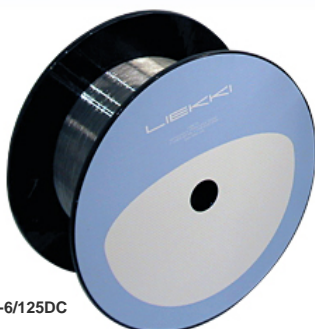


## P-20/390DC - June 28, 2017

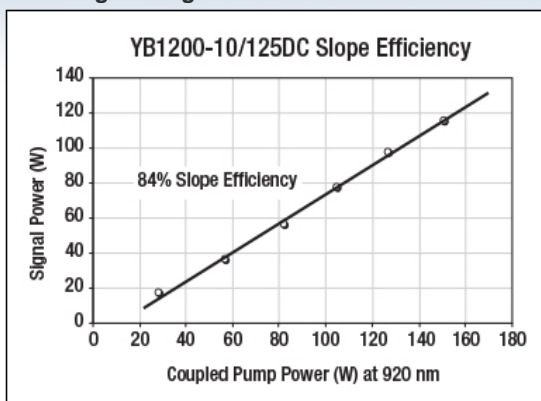
Item # P-20/390DC was discontinued on June 28, 2017. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

### YTTERBIUM-DOPED OPTICAL FIBER

- ▶ Ytterbium-Doped Fiber for Fiber Lasers and Amplifiers
- ▶ 920 nm Absorption and 1000 - 1100 nm Emission Wavelength Range
- ▶ Core- and Cladding-Pumped Versions Available
- ▶ Single Mode or Large-Mode-Area Fibers



YB1200-6/125DC



#### OVERVIEW

- Ytterbium-Doped Silica Fiber for ~1000 - 1100 nm Fiber Lasers and Amplifiers
- Single Mode and Large-Mode-Area Fibers Available
- Core- and Cladding-Pumped Designs for 1 mW to >100 W Output Power
- Matched LMA Passive Fibers Also Sold Below
- Industry-Standard Active Fiber Geometries with Ø125, Ø250, or Ø400 µm Cladding

Item #	Type	Absorption @ 920 nm	Pump Type	Core Diameter	Cladding Diameter
YB1200-4/125	SM <sup>a</sup>	280 ± 50 dB/m	Core	4.4 ± 0.8 µm MFD	125 ± 2 µm
YB1200-6/125DC	SM <sup>a</sup>	0.6 ± 0.2 dB/m	Cladding	6.0 ± 0.8 µm MFD	125 ± 2 µm
YB1200-10/125DC	LMA <sup>b</sup>	1.8 ± 0.4 dB/m		10 ± 1 µm	125 ± 2 µm
YB1200-20/400DC	LMA <sup>b</sup>	0.7 ± 0.2 dB/m		20 ± 2 µm	400 ± 15 µm
YB1200-25/250DC	LMA <sup>b</sup>	2.3 ± 0.3 dB/m		25 ± 2.5 µm	250 ± 10 µm
YB2000-10/125DC	LMA <sup>b</sup>	2.0 ± 0.4 dB/m		10 ± 1.0 µm	125 ± 2 µm

Thorlabs offers state-of-the-art ytterbium-doped optical fibers for optical amplifiers, ASE light sources, and high-power pulsed and CW fiber laser

applications operating with powers in the milliwatt to 100 W range and emitting in the 1000 - 1100 nm wavelength region. These fibers, manufactured by Liekki Ltd. in Finland, are fabricated using the latest doped fiber production technology: Liekki Direct Nanoparticle Deposition (DND). Liekki DND technology was designed to fulfill the requirements of advanced fiber applications, including short fiber lengths, flat refractive index profiles without core burnout, and large core-to-cladding ratio (large-mode-area double-clad fibers).

- Single Mode
- Large Mode Area

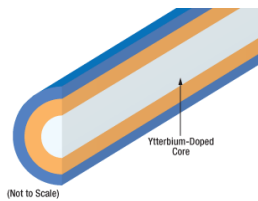


Yb-doped fibers are available with either a core-pumped or cladding-pumped (double clad) design. Core-pumped fibers are excellent for lower-power applications and provide a short active fiber length, telecom-like geometry for easy splicing and handling, and compatibility with low-cost pump diodes and standard passive single mode (SM) fibers.

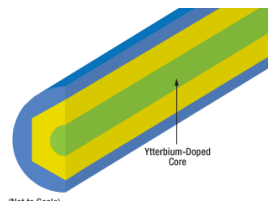


Cladding-pumped, double-clad fibers allow for higher efficiencies and higher output powers compared to their core-pumped active fiber counterparts. Cladding-pumped fibers are double clad, meaning that the fiber's coating acts as a second cladding, allowing the first cladding to function as a waveguide. Double-clad fibers typically have a low-NA single mode or large-mode-area (LMA) core for the emitted light and a high-NA, multimode first cladding for the pump light.

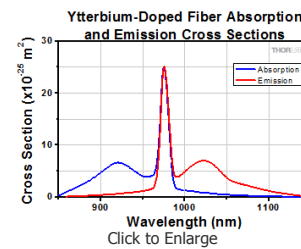
We also offer Polarization-Maintaining Yb-Doped Fibers.



Click for Details  
Core-Pumped Fiber Cross Section



Click for Details  
Cladding-Pumped Fiber Cross Section



Active Fibers Selection Guide					
Ytterbium-Doped SM and LMA	Ytterbium-Doped PM	Erbium-Doped SM and LMA	Thulium-Doped SM and LMA	Thulium-Doped PM	Doped Fluoride Fibers for MIR

S P E C S

Core-Pumped Single Mode Fiber

Item #	YB1200-4/125
MFD	4.4 ± 0.8 μm
Peak Core Absorption @ 976 nm (Nominal)	1200 dB/m
Core Absorption @ 920 nm	280 dB/m
Core Numerical Aperture (NA) (Nominal)	0.2
Cladding NA	>0.46
Cut-Off Wavelength	1010 ± 70 nm
Cladding Diameter	125 ± 2 μm
Cladding Geometry	Round
Coating Diameter	245 ± 15 μm
Coating Material	High Index Acrylate
Core Concentricity Error	<0.7 μm
Proof Test	>100 kpsi
Core Index	Proprietary <sup>a</sup>
Cladding Index	Proprietary <sup>a</sup>

- We regret that we cannot provide this proprietary information.

Cladding-Pumped, Double-Clad SM and LMA Fibers

Item #	YB1200-6/125DC	YB1200-10/125DC	YB1200-20/400DC	YB1200-25/250DC	YB2000-10/125DC
MFD	6.0 ± 0.8 μm	-	-	-	-
Peak Cladding Absorption @ 976 nm (Nominal)	2.6 dB/m	7.7 dB/m	3.0 dB/m	9.9 dB/m	-
Cladding Absorption @ 920 nm	0.6 ± 0.2 dB/m	1.8 ± 0.4 dB/m	0.7 ± 0.2 dB/m	2.3 ± 0.3 dB/m	2.0 ± 0.4 dB/m
Core Numerical Aperture (NA)	0.15 ± 0.01	0.08 ± 0.005	0.07 ± 0.005	0.070 ± 0.005	0.12 ± 0.02
Cladding NA	≥0.48	≥0.48	>0.46	≥0.48	>0.46
Core Diameter	-	10 ± 1 μm	20 ± 2 μm	25.0 ± 1.5 μm	10 ± 1.0 μm
Cladding Diameter <sup>a</sup>	125 ± 2 μm	125 ± 2 μm	400 ± 15 μm	250 ± 10 μm	125 ± 2 μm
Cladding Geometry	Octagonal	Octagonal	Octagonal	Octagonal	Octagonal
Coating (Second Cladding) Diameter	245 ± 15 μm	245 ± 15 μm	520 ± 15 μm	350 ± 15 μm	245 ± 15 μm
Coating Material	Low Index Acrylate	Low Index Acrylate	Low Index Acrylate	Low Index Acrylate	Low Index Acrylate
Core Concentricity Error	<1.0 μm	<1.5 μm	<1.5 μm	<1.5 μm	<1.5 μm
Proof Test	≥100 kpsi	≥100 kpsi	>50 kpsi	>100 kpsi	>100 kpsi
Core Index	Proprietary <sup>b</sup>				
Cladding Index	Proprietary <sup>b</sup>				

- Octagonal cladding measured flat to flat.
- We regret that we cannot provide this proprietary information.

Matched Passive LMA Fibers

Item #	P-10/125DC	P-20/390DC
Matching Active Fiber	YB1200-10/125DC	YB1200-20/400DC
Core Numerical Aperture (NA)	0.08 ± 0.005	0.07 ± 0.01
Cladding NA	≥0.48	>0.46
Core Diameter	10 ± 1.0 μm	20 ± 2 μm
Cladding Diameter	125 ± 2 μm	400 ± 8 μm
Cladding Geometry	Round	Round
Coating (Second Cladding) Diameter	245 ± 15 μm	500 ± 15 μm
Coating Material	Low Index Acrylate	Low Index Acrylate

<b>Proof Test</b>	≥100 kpsi	>50 kpsi
<b>Core Index</b>	Proprietary <sup>b</sup>	
<b>Cladding Index</b>	Proprietary <sup>b</sup>	

- We regret that we cannot provide this proprietary information.

## PUBLICATIONS

### Active Optical Fiber Publications and Further Reading

As an emerging field of research, many advancements in doped fiber laser and amplifier construction are being made. The following publications contain information that may be helpful in the construction of fiber lasers and amplifiers.

#### 2012

Bryce Samson, George Oulundsen, Adrian Carter, and Steven R. Bowman, "OPTICAL FIBER FABRICATION: Holmium-doped silica fiber designs extend fiber lasers beyond 2  $\mu\text{m}$ ," *Laser Focus World*, August 1, 2012

#### 2011

Jianwu Ding, Bryce Samson, Adrian Carter, Chiachi Wang, Kanishka Tankala, "A Monolithic Thulium Doped Single Mode Fiber Laser with 1.5ns Pulsewidth and 8kW Peak Power," *Proc. SPIE 7914, Fiber Lasers VIII: Technology, Systems, and Applications*, 79140X (February 10, 2011); doi:10.1117/12.876867

#### 2010

Timothy S. McComb, Pankaj Kadwani, R. Andrew Sims, Lawrence Shah, Christina C. C. Willis, Gavin Frith, Vikas Sudesh, Bryce Samson, Martin Richardson, "Amplification of Picosecond Pulses Generated in a Carbon Nanotube Modelocked Thulium Fiber Laser," in *Lasers, Sources and Related Photonic Devices*, OSA Technical Digest Series (CD) (Optical Society of America, 2010), paper AMB10.

G. Frith, A. Carter, B. Samson, J. Faroni, K Farley, K Tankala and G. E. Town, "Mitigation of photodegradation in 790nm-pumped Tm-doped fibers," *Proc. SPIE 7580, Fiber Lasers VII: Technology, Systems, and Applications*, 75800A (February 17, 2010); doi:10.1117/12.846230

Thomas Ehrenreich, Ryan Laveille, Imtiaz Majid, and Kanishka Tankala, Glen Rines, Peter Moulton "1-kW All-Glass Tm: fiber Laser," *SPIE Photonics West 2010: LASE Presentation, Session 16: Late-Breaking News*, January 29, 2010

#### 2009

Gavin Frith, Adrian Carter, Bryce Samson, and Graham Town, "Design considerations for short-wavelength operation of 790-nm-pumped Tm-doped fibers," *Appl. Opt.* **48**, 5072-5075 (2009)

S.D. Jackson, "The spectroscopic and energy transfer characteristics of the rare earth ions used in silicate glass fibre lasers operating in the shortwave infrared," *Laser & Photon. Rev.*, **3**: 466–482. doi: 10.1002/lpor.200810058

Peter F. Moulton, Glen A. Rines, Evgueni V. Slobodtchikov, Kevin F. Wall, Gavin Frith, Bryce Samson, and Adrian L.G. Carter, "Tm-Doped Fiber Lasers: Fundamentals and Power Scaling," *IEEE Journal of Selected Topics in quantum Electronics*, Vol. 15, No. 1, Jan/Feb 2009

#### 2006

Alexander Hemming, Shayne Bennetts, Nikita Simakov, John Haub, Adrian Carter, "Development of resonantly cladding-pumped holmium-doped fibre lasers," *Proc. SPIE 8237, Fiber Lasers IX: Technology, Systems, and Applications*, 82371J (February 9, 2012); doi:10.1117/12.909458

W. Torruellas, Y. Chen, B. McIntosh, J. Faroni, K. Tankala, S. Webster, D. Hagan, M. J. Soileau, M. Messerly, J. Dawson, "High peak power Ytterbium doped fiber amplifiers," *Proc. SPIE 6102, Fiber Lasers III: Technology, Systems, and Applications*, 61020N (February 23, 2006); doi:10.1117/12.646571

## DAMAGE THRESHOLD

### Laser-Induced Damage in Silica Optical Fibers

The following tutorial details damage mechanisms relevant to unterminated (bare) fiber, terminated optical fiber, and other fiber components from laser light sources. These mechanisms include damage that occurs at the air / glass interface (when free-space coupling or when using connectors) and in the optical fiber itself. A fiber component, such as a bare fiber, patch cable, or fused coupler, may have multiple potential avenues for damage (e.g., connectors, fiber end faces, and the device itself). The maximum power that a fiber can handle will always be limited by the lowest limit of any of these damage mechanisms.

While the damage threshold can be estimated using scaling relations and general rules, absolute damage thresholds in optical fibers are very application dependent and user specific. Users can use this guide to estimate a safe power level that minimizes the risk of damage. Following all appropriate preparation and handling guidelines, users should be able to operate a fiber component up to the specified maximum power level; if no maximum is specified for a component, users should abide by the "practical safe level" described below for safe operation of the component. Factors that can reduce power handling and

#### Quick Links

[Damage at the Air / Glass Interface](#)

[Intrinsic Damage Threshold](#)

[Preparation and Handling of Optical Fibers](#)

cause damage to a fiber component include, but are not limited to, misalignment during fiber coupling, contamination of the fiber end face, or imperfections in the fiber itself. For further discussion about an optical fiber's power handling abilities for a specific application, please contact Thorlabs' Tech Support.

### Damage at the Air / Glass Interface

There are several potential damage mechanisms that can occur at the air / glass interface. Light is incident on this interface when free-space coupling or when two fibers are mated using optical connectors. High-intensity light can damage the end face leading to reduced power handling and permanent damage to the fiber. For fibers terminated with optical connectors where the connectors are fixed to the fiber ends using epoxy, the heat generated by high-intensity light can burn the epoxy and leave residues on the fiber facet directly in the beam path.



### Damage Mechanisms on the Bare Fiber End Face

Damage mechanisms on a fiber end face can be modeled similarly to bulk optics, and industry-standard damage thresholds for UV Fused Silica substrates can be applied to silica-based fiber. However, unlike bulk optics, the relevant surface areas and beam diameters involved at the air / glass interface of an optical fiber are very small, particularly for coupling into single mode (SM) fiber. Therefore, for a given power density, the power incident on the fiber needs to be lower for a smaller beam diameter.

The table to the right lists two thresholds for optical power densities: a theoretical damage threshold and a "practical safe level". In general, the theoretical damage threshold represents the estimated maximum power density that can be incident on the fiber end face without risking damage with very good fiber end face and coupling conditions. The "practical safe level" power density represents minimal risk of fiber damage. Operating a fiber or component beyond the practical safe level is possible, but users must follow the appropriate handling instructions and verify performance at low powers prior to use.

Estimated Optical Power Densities on Air / Glass Interface <sup>a</sup>		
Type	Theoretical Damage Threshold <sup>b</sup>	Practical Safe Level <sup>c</sup>
CW (Average Power)	~1 MW/cm <sup>2</sup>	~250 kW/cm <sup>2</sup>
10 ns Pulsed (Peak Power)	~5 GW/cm <sup>2</sup>	~1 GW/cm <sup>2</sup>

- All values are specified for unterminated (bare) silica fiber and apply for free space coupling into a clean fiber end face.
- This is an estimated maximum power density that can be incident on a fiber end face without risking damage. Verification of the performance and reliability of fiber components in the system before operating at high power must be done by the user, as it is highly system dependent.
- This is the estimated safe optical power density that can be incident on a fiber end face without damaging the fiber under most operating conditions.

### Calculating the Effective Area for Single Mode and Multimode Fibers

The effective area for single mode (SM) fiber is defined by the mode field diameter (MFD), which is the cross-sectional area through which light propagates in the fiber; this area includes the fiber core and also a portion of the cladding. To achieve good efficiency when coupling into a single mode fiber, the diameter of the input beam must match the MFD of the fiber.

As an example, SM400 single mode fiber has a mode field diameter (MFD) of ~Ø3 µm operating at 400 nm, while the MFD for SMF-28 Ultra single mode fiber operating at 1550 nm is Ø10.5 µm. The effective area for these fibers can be calculated as follows:

$$\text{SM400 Fiber: Area} = \pi \times (\text{MFD}/2)^2 = \pi \times (1.5 \mu\text{m})^2 = 7.07 \mu\text{m}^2 = 7.07 \times 10^{-8} \text{ cm}^2$$

$$\text{SMF-28 Ultra Fiber: Area} = \pi \times (\text{MFD}/2)^2 = \pi \times (5.25 \mu\text{m})^2 = 86.6 \mu\text{m}^2 = 8.66 \times 10^{-7} \text{ cm}^2$$

To estimate the power level that a fiber facet can handle, the power density is multiplied by the effective area. Please note that this calculation assumes a uniform intensity profile, but most laser beams exhibit a Gaussian-like shape within single mode fiber, resulting in a higher power density at the center of the beam compared to the edges. Therefore, these calculations will slightly overestimate the power corresponding to the damage threshold or the practical safe level. Using the estimated power densities assuming a CW light source, we can determine the corresponding power levels as:

$$\begin{aligned} \text{SM400 Fiber: } & 7.07 \times 10^{-8} \text{ cm}^2 \times 1 \text{ MW/cm}^2 = 7.1 \times 10^{-8} \text{ MW} = 71 \text{ mW (Theoretical Damage Threshold)} \\ & 7.07 \times 10^{-8} \text{ cm}^2 \times 250 \text{ kW/cm}^2 = 1.8 \times 10^{-5} \text{ kW} = 18 \text{ mW (Practical Safe Level)} \end{aligned}$$

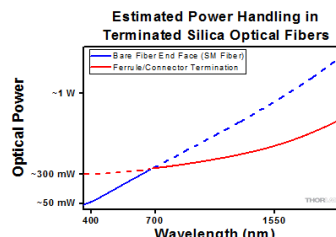
$$\begin{aligned} \text{SMF-28 Ultra Fiber: } & 8.66 \times 10^{-7} \text{ cm}^2 \times 1 \text{ MW/cm}^2 = 8.7 \times 10^{-7} \text{ MW} = 870 \text{ mW (Theoretical Damage Threshold)} \\ & 8.66 \times 10^{-7} \text{ cm}^2 \times 250 \text{ kW/cm}^2 = 2.1 \times 10^{-4} \text{ kW} = 210 \text{ mW (Practical Safe Level)} \end{aligned}$$

The effective area of a multimode (MM) fiber is defined by the core diameter, which is typically far larger than the MFD of an SM fiber. For optimal coupling, Thorlabs recommends focusing a beam to a spot roughly 70 - 80% of the core diameter. The larger effective area of MM fibers lowers the power density on the fiber end face, allowing higher optical powers (typically on the order of kilowatts) to be coupled into multimode fiber without damage.

### Damage Mechanisms Related to Ferrule / Connector Termination

Fibers terminated with optical connectors have additional power handling considerations. Fiber is typically terminated using epoxy to bond the fiber to a ceramic or steel ferrule. When light is coupled into the fiber through a connector, light that does not enter the core and propagate down the fiber is scattered into the outer layers of the fiber, into the ferrule, and the epoxy used to hold the fiber in the ferrule. If the light is intense enough, it can burn the epoxy, causing it to vaporize and deposit a residue on the face of the connector. This results in localized absorption sites on the fiber end face that reduce coupling efficiency and increase scattering, causing further damage.

For several reasons, epoxy-related damage is dependent on the wavelength. In general, light scatters more strongly at short wavelengths than at longer wavelengths. Misalignment when coupling is also more likely due to the small MFD of short-wavelength SM fiber that also produces more scattered light.



Plot showing approximate power handling levels for single mode silica optical fiber with a termination. Each line shows the estimated power level due to a specific damage mechanism. The maximum power handling is limited by the

To minimize the risk of burning the epoxy, fiber connectors can be constructed to have an epoxy-free air gap between the optical fiber and ferrule near the fiber end face. Our high-power multimode fiber patch cables use connectors with this design feature.

lowest power level from all relevant damage mechanisms (indicated by a solid line).

## Determining Power Handling with Multiple Damage Mechanisms

When fiber cables or components have multiple avenues for damage (e.g., fiber patch cables), the maximum power handling is always limited by the lowest damage threshold that is relevant to the fiber component.

As an illustrative example, the graph to the right shows an estimate of the power handling limitations of a single mode fiber patch cable due to damage to the fiber end face and damage via an optical connector. The total power handling of a terminated fiber at a given wavelength is limited by the lower of the two limitations at any given wavelength (indicated by the solid lines). A single mode fiber operating at around 488 nm is primarily limited by damage to the fiber end face (blue solid line), but fibers operating at 1550 nm are limited by damage to the optical connector (red solid line).

In the case of a multimode fiber, the effective mode area is defined by the core diameter, which is larger than the effective mode area for SM fiber. This results in a lower power density on the fiber end face and allows higher optical powers (on the order of kilowatts) to be coupled into the fiber without damage (not shown in graph). However, the damage limit of the ferrule / connector termination remains unchanged and as a result, the maximum power handling for a multimode fiber is limited by the ferrule and connector termination.

Please note that these are rough estimates of power levels where damage is very unlikely with proper handling and alignment procedures. It is worth noting that optical fibers are frequently used at power levels above those described here. However, these applications typically require expert users and testing at lower powers first to minimize risk of damage. Even still, optical fiber components should be considered a consumable lab supply if used at high power levels.

## Intrinsic Damage Threshold

In addition to damage mechanisms at the air / glass interface, optical fibers also display power handling limitations due to damage mechanisms within the optical fiber itself. These limitations will affect all fiber components as they are intrinsic to the fiber itself. Two categories of damage within the fiber are damage from bend losses and damage from photodarkening.

### Bend Losses

Bend losses occur when a fiber is bent to a point where light traveling in the core is incident on the core/cladding interface at an angle higher than the critical angle, making total internal reflection impossible. Under these circumstances, light escapes the fiber, often in a localized area. The light escaping the fiber typically has a high power density, which burns the fiber coating as well as any surrounding furcation tubing.

A special category of optical fiber, called double-clad fiber, can reduce the risk of bend-loss damage by allowing the fiber's cladding (2nd layer) to also function as a waveguide in addition to the core. By making the critical angle of the cladding/coating interface higher than the critical angle of the core/clad interface, light that escapes the core is loosely confined within the cladding. It will then leak out over a distance of centimeters or meters instead of at one localized spot within the fiber, minimizing the risk of damage. Thorlabs manufactures and sells 0.22 NA double-clad multimode fiber, which boasts very high, megawatt range power handling.

### Photodarkening

A second damage mechanism, called photodarkening or solarization, can occur in fibers used with ultraviolet or short-wavelength visible light, particularly those with germanium-doped cores. Fibers used at these wavelengths will experience increased attenuation over time. The mechanism that causes photodarkening is largely unknown, but several fiber designs have been developed to mitigate it. For example, fibers with a very low hydroxyl ion (OH) content have been found to resist photodarkening and using other dopants, such as fluorine, can also reduce photodarkening.

Even with the above strategies in place, all fibers eventually experience photodarkening when used with UV or short-wavelength light, and thus, fibers used at these wavelengths should be considered consumables.

## Preparation and Handling of Optical Fibers

### General Cleaning and Operation Guidelines

These general cleaning and operation guidelines are recommended for all fiber optic products. Users should still follow specific guidelines for an individual product as outlined in the support documentation or manual. Damage threshold calculations only apply when all appropriate cleaning and handling procedures are followed.

1. All light sources should be turned off prior to installing or integrating optical fibers (terminated or bare). This ensures that focused beams of light are not incident on fragile parts of the connector or fiber, which can possibly cause damage.
2. The power-handling capability of an optical fiber is directly linked to the quality of the fiber/connector end face. Always inspect the fiber end prior to connecting the fiber to an optical system. The fiber end face should be clean and clear of dirt and other contaminants that can cause scattering of coupled light. Bare fiber should be cleaved prior to use and users should inspect the fiber end to ensure a good quality cleave is achieved.
3. If an optical fiber is to be spliced into the optical system, users should first verify that the splice is of good quality at a low optical power prior to high-power use. Poor splice quality may increase light scattering at the splice interface, which can be a source of fiber damage.
4. Users should use low power when aligning the system and optimizing coupling; this minimizes exposure of other parts of the fiber (other than the core) to light. Damage from scattered light can occur if a high power beam is focused on the cladding, coating, or connector.

### Tips for Using Fiber at Higher Optical Power

Optical fibers and fiber components should generally be operated within safe power level limits, but under ideal conditions (very good optical alignment and very clean optical end faces), the power handling of a fiber component may be increased. Users must verify the performance and stability of a fiber component within their system prior to increasing input or output power and follow all necessary safety and operation instructions. The tips below are useful suggestions when considering increasing optical power in an optical fiber or component.

1. Splicing a fiber component into a system using a fiber splicer can increase power handling as it minimizes possibility of air/fiber interface damage. Users should follow all appropriate guidelines to prepare and make a high-quality fiber splice. Poor splices can lead to scattering or regions of highly localized heat at the splice interface that can damage the fiber.

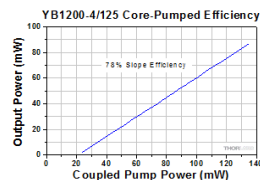
- After connecting the fiber or component, the system should be tested and aligned using a light source at low power. The system power can be ramped up slowly to the desired output power while periodically verifying all components are properly aligned and that coupling efficiency is not changing with respect to optical launch power.
- Bend losses that result from sharply bending a fiber can cause light to leak from the fiber in the stressed area. When operating at high power, the localized heating that can occur when a large amount of light escapes a small localized area (the stressed region) can damage the fiber. Avoid disturbing or accidentally bending fibers during operation to minimize bend losses.
- Users should always choose the appropriate optical fiber for a given application. For example, large-mode-area fibers are a good alternative to standard single mode fibers in high-power applications as they provide good beam quality with a larger MFD, decreasing the power density on the air/fiber interface.
- Step-index silica single mode fibers are normally not used for ultraviolet light or high-peak-power pulsed applications due to the high spatial power densities associated with these applications.

### Core-Pumped SM Yb-Doped Fiber, Single Clad

- Core-Pumped Design
- Telecom-Type Fiber Geometry for Easy Handling, Splicing, and Connectorization
- Good Spliceability to HI1060-Type Passive SM Fibers

#### Applications

- Low Noise, Low Power Preamplifiers
- ASE Sources
- CW and Pulsed Lasers and Amplifiers



Liekki YB1200-4/125 is a highly doped ytterbium fiber for low noise, low nonlinearity preamplifiers and lasers. It is a single-clad fiber for core-pumped applications. This fiber is ideal for use as a preamplifier in a fiber amplifier chain with double cladding fiber acting as a power amplifier.

This fiber's telecom-like geometry makes it compatible with low-cost pump diodes, standard single mode passive fibers, and standard telecom connectors and splicing techniques.

Item #	Cladding Geometry	Absorption @ 920 nm	Mode Field Diameter	Cladding Diameter	Coating Diameter	Core NA	Cut-Off Wavelength	Core Index	Cladding Index
YB1200-4/125	Round	280 dB/m	4.4 $\mu\text{m}$ @ 1060 nm	125 $\pm$ 2 $\mu\text{m}$	245 $\pm$ 15 $\mu\text{m}$	0.2	1010 $\pm$ 70 nm	Proprietary <sup>a</sup>	Proprietary <sup>a</sup>

- We regret that we cannot provide this proprietary information.

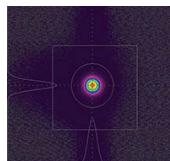
Part Number	Description	Price	Availability
YB1200-4/125	Ytterbium Doped Single Mode Fiber, 4.4 $\mu\text{m}$ MFD	\$102.00 Per Meter Volume Pricing Available	Today

### Cladding-Pumped SM and LMA Yb-Doped Fibers, Double Clad

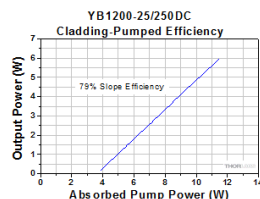
- Cladding-Pumped Design
- Single Mode (SM) or Large-Mode-Area (LMA) Operation
- High Pump Absorption with Low Photodarkening
- High Slope Efficiency (75 - 84%)

#### Applications

- High Average Power Pulsed Amplifiers
- Medium and High-Power Pulsed and CW Lasers
- Materials Processing
- Lidar
- Rangefinding



YB1200-20/400DC Typical Beam Quality



See the Table Below for Each Fiber's Slope Efficiency Graph

These Yb-doped double-clad fibers are ideal for medium- and high-power applications up to 20 W, including fiber power amplifiers. Highly efficient operation allows typical slope efficiencies of 75% to 84%. Matching passive fibers for select LMA versions are sold below.

Key Features	
YB1200-6/125DC	Telecom-like geometry for compatibility with standard components such as gratings and combiners
YB1200-10/125DC	High cladding absorption and a single mode core are ideal for fiber-based power amplifiers
YB1200-20/400DC	$\varnothing$ 400 $\mu\text{m}$ cladding for compatibility with industry-standard high-power pump lasers and delivery fibers
YB1200-25/250DC	High cladding absorption and high efficiency for high average power pulsed fiber amplifiers
YB2000-10/125DC	High doping concentration for photodarkening resistance

Coating (Second)	Slope

Item #	Cladding Geometry	Absorption @ 920 nm	Core Diameter	Cladding Diameter <sup>a</sup>	Cladding) Diameter	Core NA	Cladding NA	Efficiency Plot	Core Index	Cladding Index
YB1200-6/125DC	Octagonal	0.6 ± 0.2 dB/m	6.0 ± 0.8 μm MFD	125 ± 2 μm	245 ± 15 μm	0.15 ± 0.01	≥0.48		Proprietary <sup>b</sup>	Proprietary <sup>b</sup>
YB1200-10/125DC		1.8 ± 0.4 dB/m	10 ± 1 μm	125 ± 2 μm	245 ± 15 μm	0.08 ± 0.005				
YB1200-20/400C		0.7 ± 0.2 dB/m	20 ± 2 μm	400 ± 15 μm	500 ± 15 μm	0.07 ± 0.005	>0.46			
YB1200-25/250DC		2.3 ± 0.3 dB/m	25.0 ± 1.5 μm	250 ± 10 μm	350 ± 15 μm	0.070 ± 0.005	≥0.48			
YB2000-10/125DC		2.0 ± 0.4 dB/m	10 ± 1.0 μm	125 ± 2 μm	245 ± 15 μm	0.12 ± 0.02	>0.46	-		

- Octagonal cladding measured flat to flat.
- We regret that we cannot provide this proprietary information.

Part Number	Description	Price	Availability
YB1200-6/125DC	Ytterbium-Doped Single Mode Double Clad Fiber, 6 μm MFD	\$93.75 Per Meter Volume Pricing Available	Today
YB1200-10/125DC	Ytterbium-Doped LMA Double Clad Fiber, 10 μm Core Diameter	\$172.00 Per Meter Volume Pricing Available	Today
YB1200-20/400DC	Ytterbium-Doped LMA Double Clad Fiber, 20 μm Core Diameter	\$265.00 Per Meter Volume Pricing Available	Today
YB1200-25/250DC	Ytterbium-Doped LMA Double Clad Fiber, 25 μm Core Diameter	\$359.00 Per Meter Volume Pricing Available	Today
YB2000-10/125DC	Highly Ytterbium-Doped LMA Double Clad Fiber, 10 μm Core Diameter	\$300.00 Per Meter Volume Pricing Available	Today

### Matched Large-Mode-Area Passive Fibers

- ▶ Optimized for Coupling to Active Doped Fibers
- ▶ Core and Cladding Ranges from 10 to 20 μm and 125 to 390 μm, Respectively
- ▶ Core and Cladding NA of 0.07 to 0.08 and >0.46, Respectively

These passive large-mode-area (LMA) fibers are matched for ideal splicing with the double clad, LMA active fibers sold above. Their core diameters and numerical apertures are chosen to match that of their active counterparts to maintain excellent beam quality throughout fiber laser or amplifier systems. The outer cladding diameter is designed to "round" the shaped active fibers so as to achieve low pump coupling loss from passive to active fibers.

These large-mode-area passive fibers are coated with low-index fluoroacrylate for pumping active fibers. High-index acrylate-coated fibers are available by special request; please contact Technical Support for details.

Item #	Compatible Active Fiber	Cladding Geometry	Core Diameter	Cladding Diameter	Coating (Second Cladding) Diameter	Core NA	Cladding NA	Proof Test	Core Index	Cladding Index
P-10/125DC	YB1200-10/125DC	Round	10 ± 1 μm	125 ± 2 μm	245 ± 15 μm	0.08 ± 0.005	≥0.48	≥100 kpsi	Proprietary <sup>a</sup>	Proprietary <sup>a</sup>
P-20/390DC	YB1200-20/400DC		20 ± 2 μm	390 ± 8 μm	500 ± 15 μm	0.07 ± 0.01	>0.46	>50 kpsi		

- We regret that we cannot provide this proprietary information.

Part Number	Description	Price	Availability
P-10/125DC	Passive Double Clad Fiber, 10 μm Core, Matched to YB1200-10/125DC(-PM)	\$11.20 Per Meter Volume Pricing Available	Today
P-20/390DC	Passive Double Clad Fiber, 20 μm Core, Matched to YB1200-20/400DC	\$56.75 Per Meter Volume Pricing Available	Lead Time