New Method for Generation of a Specific Number of Pulses per Bunch in Yb-doped All-PM-Fibre Laser

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We present a new convenient method for generation of various pulse bunches in synchronously pumped linearly polarized Yb-fibre lasers. This method uses a slight mismatch between the pumping pulse repetition rate and that of the generated pulses [1]. It is shown that this method not only shortens the generated pulses substantially relative to the pumping pulses, but also can be used to generate bunches of such shortened pulses and precisely set the number of pulses per bunch. The advantages of the proposed technique are full electronic control, scalability, and possibility of high-energy (in excess of 150 nJ) bunches.

The method was implemented and studied in an Yb-fibre laser with an all-polarization-maintaining all-fibre cavity configuration (Fig. 1(a)). It is applicable also to other fibre lasers with stimulated emission, provided that kinetics of energy levels involved into the lasing are qualitatively similar to those of the Yb-fiber lasers. For instance, this is the case for Er-fibre lasers if they are pumped at a wavelength of 1480 nm.

The number of generated pulses per bunch can be continuously and reproducibly controlled by slight detuning of the pump modulation frequency with respect to the fundamental cavity frequency (~230.5 kHz in our case) within the range of 0.1–0.01%. It is demonstrated that a small deviation of the pump modulation frequency (quasi-synchronous pumping in our case) may lead not only to significant shortening of the generated pulses, but also to controllable bunch generation, including a specified number of sub-pulses per bunch as shown in Fig 1 (b-h). The generated pulse bunches feature stable structure in spite of the high integral energy. All these results are also confirmed in modelling and possess the potential of being implemented on shorter temporal scales.

The present report provides detailed discussion of experiment and numerical modelling. Also provided are estimates of applicability of the proposed approach to shorter time scales. We show that electronic controllability is a feature distinguishing the presented method from others.

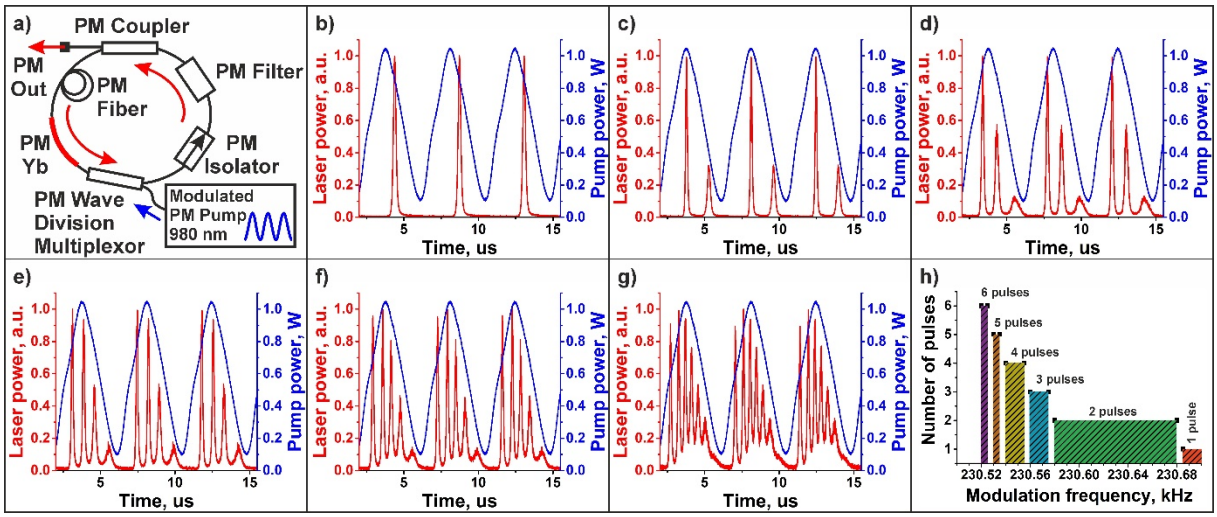

Fig. 1 (a) – schematic of the laser, (b-g) - oscillograms of the modulated pumping radiation (blue) and the resulting rains of laser pulses (red traces) obtained with modulation frequency varied from 230.7 to 230.52 kHz, (h) – number of bound pulses in bunch versus modulation frequency.

This work was supported by the Russian Foundation for Basic Research (grant No. 18-29-20025) and the Ministry of Science and Higher Education of the Russian Federation (FSUS-2020-0036).

References

[1] S. Smirnov, B. Nyushkov, A. Ivanenko, D. Kolker, S. Kobtsev. "Shaping of nanosecond pulses in ytterbium fiber lasers by synchronous sine-wave pump modulation," J. Opt. Soc. Am. B, v. 37, No. 10, 3068-3076 (2020).