Scaling toward one kilo-joule class diode-pumped solid-state laser

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Development of laser diode pumped solid-state laser (DPSSL) technologies were started from a few joule pulse energies in 1990's. After 2016, 100 J class DPSSL were demonstrated from some institute and used for application research[1-3]. 100 J lasers will be a more accessible device in many fields. And now next motivation of laser development was shifted to a 1 kJ DPSSL realization.

We have developed a 250-J class DPSSL as a feasibility study of the kilo-joule class DPSSL. The system uses transparency ceramic crystals of Yb:YAG as a laser medium. The Yb:YAG ceramics are tested its capabilities of an energy storage and an energy extraction in cryogenically cooled condition. A schematic of the laser system is shown in Fig. 1(a). The laser system equipped 250-J laser amplifier behind the 100-J laser system[1]. Yb:YAG ceramics in the 250 J laser amplifier were cooled to 175 K by cryogenic temperature and high pressure helium gas flow. These Yb:YAG ceramics were stored energy of 397 J as a result of optical pumping by LD modules. Maximum peak power of the LD pumping was over 1 MW. Output energy characteristics was shown in Fig. 1(b). As the experimental result, a 253.6 J of output energy with 26.8 ns pulse duration has been demonstrated at 78 J of seed pulse energy. Extraction efficiency from stored energy in the Yb:YAG ceramics was 44.0%. An output near field pattern shown in Fig. 1(c) has near top hat intensity profiles. The beam size was 7.9 cm in width by 7.1 cm in height. Then average fluence was evaluated to 4.5 J/cm². This is the highest output energy with high energy fluence from cryogenically cooled Yb:YAG ceramics, in our knowledge. Technology readiness levels for the kilo-joule class DPSSL using cryogenically cooled Yb:YAG ceramics scheme will be discussed through the evaluation of the latest system performance of 250 J DPSSL.

References