Development of High-Repetition-Rate and High-Pulse-Energy Nd:YAG MOPA Laser System

K. Mikami[1], N. Hasegawa[1], H. Okada[1], S. Kondo[1], M. Nishikino[1], T. Kawachi[1]

[1]*Quantum Beam Science Center, Japan Atomic Energy Agency, Kizugawa, Kyoto, Japan*
**E-mail: mikami.katsuhiro@jaea.go.jp*

Abstracts: *High-pulse-energy laser systems as pump source for Ti:Sapphire laser in a laser-driven plasma soft x-ray laser systems are required for operation with high-repetition-rate. A Nd:YAG laser system which the size was about 4 m×0.8 m was developed by master oscillator power amplifier (MOPA) platform. A laser beam of the master oscillator was amplified by the two Nd:YAG rods and the designed values of pulse energy and repetition rate were 5 J and 50 Hz with fundamental wavelength, respectively. The amplified spontaneous emission that is a significant problem in high energy laser development was almost neglected.*

High-pulse-energy Nd:YAG laser systems are required as typical pump source of Ti:Sapphire laser systems. Ti:Sapphire laser systems having high-pulse-energy would be applied into a laser-driven plasma soft x-ray laser (SXRL) system and the repetition rate determines that of the SXRL. At the Japan Atomic Energy Agency (JAEA), we developed a fully spatial coherent SXRL named TOPAZ (Twin OPtical Amplifiers using Zigzag slab) and the TOPAZ is operating with 0.1 Hz pumped by two 10 J picosecond lasers [1,2]. A high-repetition-rate SXRL was already demonstrated with frequency 5 Hz pumped by 1 J picosecond laser [3]. In this study, a new high-repetition-rate tabletop Nd:YAG laser system was developed which utilizes master oscillator power amplifier (MOPA) platform for pump source of a Ti:Sapphire laser system in SXRL. Designed values of the pulse energy and the repetition rate were 5 J and 50 Hz with fundamental wavelength, respectively. The 5-J 50-Hz laser beam will be generated second harmonics by BBO crystal and the expected output specifications of a Ti:Sapphire laser pumped by the developed laser system is over 1 J with 50 Hz.

A commercial Q-switched Nd:YAG laser system (wavelength 1064 nm, repetition rate 50 Hz, pulse width 14 ns) was combined as the master oscillator and the maximum output energy was about 400 mJ at in front of the exposure port. Two 1.1 at% Nd:YAG rods were installed in the amplifier and the seed laser beam was amplified through a double-pass in the first rod and through a single-pass in the second rod (total 3-passes). The laser system was constructed on an optical table that the size was 4.0 m×0.8 m. The Nd:YAG rods were excited by two flush lamps for each laser rod. The small signal gain coefficient and the stored energy of the installed Nd:YAG rod were 0.33 cm^{-1} and 2.4 J when each lamp energy was 50 J. The focusing length of the thermal lens effect was about 2 m and was slightly different with each direction. However, the difference could be corrected with a single lens on a ray-trace calculation and the real system. Amplified spontaneous emission (ASE) was a significant problem in high energy laser development. In this laser system, the ASE was monitored by free-running and its energy was able to almost neglect (about 5 mJ).

[1] M. Nishikino *et al.*, Appl. Opt. **47** (2008) 1129
[2] Y. Ochi *et al.*, Jap. J. Appl. Phys. **48** (2009) 120212
[3] Y. Wang *et al.*, Phys. Rev. A **72** (2005) 053807