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30TW chirped pulse amplification using the VULCAN high power Nd:glass laser.

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Abstract.

1nJ pulses from a laser diode pumped additively modelocked Nd:LMA oscillator has produced 25J using chirped pulse amplification. The output pulse duration was 800fs, the peak power 30TW, and the focused intensity $>10^{18}Wcm^{-2}$.

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Summary

This paper reports recent experiments using VULCAN, a Nd:glass amplifier sited at the Rutherford Appleton Laboratory, U.K., where 1nJ pulses from a novel laser diode pumped oscillator were amplified to energies of 25J on target. Chirped pulse amplification (CPA) has been used in solid state laser systems to avoid the power limit set by nonlinear self phase modulation and self focusing that would otherwise prevent amplification of ultrashort pulses to high peak powers.[1] The technique relies on

stretching the short pulse from the oscillator, amplifying the stretched pulse, followed by compression to its original duration.

We report the operation of a laser diode pumped oscillator based on $Nd_xLa_{1-x}MgAl_{11}O_{19}$ (Nd:LMA or LNA) which has a 1.3THz linewidth centred on 1054nm. This oscillator, shown in figure 1, was modelocked by additive pulse modelocking using a dispersion compensated Michelson interferometer. Pulses as short as 420fs were generated with pulse energies in excess of 1nJ, and average output powers of 130mW.[2] The oscillator was developed at the Optoelectronics Research Centre, Southampton University and comissioned on the VULCAN system where it has routinely been operated for periods of 12 hours without operator intervention.

A single pulse was selected, stretched by a factor of 400 to 200ps, and amplified to 50J in a single beam line of VULCAN. The net gain factor of $5x10^{10}$ results in spectral narrowing from 2.4nm to 1.6nm. The peak of the spectrum was observed to shift towards the gain maximum of Nd:glass (1054nm). The stretched pulse was recompressed using a pair of gratings (30cm by 15cm, 1740 lines per mm) separated by 2.8m. The transmission of the compression stage was typically 50% resulting in an energy on target of 25J. The compressed pulse duration, measured using a single shot autocorrelator, was 800fs yielding a peak power of 30TW. The pulses were focused into a gaseous target using a 450mm focal length off axis parabola lens and the spot size measured with an equivalent plane monitor to be 15μm by 17μm, approximately 3 times larger than the diffraction limit, consistent with the normal

performance of the VULCAN amplifier chain. The estimated peak intensity is $>10^{18}Wcm^{-2}$. Contrast ratio experiments are in progress and will be reported at the meeting.

The system has been used to perform a range of laser/plasma interaction experiments. A number of improvements are possible which would increase the pulse energy and reduce the net gain requirements. Shorter seed pulses are also desirable and the construction of a laser diode pumped Nd:glass oscillator is in progress which is expected to produce pulses of 100fs duration.

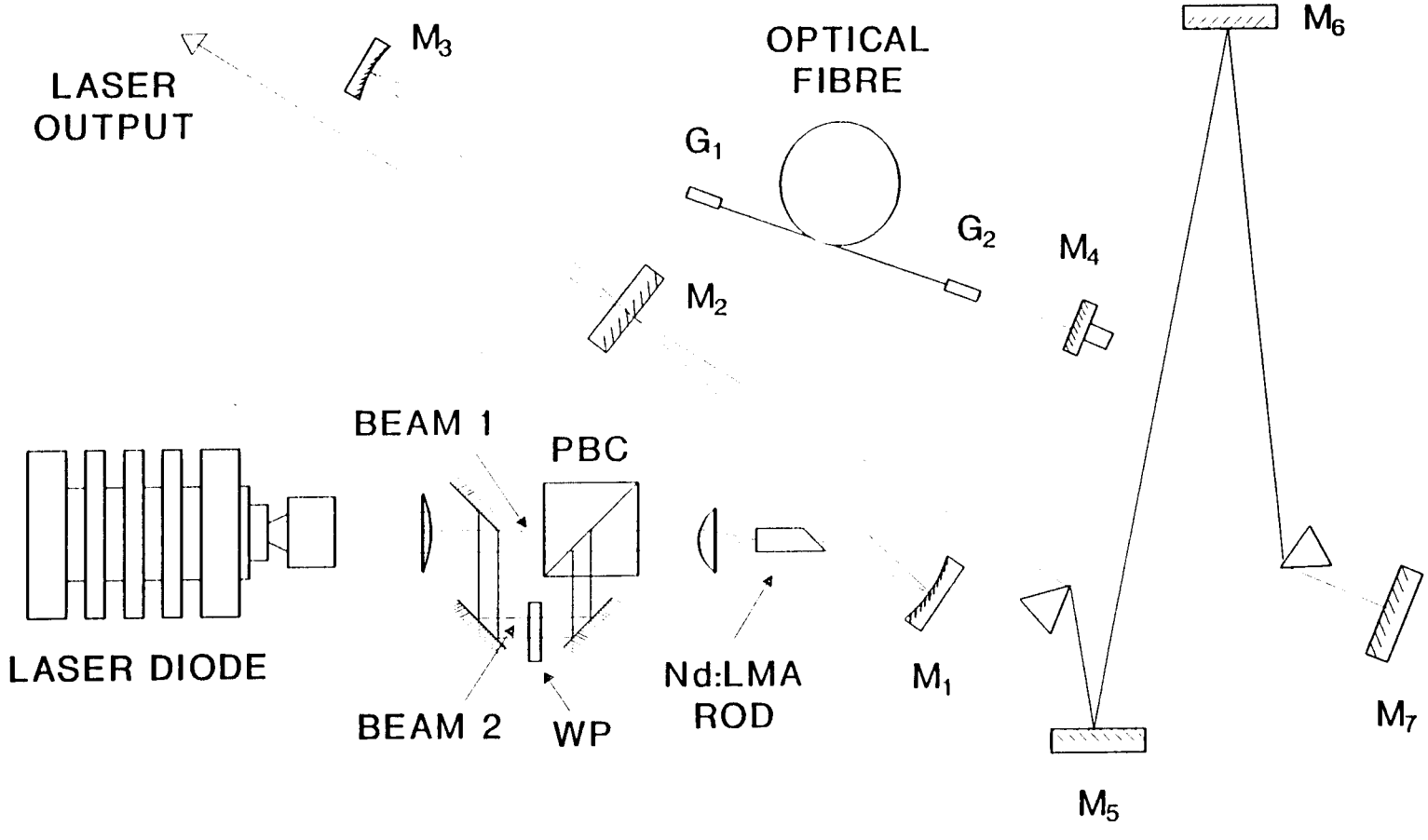
References.

1. D. Strickland. G. Mourou. "Compression of amplified chirped optical pulse". Opt. Comm. **56** 219 (1985).

2. D.W. Hughes. A.Majdabadi. J.R.M. Barr, D.C. Hanna, "420fs pulse generation from an APM modelocked. laser diode pumped Nd:LMA laser", CLEO'93, paper JTuC7, Baltimore, (1993).

Figure captions.

1. A schematic diagram of the laser diode pumped additive pulse modelocked Nd:LMA oscillator.


LASER
OUTPUT
M3
OPTICAL
FIBRE
G1
G2
M2
M4
M6
BEAM 1
PBC
LASER DIODE
BEAM 2
WP
Nd:LMA
ROD
M1
M5
M7