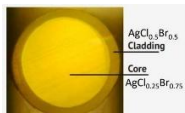


Flexible CO₂ laser delivery at 10.6 μm: Polycrystalline silver halide fibers (PIR) vs Hollow waveguides (HWG)

Our portfolio includes two key in-house technologies for high-power light transmission in the broad mid-infrared spectral range: Polycrystalline silver halide fibers (PIR) and hollow waveguides (HWG). Both technologies provide efficient transmission of CO₂ laser radiation with comparable transmission efficiencies of up to 85-90 % through a 1-meter cable achievable in properly optimized assemblies. However, the two technologies are optimized for different operating conditions. PIR fibers offer superior flexibility, lower bending losses, and greater tolerance to misalignment and beam divergence. In contrast, HWGs provide a lower output divergence beam and with no Fresnel reflection losses. Therefore, the optimal technology should be selected based on the specific requirements for beam quality, cable flexibility, installation constraints, and transmission stability. This note summarizes the differences and provides a selection rule. Additional details, such as connector types (e.g. SMA, FC-PC, and FC-APC), bending radii, etc., can be found in the respective datasheets.

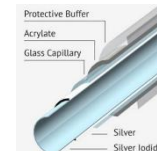
PIR - polycrystalline silver halide fiber

is a solid core/clad fiber made of AgCl_xBr_{1-x} solutions. It guides the light through total internal reflection. It has relatively low bending losses and a high numerical aperture. Special anti-reflective treatment at fiber end faces suppresses Fresnel reflection losses due to the high refractive index.



HWG - hollow silica glass waveguide

is an air-core silica capillary with an internal silver/silver iodide (AgI/Ag) reflective coating to guide the light. It has no end-face reflection and a low-divergence output. However, transmission and beam quality are sensitive to coupling optics and bending curvature.



Key cable parameters for CO₂ laser beam guiding (10.6 μm, CW)

Parameter	PIR fiber	HWG
Core / inner diameter available	240 - 900 μm core (multimode)	500 - 1000 μm bore (multimode)
Attenuation at 10.6 μm	0.2 - 0.4 dB/m	0.3 - 0.7 dB/m
Bending loss (in a full 360° loop of ø=40 cm) ^a	≈ 0.05 dB/m	≈ 0.5 - 1 dB/m
Cable absolute transmission loss if bent (in a full 360° loop of ø=40 cm) ^a	≈ -1.5 %	≈ -14 %
How transmission is improved	Anti-reflective microstructures on fiber end faces (SMART treatment; created during cable assembly)	Optimum f-number (or NA) for coupling optics
Transmission of CO ₂ laser radiation through 1 m High-Power cable ^a	up to 85-90 % for 900 μm core fiber	up to 85-90 % for 1000 μm bore waveguide
Output NA / full divergence	Effective: NA = 0.30 / 35° ^b	Effective: NA ≈ 0.05 (follows the input NA) / 5.7°
Maximum length	15 m	3 m (manufacturing setup limit)
Recommended maximum CW power ^c	35 W	30 W
Additional features	- Improved transmittance in the range 8 - 17 μm - Excellent long-term stability with minimal aging effects - Non-hygroscopic and non-toxic	- Hollow core - No Fresnel reflection at the end faces - Double polymer coating for high flexibility
Recommended for	- Stable power delivery during the bending; - Vacuum feedthrough; - Systems with high NA or high beam divergence.	- Low-divergence laser beam delivery; - Gas spectroscopy with a long optical pathlength through the waveguide.

^a Measured at 10.6 μm with a launch NA of ≈ 0.05 for 900 μm core PIR fiber with SMART treatment or 1000 μm bore waveguide

^b May depend on the cable length and be smaller (output NA ≈ 0.10 - 0.20) in case of a low input NA (e.g. input NA ≈ 0.03-0.05).

^c Values are provided for CO₂ laser (10.6 μm wavelength) with a launch NA of ≈ 0.05 and 900 μm core PIR fiber with SMART treatment or 1000 μm bore waveguide. The recommended maximum CW power depends on the core or bore diameter. Please refer to the respective datasheets for details.

Which technology should I choose?

Choose PIR when:

- stable transmission under bending is important;
- the cable must be bent or routed through a moving system where bending losses are undesirable;
- longer cable lengths are required;
- high input NA / high beam divergence must be accommodated;
- vacuum feedthrough or broadband IR transmission is required.

Choose HWG when:

- low output divergence is the primary requirement;
- bending losses can be tolerated;
- the cable can remain relatively straight;
- gas or air flow needs to be delivered through the cable;
- long optical path through the hollow waveguide is needed.



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