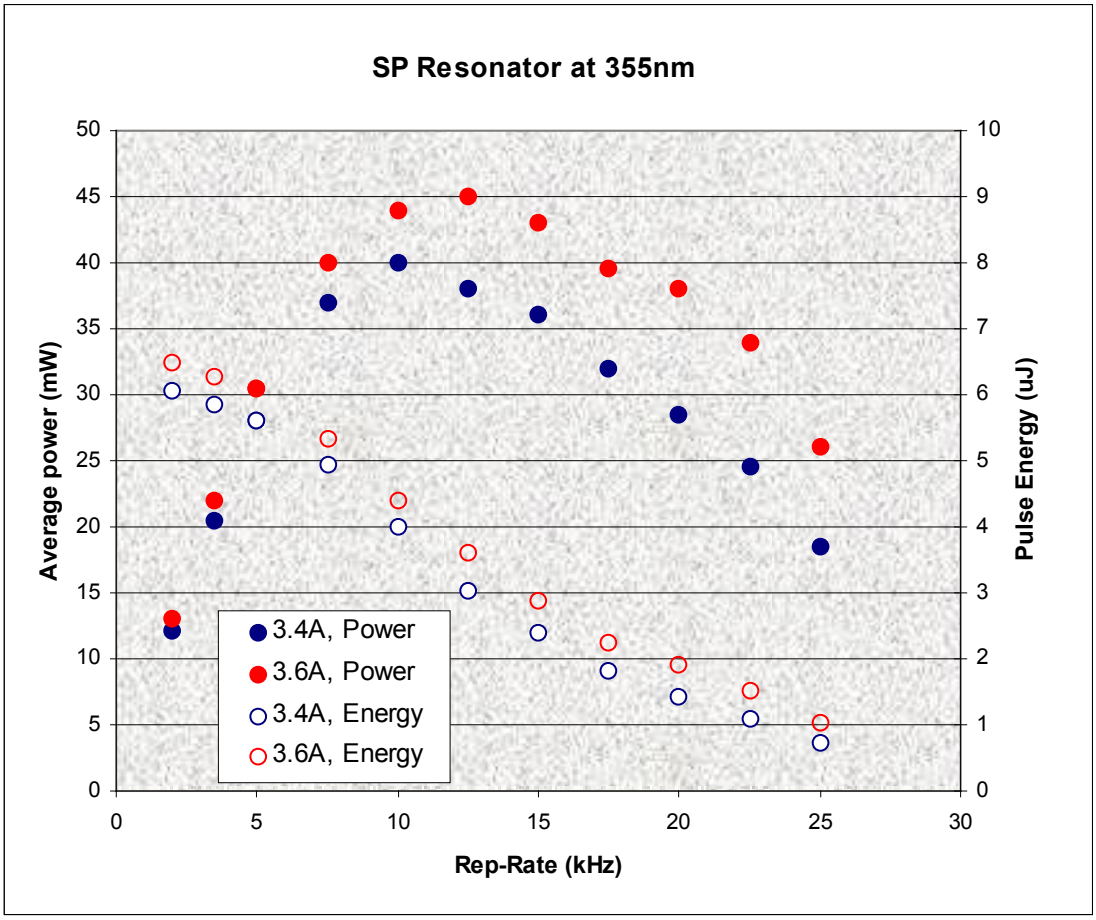

Figure (4) Change in average power and pulse energy with repetition rate at 355nm using standard AOT harmonic module based on LBO/LBO non-linear crystals. Data recorded at two different pump levels ie diode at 3.4A and 3.6A, respectively.

AOT expect that the unique capability of the new SP laser (model designation AOT-YVO-20QSPX), operating well into the picosecond pulse regime, will further expand applications for users of the Company's ACE laser range.