Pulse shaping in high gain all-fibre pulsed MOPA

F Ghiringhelli, K Vysniauskas, L M B Hickey, M N Zervas,
SPI (Southampton Photonics Inc.), Unit 3 Wellington Park, Hedge End, Southampton SO30 2QU,
Fabio.Ghiringhelli@spioptics.com
A N Malinowski, D J Richardson
Optoelectronics Research Centre, University of Southampton, Southampton S017 4JQ

Abstract : Pulse shaping is investigated in a high gain all-fibre pulsed master oscillator power amplifier seeded with a modulated diode. At 10kHz repetition rate, 100ns seed pulses collapse to ~10ns, reaching peak powers >30kW.

High peak power pulsed lasers with durations of tens of ns are useful sources for enabling a growing number of advanced industrial applications, such as marking and material processing. Compared to a single stage pulsed fibre laser, an all-fibre MOPA system offers flexibility in varying the pulse parameters, such as pulse duration and peak power. With a Q-switched seed source the performance is defined primarily by the cavity lifetime, which can limit the available operating space. The restrictions become even more severe in the short pulse (eg. < 100ns) regime. An alternative approach, which uses a directly modulated semiconductor diode as a seed laser, can offer greater control over the seed pulse characteristics and extend the performance space for the overall MOPA system. To achieve high energies and high peak powers in this scheme usually requires gains in excess of 40-50dB. With this level of gain, significant pulse reshaping can take place within the amplification chain [1]. The level of pulse reshaping will affect the output pulse duration and peak power in a non-linear manner and needs to be quantified and controlled for optimum performance. In this paper, pulse reshaping in a multi-stage fibre MOPA is investigated in detail and compared to simulation for the first time.

A modulated diode laser operating at a wavelength of 1080nm is used as a seed source[2] for a two stage Yb^{3+} doped, cladding pumped all-fibre amplifier chain. Both the pre-amplifier and post-amplifier stages are fabricated in GTwave technology[3] and are pumped at 915nm. The pre-amplifier is single mode and a series of post-amplifiers are used with different multi-mode cores. The seed laser is operated at 10-200kHz repetition rate, with pulse duration of between 20 and 210ns. The MOPA is configured to give >40dB gain, with up to 30dB in the first stage. An accurate numerical model describing the pulse evolution through the amplifier chain has been developed. The model is based on the method of lines and takes into account the distribution of gain and signal along the fibre length. It can be used to simulate and predict the effect of fibre design and pumping conditions on the pulse shape, pulse and peak power.

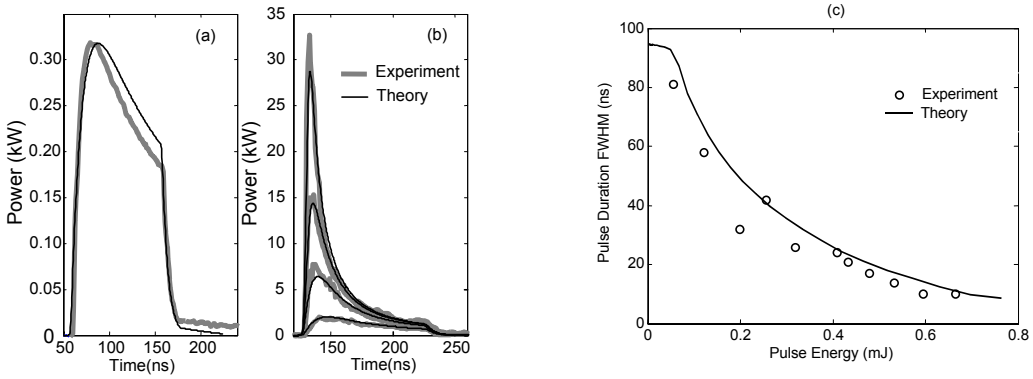

Figure 1. Output pulse shapes of (a) pre-amplifier (b) post-amplifier. (c) Output pulse FWHM as a function of pulse energy.

Figure 1 shows the results for the MOPA system operating at 10kHz, with 100ns seed pulse duration. Figures 1(a) and (b) show the output pulse shapes from the pre-amplifier and post-amplifier respectively, showing a very good agreement with the simulation. With the pump power to the pre-amplifier set to give 300mW average input power to the post-amplifier, the gain in the post amplifier is varied to show the level of reshaping. In Figure 1(b) the corresponding pulse energies are 0.12, 0.30, 0.44 and 0.61mJ as the gain is increased. Under these conditions the maximum peak power is in excess of 30kW, without any sign of SRS. In Figure 1(c) the variation of FWHM output pulse duration as a function of pulse energy is plotted and compared to theory. The degree of pulse reshaping depends on the saturation parameters of the gain medium and will be further discussed for a range of fibre geometries and operating conditions.

[1] L M Franz, J S Nodvik, J Appl. Phys. **34**, 2346 (1963)
[2] Supplied under an SPI-Bookham joint development program.
[3] A. B. Grudinin, J. Nilsson, P W Turner, Proc CLEO Europe, 10-15th Sept . 2000, Nice, France.