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Research on the adjusting technology of the thin disk laser

Rui Liu [a,b], Xihe Zhang [a,*], Faquan Gong [b], Yong Jia [b], Gang Li [b,*]

[a] School of Science, Changchun University of Science and Technology, Changchun, Jilin,130039, China
[b] Key Laboratory of Chemical lasers, Dalian Institute of Chemical Physics, Chinese Academy of Sciences, Dalian, Liaoning, 116023, China

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ABSTRACT

Thin disk laser(TDL) adjusting technology is very important in the application of high power laser. We use the ZEMAX to simulate different misalignment to guide adjusting of the coupler spot on the Yb:YAG crystal with 10% mol Yb^{3+} concentration. This way can be used to control TDL to increase output power. Finally, the experiment proves that the simulation is feasible. The pump source uses a fiber coupler laser diode which can generate a maximum output power of 700 W at 940 nm. A maximum optical–optical efficiency of 33.4% with an output power 219.9 W is achieved. Furthermore, automatized adjusting TDL technology can realize in this way. In this paper, the misalignment simulation process is reported detailedly.

1. Introduction

TDL [1] is one of the most promising concepts to realize high power [2], high efficiency [3], and good beam quality simultaneously [4]. Nowadays, the output power for a single disk can reach to more than 10 kW .The adjusting technology has become one of the main factors to the output power. It is inevitable in high power laser systems, especially in thin disk lasers [5]. In some paper, normal interferometer is used to adjust. As a top level setup, the following alignment steps occur, (i) thin disk reference mirror to parabolic mirror, (ii) four-fold mirrors, (iii) pump source and collimation optics, (iv) thin disk and resonator optics[6]. Normally, the parabolic mirror and the thin disk are the critically aligned components. In the thin disk optical layout, the parabola collects collimated light from infinity and focuses it down to the thin disk. To align the thin disk components accurately, two main elements are used; a collimated beam and a thin disk reference mirror. But TDL have opposite four prisms and one aspheric reflecting coating, and the pump spot on the crystal misalignment can be adjusted on screen by using the IR camera. Due to the dangerous of the high power pump disk laser adjusts [7–10] on-line, it's significant to how to get the best way to on-line adjust TDL is important [10–15].

In this paper, a method by using the ZEMAX to simulate the changes of different coupler cavity misalignment pump spot changes is presented. Meanwhile, the different simulated pump spot figures are compared. TDL coupler cavity can be adjusted to the exact position. It can realize a higher output power for TDLs. The method provides an important guidance to control the super output power TDL on-line adjusting.

2. Simulation section

Fig. 1 is the couple resonator of TDL and mechanical positioning prisms. If the resonator is misaligned, the light can't be coupled together. We use the optical software ZEMAX to simulate the different cases which are the misaligned couple resonator. The four prisms position can be determined by the mechanical positioning with X and Y-axes.

* Corresponding authors.
E-mail addresses: 18525398905@163.com (X. Zhang), 3798409@qq.com (G. Li).

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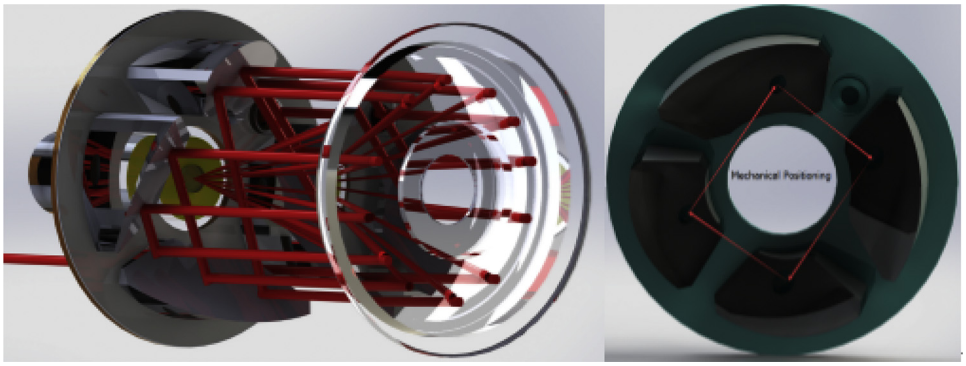

Fig. 1. The structure of the 24 pump passes TDL couple resonator and mechanical positioning prisms.

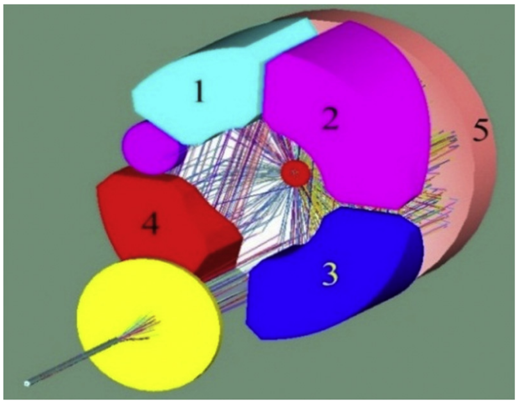

Fig. 2. The structure of the 24 pump passes prisms.

Aspherical reflector and reentrant prisms need to be numbered before tracing the light ray. Prism No.1 is cyan, No.2 is pink, No.3 is blue, No.4 is red and aspherical reflector No.5 is brick-red. We don't need to take misalignment into account because the place of the crystal can be adjusted in practical use. The structure diagram of 24 pump passes is illustrated in Fig. 2.

The misalignment is analyzed as a whole: since pump source and collimation are separated from pump coupler cavity, the still of the light source is given tacit consent, therefore, the misalignment of the pump coupler cavity and the aspheric mirror can be adjusted as a whole. The position of the crystal keeps horizon, as illustrated in the mock test No. 1–5. Finally, By rotating X, Y and Z-axes, the picture integral slope of the light spot point changes are able to acquire, as illustrated in Fig. 3.

It can be seen from the Fig. 3 that the whole coupler cavity misalignment is comparatively sensitive to the X and Y-axes. The light of the pump on the thin disk crystal changes drastically. At the same time, after the misalignment in X axis, it moves to the direction of Y and vice versa. With the enlargement of the misalignment angle in Z axis, a hollow presents in the middle of the pump spot, however, the change of the pump spot is not obvious. Compared with the misalignment in X and Y-axes, the sensitivity of TDL whole misalignment in Z axis is higher than that in the direction of X and Y-axes.

As illustrated in Fig. 4, after the misalignment of prism No.1, only in X axis, the changes of the pump spot on the thin disk crystal are drastic. There is only a hollow in the middle in the direction of Y and Z-axes. After the misalignment of prism No. 2, the pattern of the pump spot on the thin disk crystal almost remains unchanged. When it rotates around the axis X, the pump spot on the crystal moves in the opposite direction of Y axis. When it rotates around the axis Y, the pump spot on the crystal only have some transformations in horizontal direction. The pump spot shape just changes a little. Compared with X and Y-axes, the misalignment sensitivity in the direction of Z axis is bigger. Simultaneously, it can be obviously seen that prism No. 3 and No. 4 are sensitive to the refracted optical path of the thin disk laser, and the changes of the spot are a little bigger. When there is 0.15° rotation of the two prisms in the direction of X axis, the pump spot divides, and meanwhile, a movement in the direction of Y axis occurs. When the same rotation is on Y axis, the pump spot coupler changes on the crystal caused by prism No.3 is drastic and the spot will moves to the opposite direction of Y axis as well. According to the analysis, the influence of the misalignment sensitivity on prism Nos. 3 and 4 is enormous because light reflects 3 times by each of the above two prisms during the entry process of the pump light. Therefore, compared with prism No. 1 and No.2, the misalignment sensitivity of prism No. 3 and No. 4 is much higher (Fig. 4).