Multi-hundreds-kW-peak-power picosecond-light-pulse source based on a 1060-nm-band gain-switched laser diode

°Yi-Cheng Fang[1,2], Tomohiro Chaki[1,2], Yuta Kusama[1], HirohitoYamada[1,2] and Hiroyuki Yokoyama[1,2]
NICHe, Tohoku Univ.[1], Grad.School of Eng., Tohoku Univ.[2]
E-mail: fang@niche.tohoku.ac.jp

INTRODUCTION A compact, high-peak-power laser pulse source in picoseconds regime is in demand for a number of applications using nonlinear effects, including two-photon microscopy (TPM) and laser micromachining of materials. We have generated picoseconds light pulses of over 10-kW peak power from a light pulse source composed of a gain-switched laser diode (GSLD) and multistage optical fiber amplifiers (OFAs) for TPM applications.[1] Further peak-power scaling is limited by both nonlinear effects and available pumping powers in OFAs. We have shortened the pulse duration using self-phase modulation (SPM) in an OFA,[2] and this enables to obtain high peak power after a low-nonlinear-effects main amplifier.[3] Moreover, by reducing the repetition rate from a GSLD, we also have boosted peak power over 100 kW.[4] However, inter-pulses noise components mainly caused by amplified spontaneous emission (ASE) become prominent at lower repetition rates, and this causes to reduce available peak powers. We here described a GSLD-based optical pulse source with noise ratio examinations, generating over 300-kW-peak-power, picoseconds pulses at 1-MHz repetition rate.

EXPERIMENTAL 1060-nm-band optical pulses were generated from a strongly driven GSLD at 1-MHz repetition rate, and amplified by 3-stages ytterbium-doped fiber amplifiers (YDFAs). Optical band-pass filters (OBPFs) were used between YDFAs to remove ASE noises out of 1060-nm band. Figure 1 shows second-harmonic-generation (SHG) intensity autocorrelation traces (IATs) for the optical pulses in the light pulse source. The black line is the optical pulse amplified by the first stage YDFA having a pulse width of 9.6 ps (full width at half maximum, FWHM, assuming sech^2 pulse profile) and an average power of 59 μW. The noise ratio was ~35%, a considerable increment from ~5% noise ratio at 10-MHz repetition rate, indicating enlarged inter-pulses ASE noises. At the second stage YDFA, the pulses were amplified by a high-gain YDFA to generate a SPM broadened spectrum and then spectrally filtered by an OBPF at a short-wavelength edge. The pulse duration was reduced to 2.4 ps (red line) and its average power was 3.1 mW with a noise ratio of ~22%. The reduction of the noise was due to the spectral filtering at a different wavelength band, and this causes to remove ASE noises of the first stage YDFA for the following amplification. Finally, at the third stage YDFA, we used a large-mode-area (LMA, mode field diameter: 30 μm) photonic-crystal-fiber amplifier for low-nonlinearity and high-peak-power amplification. The amplified pulse (blue line) has a pulse width of 5.1 ps, showing a further pulse width broadening in the YDFA. However, by considering the average power of 2.7 W and the noise ratio of ~36%, we have presently obtained 330-kW-peak-power optical pulses. Further peak-power scaling will be studied by evaluations of nonlinear effects in the main amplifier and optimizations of the noise ratios in the light pulse source.

ACKNOWLEDGEMENT This work was supported in part by JST CREST Program “In vivo optical imaging and optical manipulation by using a novel multiphoton microscopy with advanced ultrashort light pulses and their application for cancer research and medicine ”, and also in part by the Program for Creating STart-ups from Advanced Research and Technology (START) from MEXT of Japan.

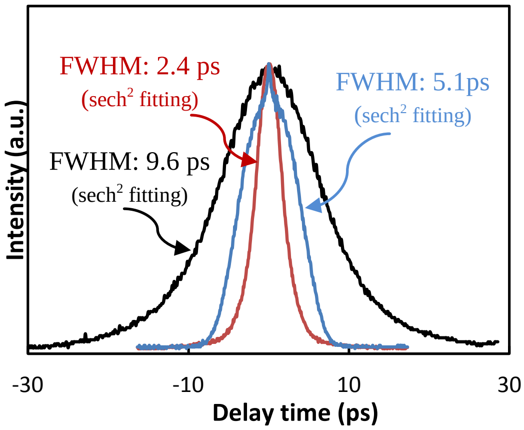

Figure 1. SHG IATs for optical pulses after the first-stage YDFA (black), after pulse shortening (red) and amplified by a LMA-PCF YDFA (blue).

References:

[1] Y. Kusama, et al., Opt. Express 22, 5746-5753 (2014).

[2] Y. Fang, Y. Kusama, and H. Yokoyama, the 75th JSAP Autumn Meeting, 19a-C8-5, Hokkaido University (2014).

[3] Y. Kusama, et al., the 75th JSAP Autumn Meeting, 19p-C8-6, Hokkaido University (2014).

[4] T. Chaki, et al., the 75th JSAP Autumn Meeting, 19p-C8-7, Hokkaido University (2014).