Development of CW and pulsed Fiber Lasers At SIOM

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Abstract

KW level CW high power output and 150W high repetition rate pulsed output are obtained with China made multimode core fibers. The laser structure and pulse amplifier technology are given in detail.

Introduction

Recent development of techniques for multimode Fiber lasers holds great promise for a wide range of applications because fiber lasers have high efficiency and exceptional beam quality. On the other-hand, fiber lasers are truly solid state with minimum of exposed optical interfaces, the high beam quality and 1 um wavelength makes it possible that the fiber laser can directly replace both diode and lamp pumped Nd:YAG lasers in many industry applications , the most important markets they will address are marking, micromachining ,automotive and biomedical.

Fiber lasers up to KW output power are now on high technological level, fiber laser systems for industrial applications are now on the market . The development of these lasers is not only in the cw and long pulsed mode operation but also in the short ps pulse mode operation. Although in the laboratory KW level system were realized several years ago, the step to the industrial level is not very fast for several reasons such as : diode bar lifetime and diode price . It is no question that the diode pumped fiber lasers offer many advantages for well known reasons:

- *High overall efficiency (20% - 30%)*
- *High life time (5000h to several tens of thousand hours)*
- *Lower energy consumption and less cooling*
- *More stable laser emission*
- *Less weight and volume, which is of special interest for making and scribing applications*
- *Less thermal load, which results in a higher beam quality*

In this paper, we report the development of fiber lasers in Shanghai Institute of Optics and fine Mechanics, It includes KW level cw fiber laser by using China made double cladding fiber; 20W average output pulsed fiber laser .

KW level cw fiber laser with China made double cladding fiber

Optical fibers play an important role in transferring the optical signal, they also act as host medium in fiber lasers and amplifiers when the rare-earth are doped into the fiber core .

However, most double-clad fibers made to date use a low-index polymer as the outer clad material to achieve the desired high numerical aperture (NA 0.3–0.45). These polymers have much poorer thermal stability than glass. In high-power applications, the polymer near the inner–outer clad interface can easily burn or gradually degrade during the high-power pump. Because of any faulty steps in beam shaping and assembling, the high-power collimated pumping beam is not so good for pumping the double-clad fiber directly. A spatial filter can be used to improve the beam quality of the high-power pump light. For two ends pumping configuration, 1050W output power was obtained with pumping power of 1400W.The experiment setup is shown in Fig.1.

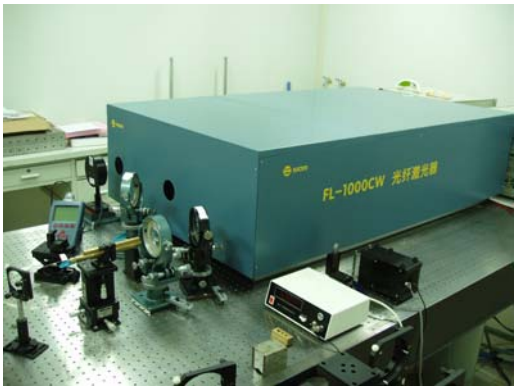

Figure 1. Experiment setup of KW level cw fiber laser

For high power fiber laser, thermal affects should be considered , because the absorption of the pumping source at two ends is rather high, the increment of the fiber temperature will damage the fiber during high power operation. These part should have cooling system to maintain the temperature within the lower region

The beam quality of the fiber laser is better than regular solid state laser, so that it can be used in many application fields. For example , 1.5mm stainless plate can be welded by 200W fiber laser beam with narrow welding gap.

Pulsed fiber laser with MOPA system

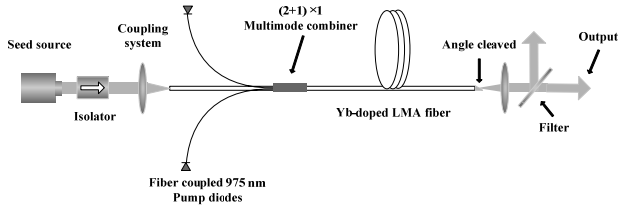

Figure 2. Experiment setup of high energy and high repetition rate all fiber MOPA system

For pulsed fiber fiber lasers, an all fiber MOPA (master oscillator and power amplifier) system is designed. The experimental setup is shown in Fig.2.The seed laser was optically isolated and launched into the signal fiber of the (2 + 1) x 1 combiner with coupling efficiency of 77%. Two fiber coupled pump diodes, each of them can provide 25 W pump power at the central wavelength of 976nm, were employed as pump source with 200um/0.22NA fiber coupled output. We use a 10 m long China-made Yb doped double cladding fiber with a core diameter of 18um as amplifier fiber. The cladding absorption coefficient of the fiber is about 2 dB/m at 976nm, the output end of the fiber is polished at an angle of 8 degree to suppress ASE or feedback in the fiber power amplifier. In this MOPA system, the power amplifier was seed with 1 W of average power and could produce pulses with average power up to 20 W. For the repetition rate varied from 50 to 175 kHz , the highest pulse energy of 0.4 mJ was obtained at the repetition rate of 50 kHz, and the pulse energy was reduced as the repetition rate increased, spectrum spread and pulse broadening were not observed in above system.

The transverse beam profile of the laser output was measured by imaging the amplifier output into a CCD camera, after fit the measured beam radius at different positions, M square factor was obtained , the best – fit value is 1.24 with 20W average output power, as shown in Fig.3.

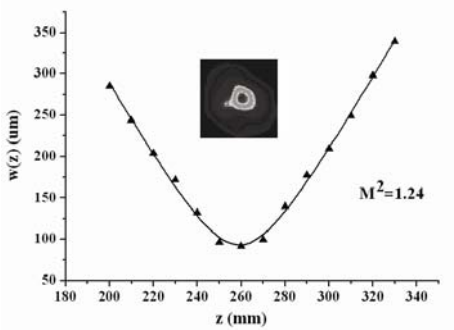

Figure 3 $1/e^2$ radius of the amplified output beam vs. location. Inset: near-field image of the amplifier output taken at the highest average power

For more higher average output power, an fiber amplifier is used for increase the output power up-to 150W with the pumping power of 210W at repetition rate of 50kHz.The double cladding fiber has large mode area of 100um, the pulse energy of the MOPA system is about 3 mJ.

Our MOPA system employs a simple and compact architecture and is therefore suitable for the use in practical applications. Because of the high average power , high repetition rate and near diffraction – limited beam quality, this laser can be used in materials processing , remote sensing and chemical detection.

References

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