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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/cm^2. 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

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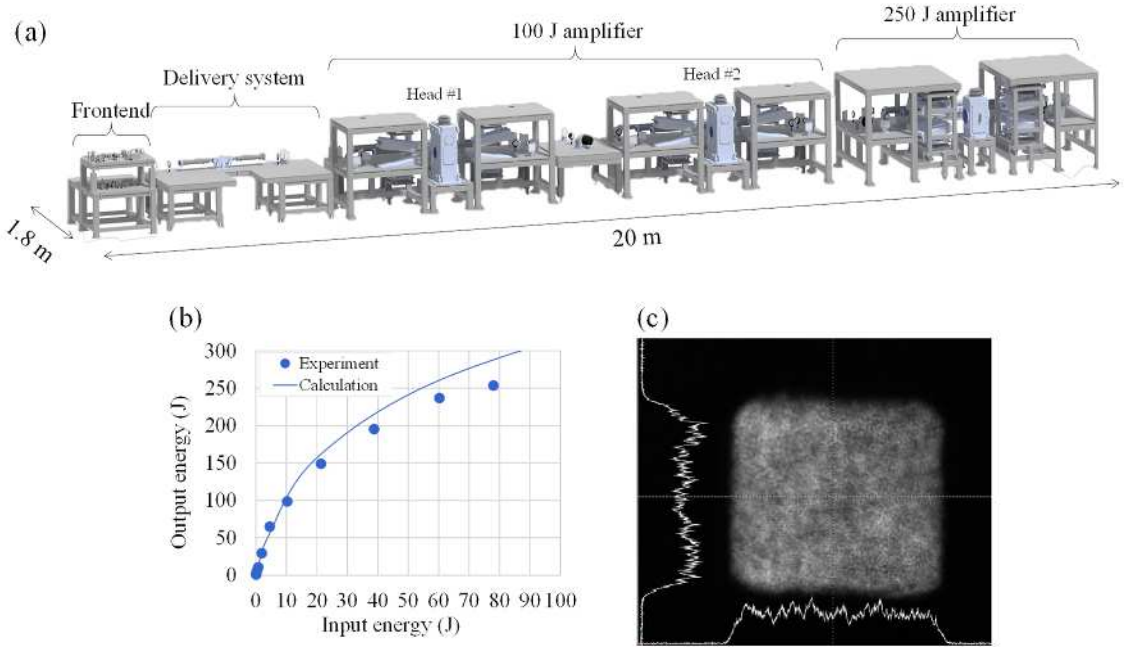

Figure 1. Schematic of LD pumped 250-J laser system(a). Output energy characteristic(b). Near-field pattern(c).