1st Asia-Pacific Conference on Plasma Physics, 18-23, 09.2017, Chengdu, China

Exploring High Pulse Energy, High Rep. Rate Laser in the Next Generation

Junji Kawanaka[1], Shigeki Tokita[1], Hidetsugu Yoshida[1], Koji Tsubakimoto[1], Kana Fujioka[1], Shinji Motokoshi[2], Masashi Yoshimura[1], Noriaki Miyanaga[1], Ryosuke Kodama[1]

[1] ILE, Osaka University, Japan, [2] Institute for Laser Technology, Japan

High-power lasers has been strongly developed expanding its pulse duration range from nanosecond to femtosecond to explore advanced application fields such like laser peening, particle acceleration, neutron source, cancer therapy and so on. More than 100 J pulse energy has been obtained in nanosecond by conventionally using a flash lamp pumped Nd:glass laser amplifier due to its large available aperture size, in picosecond by employing chirped pulse amplification (CPA) further [1]. Femtosecond lasers with tens joules, which result in petawatt peak power, use CPA or optical parametric CPA (OPCPA). The well-known Ti:sapphire CPA laser [2] and the OPCPA laser [3], however, require a high pulse energy Nd:glass nanosecond laser as a pump source necessarily. After all, even if many number of Nd:glass lasers are used, the shot-to-shot interval of more than ten seconds is required due to a poor thermal strength of Nd:glass.

The above mentioned high pulse energy lasers are starting to open the advanced application fields, both high pulse energy and high repeatability has been required for nanosecond high-power laser. A diode-pumped solid-state laser (DPSSL) is one of the most promising laser systems. In the institute of laser engineering at Osaka university, in addition to a combination of DPSSL and high quality laser ceramics, a cryogenic laser technology has been developed early in 2000's. The world's highest slope efficiency in laser operation of 90% in a laser oscillator [4] and the 100Hz, joule-class amplification with our original "TRAM" [5] have been demonstrated by using cryogenic Yb:YAG ceramics to show high potential of the next generation of high power laser material. Nowadays, the joint team of CLF/RAL in England and HiLASE in Czech has been developed 100 J, 10 Hz, 10 ns DPSSL by using He-gas cooled cryogenic Yb:YAG multi-slabs. [6]

A conductively cooled active mirror of cryogenic Yb:YAG is focused on as a key technology of the next generation of high power laser for more than 100 Hz repetition rate. 1 J, 100 Hz has been already developed by using "multi-TRAM" which is composite ceramic of three thin Yb:YAG layers and a tetragonal YAG prism, shown in fig. 1.[7] 10 J upgrade is under construction with conductively cooled Yb:YAG active mirror at low temperature in fig. 2. A power-scaled 190 J module has been conceptually designed with 10 cm x 10 cm clear aperture Yb:YAG composite ceramics with Cr:YAG edge cladding. Coherent beam combine (CBC) technique is another key technology to obtain about 1 kJ coherent output power with five modules. Combining the 2nd harmonic generation and CBC with eight modules, 2x2 tiling beams will be obtained at 1 kJ, 100 Hz at green, shown in fig. 3.

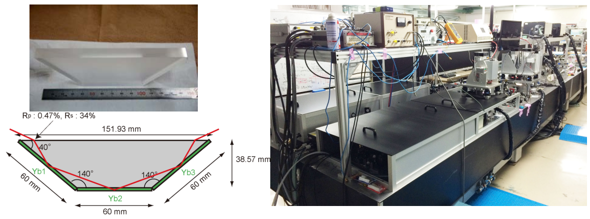

Fig. 1 (a) Yb:YAG mutli-TRAM and (b) 1 J, 100 Hz cryogenic laser system.

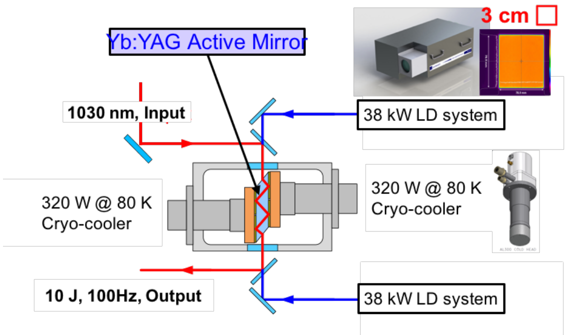

Fig. 2 10 J, 100 Hz amplifier design

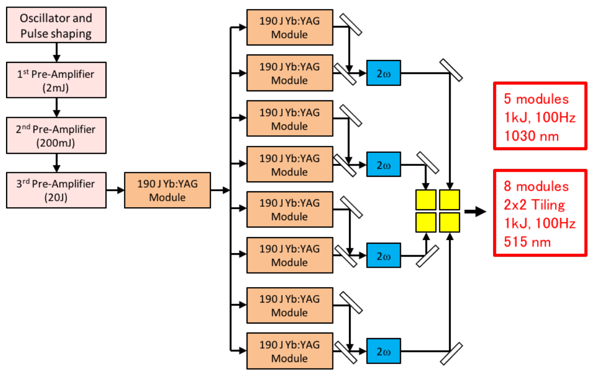

Fig. 3 kilo-joule system based on Yb:YAG module and coherent beam combine technique.

References

[1] J. Kawanaka et.al., Plenary talk, Laser Damage. SPIE, Boulder, Colorado, USA on 25-28 Sep. 2016.
[2] T. J. Yu et. al., Opt. Exp. **20**, 10807(2012).
[3] X. Zeng et. al., Opt. Lett. **42**, 2014(2017).
[4] T. Shoji et. al., Jpn. J. Appl. Phys. **43**, L496(2004).
[5] H. Furuse et. al., Opt. Lett. **34**, 3439(2009).
[6] P. Mason et. al., Optica **4**, 438(2017).
[7] M. Divoky et. al., Opt. Lett. **40**, 855 (2015)