DEVELOPMENT OF AN YB-DOPED FIBER LASER SYSTEM FOR AN ERL PHOTOCATHODE GUN

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We are developing an Yb fiber laser system that drives an ERL photocathode gun[1,2]. The Yb fiber laser is expected to have both high stability and high output power. We have developed 30W amplifier using an Yb doped photonic crystal fiber and demonstrated supercontinuum generation. We report our recent progress in this development.

Fig.1 shows the schematic of the drive laser system. The drive laser system is MOPA (Master Oscillator and Power Amplifier) type with an Yb fiber laser oscillator and two Yb fiber laser amplifiers. The Yb fiber laser is expected to have high stability and high output power. In addition, the optical parametric amplification (OPA) is done to convert the wavelength of the Yb fiber laser (1030nm) to the wavelength equal to the band gap of the photocathode NEA-GaAs (700-800nm). Firstly, two lights are diverged from the light amplified by the Yb fiber laser amplifier. And the one is converted to the second harmonic (SH, 515nm) by the nonlinear optical crystal, the other is converted to the supercontinuum light (SC, 800±50nm) by the high nonlinear photonic crystal fiber. Finally, OPA is done using SH as the pumping light and SC as the seed light.

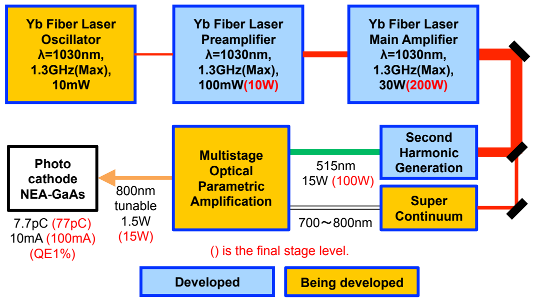

Fig.1. Schematic of drive laser system

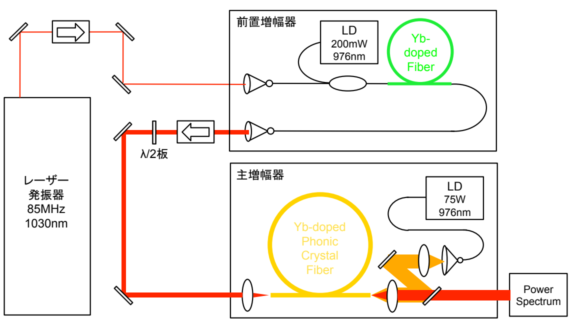

Fig.2. Schematic of Yb fiber laser amplifier

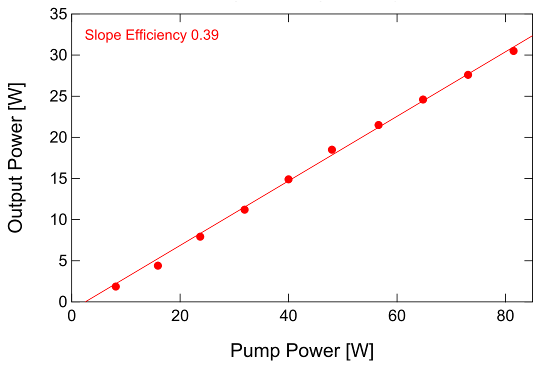

Fig.3. Amplifier slope efficiency

Fig.2 shows the system schematic of the Yb fiber laser amplifier. An Yb doped photonic crystal fiber is used to amplify the seed pulse. Because the photonic crystal fiber has a large core doped with Yb ions and a clad having periodically allocated air holes, it can significantly amplify the seed pulse without nonlinear optical effect. We evaluated the amplifier slope efficiency, the optical spectrum and the pulse duration using the 85MHz seed pulse. Fig.3 shows the amplifier slope efficiency. The slope efficiency is 40%. The 85MHz pulse can be amplified to 31W and have almost the same pulse energy as is required at 1.3-GHz repetition rate for the ERL. Fig.4 shows spectra of a seed pulse and amplified pulses. A dot line shows the seed pulse and solid lines amplified pulses. FWHMs of amplified spectra are about 10nm, and significant bandwidth broadening does not appear. Fig.5 shows the autocorrelation traces of a seed pulse and amplified pulses. The autocorrelation trace is the convolution of two pulses into which a pulse is divided. FWHMs of the autocorrelation traces are about 10ps and almost unchanged. Therefore, we can confirm that nonlinear optical effect that causes the pulse distortion is suppressed in the Yb doped photonic crystal fiber laser amplifier.

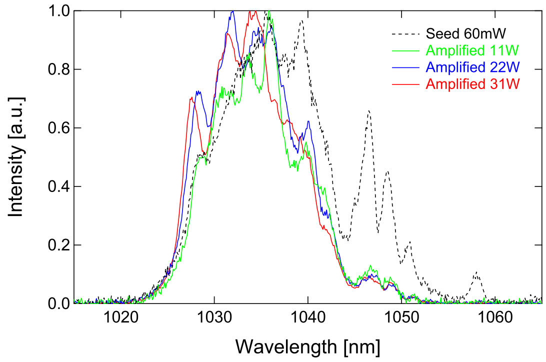

Fig.4. Optical Spectrum

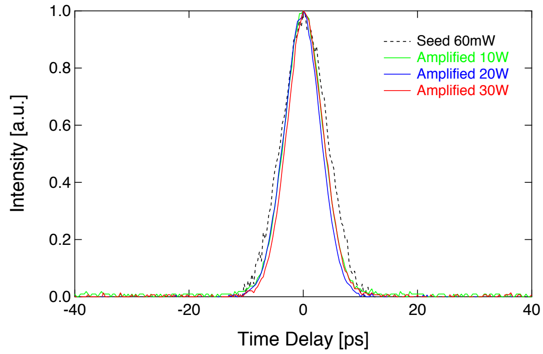

Fig.5. Autocorrelation trace

In order to use as the seed light of OPA, we generated SC by the high nonlinear phonic crystal fiber. Fig.2 shows the schematic of the experiment setup. The 85MHz amplified pulse (2W) was input into the high nonlinear photonic crystal fiber. Because the high nonlinear photonic crystal fiber has low dispersion around the wavelength 1um, the input pulse whose wavelength is 1030nm can propagate with its peak intensity kept and the broadband SC can be generated efficiently. In order to extract frequency component around 800nm from SC, the broadband SC is reflected by two mirrors that have the center wavelength at 800nm.

Fig.3 shows the spectrum of SC. The center wavelength is 800nm and the bandwidth is 80nm. The average power is 0.19W and the conversion efficiency is 9.5%(=0.19W/2W). The next subject is to shift the center wavelength of SC toward shorter wavelength, 700nm.

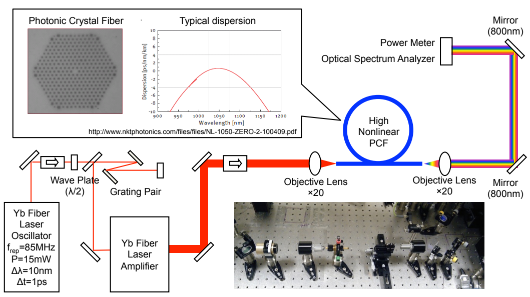

Fig.6. Setup of supercontinuum

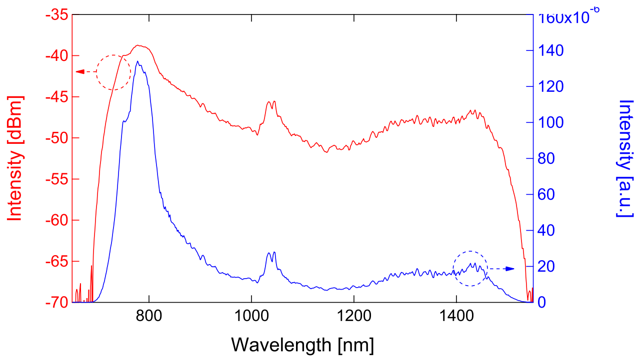

Fig.7. Optical spectrum of supercontinuum

References

[1] R. Hajima et al. (ed.), KEK Report 2007-7/JAEA-Research 2008-032 (2008) (in Japanese).

[2] R. Kasahara, et al., in Proceedings of the 8th annual meeting of particle accelerator society of Japan. (in press)