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Development of Solar-Pumped Laser

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Development of renewable energy technologies is essential for realizing the sustainable society. In particular, sunlight is a promising renewable energy source. However, the sunlight is incoherent and difficult to use directly. Therefore, a solar-pumped laser, which directly converts sunlight into coherent laser light, is a promising technology.

The first solar-pumped laser was realized in 1966 by C. G. Young [1]. Since then, although various studies have been performed, there has been little improvement in efficiency because there was no specific application. However, several applications of solar pumped lasers have been proposed in recent years [2,3] and researches on solar-pumped lasers is becoming more active.

I started my new research about solar-pumped laser in 2005 and the output power of the first solar- pumped laser system was only about 3 mW [4]. The first system was very simple, using a Fresnel lens with a diameter of 500 mm as the focusing system and a cylindrical Cr/Nd:YAG ceramics with a diameter of 2 mm and a length of 2 mm as the laser medium. After that, we realized 24.4 W of laser output by increasing the size of the Fresnel lens and improving the secondary focusing system and the cooling system [5]. Efficiency of a solar-pumped laser system is evaluated by the total area efficiency, which is the output power divided by the area of the primary concentrator. The system had a total area efficiency of 14 W/m^2, which was the world record at that time. Furthermore, we realized 80 W of the laser output and 24.4 W/m^2 of the total area efficiency by increasing size of the Fresnel lens to 4 m^2 and newly designing the secondary concentrator [6]. Finally, we developed the third concentrator called liquid light-guide lens (LLGL) which concentrate the solar power by refraction of the cooling water and realized 120 W of the laser output and 30 W/m^2 of the total area efficiency [7]. However, due to the difficulty of making a huge Fresnel lens, the transmittance of the Fresnel lens of 4 m^2 was about 50%. Therefore, we are currently developing a solar-pumped laser system using a 1m^2 class of a Fresnel lens [8].

In recent years, the solar-pumped laser is studied by several researchers and further progress has been made. Especially, the total area efficiency of 32.1 W/m^2 was realized by Z. Guan. [9].

In my talk, I would like to talk about the histories, the difficulties and some researches of solar-pumped laser. Especially, this talk focuses on the solar-pumped laser that I have actually been working on.

References

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