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2ps duration optical pulse source based on a 1060nm-band gain-switched semiconductor laser diode

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INTRODUCTION Development of a compact and high-peak-power picoseconds optical pulse source is highly desirable for two-photon microscopy (TPM). We have demonstrated an optical pulse source employing a 1060-nm-band gain-switched laser diode (GSLD) and its application for TPM.[1] To obtain high-peak-power optical pulses, we amplify GSLD picoseconds pulses by optical fiber amplifiers (OFAs). Nonlinear-optic effects (mainly by self-phase-modulation, SPM) should be suppressed during optical amplification process in general,[2] but this is not easy for picoseconds optical pulse amplification in OFAs. While SPM-induced nonlinearity in OFAs is sometimes detrimental, we can often utilize it to take advantages for obtaining even more versatile optical pulse features.[3] We here describe an advanced GSLD-base optical pulse source which uses SPM-induced spectral broadening in an ytterbium-doped fiber amplifier (YDFA) to generate shorter pulses for high-peak-power applications.

EXPERIMENTAL 1060nm-band optical pulses were generated from a strongly driven GSLD at 10-MHz repetition rate, and after spectral shaping the optical pulses were amplified by a high gain (30-dB small signal gain) YDFA to induce the nonlinear spectrum broadening mainly by SPM. We have developed a new DFB-LD to generate 5-ps optical pulses by strong gain-switching operations, and this enables to enhance the spectrum broadening in the YDFA. We have extracted proper spectral components from the SPM-broadened spectrum by using an optical band-pass-filter (BPF). By this way, we have obtained optical pulses having 2-ps duration and a few hundred watts peak-power.

Figure 1 shows a second-harmonic-generation (SHG) intensity autocorrelation trace (IAT) for the optical pulses from a GSLD source of 130-μW average power at 10 MHz. The pulse width is 5.3 ps (assuming $sech^2$ pulse profile) centered at 1063.4 nm. On the other hand, Fig. 2 shows IAT data for the optical pulses amplified by the YDFA and spectrally re-shaped. In this case, the pulse duration is 2.2 ps, and the average power is 7.7 mW, and thus the peak-power is 350 W. In comparison with input optical pulses, the peak power is enlarged over 100 times and the pulse duration is reduced by a factor of 2.4. We have presently obtained these optical pulse features in the pre-amplification stage. Therefore, with combining an additional stage YDFA (main amplifier), which is properly designed toward reduced nonlinear effects and high output power, over hundred-kilowatts peak power optical pulses are expected. These picoseconds optical pulses are useful for many purposes including TPM, and micro-, nano-laser-processing.

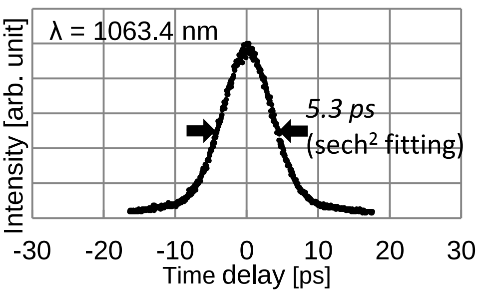

Fig. 1. SHG intensity autocorrelation trace for optical pulses from GSLD

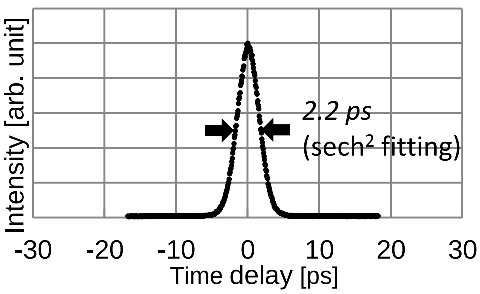

Fig. 2. SHG intensity autocorrelation trace for spectrally extracted optical pulses after YDFA.

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References:

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