Advanced Optical Technology Ltd

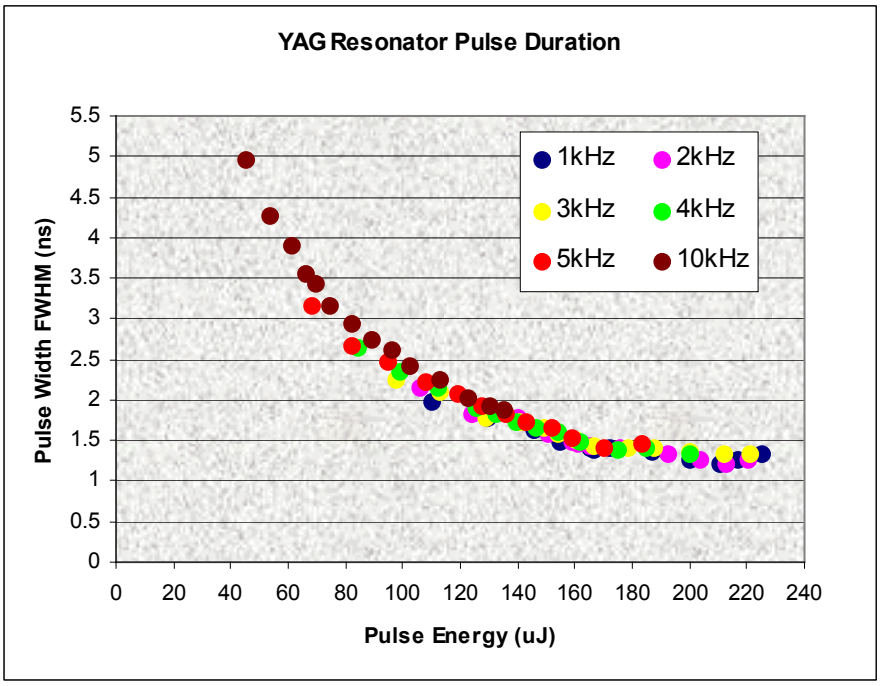
Technical Note No: 17

Short Laser Pulses with Increased Energy

There are a number of laser applications that don't need high repetition-rates but would benefit from greater pulse energy. In such cases, the average power requirement remains modest and an ideal (cost-effective) solution doesn't necessarily involve use of a MOPA format ie adding an amplifier eg see Pearce S, Ireland CLM and Dyer PE (2005). In response to this requirement, AOT has studied the limitations to pulse energy from short pulse oscillators at modest (ie few kHz) repetition-rates.

The various models of oscillator performance all point to the need to ensure a short resonator and high round-trip gain to allow generation of short oscillator pulses: see for example Degnan JJ (1989) and Siegman (1986). Practical issues that affect the oscillator design include; limits to miniaturization of essential resonator components, the maximum achievable gain hold-off of the Q-switch, the requirement of efficient TEMoo mode pumping/selection, and the threshold for the on-set of non-linear effects such as optical/dielectric breakdown and damage, power loss due to stimulated Raman emission, etc: eg see Koechner W (1999), and Pearce S, Ireland CLM and Dyer P (2006).

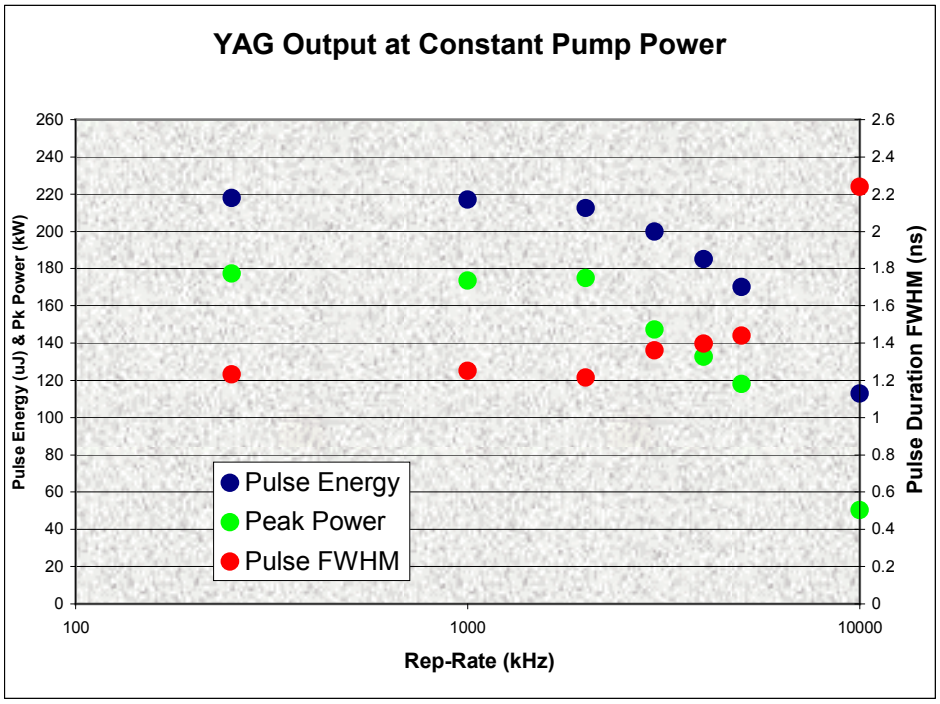
In the case that high energy as well as short pulses are required, a gain medium with a long storage life-time, low up-conversion (loss) coefficient, and modest stimulated emission cross-section is desirable. When coupled with a user need that doesn't require very high rep-rates, this combination of requirement favours Nd:YAG over Nd:YVO_4 as the laser gain material.



6 February, 2008

We have investigated a number of the practical limits of Nd:YAG in miniature short pulse oscillators with a view to offering our customers short pulses at higher pulse energy in the rep-rate range to 10kHz.

The development work has been based on our standard oscillator format eg as used in the AOT-YAG-10Q. The low rep-rate resonator optimization process, based on the model in Pearce et al (2006), has allowed significantly higher pulse energies to be achieved without detriment to reliability or lengthening the laser pulses. The trial results are summarized by the first two figures included in this note. The first (above) shows the relationship between pulse energy and pulse duration for the resonator, and the second (below) the impact of rep-rate on key pulse parameters. As expected with Nd:YAG as the gain medium, the pulse parameters are near constant for rep-rates to 2-3kHz.



Measurements of the UV performance of the oscillator were made with a standard harmonic module employing 15mm LBO doubling and mixing crystals. The results are shown in the final figure. The achievement of energy conversion to above 40% indicated that the 1064nm TEMoo mode pump beam quality was excellent. The efficiency role-over at the highest input energies strongly suggested that shorter crystals might well be needed for an optimised arrangement and give even better UV performance.

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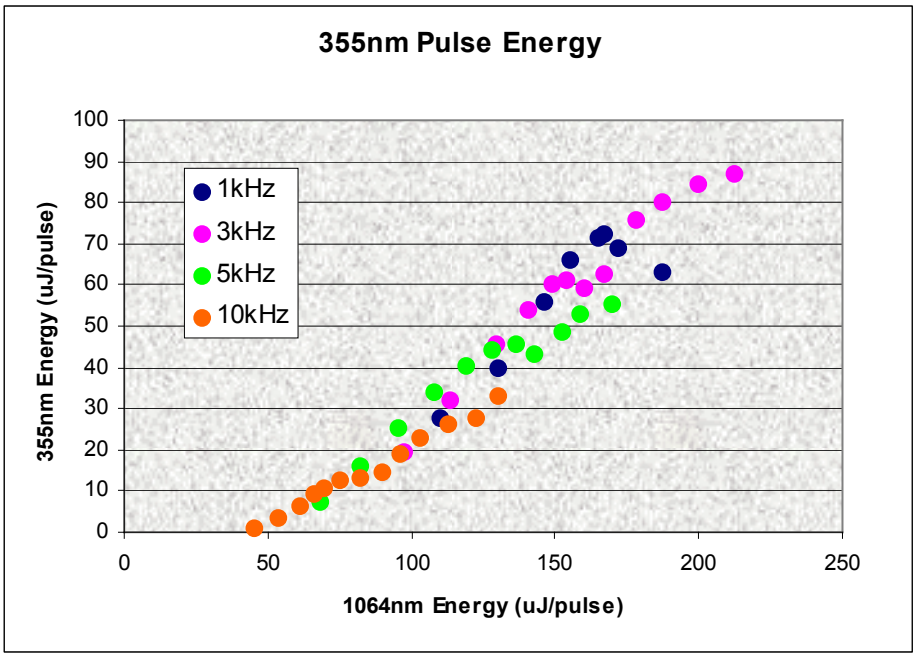

This encouraging laboratory development has led us to introduce a higher energy version of our YAG oscillator (new model designation: AOT-YAG-10QE) for those requiring higher energy and peak power pulses at modest kHz rates.

Pearce S, Ireland CLM, and Dyer PE, 'Simplified Analysis of Double-Pass Amplification with Pulse Overlap and Application to Nd:YVO_4 Laser', Optics Communications, Vol 255, p297-303, (2005).

Siegman AE, 'Lasers', Science Books, Sausalito, (1986)

Degnan JJ, IEEE Journal Quant Electron., Vol QE-25, p214-218, (1989).

Koechner W, 'Solid-State Laser Engineering', Fifth Edition, Springer-Verlag, Berlin 1999.

Pearce S, Ireland CLM, and Dyer PE, 'Solid-State Raman Laser Generating < 1ns Mulit-Kilohertz Pulses at 1096nm', Optics Communications, Vol 260, p680-686, (2006).

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