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Mode-locked NALM-based fibre laser with controllable operation regimes

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*THE REAL SCIENCE

INTRODUCTION

This work reports, for the first time, the results of the development and study of an Yb-fibre master oscillator, in which a variety of mode-locked regimes may be created in a controlled way electronically, including regimes producing picosecond single-scale pulses and double-scale trains. The possibility of electronic switching among generation regimes of the developed laser relies on a non-linear amplifying loop mirror of a new generation featuring two stretches of active fibre with two independently controlled pump modules. This work presents a detailed description of the experimental set-up and discusses the application prospects of the newly developed universal laser.

EXPERIMENTAL SET-UP

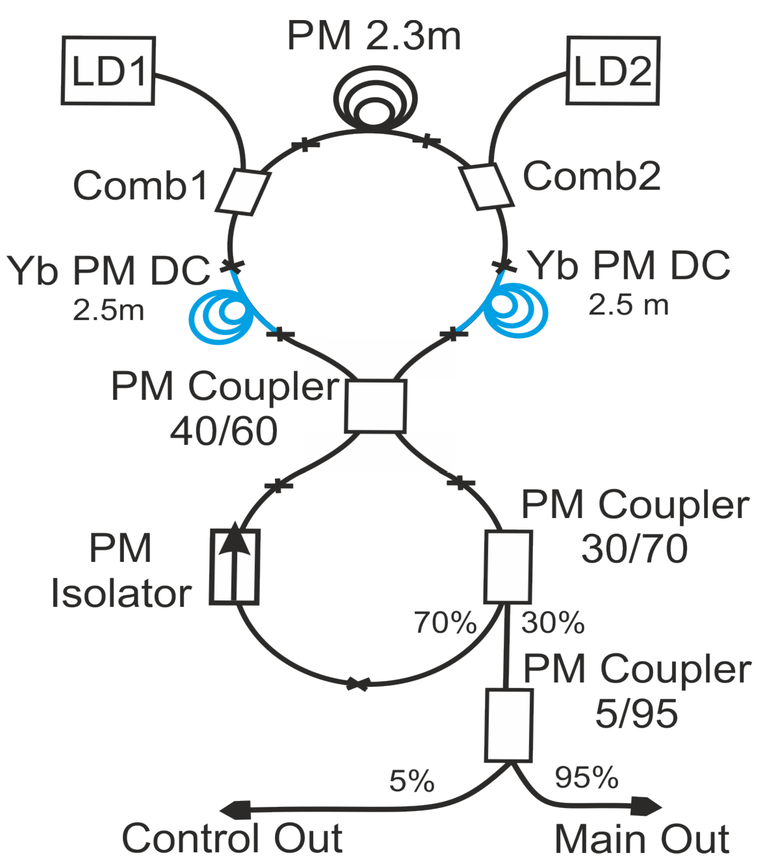

Fig. 1. Laser scheme: LD1, LD2 – laser diode pump sources, Comb1, Comb2 – WDM couplers, Yb DC PM – active fibre.

The laser generation regimes were controlled by adjustment of the pump source output: the absolute levels of the pump powers and their ratio. The computerised control system used with this laser can store the set values of the pump powers and recall them at the user request later.

EXPERIMENT

The laser generated the three materially different self-starting mode-locked regimes. In these regimes, pulses were generated with different degree of coherence, as well as different shapes of the temporal and spectral intensity distribution and the signal-to-noise ratio of the inter-mode RF beats. The average power and duration of the pulses in each of this regimes can be vary due to the selection of the level and the ratio of the pump powers.

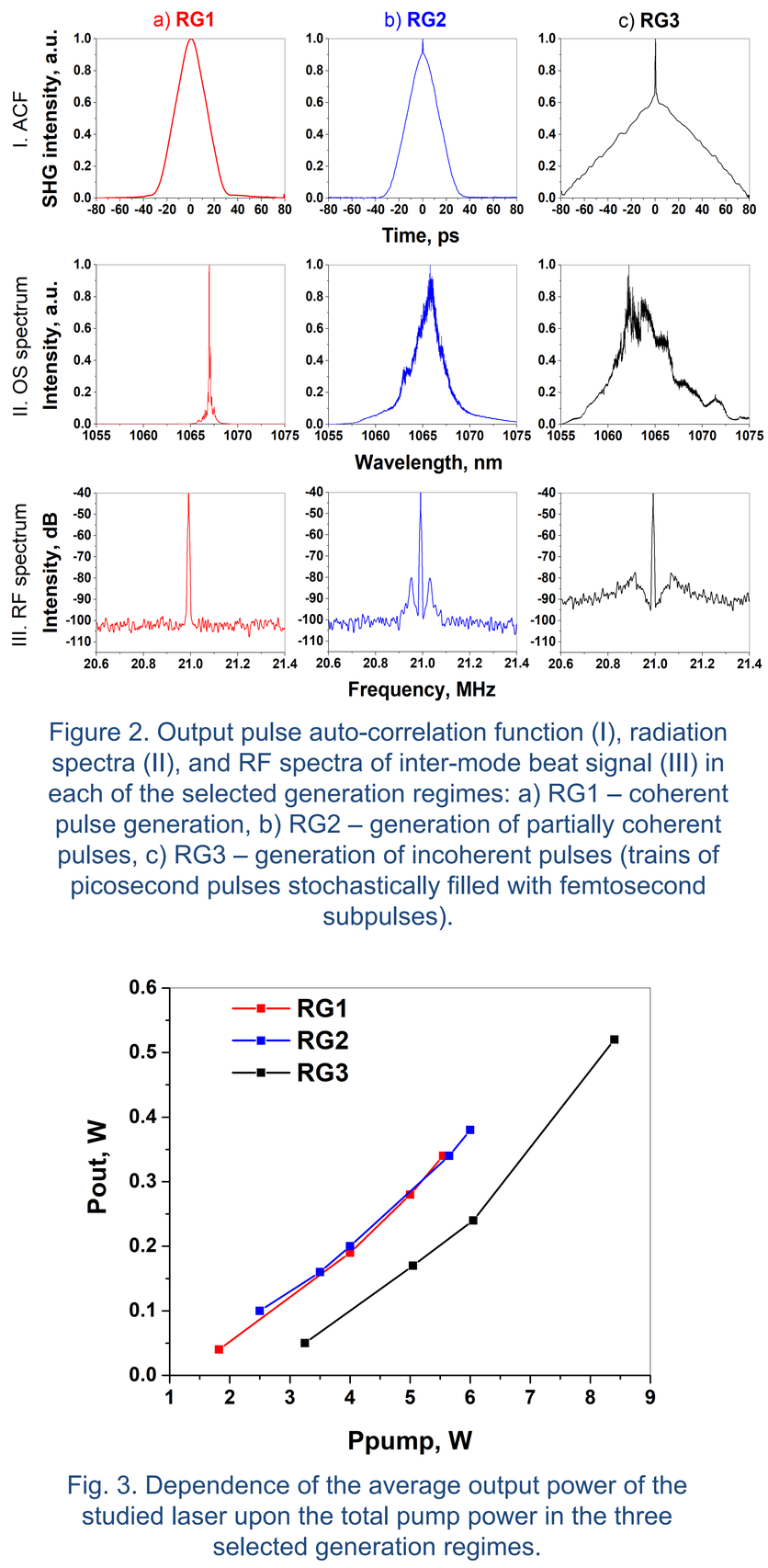

Figure 2. Output pulse auto-correlation function (I), radiation spectra (II), and RF spectra of inter-mode beat signal (III) in each of the selected generation regimes: a) RG1 – coherent pulse generation, b) RG2 – generation of partially coherent pulses, c) RG3 – generation of incoherent pulses (trains of picosecond pulses stochastically filled with femtosecond subpulses).

Fig. 3. Dependence of the average output power of the studied laser upon the total pump power in the three selected generation regimes.

RESULTS

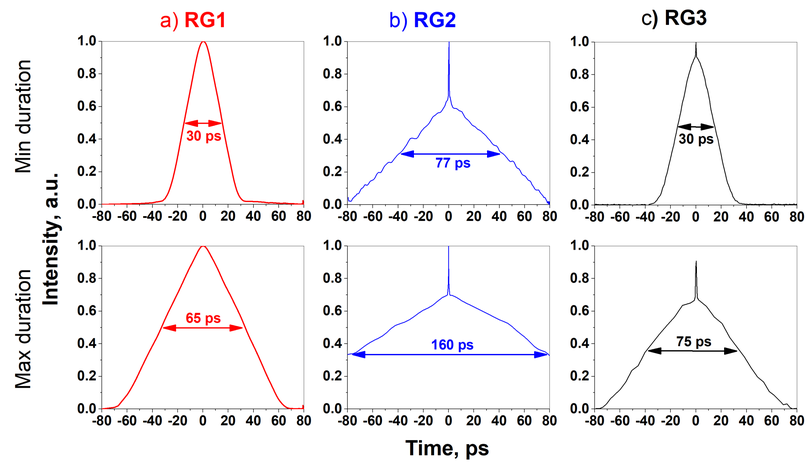

Fig. 4. Auto-correlation function of the generated pulses with the minimal and maximal duration for each of the three presented generation regimes.

By simultaneously raising levels and adjusting the ratio of the pump power it was possible to increase the average output power up to 340 mW (which corresponds to pulse energy increase from 1.8 to 16.5 nJ) with conservation of pulse duration around 35 ps and the highest achieved peak power of 300 W.

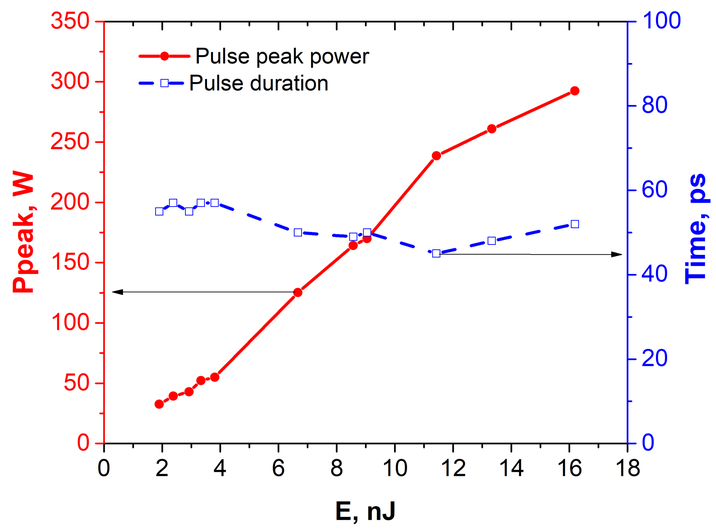

Fig. 5. Peak output pulse power and duration plotted against the output pulse energy.

CONCLUSIONS

The results of our studies prove the possibility of electronically controlled reproducible generation of ultra-short light pulses in NALM2-based mode-locked fibre lasers. The proposed modified non-linear amplifying loop mirror featuring two active media allows achievement of relatively high average output radiation power (in excess of 0.5 W) directly at the output of a master oscillator, such as the studied laser.

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