Technical Note 8

Performance Overview

ACE™ lasers from Advanced Optical Technology comprise oscillators and oscillators plus amplfiers (MOPAs), and offer unique capability in all applications where high intensity TEMoo short pulses are essential for user success. The ACE Oscillator range of Q-switched diode pumped solid-state lasers can operate to 100kHz, and is unique in being able to achieve less than 500ps pulse duration and 50kW peak power performance. MOPA models operate with similar rep-rates and pulse durations, but at significantly higher power i.e. into the several Watts range. In all cases, proprietary active Q-switching technology provides sub-nanosecond-timing jitter for the most demanding applications.

ACE Oscillator Models

The following figures are indicative of the high performance achieved by the laser source design.

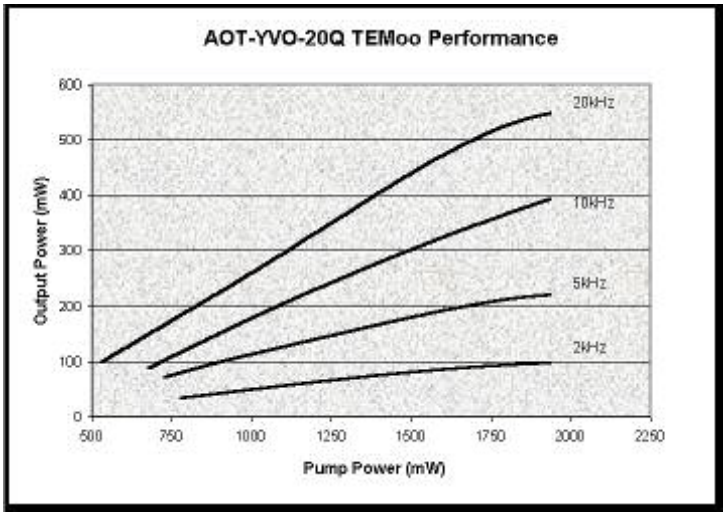
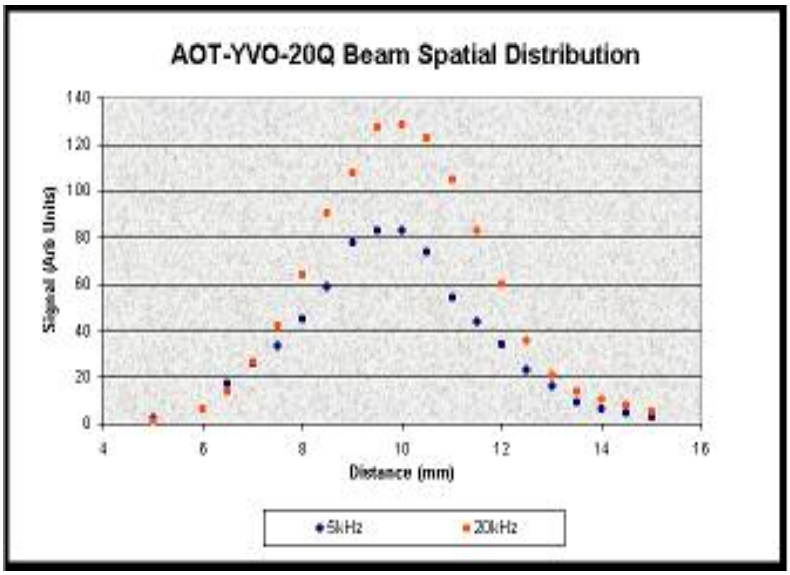


Figure (1)
Average TEMoo output power of the AOT-YVO-20Q oscillator in Q-switched mode at different repetition rates illustrating the high efficiency achieved

Figure (2)
Far field spatial profile of AOT-YVO-20Q oscillator at 5kHz and 20kHz, where output was 50mW and 250mW respectively. The change in beam divergence between the operation at the two pulse frequencies is < 10%



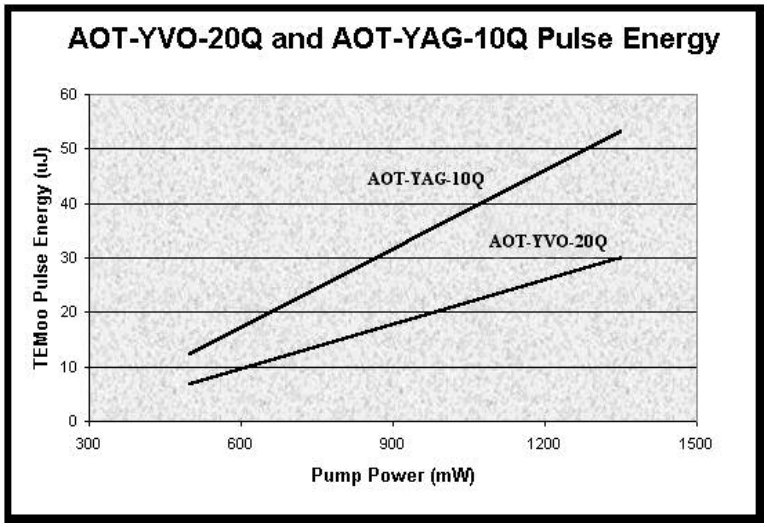


Figure (3)
Relative pulse energy performance of AOT-YVO-20Q and AOT-YAG-10Q lasers at low repetition rates. Because of the longer storage time (230µs versus 100µs) the max pulse energy from the YAG oscillator is near x2 that of the YVO oscillator.

Figures (4 & 5): The combination of exceptionally short Q-switched pulse duration and high beam quality provides high conversion efficiency to harmonic wavelengths. For example, in the standard format KTP gives up to 50% conversion to 532nm with both YVO4 and YAG pulses. AOT select the non-linear crystals to best match the power range of each model, and maintain efficient conversion for the rep-rate range covered.

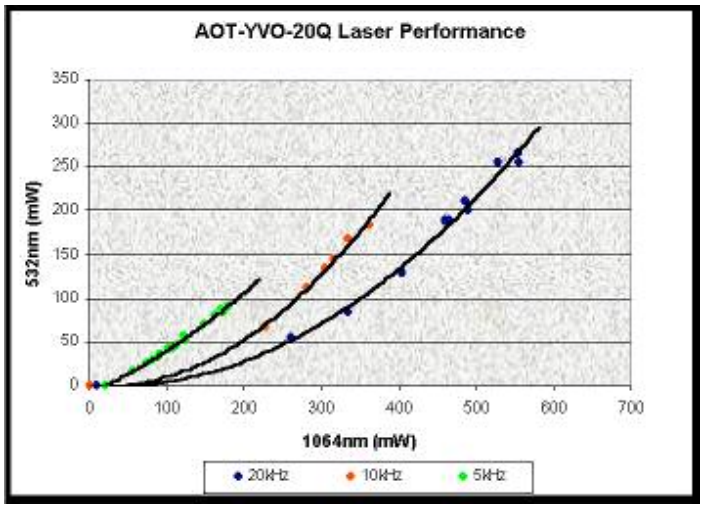


Figure (4)

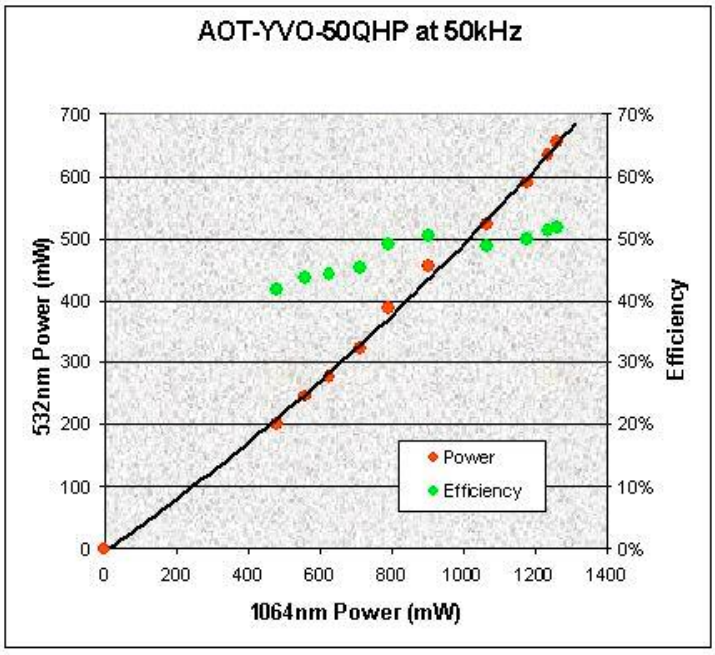


Figure (5)

The ACE YVO4 lasers provide very short duration pulses even at high repetition rates. The traces in Figure *(6a and b)* are of 1064nm pulses from an AOT-YVO-20QSP and an AOT-YVO-20Q oscillator, respectively. The former *(a)* was recorded at 5kHz with a 2Ghz bandwidth oscilloscope (time scale 500ps/cm) and the latter *(b)* at 10kHz with a 5GHz sampling scope (time scale 1ns/cm). The records show 1064nm pulses with a FWHM duration of ~600ps and 1.5ns, respectively. The company maintains a very active R&D program, and early in 2005, introduced SPX models that produce pulses of duration below 500ps at 1064nm, and in a range down to ~350ps at harmonic wavelengths

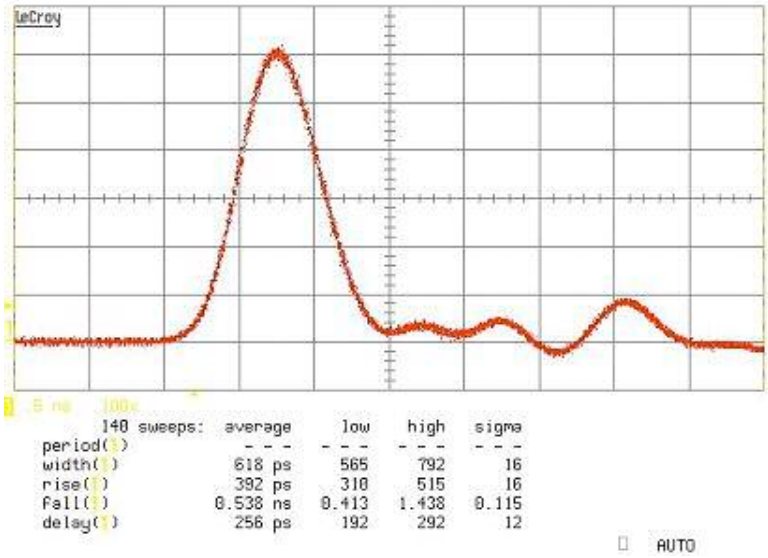


Figure (6a)

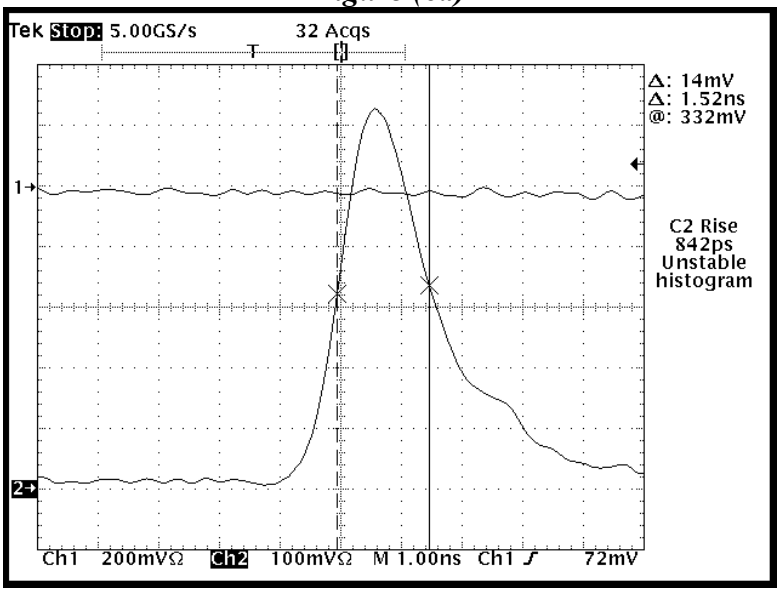


Figure (6b)

ACE MOPA Models

As with all designs of laser oscillator, optical intensity and beam quality considerations mainly determine the practical power performance limit. For higher peak and average power, amplifiers are added. The ACE range of MOPA lasers use a simple and very efficient design that can significantly increase the performance of ACE oscillators. MOPA models can deliver a maximum peak power of ~200kW and average power of >2W

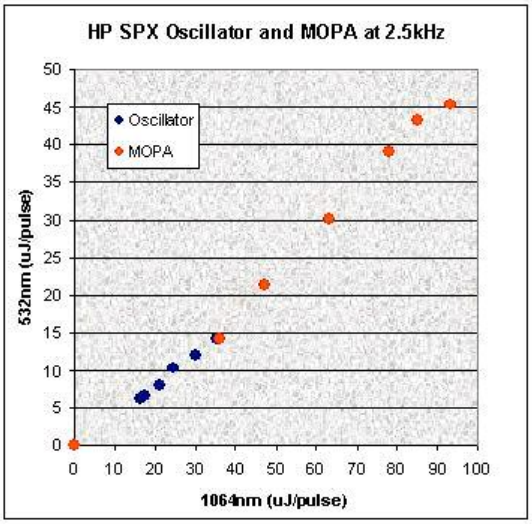


Figure (7)

Harmonic conversion efficiency is an important indication of beam quality after amplification. For most users an excellent TEMoo beam profile is quite critical for their application. The MOPA amplifier allows this maintencance of good beam quality, as indicated by the data in Figure (7). In this example, it can be seen that the energy conversion efficiency of the HP-SPX oscillator is ~50%, a value that doesn't change for the MOPA as the amplifier pump power is changed over it's full range. In this case, at the maximum pump power, 90µJ, ~ 500ps pulses at 1064nm were converted to 45µJ, 400ps pulses at 532nm

Maintenance of high intensity (short pulse duration and good beam quality) is particularly important for good harmonic conversion efficiency at high rep-rates. The HP MOPA models are particularly suited to high rep-rate (25kHz - 100kHz) operation, as the available high pump (HP) power provides relatively high gain which keeps the pulse short. In the example in Figure (8), the MOPA was optimised for ~ 50kHz operation, and can be seen to have achieved excellent conversion of power from the IR to the UV. In this example, the 1064nm pulses were of duration 1.5ns and the 355nm pulses <1ns duration. At high pumping, the average power conversion was 30% and the peak power conversion ~ 50% to the UV.

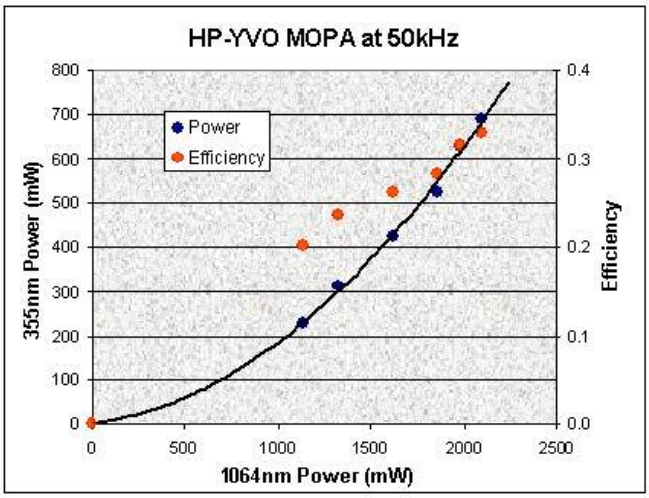


Figure (8)

High power, short pulse MOPA performance can be extended by further similar stages of amplification. AOT offer special systems based on twin amplifiers that provide IR power of > 4W, and the option of 532nm power to 2W and UV power of > 1W

Fibre Delivery

As a special option, AOT can supply fibre optic beam delivery (FOBD) with all models. The option allows the user great flexibility in beam delivery, and can provide the opportunity to achieve an application not otherwise possible. However, at the very high intensities achieved by the ACE laser models, fundamental limitations impact fibre use, and it can degrade both power and beam quality. For this reason, AOT would advise customers with a potential interest in a FOBD option to contact the company to discuss their particular requirements.

For further technical information please refer to Technical Note (7) - Fibre Delivery of ACE Laser Pulses, Technical Note (9)- Fibre Delivery in the UV and Technical Note (13)- Use of Photonic Fibre to Deliver ACE Laser Pulses.