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We understand that any items that the administration ultimately determines to be within the scope of Tier I would be ineligible for license exception STA. We also note that ECCN 6A005 is among a list of ECCNs that are being considered in whole or in part to be ineligible for license exception STA as they may in whole or in part meet the Tier I criteria. As Tier I refers to items and technologies related to WMD or items that are almost exclusively available from the United States and which provide critical military or intelligence advantage to the US, we feel that 6A005 can at best be considered to meet the Tier I criteria "IN PART" and NOT "IN WHOLE."

6A005 includes lasers (fiber lasers) and components for lasers (including double clad fibers). Many fiber lasers as well as double clad fibers that are currently controlled by ECCN 6A005 are widely available from a range of companies and institutions outside of the United States. European and Asian countries currently manufacture and supply a range of products that are controlled under ECCN 6A005, putting US manufacturers at a significant commercial disadvantage. Many products are neither critical to US military of intelligence advantage NOR are exclusively available from the US.

Foreign availability documentation, specifically related to components for fiber lasers, vis-à-vis doped clad fibers has been previously made available to the Department of Commerce. We herewith attach documents that are relevant to showing foreign availability of a variety of fibers that are currently controlled by ECCN 6A005. The document not only includes fiber and laser manufacturers in countries such as China but also includes Wassenaar member state companies selling the fibers. The ubiquitous availability of double clad fibers outside the US should be considered as reason NOT to include the "WHOLE" of ECCN 6A005 in Tier 1.

The attached documents also include availability of fiber lasers of high enough power levels that would be controlled by ECCN 6A005. Just as in the case of double clad fibers as a component for fiber lasers, a variety non-US companies make fiber lasers currently controlled by ECCN 6A005. Not all fiber lasers are exclusively available in the US. Therefore, even from a laser perspective, ECCN 6A005 can ONLY "IN PART" be considered to meet Tier 1.

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175-W continuous-wave master oscillator power amplifier structure ytterbium-doped all-fiber laser

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We report on hundred watts range ytterbium-doped all-fiber laser assembly based on the master oscillator power amplifier structure. It consisted of an oscillator and an amplifier with all-fiber components. And fiber fusion splice made the laser be an integrated fiber system. It generated up to 175.5 W of continuous-wave (CW) output power at 1085 nm with more than 75% extraction efficiency in the amplifier when the total coupled pump power into the double clad fiber was 270 W.

OCIS codes: 140.3510, 140.3480.

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In recent years, fiber lasers play an important role and are widely used in many fields, such as sensor, materials processing, and military applications[1,2]. The combination of small size, maintenance-free operation, ease of cooling, high efficiency, and outstanding beam quality has made the fiber laser become very attractive laser source[3−5]. In particular, ytterbium (Yb)-doped fibers offer a very low quantum defect and a very broad emission between 1 and 1.1 μm[6,7]. Triggered by the progress in high-brightness pump diodes and the availability of large mode area (LMA) double-clad gain fibers, several Yb-doped fiber lasers with output powers approaching the kW-range in the continuous regime have been reported[8]. These demonstrations typically employed a length of gain fiber pumped via free-space coupling and bulk optics as the reflector. However, the availability of integrated all-fiber laser is crucial for making this technology available for a variety of application. All-fiber laser employs all-fiber components to replace the bulk-optic interface in the present laser configurations and consequently becomes compact, rugged and reliable. There are fewer reports on the integrated all-fiber laser. For example, IPG photonics reported on the significant increase of all-fiber format single-mode Yb-doped continuous-wave (CW) fiber laser output power to 1.96 kW with $M^2 < 1.2$, demonstrated during a laboratory test in 2005[9]. During 2006, Norman *et al.* reported for the first time on the power-scaling extension of SPI's proprietary side coupled cladding-pumped GT-wave technology platform with 400-W output power[10]. In this paper, we report the development of a low noise, 175.5-W CW side-pumped Yb-doped all-fiber laser. To the best of our knowledge, this is the highest CW power of all-fiber laser ever reported in China.

The developed fiber laser consists of two stages: laser oscillator and booster amplifier. They are connected by the fusion splice, which make the all-fiber laser system require less maintenance and no misalignments. The experimental setup is depicted in Fig. 1.

The laser oscillator contained gain fibers, a 7×1 multi-mode combiner, and a pair of fiber Bragg gratings. We used commercially available LMA-YDF-20/400 Yb-doped double clad fiber as the gain medium whose length is 15 m. The fiber has a 20-μm diameter core with a low numerical aperture (NA) of 0.06. The geometric shape of inner cladding is octagonal as shown in Fig. 2, and the diameter and NA are 400 μm and 0.46 respectively. The 7×1 multi-mode combiner was used to couple the pump light into the inner cladding of gain fiber. The combiner has seven pump delivery fibers with standard diameter of 200/220 μm and a NA of 0.22. The laser cavity is formed by a pair of fiber Bragg gratings. One of them was used as the high reflector and the other was used as the output coupler. In our experiment, we employed six 20-W fiber-coupled pump diodes modules (200/220-μm 0.22-NA delivery fiber) to provide 975-nm

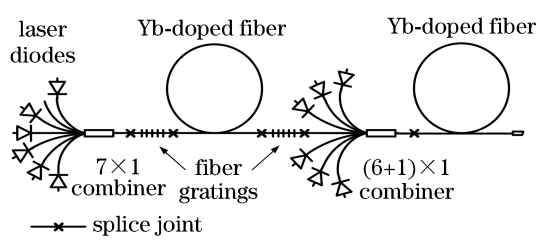

Fig. 1. Experimental arrangement of master oscillator power amplifier (MOPA) structure all-fiber laser.

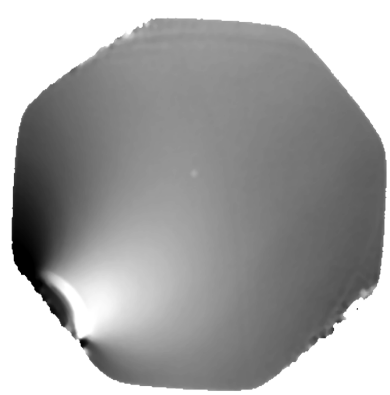

Fig. 2. Inner cladding shape of gain fiber.

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An acousto-optic Q-switched fiber laser using China-made double-cladding fiber

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A simple laser-diode pumped acoustic-optic Q-switched fiber laser is reported by using China-made large-mode-area ytterbium-doped fiber. Q-switched pulses with a beam quality factor of $M^2 \approx 2$ and several hundred nanoseconds pulse duration are achieved at the repetition rate of $1-50$ kHz. When the repetition rate is 1 kHz, the pulse energy is 0.93 mJ with the pulse duration of 132 ns. Meanwhile, the profile of laser pulses shows some mode-locking phenomena, the mechanism of the phenomena is discussed.

OCIS codes: 140.3510, 140.3540, 140.4050, 140.3480.

In recent years there has been considerable interest in developing Q-switched rare-earth-doped fiber lasers because of the advantages of fiber such as high gain, excellent conversion efficiency, excellent beam quality, good compactness, and low propagation loss. With the adoption of double-clad pumping techniques, kilowatt peak power, millijoule energy high-brightness pulses are obtained.

There are many practical applications, including range finding, remote sensing, laser cutting and drilling or laser marking require short, and high-peak-power pulses. For these applications Q-switched double-cladding fiber laser is preferred. More recent works of Q-switched fiber laser to generate high-peak power and high-energy pulse have been reported[1−5].

In this letter, an acousto-optic Q-switched fiber laser using China-made Yb^{3+}-doped double-cladding (YDDC) fiber is reported. The configuration of the YDDC fiber-laser cavity is shown in Fig. 1. The YDDC laser is pumped by a continuous wave (CW) fiber-coupled laser-diode system (975 nm) with a fiber core diameter of 200 μm and a numerical aperture (NA) of 0.22. The pumping light is directed through a 45° dichroic mirror (90% transmittance at near 975 nm, 99.5% reflectivity at 1080 nm) and focused into the Yb^{3+}-doped double-cladding fiber by the optical coupling system with a coupling efficiency of 89% approximately. The large-mode-area dispersion compensation fiber (DCF) (fabricated by Fiberhome Telecommunication Tech Co., Ltd., China) has a Yb^{3+}-doped core of 40 μm and an inner-clad of 600/650 μm. The input end face of the fiber is perpendicular to the fiber axis. The other end of the fiber is cleaved at an angle of 10° to suppress feedback from Fresnel reflections. Then the laser out of the fiber end is collimated by a lens and sent into an acousto-optic modulator (AOM) which has a diffraction efficiency of 80% at a wavelength of 1.1 μm, a rise time of less than 150 ns, and a radio frequency of 80 MHz. A fast photometer and a 600-MHz digital oscilloscope (Lecroy WR62XR) are used to measure the pulse profile. A power meter (Spectra-Physics 407 A) is used to detect the output average power. A 2-m-long silica YDDC fiber is coiled by a 15-cm-diameter circle in order to get the high-quality mode output. The acousto-optic modulator operates in the zeroth-order diffraction mode with the deflected beam reflected back into the fiber by a high-reflection (99.5%, 1080 nm) mirror.

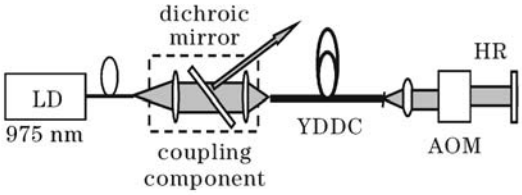

Fig. 1. Setup of Q-switched YDDC laser.

The average power and duration of the Q-switched pulse as functions of absorption power are given in Fig. 2. It is evident that the pulse duration decreases with increasing pumping power and decreasing repetition rate. The pulse profiles under the same pumping power are shown in Fig. 3 with the different repetition rates. At the repetition rate of 1 kHz, a 0.9-mJ, 132-ns pulse is achieved. The train of pulse is revealed in Fig. 4, and the pulse-pulse fluctuation is about 20%. It is found that with increasing modulation repetition rate of AOM, the

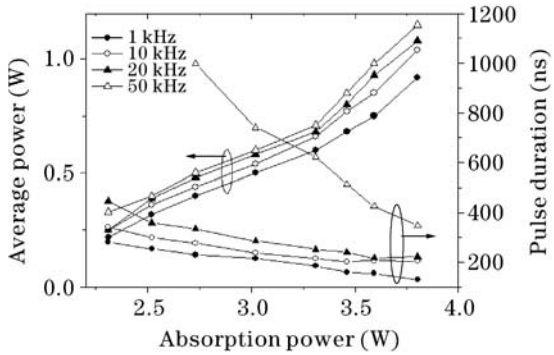

Fig. 2. Power and Q-switching pulse duration versus the absorption pumping power.

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113-W in-phase mode output from two ytterbium-doped large-core double-cladding fiber lasers

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Phase locking for two ytterbium-doped large-core fiber lasers has been demonstrated by using a self-imaging confocal resonator with a spatial filter. Steady high-contrast interference stripes are observed. The visibilities of coherent and incoherent stripes are 59% and 6%, respectively. The measured width of the central strip is in good agreement with the calculated result. For in-phase mode, the output power of the phase-locked fiber laser array is up to 113 W and corresponding slope efficiency is 38.5%.

OCIS codes: 060.2320, 140.3290, 030.1670, 070.6110.

Recently, with the development of industry and communication, higher quality and higher power of laser beam are required by means of beam coherent combination techniques which can improve power of beams with excellent quality. Fiber lasers are applied widely in beam combination techniques because of the advantages of compactness, convenience and efficiency. Nowadays, researchers have presented many beam combination techniques with fiber lasers, including the master oscillator power amplifier (MOPA) arrangement, the all-fiber coherent technique, the self-organization of multicore fiber, and the self-Fourier (S-F) cavity[1−4]. However, these experiments have been operated under low power level. The spectral combining approach[5], which uses a volume Bragg grating (VBG) of dispersive element to combine two fiber laser beams in both near- and far-fields, requires each fiber laser working at a slight different wavelengths. For various operation media such as Nd:YVO_4 and Nd:YAG, coherent addition of laser array beam has been demonstrated by the use of self-imaging resonator[6,7]. The self-imaging resonator is a special Fourier cavity and phase locking of various lasers have been realized by using Fourier cavity[8−10]. Phase locking of fiber laser arrays with a self-imaging resonator have been also realized under low power condition[11,12]. In this method, phase correction of fiber lasers is passive, which is realized by means of self-adjusting process of the resonance frequencies of fiber laser arrays to adapt to change in the optical path lengths. Furthermore, this method does not need polarization controlling of each fiber laser beam, because a polarization eigenstate can always be found in the two elements system regardless of relative orientation. Using this method, a number of fiber lasers with different lengths are coupled into a common self-imaging resonator with a spatial filter for phase locking.

For improving coherent output power of the phase-locked fiber laser array, power scaling of the single fiber laser is a feasible approach with an identical self-imaging resonator. A large-core fiber is geometry of choice for power scaling of double-cladding fiber (DCF) lasers and a large-core fiber laser with 1 kW of continuous-wave (CW) output power has been reported[13]. For end-pumped configuration of fiber lasers, a large inner cladding is necessary to accommodate the large pump beam for high output power. A large core is also required to mainly be due to degrading background loss, suppressing nonlinear-scattering.

In this letter, we describe further power scaling of the phase-locked fiber laser array with a self-imaging resonator to a in-phase mode power of 113 W. For this to be possible, we use a higher pump power and a larger-core DCF than before. Steady interference stripes with visibility of 59% are observed.

Our experimental setup is illustrated in Fig. 1. Two diode array lasers with emitting wavelength of 975 nm are used as pump sources in the phase locking experiment. Pump beams from diode array lasers through two spatial filters are coupled into ytterbium-doped DCFs by using two aspheric lenses, which are end-pumped configuration for the two fiber lasers. Two ytterbium-doped double-cladding D-shape fibers with a core diameter of 30 μm and an inner clad diameter of 400/450 μm for the shorter/longer axis are used as active media. Both the two fibers were drawn from the same preform. The fiber lengths are 13.4 and 11.6 m, respectively. The nominal numerical aperture (NA) is 0.16 for the core and 0.37 for the inner cladding. The self-imaging resonator consists of two flat dichroic input mirrors (M1 and M2) with high reflectivity of $> 99.8\%$ for $1080 - 1150$ nm and high transmission of $\sim 95\%$ for 975 nm, a convergent lens (L3) with focal length of $f = 500$ mm as Fourier transform lens in this system, and a flat semitransparent output mirror (Mo) with 25% reflectivity for $1080 - 1150$ nm. M1 and

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7.3-W single-frequency master-oscillator fiber power amplifier with China-made double-clad fiber

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A narrow-linewidth master-oscillator fiber power amplifier system was presented, in which an ultrastable, continuous-wave, single-frequency laser was adopted as the master oscillator and a China-made Yb-doped large-mode-area fiber was used as the power amplifier medium. The system generates single-frequency radiation up to 7.3 W at 1064-nm wavelength with 39% slope efficiency and 26% optical-optical power conversion efficiency. The spectral characteristics as well as the suppression of amplified spontaneous emission were discussed in detail.

OCIS codes: 060.2320, 140.3280.

High-power, low-noise, single-frequency laser sources with very narrow-linewidths are of great interest in many scientific and engineering applications, such as spectral beam combination[1], gravitational-wave detection, wavelength conversion, and optical fiber communication. However, high-power operation of single-frequency oscillator is achieved difficultly. Therefore, the so-called master-oscillator power amplifier (MOPA) architecture which uses a low-power single-frequency seed source followed by high-power amplification is often adopted. In the past several years some experimental studies on the single-frequency master-oscillator fiber power amplifier (MOFPA) have been conducted. For example, using a 30-m-long Nd-doped single-mode double-clad fiber, Zawischa *et al.* described a Nd-based MOFPA that was capable of generating single-frequency radiation up to 5.5 W at 1064 nm with an approximately 27% slope efficiency with respect to the launched pump power[2]. Hildebrandt *et al.* reported on a MOFPA system consisting of a diode-pumped Yb:YAG monolithic nonplanar ring oscillator (NPRO) as the master oscillator and a large-mode-area (LMA) double-clad fiber as the power amplifier[3]. The system emitted single-frequency radiation up to 7.8 W at 1030 nm with a slope efficiency of 36% and an optical-optical power conversion efficiency of 26%. In 2003, Liem *et al.* presented a MOFPA system emitting narrow-linewidth single-frequency radiation of 108 W at 1064 nm with low noise and excellent spectral properties by use of a 9.4-m-long Yb-doped LMA fiber[4]. In addition, a narrow-linewidth distributed feedback laser source was even amplified to 264 W without a sign of stimulated Brillouin scattering (SBS) owing to a specific thermal fiber management[5]. In China, Wang *et al.* analyzed and simulated the suppression condition of SBS in high-power single-frequency fiber amplifier in 2006[6]. At the same time, a single-frequency fiber amplifier with 6.65-W continuous-wave (CW) output power was demonstrated by use of a 4.4-m-long Yb-doped double-clad fiber[7]. The overall slope efficiency with respect to the launched pump power is 30.6%. It is noted that the fibers adopted in their MOFPA systems are all oversea. In this paper, using a China-made LMA fiber (fabricated by Fiberhome Telecommunication Tech Co. Ltd., China) as the power amplifier, we obtain a 7.3-W narrow-linewidth single-frequency output with a slope efficiency of 39%. The optical emission spectrum is investigated with respect to the suppression of amplified spontaneous emission (ASE).

The double-clad Yb-doped LMA fiber used in the experiment was designed by our independent technology and fabricated by standard modified chemical-vapor deposition (MCVD). Figures 1(a) and (b) show

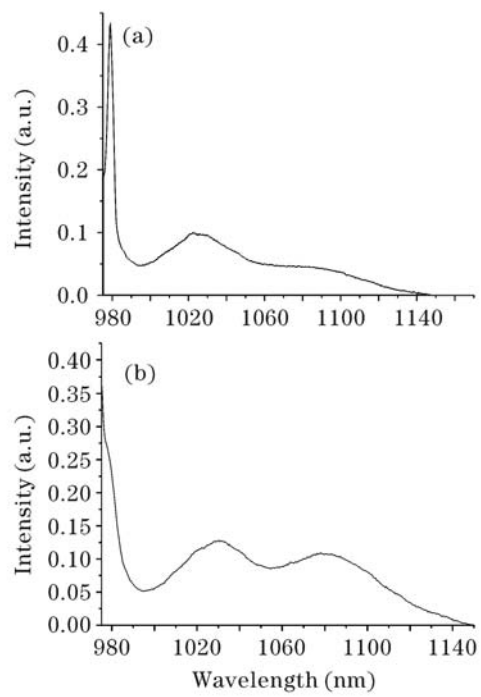

Fig. 1. Fluorescence spectra of (a) the China-made double-clad Yb-doped fiber and (b) the JDSU double-clad Yb-doped fiber.

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Cladding-pumped Er/Yb co-doped *Q*-switched all fiber laser

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A compact *Q*-switched laser based on Er/Yb co-doped fiber is demonstrated. Operating in repetition rate of 10−100 kHz and *Q*-switching window time of 100 ns−2 μs, the laser is optimized in the amplitude and stability of the pulses. At the repetition rate of 100 kHz, and maximum power of 1.75 W, average output power of 264 mW and a slope efficiency of 14% were obtained. The maximum pulse energy reached to 2.6 μJ at the repetition rate of 100 kHz.

OCIS codes: 140.3540, 140.3510, 140.3500.

Q-switched lasers find widespread applications in laser trimming, marking and welding of various solid materials. Further applications can be found in different areas of science and technology. Laser systems based on double-clad rare-earth-doped fibers are attractive for compact and very efficient high-power and high-energy short pulse generation. Their main performance advantages, compared with conventional bulk solid-state lasers, result from the combination of beam confinement and excellent heat dissipation. The development of new fiber optic laser systems is of permanent interest in the optical field, especially on the communication spectral window. Operating in the communication and eye-safe band, erbium-doped fiber lasers and amplifiers have received much attention in recently years. In particular, erbium-doped fiber lasers have shown a variety of potential applications, such as sources for wave divided multiplexing and soliton communications systems, medicine, sensing and spectroscopy. In order to produce an erbium-doped *Q*-switched laser many different approaches are employed. Passive *Q*-switching can be obtained with a saturable absorber constructed by inserting a segment of samarium-doped fiber into a ring cavity[1]. Active *Q*-switching was performed by an electro-optic modulator, an acousto-optic modulator (AOM), or an intensity modulator based on the transmission of a coupler in the cavity[2−3].

However, erbium-doped fiber laser is a three-level laser system, in which the upper lasing level is connected to its ground state. Therefore, the ground-state population must be bleached completely in order to reach the lasing threshold for laser operation. The use of high Er^{3+} concentrations can increase the pump photon absorption and provide higher gain coefficients, and ion-ion interactions by uniform and pair-induced up-conversion mechanisms can lead to degradation in the efficiency. One of the easy and effective ways to solve this problem is to co-dope Yb^{3+} with Er^{3+} in fibers. The Yb^{3+} ions with large peak absorption cross-section can provide a highly efficient means of indirect pumping for Er^{3+} ions, so one can decrease the Er^{3+} ion doping concentration owing to the strong sensitization of Yb^{3+} ions in the Er^{3+}-doped fibers. Thus, the ion-pair-induced self-pulsing in Er^{3+}-doped fiber lasers can be effectively suppressed, and the output stability can be increased. Meanwhile, a much higher pump absorption efficiency will be achieved[4−8]. Today diode-pumped rod solid-state lasers are well established in the low-power regime, due to their inherent stability, efficiency and robustness. In this paper, we present a compact Er^{3+}/Yb^{3+} co-doped double cladding all fiber *Q*-switched laser source operating at 1550 nm.

The schematic diagram of the compact *Q*-switched Er/Yb co-doped double cladding fiber (EYDF) laser is shown in Fig. 1. The gain medium of the laser was a 9-m EYDF, which has a core diameter of 7-μm, an inner cladding diameter of 130-μm, an outer cladding diameter of 245-μm, and numerical apertures of the core to the inner cladding and the inner cladding to the outer cladding are 0.14 and 0.46 respectively. The concentrations of Yb^{3+} and Er^{3+} are $N_{Yb}=1.2\times10^{26}$ m^{-3}, $N_{Er}=1.0\times10^{25}$ m^{-3}. Two Bragg gratings (FBG1 and FBG2), written on hydrogen loaded double cladding fiber with core diameter of 9 μm, inner cladding diameter of 85 μm, and outer cladding diameter of 125-μm, were employed as the cavity mirrors. Bragg wavelengths of both gratings are very close (less than 0.2 nm of spectral difference) at 1550-nm wavelength. And the bandwidth of the FBGs is less than 0.3-nm, which can ensure the narrow bandwidth of output spectrum. The reflectivities of FBG1 and FBG2 were 99.8% and 20%, respectively. The transmission spectrum of FBG1 is shown in Fig. 2. The laser was pumped by a 975-nm pig-tailed laser diode (LD) module with maximum power of 4 W and multimode

Fig. 1. Schematic diagram of the *Q*-switched EYDF fiber laser.

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High power low-order modes operation of a multimode fiber laser

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Coiling technique is used to suppress high-order modes of a large mode area (LMA) double clad multimode fiber. Output powers and beam quality factors M^2 are measured under two different coiling radii. 217 W with M^2 of 2.96 can be obtained for coiling radius of 165 mm and 160 W with M^2 of 1.38 for 52 mm. The corresponding slope efficiencies are 60% and 48%. With smaller coiling radius, the brightness is 3.4 times as high as that of the larger one.

OCIS codes: 140.0140, 140.3510.

Owing to the development of double clad fiber (DCF) and high power diode pumps, over 400-W DCF laser with single-mode can be obtained[1]. However, the scalability to higher power is limited by the amplified spontaneous emission (ASE) and various nonlinear processes, including stimulated Raman scattering (SRS), stimulated Brillouin scattering (SBS), and self-phase modulation[2]. As we know, the nonlinear effects are inversely proportional to the mode-field area[3], so they can be decreased by employing fibers of large mode area (LMA). Compared with the conventional fiber, LMA fiber has a relatively larger core but lower numerical aperture (NA). With the use of LMA double clad fiber, the output powers of fiber lasers increase dramatically[4−8].

LMA fiber is always too large to maintain single-mode operation (the normalized frequency $V < 2.405$) and multiple high-order modes are oscillated, which makes the beam quality degrade and the brightness of the laser drop. To achieve near single-mode laser with LMA fiber, experts have used many ways, such as coiling the fiber[2], manipulating the fiber index and dopant distributions[9,10], tapering the fiber sections[11], optimizing the seed conditions[12] and so on. Of all these, the coiling technique is the simplest and most economical. According to the fiber bend loss theory of Marcuse[13,14], high-order modes are more sensitive to bend loss, so they can be discriminated through coiling the fiber. As high-order modes are suppressed, the beam quality upgrades. In this paper, 160-W output with M^2 of 1.38 is obtained by coiling the homemade LMA double clad fiber.

The fiber used in the experiment is provided by FiberHome Telecom. Tech. Co. Ltd., China. To obtain high power output laser, it has a 43 μm diameter Yb-doped core with a NA of 0.08 ($V \approx 9.9$ at 1090 nm), and a 650/600 μm D-shaped inner cladding with a NA of 0.48. The length of the fiber is 8 m.

The experimental setup is shown in Fig. 1. Pump from a diode laser is focused into the double clad fiber with an aspheric lens, in front of which a dichroic mirror (975 nm, $T \sim 95\%$; 1050—1150 nm, $R > 99.8\%$) and an external cavity mirror (1050—1150 nm, $R > 99.8\%$) are placed to act as the input feedback mirror. In order to filter the residual pump light in the collimated output light, another dichroic mirror is employed. Then the beam is focused with an aspheric lens, whose focus length is 300 mm for visible light. By measuring beam radii along the propagation direction with a knife edge, we can determine the beam quality factor M^2 of the laser[15].

For a multimode laser beam, the radius $\omega(z)$ at propagation coordinate z can be obtained from the beam propagation equation[15]

$$\omega^2(z) = \omega_0^2 + \left(\frac{M^2\lambda}{\pi\omega_0}\right)^2 (z - z_0)^2, \quad (1)$$

here ω_0 and z_0 are the radius and the coordinate of the waist, respectively, λ is the laser wavelength.

In the experiment, the fiber is coiled around a cylindrical mandrel, whose radius can be measured easily. To contrast the influence of the coiling over the high-order modes suppressing, mandrels with radii of 165 and 52 mm are employed respectively. Based on the measured value, the simulated result of M^2 is illustrated in Fig. 2.

As shown in Figs. 2(a) and (b), the corresponding beam quality factors M^2 are 2.96 for 165-mm coiling radius and 1.38 for 52-mm one. Under different conditions, z_0 is a little more than 300 mm because the laser has a larger wavelength than visible light and the waist radii of the

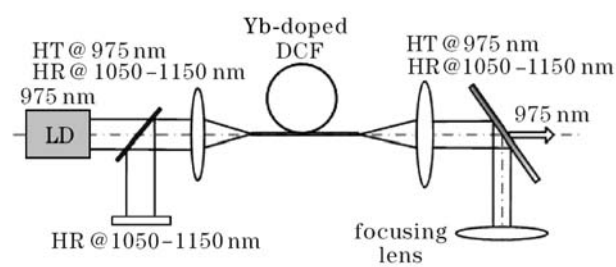

Fig. 1. Experimental setup.

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A 110-W fiber laser with homemade double-clad fiber

Dong Xue (薛 冬)[1,3], Qihong Lou (楼祺洪)[1], Jun Zhou (周 军)[1], Lingfeng Kong (孔令峰)[1], Jinyan Li (李进延)[2], and Shiyu Li (李诗愈)[2]

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[2]*Fiberhome Telecommunication Tech Co. Ltd., Wuhan 430073*

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Received October 13, 2004

A high-power ytterbium-doped fiber laser (YDFL) with homemade double-clad fiber (DCF) is introduced in this letter. The geometric parameter and laser characteristics of the fiber have been studied. With one-end-pumping scheme, pumped by a high-power laser diode with launching power of 280 W, a maximum continuous wave (CW) output of 110 W is obtained with an optical-to-optical efficiency of 40%.

OCIS codes: 060.2320, 140.3510, 140.3480.

High-power fiber lasers are now mature products and have numerous applications in medical, military, industrial processing, and modern telecommunication because of some unique advantages including high conversion efficiency, excellent beam quality, less thermal effect, and small volume and weight, etc.. Usually single mode fiber lasers are pumped by single mode diode with low output power. Double-clad fiber lasers (DCFLs) overcome the problem of launching the power from multimode pumps into single mode core by a large multimode section surrounding the doped core which propagates the pump light. Improvement in high power multimode diode combined with double-clad fiber (DCF) technology permits DCFLs to be very efficient and promising. They are mainly operating in continuous wave (CW), Q-switch, or mode lock regimes. Ytterbium-doping is attractive for high-power cladding-pumped fiber lasers for its high efficiency and high pump absorption[1]. The output power of Yb^{3+}-doped fiber laser (YDFL) reaches more than 100 W due to the high damage threshold of the silica host[2]. Ytterbium DCFL is largely used as a pump source for Raman fiber laser (RFL), which is used for testing components, pumping erbium-doped fiber amplifier (EDFA) and Raman amplifier.

Dominic *et al.* first demonstrated 110-W fiber laser in 1999, which was pumped from both ends of the Yb^{3+}-doped double-clad fiber (DCF) by four beam-shaped 915-nm diode bars[2]. CW output powers of 610 W[3] and 1 kW[4] from a large-core Yb^{3+}-doped DCFL were reported by Jeong *et al.* in this year by using one diode laser at one end and two at each, respectively. Combining the output beams of several 100-W-class fiber lasers[5], fiber laser with output power of more than 2 kW was developed in IPG Photonics. In China, the fiber lasers with CW output powers of 6.5[6], 30[7], and 115 W[8] were reported.

The above mentioned fibers are all imported Yb^{3+}-doped DCF. 110-W CW output power is obtained from a homemade Yb^{3+}-doped DCF (Fiberhome Telecommunication Tech Co. Ltd.). The fiber was pulled from a D-shape performance which was fabricated by the modified chemical-vapor deposition (MCVD) and solution doping techniques. The geometric parameter and the fluorescence characteristic of the fiber were measured. This fiber had a 16-μm Yb-doped core diameter with a numerical aperture (NA) of 0.18, and the inner cladding had a 400/450 μm diameter for the shorter/longer axis with a NA of 0.36. The performance was milled to D-shape before being drawn to fiber, so as to improve the cladding-mode overlapping with the Yb-doped core. Fluorescent lifetime of the fiber is 840 μs, and the fluorescence spectrum of 6-m Yb^{3+}-doped DCF is presented in Fig. 1.

The experimental setup is shown in Fig. 2. Both ends of the fiber are perpendicularly cleaved relative to the fiber axis. The laser cavity is formed between the two facets of the fiber. The fiber is cladding-pumped with one-end-coupling scheme by a diode stack emitting at $\sim$ 975 nm with 5-nm spectral width. The collimated output beam dimension is 40 × 40 (mm), so the beam from this kind of source is necessarily rather large when

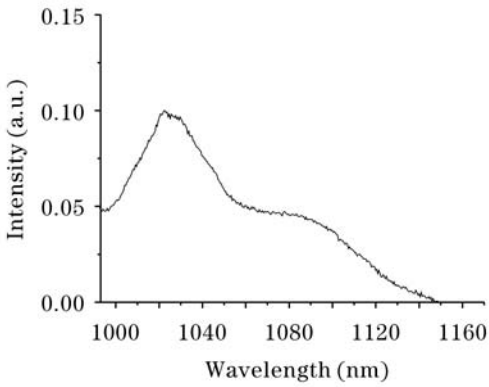

Fig. 1. The fluorescence spectrum of 6-m Yb-doped DCF.

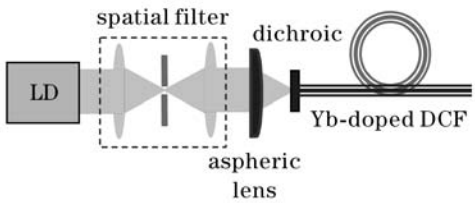

Fig. 2. Experimental setup.

Power amplifier for 1064 nm using Yb^{3+}-doped double-clad fiber

Lingfeng Kong (孔令峰), Qihong Lou (楼祺洪), Jun Zhou (周 军), Zhonglin Wu (吴中林), Jingxing Dong (董景星), Yunrong Wei (魏运荣), Jianqiang Zhu (朱健强), and Zhijiang Wang (王之江)

Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, Shanghai 201800

Received October 8, 2003

A master-oscillator fiber power amplifier (MOPA) system is presented, which consists of a single mode laser as the master oscillator and an Yb^{3+}-doped large-mode-area double-clad fiber as the power amplifier. The system emits up to 6 W of amplified radiation at a wavelength of 1064 nm. The slope efficiency and extracted pulse energy as a function of pulse repetition rate are analyzed.

OCIS codes: 060.2320, 140.3280.

Laser systems based on double-clad rare-earth doped fibers are an attractive technology for compact and efficient high-energy short pulse generation with excellent beam quality, The main performance advantages relative to conventional solid-state lasers arise from the combination of beam confinement and excellent heat dissipation due to the large surface area-to gain volume ratio of doped fiber. One way to increase the pulse energies in fiber is to increase the mode area, although it cannot be increased indefinitely without comprising the modal quality of the output. In 2000, a Q-switched, 5-W average output power amplifier using Yb^{3+}-doped double-clad fiber was reported[1]. Further, single-frequency master-oscillator fiber power amplifier (MOPA) emits up to 20 W[2], picosecond fiber amplifier is capable of generating 51.2 W[3], nanosecond fiber amplifier can even produce up to 100-W average power at 50-kHz repetition rate, corresponding to pulse energy of 2 mJ[4]. In this paper, a MOPA that could emit up to 6 W using Yb^{3+}-doped double-clad fiber is reported.

The setup of fiber amplifier is shown in Fig. 1. As a seed source a Q-switched single mode laser is applied. The laser delivers average powers up to 1 W between 20 and 100 kHz repetition rate at 1064 nm. A Faraday isolator protects the seed laser from backreflections. The length of double-clad fiber is 25 m that has low numerical aperture (NA) large mode area with a 30-μm diameter, a 0.06-NA step-index Yb^{3+}-doped core, and 400/350-μm D-shaped inner cladding with NA of 0.38. The doping Yb^{3+}-concentration is 500 ppm(mol) Yb_2O_3. The small ratio of the inner cladding area to the active core area of $\sim$ 170 ensures that more than 90% of the launched pump light is absorbed in the fiber, which is coiled by 32-cm diameter cylindrical mandrel in air, without any special cooling device. Polishing both fiber ends at an angle of 5 − 10 degrees suppresses laser operation and seeding of amplified spontaneous emission of the high power fiber amplifier as a result of Fresnel reflections. The fiber amplifier is pumped by a laser diode which is water-cooled and the operating temperature from 18 to 22 °C, central wavelength is about 975 nm. Two lenses, which have short focal length, are used to couple the pump light into the inner cladding with a coupling efficiency of $\sim$ 60%. A high transmission for pump light and high reflection for amplified light dichroic mirror is placed by an angle of 45° to separate the pump and amplified light.Two reflect mirrors are used to shorten the length of the system. An aspheric lens is used to couple the seed light into the active core with high efficiency.

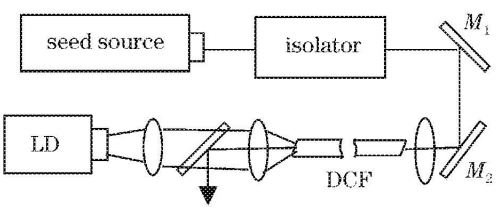

Fig. 1. Experimental setup of MOPA.

Average power up to 6 W of amplified pulses at 18-W launched pump power can be realized when the double-clad fiber is seeded with 0.3 W of power. The incident seed power is 0.5 W, actually the power coupled into the core is only 0.3 W which is measured with the truncation method. The slope efficiency of this Yb^{3+}-doped fiber amplifier yields 46.2% with respect to the launched pump power, as shown in Fig. 2. The launched pump power means the power in the input end of the fiber, which is detected using the truncation method[5]. Seed power of only a few hundred milliwatts is sufficient to saturate this fiber[6], therefore the portion of amplified spontaneous emission in the output is negligible even at low

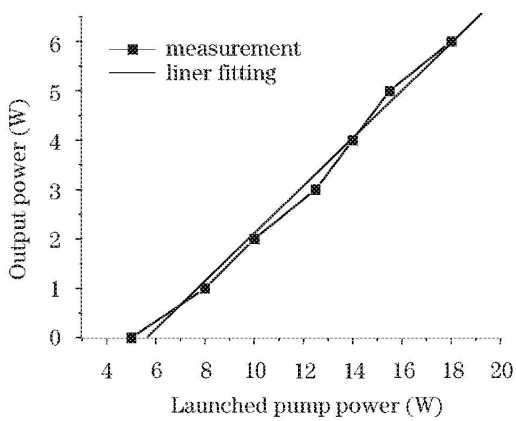

Fig. 2. Output power of amplifier against launched pump power.

FiberHome Technologies

Introduction
Organizational Structure
History Highlight
Human Resources
Quality System
Global Marketing
Sharing Future

FIBERHOME BRINGS YOU TO THE OPTICAL COMMUNICATION WORLD

FiberHome Technologies Group is the most outstanding product and solution provider in China in the field of information and communications. The first optical fiber in China was pulled out in FiberHome Technologies.

Established in 1974, Wuhan Research Institute of Post and Telecommunications (WRI) is the predecessor of FiberHome Technologies Group.

Wuhan Research Institute of Post and Telecommunications (WRI) has been the National Research Center for Fiber-Optic Communication Technology and Engineering, the seminary of China's optical communication and also the only research and industrial entity in China incorporating the research, development and marketing of three strategic technologies in optical communication field: optical communication systems, optical fibers and cables and photoelectronic devices. Approved by the state, it is the National Research Center for Fiber-Optic Communication Technologies and Engineering, the National Research Center for Optoelectronic Technologies (Wuhan Branch) and the National Industrialization Base for High and New Technology R/D Planning Results.

The Group has inherited and carry forward WRI's profound technical background in the field of optical communication and realized growth in great stride in terms of marketing and industrialization capabilities. The market share of its optical transmission systems and optical cable products have been in the front rank of the domestic manufacturers and the occupancies of its optical active and passive devices in the home market have been in the first place.

Through development for nearly 30 years, the Group has evolved a development pattern of three industries: fiber-optic communication, future public network represented by IP and wireless communication. At present, with a total staff of over 4000, it incorporates several subsidiaries of different forms--listed, controlled, fully-owned and joint venture. Its total capital has reached RMB 5.8 billion yuan. It is also a key enterprise in China Optical Valley, Wuhan.

Main Productes
A.Hign-Speed Broadband Optical Transmission Systems
B.Fiber-Optic Broadband Access System
C.IP Network Routing and Switch SystemsIP
D.Wireless Communication and Power Supply
E.Fiber and Cable Products
F.Photoelectronic Devices

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FiberHome Technologies

Introduction
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Globe Marketing

MARKETING IN CHINA

In Optical Transmission Equipment, Optical Fibers/Cables and Optical Devices, FiberHome Technologies leads the Top 10 China's Most Competitive Enterprises during 2007-2008. It is also one of the Annual Top 10 Enterprises owning the Most Competitive Brands in China's Optical Fiber Communication Market.

In Optoelectronic devices, FiberHome Technologies continues to hold No.1 position in China.

In Telecom Backbone market, it ranks No.2 in China and dominates 25% of the market share by June 2008. It also holds more than 25% share of the private Backbone Network.

Cumulatively, it has supplied over 50 million km of fiber cables, ranking No.2 in China optical fiber and cable products market.

It is an active initiator and promoter of the FTTH industry and a main contributor of the relevant standards. It has put into operation the first commercial FTTH project in China, won the title of "Chinese Annual Successful FTTH Brand" and has received domestic orders of 1 million lines for first half of 2008.

As a principal domestic data networking product provider, its competitive superiorities in IP and broadband access products have taken shape in China. Its Ethernet switch series won the title of "Chinese Famous Brand in 2007".

FiberHome Technologies has developed a full series of softswitch solutions from the core of switching layer to access layer and terminals. In the year 2006, it has won the title of "Annual Successful Soft Switch Brand" in China.

In the field of wireless communications, Network Optimizing product series of FiberHome Technologies has become one of the leading brands in China. It has achieved more than 16% of the domestic repeater market.

FiberHome Technologies has installed and commissioned a domestic TD-SCDMA pilot network. It has also realized commercial scale application of WIMAX in the regional markets of China Mobile and China Netcom.

MARKETING AROUND THE WORLD

With the set-up of its global marketing network, products of FiberHome Technologies have been exported to 65 countries in Asia, Europe, Africa, America and Oceania, covering five major continents.

In respect of optoelectronic devices, principal customers of FiberHome Technologies are spread over United States of America, Japan and European Union. It is fast becoming one of the top 5 major optoelectronic device suppliers in the world. In terms of equipment and systems, its main customer groups are in Asia, Africa and Latin America. Its optical cable products have been deployed in backbone projects in Southeast Asia, Middle East, South Asia, CIS and Africa.

FiberHome has constructed backbone, trunk lines and access networks for major telecom service providers in Southeast Asia, Middle East, South Asia, Latin America, CIS and Africa. FiberHome also provided total solutions for private communication network owners like power, gas, railway, highway and education organizations. The customers benefit from the sharing of technology development, transfer of know how as well as the expertise and devotion of FiberHome in building up the best communication networks for its partners.

FiberHome Technologies

Products & Solutions

Products
- Optical Network Products
- Access Series
- Data Series
- Fiber & Cable
- SoftSwitch
- Wireless Communication
- Other Products

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All Solution

Application Cases
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Special Fiber

Result 19 items found. Display page 2 of 2

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- FiberHome®1480nm Specialty Cut-off Single Mode Fiber
- FiberHome®1060nm Specialty Cut-off Single Mode Fiber
- FiberHome®980nm Specialty Cut-off Single Mode Fiber
- FiberHome®800nm Specialty Cut-off Single Mode Fiber
- FiberHome® Double Cladding Fiber, DCF
- FiberHome® Er-Yb Co-doped Fiber, EYDF
- FiberHome®Ytterbium-doped fiber, YDF-C
- FiberHome® Erbium-doped fiber(EDF)

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FiberHome® Double Cladding Fiber, DCF

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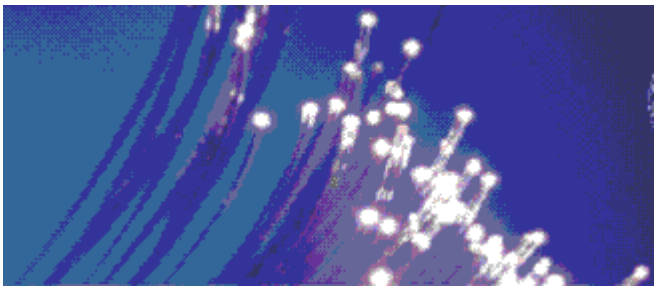

Document index No: SPECIALTY FIBER001-D

Issue: 2004.08

Certificated by ISO 9001

Stock trading code of shanghai stock exchange: 600498

Application

- High outpower fiber lasers
- Amplifiers

Features

- Patented process provides outstanding consistency and uniformity
- Excellent geometry control
- High doping concentration reduces non-linearities and fiber length
- Co-doping technology provides high efficient energy transfer
- High slope efficiency
- High numerical aperture
- High reliability
- Low background loss

Key Specifications

Properties	Value
Dopants	Er, Yb, Tm, Nd, Er/Yb
Doped concentration	2000~8000PPM
Core diameter, μm	5~50
Core numerical aperture (NA)	0.06~0.25
Inner cladding geometry	D, rectangle
Inner cladding diameter, μm	80,125,250,400,500,600,650
Outer cladding thickness, μm	≤150
Inner cladding numerical aperture (NA)	0.20~0.60

Picked comments

FiberHome® Er-Yb Co-doped Fiber, EYDF

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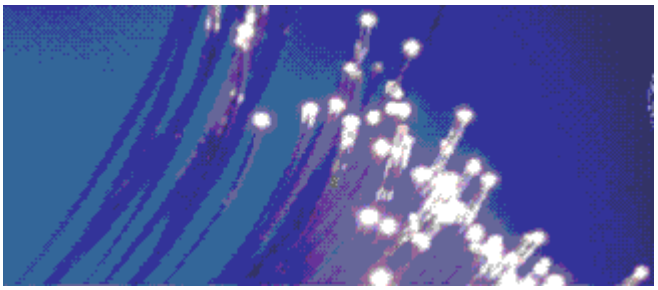

Document index No: SPECIALTY FIBER001-C

Issue: 2004.08

Certificated by ISO 9001

Stock trading code of shanghai stock exchange: 600498

Application

- High saturated output power amplifier

Features

- Patented process provides outstanding consistency and uniformity
- Excellent geometry control
- Excellent mode-field diameter designed, low splice loss
- Excellent environmental stability

Key Specification

Cutoff wavelength, nm	850~1100
Numerical aperture	0.20~0.24
Mode-field diameter@980nm, µm	6.1~6.5
Mode-field diameter@1550nm, µm	7.4~7.8
absorption@1532nm, dB/m	20 (nominal)
Background absorption@1200nm, dB/km	< 20
Proof test	1% (100 kpsi)
Cladding diameter, µm	125 ±1

Picked comments

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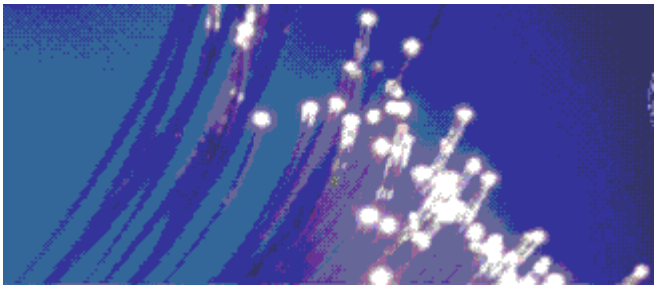
FiberHome®Ytterbium-doped fiber, YDF-C

Order Form

Product Information



Document index No: SPECIALTY FIBER001-B

Issue: 2003.12

Substitute: 2001.5

Certificated by ISO 9001

Stock trading code of shanghai stock exchange: 600498

Application

- Tunable fiber lasers and amplifiers at 970~1160nm
- Pump lasers of Raman amplifiers

Features

- Patented process provides outstanding consistency and uniformity
- Excellent geometry control
- Excellent mode-field diameter designed, low splice loss
- Excellent environmental stability

Key Specifications

Fiber number	YDF-C
Yb concentration	1000~10000PPM
Core diameter, μm	4.0~7.0
Numerical aperture	0.17±0.02
Cutoff wavelength, nm	900±50
absorption@915nm, dB/m	5~50
Background absorption, dB/km	< 15
Proof test	1% or 2% (100 kpsi or 200 kpsi)
Cladding diameter, μm	125±1
Core-to cladding offset, μm	< 0.8
Coating diameter, μm	245±10

About us

Raycus Fiber Laser Technologies Co. Ltd. founded in 2007, is the leading high power fiber laser manufacturer in China. With deep understanding of laser technologies and specialty fibers, Raycus Fiber laser is the first in China to successfully produce and industrialize the high power fiber laser.

So far, the company has supplied to the market the following high power fiber laser products including 10W to 50W pulsed fiber lasers and 10W to 100W continuous wave fiber lasers. Higher powered fiber laser products greater than 100W and 1000W will be introduced to the market soon. Other high power products based on customer specification is also available.

"High quality, excellent service, low operating costs and customer priority" Our mission is to serve the laser products industry with advanced high power fiber laser products and viable solution to enhance the quality and efficiency of industrial production by laser technologies.

Raycus----the experts in fiber lasers technologies.

Raycus Fiber Laser Technologies Co. Ltd. P.C.：430223 Tel：86-27-87180383 Fax：86-27-87180387
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Website：http://www.raycuslaser.com Email: sales@raycuslaser.com

Technical Support：jinglun tech

Raycus attended the Munich Laser Photonic show in Shanghai

Time：2009-04-02 readcount：16Times

The LASER World of PHOTONICS China was held in Shanghai from March 17th to 19th 2009. Raycus fiber laser, as the only localized high power fiber laser makers, attended this biggest event. More than 300 world well-known laser manufacturer from both domestic and overseas gathered in the show.

Raycus brought 10W, 20W Pulsed and 200W Continous Wave fiber lasers to the show.

Speaking about the company target of 2009, Dr Yan said that 2009 will be a very important year for Raycus. Raycus will on one hand commercialized the matured products to increase the sales revenues, and on the other hand develop more competitive products including 1000W and greater than 1000W high power product.

Raycus attracted great attention of media and laser industries at the exhibition. Many customers showed their great willingness to cooperate with Raycus.

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Website：http://www.raycuslaser.com Email: sales@raycuslaser.com

Technical Support：jinglun tech

Raycus attended the Laser Exposition 2008 in Nanjing

Time：2008-11-10 readcount：54Times

Raycus actively attend the Laser Exposition which was held in Nanjing from 10th to 11th November 2008 inclusive. Dr Yan give a presentation focus on industrialing of China's fiber laser and the importance to breakthrough the overseas monopoly.It is highly recognized and appraised by the experts and relate corporations absent.After the meeting, we had deeply communication with them and they show great interests in our products .

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Technical Support：jinglun tech

Wuhan city vice mayor Shanla Yuan visited Raycus

Time：2008-10-29 readcount：29Times

Wuhan city vice mayor Shanla Yuan visited Raycus on 29th,Octorber 2008. He was highly appraised our contribution to Chinese traditional laser industry. Meanwhile,he hope us improve the products quality promptly and make them surpass advanced world levels . “To be the national fiber laser leader”. Finally, he expressed.

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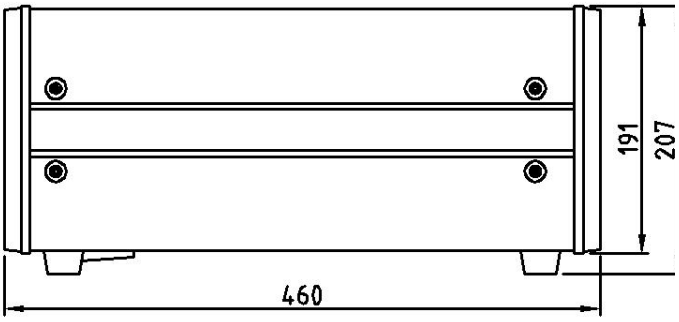
100W Continous Wave Fiber Laser

➢ Applications

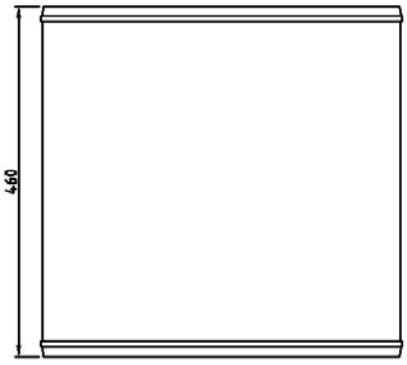
* Micromachining
* cutting
* drilling
* thermal printing
* 3-D deformation

➢ Dimensions

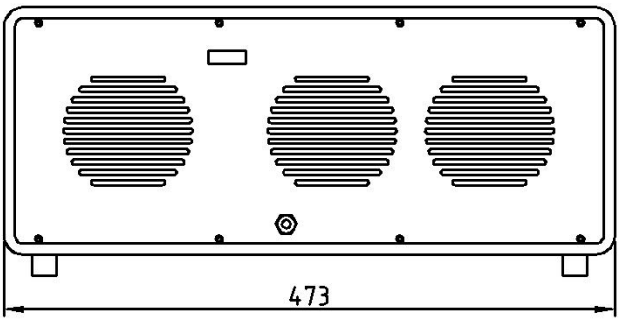
Side view



Top view



Front view



➢ Specifications

Operating mode	100W CW
Central emission wavelength（nm）	1064±1
Polarization	random
Nominal average output power（W）	100
Output power adjustment range（%）	5-100
Output power instability (%)	<3
Beam quality（M^2）	<1.2
Output fiber cable length（m）	3
Working voltage（AC）	220/110
Power consumption（20℃）（W）	440
Cooled	wind
Dimension W×D×H（mm）	482×435×175
Working temperature range（℃）	0-45
Working humidity range（%）	10-95

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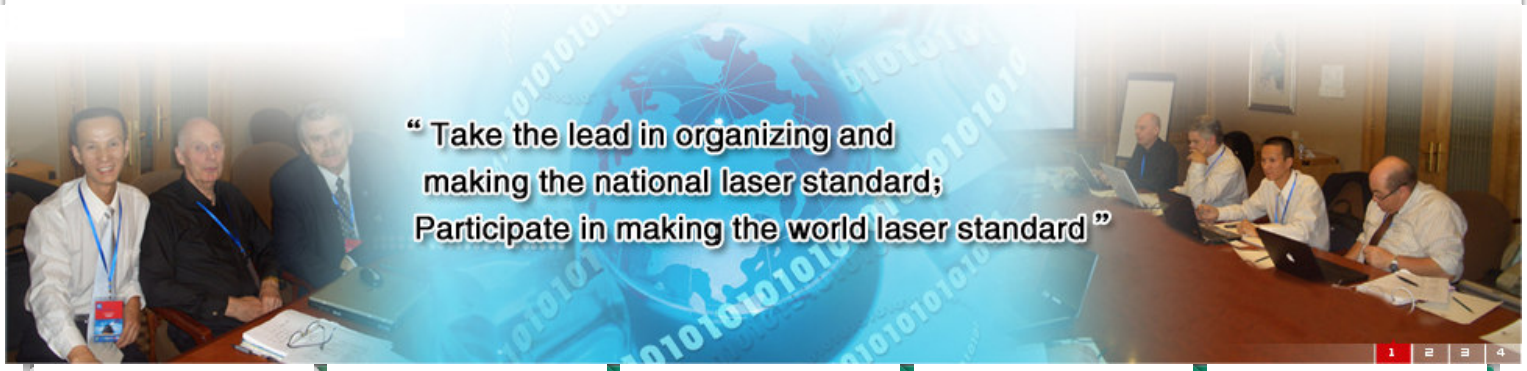

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- Silicon laser scribing machine
- ITO film laser scribing machine
- Double-reel Laser Perforating System for Tipping Paper
- Laser trimming machine

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- CNC laser welding system
- Laser texturing system
- Laser heat treatment system
- Laser Tailored Bland Laser Welding system

Plasma cutting system

- Plasma cutting system

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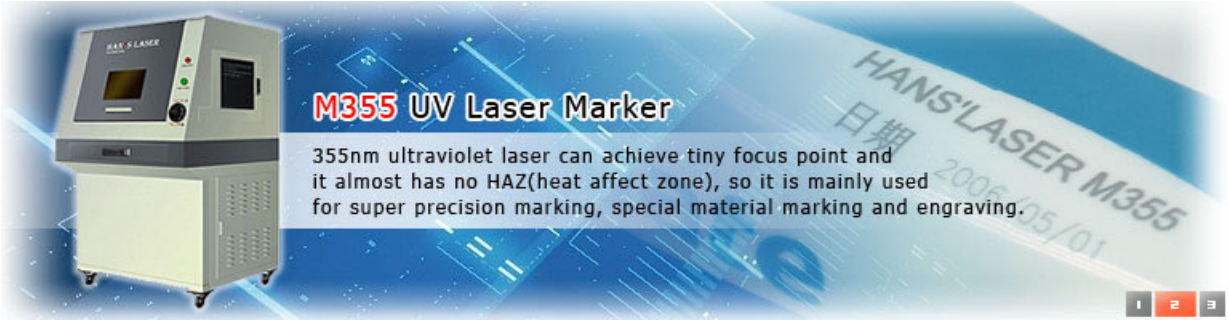

About Han's Laser

Established in 1996, Han's Laser Technology Co. Ltd became one of the largest laser machine manufacturing companies in the world with record growth and sales of industrial laser machines. Year-over-year sales doubled to exceed over 4000 systems sold in the prior year with great success in the sale of laser cutting equipment.

The company's success has come from the development of many advanced technologies including 4 self-developed and U.S. registered patents, 73 practical National Inventor patents, 36 software copyrights and 8 exclusive technologies. These key laser technologies and innovations are then integrated with premium components supplied from the United States, the United Kingdom, Germany, Japan and other leading suppliers throughout the world. The machines are then assembled or manufactured in one of several highly efficient state-of-the-art factories. As a result, Han's Laser is able to offer its clients the most advanced laser machines for a wide variety of industrial applications at very affordable prices. For example, Han's offers a 3-in-1 Laser Cutter/Laser Driller/Laser Engraver which will outperform many competitive systems at a fraction of the cost. Quality control engineers then carefully manage production and assembly of each YAG laser marker or laser welder with ISO9001:2000 Management System Standards, as certified in 2001, to insure customer's receive peak performance from the most reliable machines.

Han's customers include world-class electronics companies such as Sony®, Panasonic® and many other top industrial companies throughout Europe, Asia, Australia, North and South America. Business supply partners include Northrop Grummon's (CEO) Cutting Edge Optronics, GSI Lumonics, Coherent Lasers, SMC, THK, FAGOR and internationally recognized technology companies. The Han's Laser staff now includes over 2,000 passionate employees with six academic experts and over 60 engineers holding Master's degrees and/or PhDs.

Han's Laser Technology Corp, establised in the United States

more

Click here for complimentary admission

Visit Han's Laser Technology Co. in **Booth 963**
February 10-12, 2009

News

- Han's Laser Launches OEM Sales & Unveils New Lasers at IMTS
- Google Finance - Han's Laser Current Stock Price
- BusinessWeek - Han's Laser
- Forbes - Han's Laser Opens New U.S. Services & Manufacturing Center
- Han's Laser Opens U.S. Branch
- Han's Laser Achieves ISO9001:2000 Certification
- INFOWORLD - Han's Laser

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Product Quote

Technical Support

Industry Partners

Coherent

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System Special

HAN'S YAG-M50 Laser Marker

General purpose model, Laser output power 50W, High performance and speed.

Han's 50Watt Diode Pumped YAG Laser Marker

All-purpose Diode Pumped Solid State YAG Laser Engraver. Detached, straight cavity configuration.

3-in-1 Laser Cutter - Engraver - Driller

Large 36" x 24" vector cutting table with Industrial grade high duty cycle Coherent^{tm} laser core.

Han's W60 High Precision Laser Welder

In general, this laser welder can repair breaks, fuse two pieces together, fill air bubbles and mend cracks.

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YLP-10

Photo

Product features

The YLP-10 is a new generation marking system developed by our company using the most advanced technology currently available. The laser is produced utilizing a fiber laser source.
The fiber laser marker has high electro-optic conversion efficiency. Air cooling, compact design, excellent beam quality, and high reliability make this a very attractive product.

Applications & materials

The laser marker can mark on most of metals and some non-metals and is mainly used on clocks and molding, which require exquisite detail.

Technical data

Max. laser average power: 10W

Wavelength: 1060nm

Beam quality M^2 <2

Repeat frequency: 20KHz ---100KHz

Marking scope: 100mm×100mm / 150mm×150mm

Linear speed: ≤7000mm/s

Marking depth: ≤0.4mm

Min. line width: 0.012mm

Min. character size: 0.15mm

Repeat accuracy: ±0.003mm

Electrical source: 220V / 50Hz / 4A

Power consumed: 500W

Dimensions: 500mm×500mm×300mm

Cooling system: 300mm×250mm×500mm

Sample

E-CWS-20A

Photo

Product features

Fiber optic ceramic laser slicer is a laser cutting device for processing of electronic industry, mainly used for cutting ceramic base plates of 0201 and 0510. The slicer adopts imported IPG20W fiber optic laser unit with feathers of high beam quality, fine mode, small focusing facula, 25μm-30μm seam width, stable performance, maintenance-free, and non-contact cutting. High-precision 2D shifting platform, micro-inertia servo motor, precision ball bearing linear guide rail, ±10μm positioning precision, 220mm×150mm scope. The worktable adopts 5-point positioning method, pneumatic clamping positioning, and vacuum absorption. High movement precision, slicing (cutting) speed and cutting quality, stead performance, low power consumption. It is the combination of laser technology, precision machinery, electronic technology, computer and other advanced technologies. The whole set of system is controlled by computer of which OS is Windows, operating interface is whole Chinese interface. Self-developed software makes the operation simple. Compact structure and high automation, automatic error alarm.

E-CWS-20A

Manual focusing, loading and unloading.

High-precision manual rotary worktable, the minimum scale is: 0.03mm.

Applications & materials

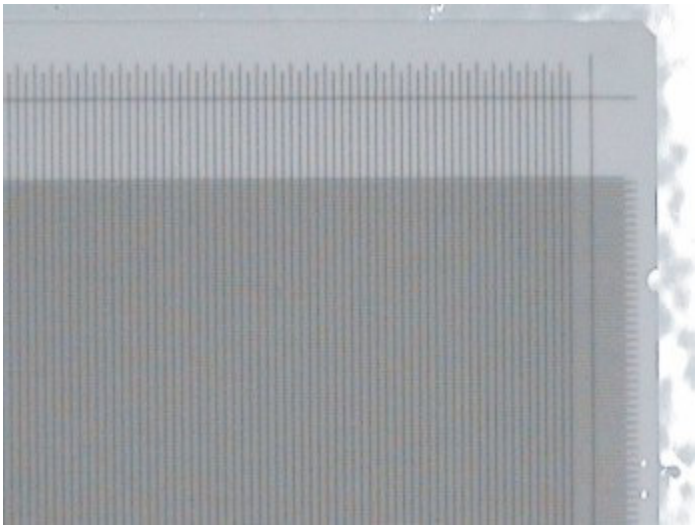
for processing of electronic industry, mainly used for cutting ceramic base plates of 0201 and 0510.

Technical data

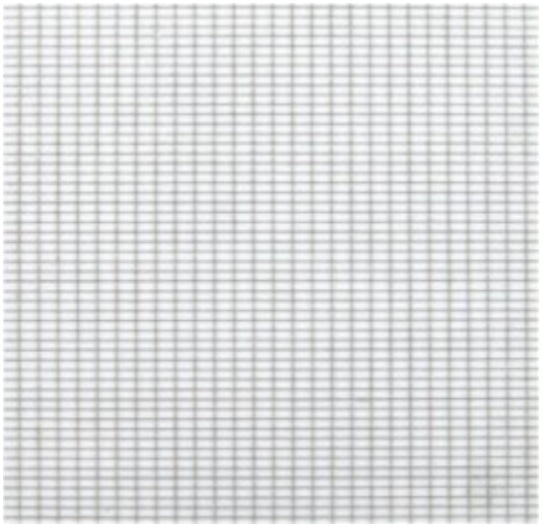
Laser unit	Fiber optic laser unit
Standard average output power	20W
Power adjusting range	10-100%
Long-term power stability	< 5%
Typical beam quality (M^2)	1.4
Single pulse energy (MJ)	1
Central wavelength	1060-1070nm
Pulse width	100ns
Pulse repetition rate	10-100KHz
Operating voltage	24V DC
Typical power consumption	180W
Worktable	
Slicing speed	250mm/s
Min. slicing line width	20μm
Max. slicing depth	200μm
Positioning accuracy	±10μm
Interval (PITCH)	±10μm
Coincidency	±10μm
Whole machine	

Total power	4KW
Electrical source	220V / 50Hz / 20A
Total weight	800kg
Whole dimensions (W×L×H)	900mm×1874mm×1580mm

Sample



Ceramic base plate cutting



Ceramic base plate cutting

nLIGHT

HIGH-POWER SEMICONDUCTOR LASERS AND FIBERS

nLIGHT offers global support through state-of-the-art manufacturing and application centers in North America, Europe and China.

VANCOUVER, WA

nLIGHT's manufacturing facility in Vancouver, WA is approximately 65,000 sq. ft. (6.000 m²) with more than 24,000 sq. ft. (2.200 m²) clean room environment, ranging from class 100 to class 10,000 clean rooms. The facility also includes our research and development center.

HILLSBORO, OR

nLIGHT's manufacturing facility in Hillsboro, OR is approximately 32,000 sq. ft. (3.000 m²) with more than 13,000 sq. ft. (1.200 m²) clean room environment. The facility is well equipped with a wide variety of optical, fiber and hybrid packaging equipment.

HEILBRONN, GERMANY

nLIGHT's manufacturing facility in Heilbronn, Germany is approximately 3,230 sq.ft. (300 m²) and covers the assembly of industrial direct diode laser systems and OEM modules.

SHANGHAI, CHINA

PRESS RELEASES

nLIGHT Ships Industry Leading Brightness from Pearl™ Diode Modules for Next Generation Fiber Laser Pumps

nLIGHT Introduces New Line of Photodarkening Resistant Fibers

NEW PRODUCTS

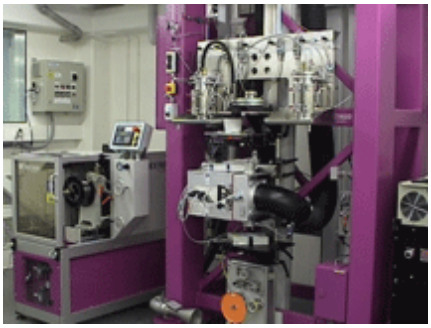
LIEKKI™ Er120-20/125

LIEKKI™ Yb2000-10/125

LIEKKI™ Yb2000-7/125

nLIGHT's manufacturing facility in Shanghai, China is approximately 26,000 sq. ft. (2.400 m²) with more than 10,500 sq. ft. (1000 m²) clean room environment, including areas for preform manufacturing, diode laser testing and engine assembly. Click here to visit our Chinese website

LOHJA, FINLAND



nLIGHT's manufacturing facility in Lohja, Finland is approximately 20,400 sq.ft. (1.900 m²) with a clean room environment, including areas for preform manufacturing, fiber drawing, fiber measurement and testing, and optical engine assembly.

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English

nLIGHT

HIGH-POWER SEMICONDUCTOR LASERS AND FIBERS

LIEKKI™ YTTERBIUM FIBERS

nLIGHT's ytterbium fiber product series offers moderate to extremely high dopant concentrations resulting in application lengths suitable for multiple applications. Our direct nanoparticle deposition (DND) fiber production technology allows creating fibers with very high homogeneity minimizing clustering and photodarkening.

LIEKKI™ ytterbium fibers are available in the following fiber types

- Single mode and large mode area (LMA)
- Single, double and triple cladding
- Polarization maintaining (PM) and non-PM

Our LIEKKI™ Yb600, Yb700, Yb1200 and Yb2000 product series covers the broad application field of ytterbium fibers ranging from low-power preamplifiers to high-average-power pulsed amplifiers and high-continuous wave (CW) power fiber lasers.

Explanation for LIEKKI™ fiber product codes

AABBBB-CC/DDOpt 1 – Opt 2 – Opt 3

AA =	Fiber dopant
BBBB =	Peak core absorption at 976nm for ytterbium Peak core absorption at 1530nm for erbium
CC =	Core diameter
DD =	Cladding diameter
Opt 1 =	Double clad/DC
Opt 2 =	Polarization maintaining/PM
Opt 3 =	High cutoff/HC

For academic users we offer a special product package. Please contact us for more information.

LIEKKI™ Yb600-20/125
LIEKKI™ Yb600-20/125 fibers are amplifier fibers for low to medium output powers. The fibers have high photodarkening resistivity and a short application length.

LIEKKI™ Yb700-25/250
LIEKKI™ Yb700-25/250 fibers are amplifier fibers for medium to high output powers. The fibers have high photodarkening resistivity and a short application length.

LIEKKI™ Yb700-30/250
LIEKKI™ Yb700-30/250 fibers are amplifier fibers for medium to high output powers. The fibers have high photodarkening resistivity and a short application length.

LIEKKI™ Yb1200-4/125
LIEKKI™ Yb1200-4/125 fibers are highly doped single mode ytterbium fibers for low-noise, low-nonlinearity preamplifiers and lasers.

EASY SPLICE SOFTWARE

LIEKKI™ EasySplice is complimentary software that provides you with optimal splicing parameters for all LIEKKI™ fibers.

Please click here to read more

ALL PRODUCTS

Pearl™ High-Power Fiber-Coupled Modules

Single Emitter Diode Laser Devices

Optotools™ Industrial Diode Laser Modules

Conduction Cooled (CS) Diode Laser Bars

Cascades™ Actively Cooled Diode Laser Bars

Summit™ QCW Diode Laser Products

LIEKKI™ High-Power Fibers

LIEKKI™ Components

LIEKKI™ Optical Engines

LIEKKI™ Application Designer

NEW PRODUCTS

LIEKKI™ Er120-20/125

LIEKKI™ Yb2000-10/125

LIEKKI™ Yb2000-7/125

LIEKKI™ Yb1200-6/125
LIEKKI™ Yb1200-6/125 fibers are highly doped single mode ytterbium fibers for medium-power fiber laser and amplifier applications.

LIEKKI™ Yb1200-10/125
LIEKKI™ Yb1200-10/125 fibers are highly doped large mode area ytterbium fibers for medium-power fiber laser and amplifier applications.

LIEKKI™ Yb1200-12/125
LIEKKI™ Yb1200-12/125 fibers are highly doped ytterbium fibers for medium-power fiber laser and amplifier applications.

LIEKKI™ Yb1200-20/125
LIEKKI™ Yb1200-20/125 fibers are highly doped ytterbium fibers ideally suited for compact high-average-power pulsed amplifier applications where large mode area and short fiber length are critical for suppression of nonlinear effects.

LIEKKI™ Yb1200-20/400
LIEKKI™ Yb1200-20/400 fibers are highly doped ytterbium fibers for medium-power fiber lasers and amplifiers.

LIEKKI™ Yb1200-25/250
LIEKKI™ Yb1200-25/250 fibers are highly doped ytterbium fibers which feature very high cladding absorption, high efficiency per application length and excellent beam quality.

LIEKKI™ Yb1200-30/250
LIEKKI™ Yb1200-30/250 fibers are highly doped ytterbium fibers which feature very high cladding absorption, high efficiency per application length and excellent beam quality.

LIEKKI™ Yb2000-7/125
LIEKKI™ Yb2000-7/125 fibers are highly doped, have very high photodarkening resistivity and are suitable for low-power amplifier or laser applications.

LIEKKI™ Yb2000-10/125
LIEKKI™ Yb2000-10/125 fibers are highly doped, have very high photodarkening resistivity and are suitable for low-power amplifier or laser applications.

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English

CorActive Specialty Optical Fiber Manufacturer

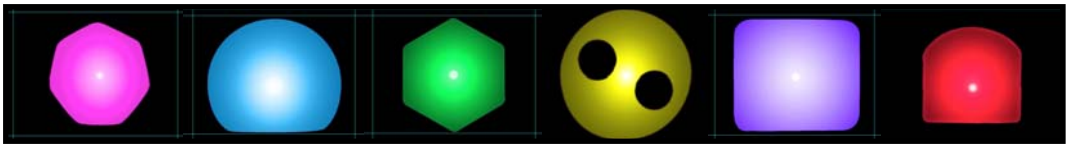
PM and non PM
Yb Double Clad Optical Fiber

CorActive's Ytterbium Doped **Double Clad Optical Fiber (DCOF)** capabilities have been specifically developed to match the requirements of Industrial LASERs and IR sources. CorActive's DCOF offer a higher doping concentration and among the highest QCE values in the industry. Combining these critical elements in CorActive's Yb DCOF ensures minimum fiber length, minimum pump power and reduced non-linearities. This translates directly into substantial savings when building a high power source or LASER.

CorActive Yb DCOF Product Features and Benefits

Yb DCOF Product Features	Customer Benefits
High Yb Doping Concentration	Reduces non-linearities with minimum fiber length optimizing LASER designs
Unrivaled Power Conversion Efficiency	High fiber PCE enables lower pump power which results in pump cost savings
Unique Pump Guide Shape	Reduces helical mode propagation and increase absorption efficiency
Consistent Reproducibility	Reduces manufacturing costs and increases production yield
Lower Absorption Variability	Consistent high quality fiber ensures lower production costs
Industry Leading Fiber Geometry	Increases signal transfer with precision core alignment

EXAMPLE CLADDING SHAPES:



CorActive's Unique Advantages

Appropriately scaled production facilities and an excellent financial position ensure that CorActive's Specialty Optical Fiber products are among the most cost effective available.

Focused on specialty optical fiber design and manufacture to ensure high quality products.

Full line specialty optical fiber supplier – EDF, UV Sensitive, Attenuating, IR and Double Clad optical fibers available.

Custom specialty optical fiber designs available upon request.

Strategic supplier relationship – CorActive does not compete with its customers.

Yb Doped Double Clad Optical Fiber

Optical Fiber Specifications

CorActive standard products. Custom fiber products available.

Single Mode Yb Doped DCOF

Optical Properties	LAS-Yb-06-01	LAS-Yb-10-02	LAS-Yb-10-03	LAS-Yb-10-PM-01
Core Diameter (µm)	6.5 ± 1.0	10 ± 1	10 ± 1	10 ± 1
Core N.A. (nominal)	0.12 ± 0.02	0.08 ± 0.01	0.08 ± 0.01	0.08 ± 0.01
Clad Absorption @ 915nm (dB/m)	0.65 ± 0.15	2.0 ± 0.2	1.0 ± 0.1	> 1
Clad Absorption @975nm (dB/m)	2.5 (typ.)	6.0 (typ.)	3.3 (typ.)	> 3.3 (typ.)
Beat length				< 4mm @ 633nm
Physical & Geometric Properties				
Cladding Shape	Hexagonal	Octagonal	Hexagonal	Octagonal
Cladding Diameter (µm)	125 ± 1.5	126.5 ± 1.5	200 ± 20	126.5 ± 6
Matching Fibers				
Matched Undoped DCOF	REL-MC-06	REL-Un-10	REL-Un-10-02	
Matched Undoped SCOF	Si-12-06	Si-08-10	Si-08-10-01	

Large Mode Area Yb Doped DCOF

Optical Properties	HPA-Yb-20-02	HPA-Yb-20-01	HPA-Yb-28-01	HPA-Yb-44-01
Core Diameter (µm)	20 ± 1	20 ± 2	28 ± 2.5	43.5 ± 1.5
Core N.A. (nominal)	0.06 ± 0.01	0.06 ± 0.01	0.06 ± 0.01	0.06 ± 0.01
Clad Absorption @ 915nm (dB/m)	> 4	1.1 ± 0.1	2.0 ± 0.3	2.0 ± 0.3
Clad Absorption @975nm (dB/m)			> 2.5	> 6
Physical & Geometric Properties				
Cladding Shape	Octagonal	Hexagonal	Hexagonal	“D” Shape
Cladding Diameter (µm)	128 ± 2	400 ± 10	400 ± 40	400 ± 40
Matching Fibers				
Matched Undoped DCOF	REL-Un-20-01	REL-Un-20-02	REL-Un-28-01	
Matched Undoped SCOF	Si-06-20		Si-06-28	

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Tel.: 1-866-845-2466 or (418) 845-2466 • www.coractive.com • sales@coractive.com

Yb Doped Double Clad Optical Fiber

Optical Fiber Specifications

Multi Mode Yb Doped DCOF

Optical Properties	HPA-Yb-13-01	HPA-Yb-25-01	HPA-Yb-37-01	HAP-Yb-34-01	HPA-Yb-140-02
Core Diameter (µm)	13 ± 1	25 ± 2	37 ± 2	33.5 ± 2.5	140 ± 10
Core N.A. (nominal)	0.12 ± 0.01	0.10 ± 0.02	0.14 ± 0.01	0.14 ± 0.01	0.07 ± 0.01
Clad Absorption @ 915nm (dB/m)			8.0 ± 2	2.0 ± 0.3	6.5 ± 1.0
Clad Absorption @ 975nm (dB/m)	10.5 ± 0.5	> 11			
Physical & Geometric Properties					
Cladding Shape	Rectangular	Rectangular	Hexagonal	“D” Shape	“D” Shape
Cladding Diameter (µm)	130 x 150 ± 5	130 x 150 ± 5	125 ± 5	400 ± 40	400 ± 40

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