Technology Introduction to Double-cladding Yb-doped Fibre in Optical Fibre Laser

Yang Yucheng, Huang Hongqi, Meng Yue, Sun Cheng, Zhong Li

Abstract: Yb-doped double-cladding fibre is mainly used in 1 μm optical fibre lasers. The 10/125 and 20/125 optical fibre produced by YOFC meets the stringent aging conditions and can meet the application requirements of 20w pulsed laser. The conversion efficiency of 20/400 double-cladding Yb-doped fibre designed for high power laser is up to 67%, which can output 1400w laser stably and continuously.

Key words: optical fibre laser, double-cladding Yb-doped fibre, marking, high power, aging

1 Introduction

Thanks to the rapid development and gradual maturity of the material processing industry, the share of industrial lasers in the global laser market keeps growing, in which the performance of optical fibre lasers is particularly outstanding, and the growth of domestic fibre lasers in the market is also gaining momentum. According to statistics, the domestic production capacity of optical fibre lasers reached 74,000 in 2016, mainly consisting of nearly 60,000 low-power optical fibre lasers, 12,000 medium-power optical fibre lasers and over 2,000 high-power optical fibre lasers.

In optical fibre laser system, active optical fibre and passive optical fibre, laser diode and all kinds of optical fibre devices are gradually maturing and progressing, which brings great development for optical fibre lasers and amplifiers. Based on the characteristics of double-cladding Yb-doped fibre, especially large-mode-area double-cladding Yb-doped fibre (LMA DC-YDF) and the matching large-mode-area double-cladding passive fibre (LMA DC-GDF), optical fibre lasers show the advantages of high output power (peak power, average power), excellent laser beam quality, integration and low cost.

Domestic optical fibre lasers have shown remarkable performance in recent years, but most of that is in the field of medium and low power. According to the relevant data statistics, the shipments of domestic optical fibre lasers of small and medium power account for more than 92%. Foreign companies still dominate in high power application. Although domestic enterprises make great progress relying on the localization of devices such as pumping source encapsulation, pump combiner, energy combiner, isolator, optical fibre grating and laser transmission components, and gradually get rid of dependence on foreign enterprises, there is still a big gap in the technology and quality of some key devices, such as pumping source chip, matching large-mode-area double-cladding passive fibre and large-mode-area double-cladding Yb-doped fibre, which, with full power range, have not been locally produced in massive quantity. At present, most of the optical fibre laser manufacturers use imported large double-cladding Yb-doped fibre and match it with double-cladding passive fibre imported as the same, which indicates that the core raw materials of optical fibre lasers are not localized. At the same time, the stringent verification standards and long verification period further lead to the lagging update and

improvement of optical fibre products for lasers. It can be seen that the localization of Yb-doped double-cladding fibre and double-cladding passive fibre is an important reason that restricts the development of optical fibre lasers in China. Therefore, the task of localization is very important and urgent.

2 125 series Yb-doped double-cladding fibre

After five years of technical accumulation, platform building and product serialization, YOFC has gradually promoted 125 μm series large-mode-area double-cladding Yb-doped fibre for low power fibre laser and 20/400 series double-cladding Yb-doped fibre for medium and high power fibre laser.

YOFC adopts CDS chelate and Al-P-Yb ternary doping process for the first time in China through MCVD platform, which optimizes the photodarkening performance and high-power shock resistance of Yb-doped fibre. At the same time, with the many years of accumulated process technologies, YOFC has established a mature process route for large preform. This route not only greatly improves the productivity of single optical fibre preform, but also improves the batch consistency and geometrical uniformity of optical fibre.

The 125μm large-mode-area double-cladding Yb-doped fibre includes the following two models:

Table 1 Parameters of 125μm large-mode-area double-cladding Yb-doped fibre (LMA DC YDF)

Parameter	10/125	20/125
Fibre core diameter (μm)	10	20
Fibre core NA	0.08±0.05	0.08±0.05
Cladding diameter (μm)	125	125
Cladding shape	Octagon	Octagon
Cladding absorption coefficient (dB/m)	1.6±0.3	3.6±0.4
Slope efficiency	>75%	>70%
Cladding NA	>0.46	>0.46

125 μm series large-mode-area double-cladding Yb-doped fibre mainly aims at the market of typical MOPA and Q switch 20W optical fibre laser marking. In the table, the high absorption coefficient (> 1.6 dB/m @ 915nm) of DC-10/125 YDF and the optical efficiency greater than 60% can keep the primary usable length at about 4m. For MOPA-type optical fibre marking machine, it can significantly reduce the length of optical fibre and save cost. The flat absorption near 915 nm of the fibre can reduce the design requirement for cooling of the laser system. For the Q switch optical fibre marking machine, reducing the primary resonant cavity length, reducing the loss inside cavity, compressing the pulse width and increasing the broadening redundancy of the secondary pulse width are the reliable guarantee to improve the marking quality.

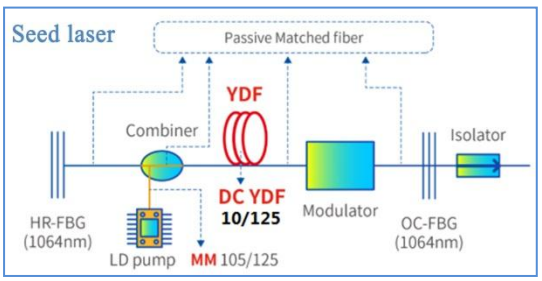

Figure 1 YOFC Low Power Active and Passive Solutions

The power output of the laser can be controlled between 19w and 21w and the pulse width can be

controlled between 90ns and 110ns by using YOFC double-cladding 10/125 and 20/125 Yb-doped fibre. At the same time, because the YOFC DC-YDF of 20/125 adopts the design of large mode area, the optical fibre laser can keep the laser beam output of nearly M2 < 1.5 after 20 μm fibre core doping is optimized.

YOFC uses the optimized optical fibre drawing process so that the optical fibre has been significantly improved in environmental stability. Especially, the optical fibre has passed the rapid aging test in the harsh environment with high temperature and high humidity: after aging at 125 ℃ under the pressure of 2 atmospheres for 8 hours, the peeling strength between the glass cladding and the inner coating is still the same. The output power of the optical fibre laser with YOFC optical fibre fluctuates within 5% during the continuous 500-hour test by the laser manufacturer. After aging under the conditions of 85 ℃/85% RH, the power fluctuation of the optical fibre laser with YOFC 125 μm double-cladding Yb-doped fibre keeps within 3%, meanwhile, the laser beam quality of the secondary output is still good.

3 20/400 double-cladding Yb-doped fibre

In view of the key optical fibre raw materials used in medium and high power CW lasers of 300W-1500W, YOFC has promoted large-mode-area double-cladding 20/400 Yb-doped fibre. The specifications are as follows:

Table 2 Parameters of large-mode-area double-cladding 20/400 Yb-doped fibre

Parameter	20/400
Fibre core diameter (μm)	20.0±2.0
Fibre core NA	0.065±0.05
Cladding diameter (μm)	400±5
Cladding shape	Octagon
Cladding absorption coefficient (dB/m)	0.39±0.3
Cladding NA	>0.46
Optical efficiency (915nm)	>65%

The cost of medium and high power CW lasers is mainly concentrated in the total power and heat management The active optical fibre produced by YOFC has high conversion efficiency, which can reduce the power output of pumping source and reduce the difficulty of heat management. At the same time, higher conversion efficiency can reduce the heat generated by optical fibre, which greatly slows down the aging speed of optical fibre coating caused by serious heat, improves the life of optical fibre and even the whole machine, and keeps the stable output of power for a longer time.

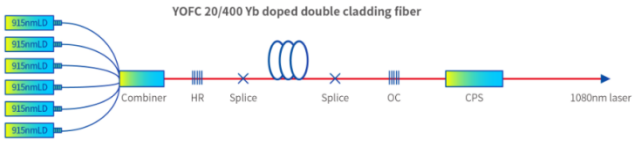

Figure 2 Schematic diagram of high power 20/400 fibre laser

As shown in Figure 2, the optical efficiency of the YOFC large-mode-area double-cladding 20/400 Yb-doped fibre is up to 67% when the 915nm pump source coupling is tested with 1080nm high and low reflection grating pairs At the same time, the optical efficiency increases with the increase of pumping power. (See Figure 3 for test results)

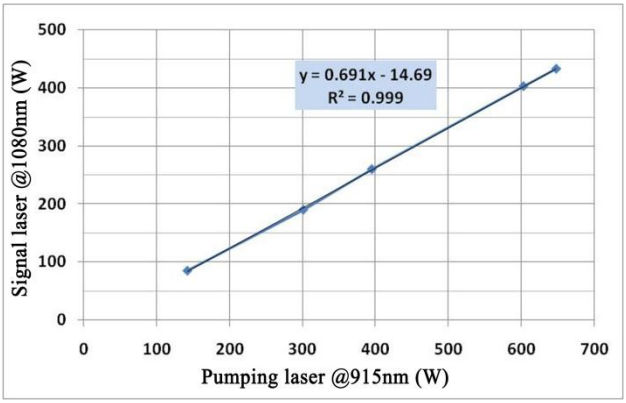

Figure 3 915nm Pumping Optical Efficiency Test Results

In order to verify the stability of YOFC 20/400 optical fibre at higher power, the tester added a set of 1400W stability test experiments. The test results show that the power fluctuation of YOFC 20/400 optical fibre is 0.21% within 1 hour, as shown in Figure 4.

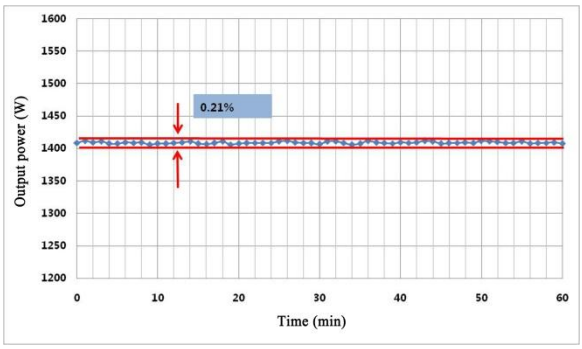

Figure 4 1400W power test in continuous 1 hour

4 Summary

To sum up, in the two types of 125 μm series double-cladding Yb-doped optical fibre (10/125 and 20/125) promoted by YOFC for low-power optical fibre laser for marking, the coating and glass cladding are closely bonded under high temperature and high humidity, which ensures long-term reliability. The conversion efficiency of double-cladding 20/400 Yb-doped fibre at medium power is up to 67%, and the power fluctuation of 1400w output is very stable.

Focusing on the future optical fibre laser market, based on the deep understanding of optical fibre laser and its application, YOFC makes full use of its development and production platform of special optical fibre, technical ability and enriched process accumulation, and strives to provide high-quality special optical fibre made in China for the industry!

长飞光纤光缆股份有限公司
Yangtze Optical Fibre and Cable Joint Stock Limited Company
地址：武汉市光谷大道9号（430073）
ADD：No.9 Optics Valley Avenue, Wuhan, Hubei, China(P.C.: 430073)
电话(Tel)：+86 400-991-6698
邮箱(Email)：marketing@yofc.com
www.yofc.com