High Energy Sub-nanosecond Kilohertz Amplified Laser Sources near 1 µm

***Ivan Buchvarov*[1,2]**

1. Physics Department, Sofia University, 5 James Bourchier Blvd., BG-1164 Sofia, Bulgaria

2. ITMO University, 197101 St. Petersburg, Russia

Currently lasers are perceived as unique light that can produce specific states of matter through selective manipulations that could not be realized using any other conventional incoherent addition of thermal or electronic energy to a system. Although the selective laser chemistry is still a dream, the selective control of material processing done by optimization of laser intensity, as well as the temporal, spatial and spectral characteristics of the laser radiation is frequently used to move some contemporary technologies beyond their limits. For instance, in various systems efficient light-matter interactions require optical pulses much shorter than the thermal and acoustic confinement times of materials and sufficiently high pulse energies to perform material manipulation or ablation [1]. In addition, the average power of the lasers has to be large enough (x10-100 W) to enable "high throughput" and useful product yields. Thus reliable high-energy (>10 mJ) laser systems with high-peak power (>10 MW) pulses at kHz repetition rates, having diffraction-limited beams are of fundamental interest for both scientific, industrial and defense applications, including material processing and synthesis, various LIDARs, chemical sensing, highly efficient nonlinear frequency conversions, etc. Many of these applications require the temporal profile of the laser output to be a burst of picosecond pulses or a single smooth sub-nanosecond pulse. However, the majority of the existing kHz nanosecond laser systems emitting in the near-infrared spectral region around 1 micron have output energy below few tens of mJ, where the repetition rate does not exceed 10-100 Hz and beam profile is far from single TEM00 mode.

In the recent years, a significant amount of efforts have been focused on the development of passively Q-switched microchip lasers to generate sub-1 ns pulses with diffraction limited laser beams at a kilohertz repetition rate. They address the technological challenges to achieve high peak power while keeping the laser designs compact and robust. Nevertheless, they have significant drawbacks – the output energies are typically in the range of a few hundred µJ, which is not sufficient to reach saturation of the amplification in Nd/Yb-based large-diameter power amplifiers. Hence, a pre-amplifier must be employed in order to boost the oscillator pulse energy up to a few mJ, required for efficient extraction of the stored energy in the power amplifier [2-4]. This report is focused on the design of diode-pumped amplifiers, which can provide a combination of high gain and high efficiency with high stability, while preserving the pulse duration, spatial quality and linear polarization of the beams without the need of cryogenic cooling. Taking advantage of the recent progress in 20% duty cycle quasi-CW pump diodes, single-mode single-frequency sub-nanosecond laser pulse can be easily scaled up to 50-100 mJ range at ~1 kHz repetition rate. Similar architectures of the power application stages could be utilized successfully in the case of low power picosecond-burst input in order to obtain high average power, kW bursts of picosecond pulses at a kilohertz repetition rate.

References

[1] G. S. Edwards, et al.,"Applications of free-electron lasers in the biological and material sciences", Photochemistry and Photobiology, **81**, 711 (2005).
[2] A. Agnesi, F. Pirzio in, *Advances in Solid-State Lasers: Development and Applications,* M. Grishin ed.(InTech, 2010, sciyo.com) Chapter 11.
[3] D. Chuchumishev, A. Gaydardzhiev, A. Trifonov, I. Buchvarov, "Single-frequency MOPA system with near-diffraction-limited beam quality", Quantum Electronics, **42 (**6), 528, (2012).
[4] B. Oreshkov, D. Chuchumishev, H. Iliev, A. Trifonov, Torsten Fiebig, Claus-Peter Richter, I. Buchvarov,"52-mJ, kHz-Nd:YAG Laser with Diffraction Limited Output" ,CLEO: 2014, OSA Technical Digest (online), paper JW2A.84

978-1-5090-6736-7/17/$31.00 ©2017 IEEE