Design of a solar-pumped frequency-doubled 532 nm Nd:YVO_4 laser

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Abstract. During the last year we have made progresson a development of a frequency-doubled 532 nm Nd:YVO_4 laser pumped by solar light. The research aimed to demonstrate solar pumped lasers consisting of the optically contracted Nd:YVO_4 crystal and KTP crystal with a system of laser mirrors deposited onto crystal sides. The Cassegrain reflector is used as the configuration.This solar pumped laser system is appealing for a variety applications including laser communication, imaging and defense applications.

Keywords: Lasers , Solar pumped laser, Optically pumped lasers

1. Introduction

Solar energy has been proposed as an energy source for optically pumped lasers[1-4]. Both CW laser and Q-switch lasers have been attempted using the excitation from solar light [5-8].Solar pumped lasers are attractive for high energy materials and space applications[9]. Solar concentration styles have been developed for efficient pumping approaches[10-12]. Solar parabolic-based collectors andeconomical Fresnel lens-based collectors have played as an important role to convert solar energy to laser emission.

Our research focuses on the configuration based on the Cassegrain reflector to achieve the laser emission pumped by solar light. In this study, a parabolic mirror in such asolar collector was constructed.This design is explored to combine with technological advances in solid state lasers providing the various choices of laser emission wavelengths using a frequency-doubled 532 nm Nd:YVO_4 laser as an example.

2. Methodology

Figure 1 shows the layout of the Cassegrain reflector. The incoming sun lights are reflected by the large parabolic mirror and small hyperbolic reflector respectively. The highly reflecting mirrors allow an efficient pumping laser source.

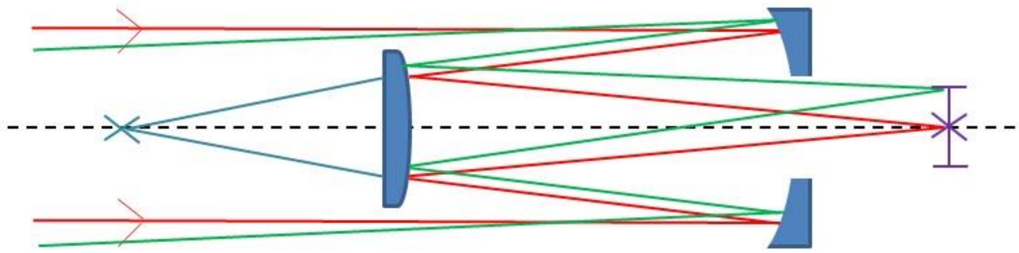


Figure 1. Schematic of the Cassegrain reflector as a solar collector.

The hyperbolic mirror reflects and focuses the sun light on one of its two foci where a laser crystal is located. In the practice, the small size of frequency-doubled 532 nm Nd:YVO_4 crystal is suitable for the pumping configuration. In this state of our research, the large parabolic is constructed. To show the feasibility of the design, a ray tracing program is used to explore the configuration parameters.

3. Results and Discussion

Figure 2 shows the home-built large parabolic mirror which has the diameter of 2.5 m.The parabolic mirror was constructed at LANDOS.The focus distance of the mirror is 1.5 m. The middle hole of the mirror has the diameter of 10 cm.In Thailand, the maximum solar radiation intensity is about 800 W/m^2 in April and May. The home-built parabolic mirror can collect about 3.9 kW of solar power. In this preliminary study, the infrared laser efficiency of Nd:YVO_4 crystal approaching 10% was demonstrated. Therefore 390 W laser power can be achieved in this collector system. Since the conversion efficiency from 1064 nm to 532 nm of the frequency-doubled 532 nm Nd:YVO_4 crystal was determined experimentally to be 20%, the frequency-double 532 nm radiation approaching 80 W can be expected from the setup.

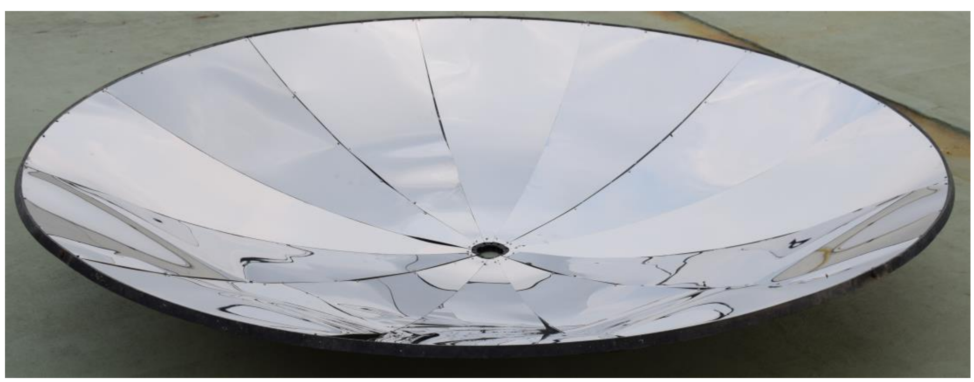
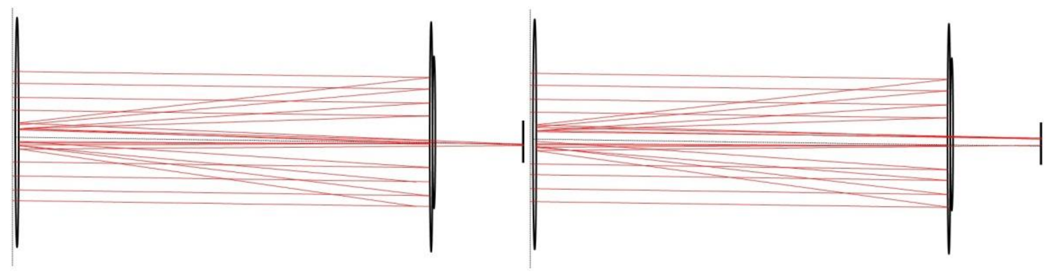


Figure 2. The home-built parabolic mirror for the solar pump laser.

Figure 3 shows the possibility of the design modified from the output of a ray tracing program. According to the light distribution in the collector system, it should be cleared that the specification of the hyperbolic mirror has to be related to the home-built parabolic mirror. This is necessary in order to efficiently transfer sunlight to the laser material. It is evident that the sun tracking error causes the varied volume of the excitation on the laser crystal that would decrease the pumping efficiency.



(a) (b)

Figure 3. The simulation results modified from a ray tracing program; (a) no tracking error and (b) with tracking error.

4. Conclusion

We have made a progress on the home-built parabolic mirror for the Cassegrain reflector. Based on theconfiguration, the infrared laser emission is possible approaching 390 W while the frequency-double 532 nm radiation approaching 80 W can be achievable. The simulation of the design enables us to further explore the mirror parameters and the range of the tracking error angle.

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