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Yueting Wu, Haiqiang Yang, Fengchao Zhang, Zhenkun Yu, Chao Lang, Xiaohua Chen, "Blue diode laser development for industrial processing," Proc. SPIE 12403, High-Power Diode Laser Technology XXI, 124030W (14 March 2023); doi: 10.1117/12.2651167

SPIE.

Event: SPIE LASE, 2023, San Francisco, California, United States

Blue Diode Laser Development for Industrial Processing

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Abstract

A compact high-brightness blue laser is designed and developed. Through BPP theory and ZEMAX simulation, 18pcs TO-packaged 5W blue lasers are coupled into a 113μm core diameter 0.15NA optical fiber using polarization and optical fiber coupling technology. More than 75W output power is obtained, coupling efficiency exceeds 88%. Optical fiber end face spot with uniformity of more than 90% can be achieved by coupling the square optical fiber, which provides an ideal light source for medium power applications with high beam quality requirements such as gold foil welding and cutting, wire stripping, medical, etc.

1.Introduction

Since the advent of blue laser, high brightness has become a goal of development, with the development of semiconductor chip technology, power of blue laser chip has been continuously increased. At present, the highest power of blue laser chip of NICHIA can reach 6W. Osram, Sharp and Panasonic have all launched blue laser chip with power up to 5W.

Benefit from high absorption rate of blue light, blue diode laser can achieve high welding quality for non-ferrous metals. A number of laser companies focus on the development of high-power and high-brightness blue laser: Laserline lanuchs 3000W blue laser with 600μm core diameter optical fiber and NA0.1; NUBURU lanuchs AI1500 blue laser with 100μm core diameter optical fiber and NA0.22; BWT lanuched 1000W blue laser with 330μm core diameter optical fiber and NA0.22 at 2021.

In some applications such as copper foil and gold foil cutting, welding, marking, wire stripping, scientific research, etc., the requirement of power is not high, but there are certain requirements for beam quality and portability, while medium-power and high-brightness blue laser are rarely reported. By polarization and optical fiber coupling technology, more than 75W output power is obtained through 113μm core diameter 0.15NA optical fiber. A compact high brightness blue diode laser with conduction and heat dissipation is developed to meet such requirements.

High-Power Diode Laser Technology XXI, edited by Mark S. Zediker, Erik P. Zucker,
Proc. of SPIE Vol. 12403, 124030W · © 2023 SPIE · 0277-786X
doi: 10.1117/12.2651167

2.Optical Design

To obtain a relatively ideal coupling efficiency, the optical parameter product of the spot and the optical parameter product need to satisfy the following relationship[1]:

$$d_{in} < d_{core}$$

$$\theta_{in} < \theta_{max} = 2arcsin(NA)$$

$$BPP_{laser} = mBPP_f + nBPP_S < BPP_F = \frac{d_{core} \cdot NA}{2}$$

d_{in} is the spot diameter of the incident beam, θ_{in} is the full angle of the far-field divergence angle of the incident beam, d_{core} is the diameter of the fiber core, θ_{max} is the full angle of the maximum incidence angle of the fiber, NA is the numerical aperture of the fiber, BPP_{laser} is the BPP of the laser beam, BPP_f is the fast axis direction BPP of the laser chip, BPP_S is the slow axis direction BPP of the laser chip, BPP_F is the BPP of optical fiber, *m,n* are the number of chips stacked on the fast and slow axis.

Considering the high photon energy of blue light and the effect of the atmosphere on the degradation behavior of GaN-based LDs [2], in order to obtain a high-reliability output, choose TO-packaged blue laser with 5W output power. According to the BPP (beam parameter product) theory and ZEMAX simulation, 9pcs TO-packaged lasers are combined in fast axis to match with the fiber's BPP parameters, then 18pcs diode lasers are coupled into 113μm core diameter fiber based on polarization combination.

Use an aspheric lens to collimate the output beam of the TO-packaged laser, then cylindrical lens groups are used to expand the slow axis beam by 5 times and reduce the fast axis beam by 6.5 times, then the fast and slow axis beams coupled into the fiber at the same time with a focusing lens. Fig.1 shows schematic of light path, stagger arrangement used to effectively reduce the system volume.

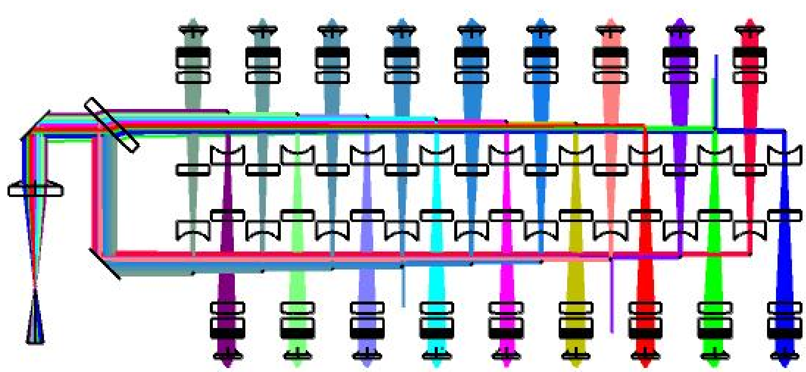

Figure 1. Schematic of light path

Simulation focus spot size about 80μm*60μm at fiber incidence end face, as shown in Fig.2(a), output spot as shown in Fig.2(b).

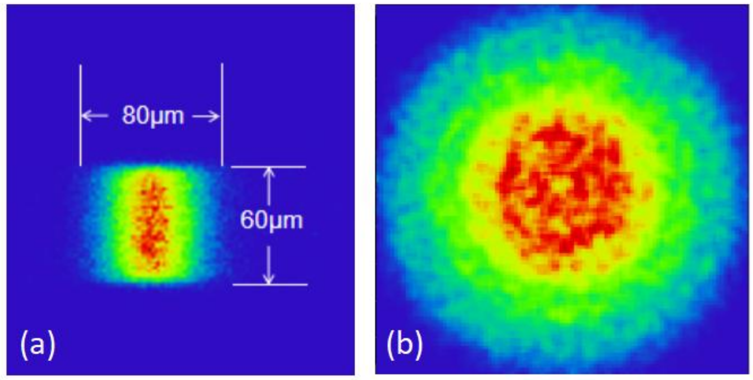

Figure 2. (a)Focus spot size at fiber incidence end face (b)Output spot

3.Results

The miniaturized design and the mechanical structure design of conduction and heat dissipation make it more flexible and convenient to use.The overall package size is 170mm*120mm*24mm. Fig.3 shows the layout of blue diode laser.

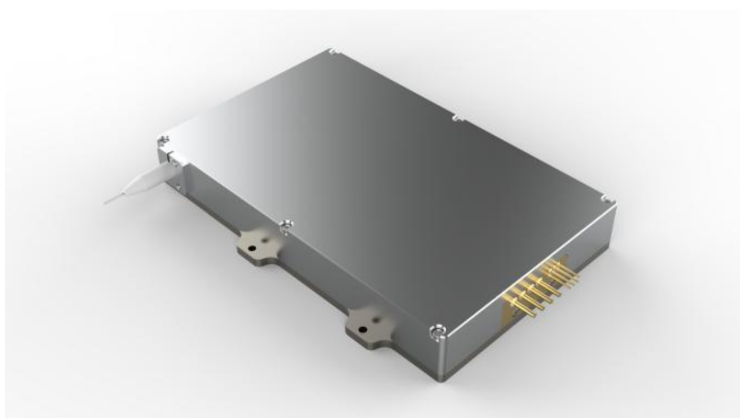

Figure 3. Blue diode laser layout

The coupling efficiency exceeds 88%, more than 75W power is obtained through a 5m long , 113μm core diameter, 0.15NA optical fiber, PIV data as shown in Fig.4.

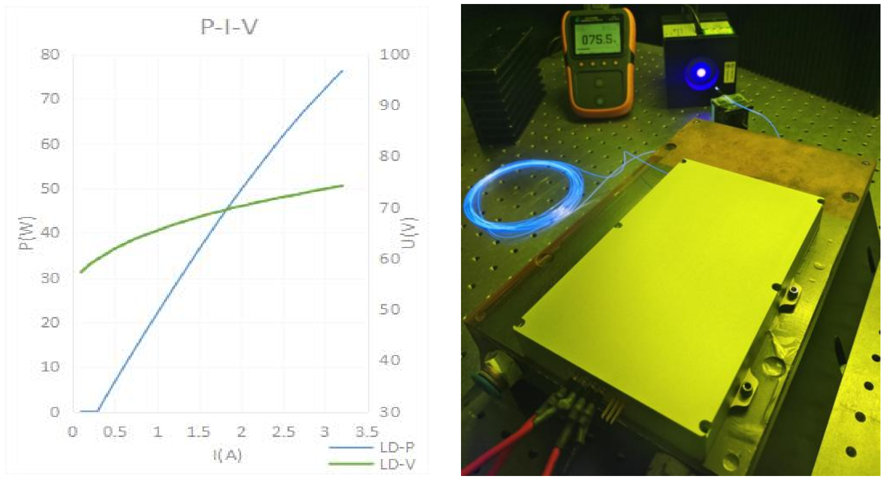

Figure 4. Power and voltage test data

Based on this package, BWT can also provide a choice of 100μm*100μm square homogenized beam, which uniformity is more than 90%, Fig.5 shows the test homogenized beam. The quality of homogenized beam is stable enough to avoid the interference of fiber vibration or bending. It provides an ideal light source for 3D printing, wire stripping and other applications.

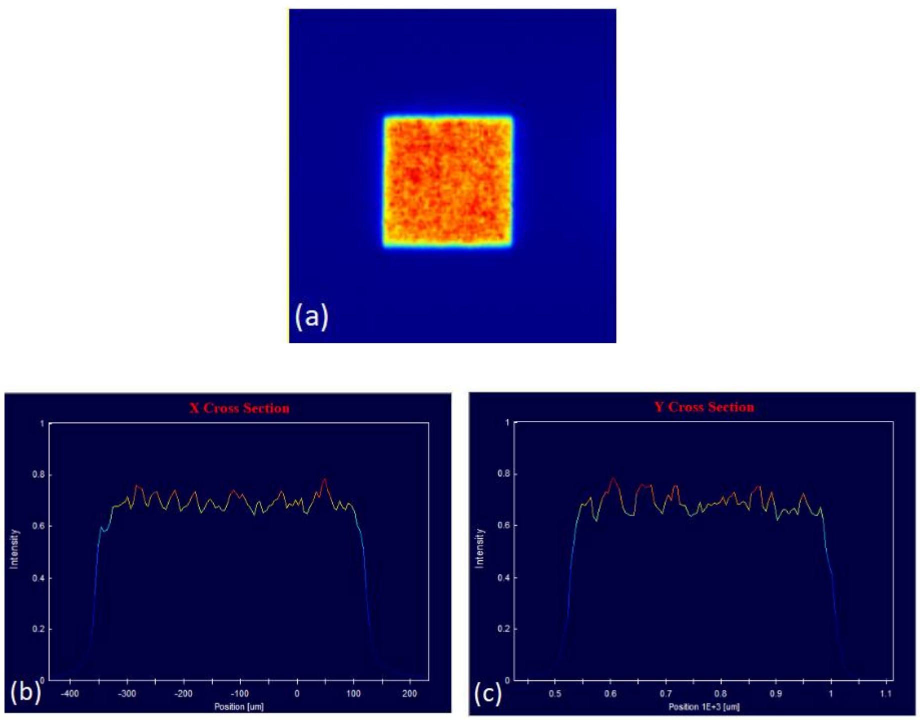

Figure 5. (a)100μm*100μm square homogenized beam at end face of fiber
(b)X cross section power distribution (c)Y cross section power distribution

Conduct a stability test on the laser, the fluctuation of output power is less than 1% under 45 minutes operation, Fig.6 shows the test data. 2000H long-term aging at 3.5A, power variation rate less than

3%.

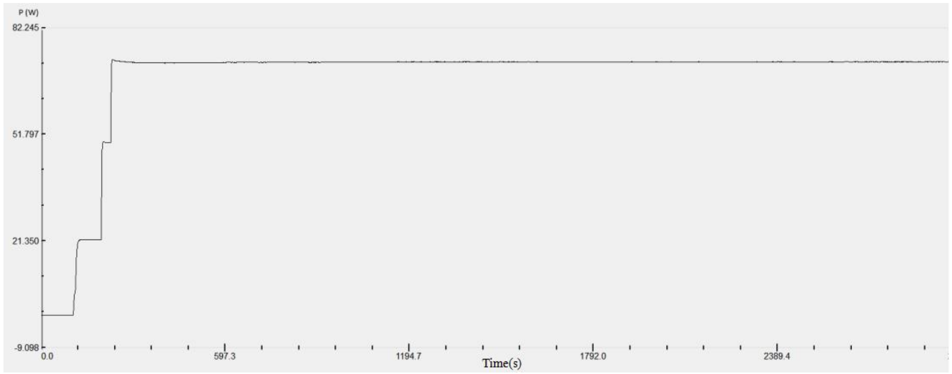

Figure 6. Stability test data

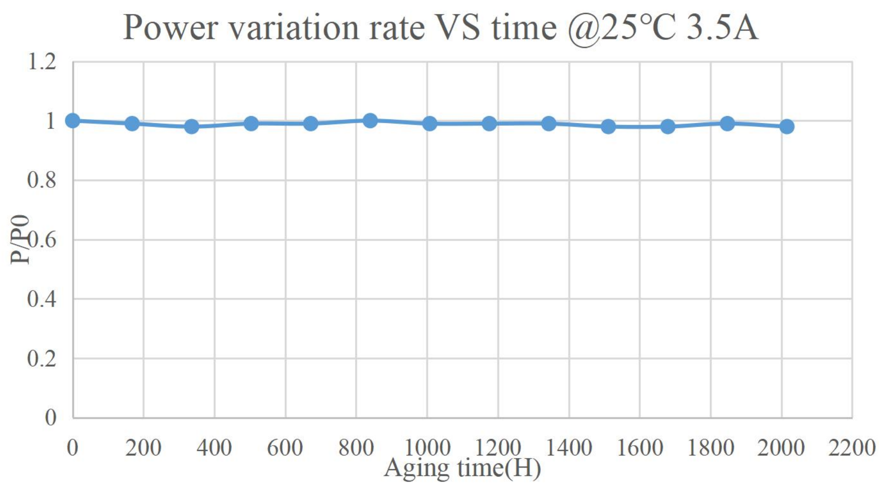

Figure 7. Long-term aging test data

4.Conclusion

18pcs TO-packaged 5W diode lasers are coupled into a 113μm core diameter fiber 0.15NA based on polarization combination and coupling technology, coupling efficiency exceeds 88%, more than 75W is obtained. Optical fiber end face spot with uniformity of more than 90% can be achieved by coupling the square optical fiber, BWT Provides an ideal high-beam quality blue light for medium power applications.

Reference

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