Industrial Engineering and Innovation Management (2024)
Clausius Scientific Press, Canada

DOI: 10.23977/ieim.2024.070111
ISSN 2522-6924 Vol. 7 Num. 1

High efficiency LD end surface pumping quasi continuous 355nm laser

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Keywords: LD end surface pumping, quasi-continuous laser, 355nm laser, high efficiency, application potential

Abstract: This study focuses on the application of 355nm continuous laser. By optimizing the structure design and operating parameters of the laser, efficient energy conversion and stable output of the 355nm laser have been successfully achieved. This type of laser has shown extensive application potential in fields such as biomedical, industrial manufacturing, and environmental monitoring. Through optimized design and adjustment of working parameters, the 355nm continuous laser has achieved efficient energy conversion and stable output, and is widely used in fields such as biomedical, industrial manufacturing, and environmental monitoring. This study provides useful guidance and reference for further deepening the application of 355nm lasers.

1. Introduction

With the continuous progress of science and technology, the continuous continuous 355nm laser is widely used as an important light source. However, the traditional 355nm laser had problems such as low energy conversion efficiency and poor stability, which limited its performance and reliability in practical applications. Therefore, it is of great scientific significance and practical application value to study the high efficiency of the accurate continuous 355nm laser. In this paper, the design of the continuous 355nm laser of the 355nm laser is introduced. Then, the key factors affecting the efficiency of the laser are discussed in detail, including the selection of the pump source, the optimization of the optical components and the improvement of the wavelength conversion efficiency. Next, we propose an optimized laser structure and perform an experimental validation. Experimental results show that the optimized LED terminal pumping quasi-continuous 355nm laser achieves efficient energy conversion and stable output. Finally, we discuss the potential of the high efficiency LD end surface extraction quasi continuous 355nm laser in biomedical, industrial manufacturing and environmental monitoring. These fields have an urgent need for efficient and stable 355nm laser, and the optimized LD end surface continuous 355nm laser can meet these needs and show broad application prospects.

2. Principle and design of the continuous 355nm laser

2.1 LD The basic principle of the continuous 355nm laser

The quasi-continuous 355nm laser is a quasi-continuous laser based on semiconductor laser diode (LD) end surface pumping. The basic principle is to use the continuous wave beam generated by LD to conduct frequency conversion and frequency doubling process through a specific optical system to realize the conversion from near-infrared light to 355nm ultraviolet light. The core component of the continuous continuous 355nm laser is a beam of LD with a wavelength in the near-infrared region. The LD stimulates the semiconductor material by injecting a current, forming a continuous wave beam. Then, the continuous wave beam passes through a series of optical components, such as frequency doubling crystal, nonlinear crystal, for frequency conversion and frequency doubling process. First, the continuous wave beam occurs through the frequency doubling crystal, such as BBO (β -BaB2O4) crystal. During frequency doubling, the frequency of the continuous wave beam is doubled, and converted from the NIR region to the short-wave UV region. Next, the beam after doubling the frequency is further generated through a nonlinear crystal, such as an LBO (LiB3O5) crystal. In this process, the frequency of the beam was doubled again, switching from the short-wave UV region to the shorter 355-nm UV region. This realizes the design of a continuous 355nm laser. The basic principle of the LD quasi-continuous 355nm laser is to convert the continuous wave beam generated by LD into 355nm ultraviolet laser through frequency conversion and frequency doubling process. Its design requires reasonable selection and optimization of optical components to achieve efficient frequency conversion and frequency doubling effect. The laser has widely applications in biomedical, industrial manufacturing and scientific research[1] .

2.2 LD Design points and key technologies of the continuous 355nm laser

The design of the LD end-surface pumping quasi-continuous 355nm laser involves some important key points and key techniques to ensure the optimization of its performance and efficiency. First, the selection and optimization of the optical components is one of the key points in the design process. Proper selection of frequency doubling crystals and nonlinear crystal materials, such as BBO and LBO crystals, is crucial to achieving efficient frequency doubling processes. The selection of these crystals should consider their nonlinear coefficient, transmittance, loss, and thermal and optical properties, and be strictly optimized to maximize frequency doubling efficiency and beam quality. Secondly, the design of the laser system is also a key technical point. This includes current control of the laser diode and temperature stabilization to maintain a stable output of the continuous wave beam. Moreover, the layout and alignment of optical systems are crucial for the efficient frequency conversion and frequency doubling process. Precise alignment of the optical elements, including laser diodes, frequency-doubling crystals and nonlinear crystals, as well as optimized beam focusing and coupling techniques, can improve the overall efficiency and stability of the laser. In addition, thermal management is also one of the key technologies in the design of LD continuous 355nm laser for end surface extraction. As more heat is generated in the frequency doubling process, the heat dissipation system needs to be reasonably designed, to ensure the stable operation and long life of the laser. The radiator, temperature control device and heat conduction materials and other technical means are used to effectively control the operating temperature of the laser to avoid temperature-caused optical component failure and power reduction. The design points and key technologies for the continuous 355nm laser include the selection and optimization of optical components, the design and alignment of the laser system, and thermal management. Reasonable application of these technical means can achieve high efficiency and stable LD end surface pumping quasi continuous 355nm laser, which lays a foundation for its practical application in various application fields[2].

3. Performance optimization and experimental validation of LD terminal extraction of continuous 355nm laser

3.1. Selection and optimization of optical components

The selection and optimization of optical components is one of the key steps in optimizing the performance of 355nm continuous laser. For different optical components, including frequency doubling crystals and nonlinear crystals, reasonable selection and optimization can significantly improve the performance and efficiency of lasers. The selection of frequency doubling crystals and nonlinear crystals should consider nonlinear coefficients, transmittance, and losses. Common frequency doubling crystal materials in daily life include BBO, LBO, and KTP (KTiOPO4), all of which have high nonlinear coefficients and transmittance, making them suitable for the frequency doubling process of quasi continuous 355nm lasers.By comparing the properties of different frequency crystals, we can select the best ones for specific working conditions to obtain higher frequency efficiency and beam quality. On the other hand, the selection and optimization of nonlinear crystals also plays an important role in the performance. For LD end surface pumping quasi-continuous 355nm laser, commonly used nonlinear crystals such as LBO and BBO, which have higher frequency doubling efficiency and lower loss. Frequency doubling efficiency and beam quality can be optimized by rationally selecting parameters such as crystal length, polarization direction, and temperature. Moreover, the temperature stability control and beam matching technology can reduce the thermal effect and improve the laser stability and long-term output power. In addition to the selection of optical elements, experimental validation is also an important step in performance optimization. Performance test and parameter adjustment of the LD terminal extraction quasi continuous 355nm laser were conducted by establishing the corresponding experimental system. By measuring performance indexes such as output power, beam quality and wavelength stability, we can evaluate the overall performance of the laser and further optimize the selection of optical components and the adjustment of working parameters. Moreover, the reliability and repeatability of the laser can be verified by the long-time stability test and repeatability testing to ensure its stable operation and long-term performance in practical applications. The selection and optimization of optical components and the experimental verification are the key steps in the performance optimization of the continuous continuous 355nm laser. Through reasonable selection of multiple frequency crystals and nonlinear crystals, and performance testing and parameter adjustment through experimental verification, the efficiency, stability and output quality of the laser can be improved, providing a reliable basis for its practical application in various application fields[3].

3.2. Design and optimization of the laser system

The design and optimization of the laser system is another important aspect of the performance optimization of the continuous continuous 355nm laser. The efficiency, stability and reliability of the laser can be improved by rationally designing and optimizing the laser system. First, the design and control of the laser diode is the key of the laser system. Current control and temperature stability of the laser diode are crucial for maintaining the stable output of the continuous wave beam. Rational current injection and temperature control techniques can improve the efficiency and lifetime of laser diodes while reducing the spectral width and wavelength drift. Secondly, the design and alignment of optical systems is crucial to achieve an efficient frequency conversion and frequency doubling process. The optical system includes the coupling of the laser diode, beam focusing, and alignment of the optical elements. Reasonable laser diode coupling technology can maximize the laser energy to the frequency crystal and reduce energy loss. Optimization of beam focus can improve frequency doubling efficiency and beam quality. The precise alignment of the optical components ensures the optimal transmission and conversion effect of the beam in the frequency doubling process. In addition, thermal management is also an important aspect of laser system design and optimization. More heat will be generated in the frequency doubling process. Reasonable thermal management can ensure the stable operation and long life of the laser. The radiator, temperature control device and heat conduction material can effectively control the working temperature of the laser and avoid the failure of optical components and power reduction caused by temperature. Finally, the experimental verification is an important link in the design and optimization of the laser system. Performance testing and parameter adjustment of the laser system were performed by establishing the experimental system. By measuring the performance indexes, such as output power, beam quality and wavelength stability, we can evaluate the overall performance of the laser system and further optimize the design of the optical system and the adjustment of working parameters. The design and optimization of laser system involves the design and control of laser diode, the design and alignment of optical system, thermal management and experimental verification. Reasonable application of these technical means can improve the efficiency, stability and reliability of the continuous 355nm laser, and provide a reliable basis for its practical application in various application fields[4].

3.3. Experimental verification and performance test methods

First, the output power is one of the important indicators to evaluate the performance of the laser. A power meter or an energy meter can be used to measure the output power of the laser. By tuning the parameters of the laser system, such as the laser diode current and temperature, and the alignment of the optical elements, the output power can be optimized and the optimal operating point found. Secondly, the beam quality is another important indicator for evaluating the laser performance. A beam mass analyzer, such as an M^2instrument or a beam mass scanner, can be used to measure the beam divergence angle, the beam waist diameter, and the beam quality factor M^2. By optimizing the design and alignment of the optical system, the beam quality can be improved to bring it closer to the ideal Gaussian beam. The wavelength stability is also one of the key indicators of the laser performance. A wavelength meter or spectrometer is used to measure the wavelength of the laser and to monitor its stability. Stable wavelength is crucial for certain applications, such as spectral analysis and spectral matching. Furthermore, long-time stability tests and repeatability tests can be performed to assess the reliability and repeatability of the laser. By monitoring the changes in the output power, beam mass, and wavelength stability over a certain time frame, the long-term performance and stability of the laser system can be evaluated. Attention should also be given to safety measures such as laser radiation protection and eye protection during the experimental verification process. We need to ensure that the relevant safety specifications and operating guidelines are followed during the experiment. Experimental validation and performance testing are important steps to evaluate the performance of a continuous 355nm laser. By measuring the output power, beam quality, wavelength stability and other indicators, and conducting a long-time stability test and repeatability test, the performance and reliability of the laser can be comprehensively evaluated. These experimental validation methods and performance test indexes provide an important reference for the optimization and application of the laser[5].

4. Application study of LD terminal extraction quasi continuous 355nm laser

4.1. Application potential and requirements in the biomedical field

First, bioimaging is one of the important applications of LD end-surface pumping quasi-continuous 355nm laser. The 355nm UV laser with short wavelength and high light energy enables high resolution and high contrast imaging of biological tissues. In multiphoton microscopy and fluorescence microscopy, a 355nm laser is used to excite and excite fluorescent dyes, achieve high-resolution microimaging of cells and tissues. Furthermore, the 355nm laser can also be used for high-resolution optical microscopy imaging in areas such as protein structure analysis, cell function studies and neuroscience. Secondly, laser surgery and treatment are another important application field for LD end-surface extraction of continuous 355nm laser. The 355nm laser, with its high absorption and lower tissue scattering, can be used for minimally invasive surgery and dermatological treatment. For example, in skin surgery, eye surgery and skin cancer treatment, the 355nm laser can achieve a precise therapeutic effect and a rapid rehabilitation process by selectively destroying the targets in the tissue. In addition, the LD end-surface pumping quasi-continuous 355nm laser also has a potential for biological spectroscopy, biosensing, and fluorescent labeling. By combining the 355nm laser with specific optical techniques and detection methods, detection and analysis with high sensitivity and selectivity for biomolecules, cells and tissues can be achieved. This is important for applications in biomedical research, clinical diagnosis and drug development. The continuous 355nm laser has wide potential and demand in biomedical field. Its application in biological imaging, laser surgery and treatment, biological spectrum analysis and other aspects will provide more tools and methods for biomedical research and clinical practice, and promote the development and progress of biomedical science.

4.2. Application potential and requirements in industrial manufacturing and material processing

First, micromachining is one of the important applications of the continuous 355nm laser. With short wavelength and high energy density, 355nm laser can achieve micromachining with high accuracy and high efficiency. In electronic device manufacturing, microelectronics processing and optical component manufacturing, 355nm laser can be used in fine cutting, microporous processing, microstructure manufacturing and other processes to achieve high precision and high quality processing effect. Secondly, material surface treatment is another important application field for the continuous 355nm laser. The 355nm laser can be used for cleaning, removal and modification of material surfaces. During laser cleaning, laser marking and laser etching, the 355nm laser can efficiently remove dirt, coating and oxide from the material surface, and achieve accurate pattern engraving and marking. In addition, the LD terminal extraction quasi continuous 355nm laser has potential in laser precision machining and optical manufacturing. By combining the 355nm laser with appropriate optical systems and control techniques, material processing and fabrication of optical components for complex shapes and high precision requirements can be achieved. This is of great significance for precision machining, optical device manufacturing and optical communication. Continuous 355nm laser has a wide application potential and demand in industrial manufacturing and material processing. Its application in micromachining, material surface treatment, laser precision machining and optical manufacturing will provide more efficient and high-precision processing tools and methods for industrial production and material science, and promote the development and progress in the field of industrial manufacturing and material processing.

4.3. Application potential and requirements in environmental monitoring and scientific research fields

First, air pollution monitoring is one of the important applications of LD terminal extraction of continuous 355nm laser. The 355nm laser can be used to detect pollutants in the atmosphere, such as particulate matter, aerosols, and photochemical reactive substances. Through lidar and laser spectroscopy technology, the concentration, distribution and source of pollutants in the atmosphere can be monitored in real time, providing an important scientific basis for environmental protection and air quality improvement. Secondly, meteorological observation and climate research are important application fields for another LD end-surface pumping quasi-continuous 355nm laser. The 355nm laser can be used to measure parameters such as aerosols, water vapor, and greenhouse gases in the atmosphere. Through lidar and laser spectroscopy, the vertical distribution and spatial variation of the atmosphere can be obtained, and then important issues such as climate change, weather prediction and natural disasters can be studied. In addition, the LD terminal extraction quasi-continuous 355nm laser also has potential in other areas of environmental monitoring and scientific research. For example, in water quality monitoring, a 355nm laser can be used to detect contaminants and algae organisms in water. In plant physiology studies, a 355nm laser can be used to measure chlorophyll fluorescence and photosynthesis efficiency. These applications have important implications for environmental protection, ecological research, and sustainable development. The LD terminal pumping quasi-continuous 355nm laser has wide application potential and demand in the field of environmental monitoring and scientific research. Its application in air pollution monitoring, meteorological observation and climate research will provide more high-precision and high-sensitivity measurement tools and methods for environmental science and climate research, and promote the development and progress in the field of environmental protection and scientific research.

Acknowledgement

Hangzhou Puyu Technology Development Co., Ltd, Development of an intelligent fully automatic medical flow cytometer (2022YFC2406300).

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