High-Energy Picosecond Tunable Solid-State Laser System with GHz Repetition Rate

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Hundred or thousands nanosecond long macropulses containing trains of picosecond pulses are usually produced only in FEL facilities. The extraordinary wide wavelength tuning range, the peculiar temporal shape and the remarkable energy level of Free Electron Lasers emission make these huge, complex and expensive systems, substantially irreplaceable in many scientific, industrial and medical applications. Typically, FELs in the near infrared wavelength region generate trains of few picosecond micropulses in few μs macropulses and produce few hundreds mJ of energy per macropulse. In this work we describe a totally different solution based on a MOPA all-solid state laser system, developed for a investigation of the dynamic Casimir effect[1], that shows performances substantially comparable to the ones mentioned above.

A conceptual scheme of the laser system is shown in Fig. 1a. The master oscillator relies on a passively mode-locked, 3-cm long, V-folded cavity. The active medium is a plane-Brewster, *a*-cut 1% doped Nd:YVO_4 crystal, pumped by a 1-W CW laser diode emitting at 808 nm. The residual loss of the Brewster-cut face provides the output coupling. As already proved for a similar Nd:$GdVO_4$ based multi GHz oscillator[2], the reduced amount of output coupling allowed to overcome the Q-switching instabilities even at high repetition rates. An acousto-optical modulator picks up a bunch of pulses from the 5-GHz repetition rate continuous train. For our specific purposes we had to manage trains containing from 1000 to 2500 pulses (200-500 ns-long pulse envelopes) but in principle wider envelopes could be generated, also with different micropulse repetition rate. A home made control electronics allowed to tailor the correct temporal shape for the injected macropulse seed, in order to compensate for gain saturation induced distortions introduced by amplification stages (see Fig. 1b inset).

The high-gain preamplifier employs two *a*-cut Nd:YVO_4 slabs (14x4x2 mm^3), 1% doped, each side-pumped by a QCW 150-W peak power laser diode array in a grazing incidence, total internal reflection configuration[3]. The boost amplifier relies on a couple of flashlamp-pumped Nd:YAG rods (12-cm long). A total gain exceeding 90 dB (≈ 60 dB + 33 dB) has been measured, mainly limited by ASE. This corresponds to an output energy at 1064 nm of about 250 mJ per macropulse at 1 Hz repetition rate. Pulse duration (see Fig. 1b) and diffraction-limited beam quality were well preserved during amplification, allowing efficient SHG in a 16-mm long type-I LBO crystal. The SHG stage output was used to synchronously pump a KTP OPO eventually yielding macropulse energy as high as 40 mJ at the requested final wavelength in the range 750-850 nm.

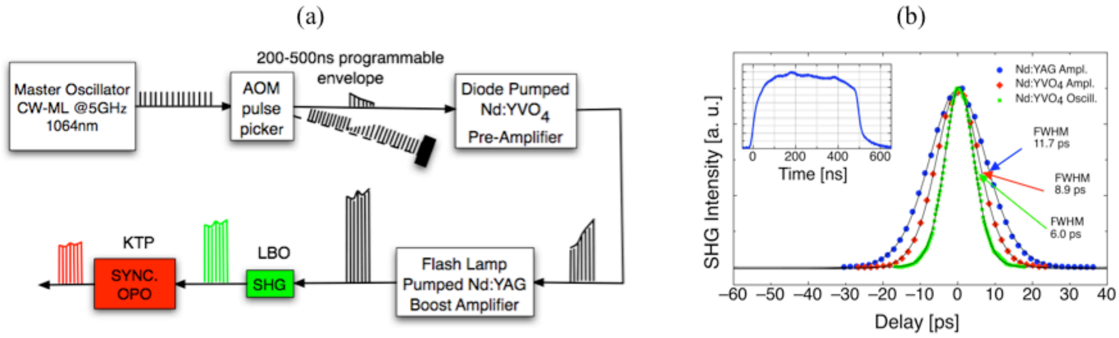

Fig. 1 (a) Laser system conceptual scheme; (b) pulse autocorrelations of the master oscillator (green), first amplification stage (red) and final amplification stage (blue). The inset shows the amplified macropulse temporal envelope after the amplification chain.

References

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