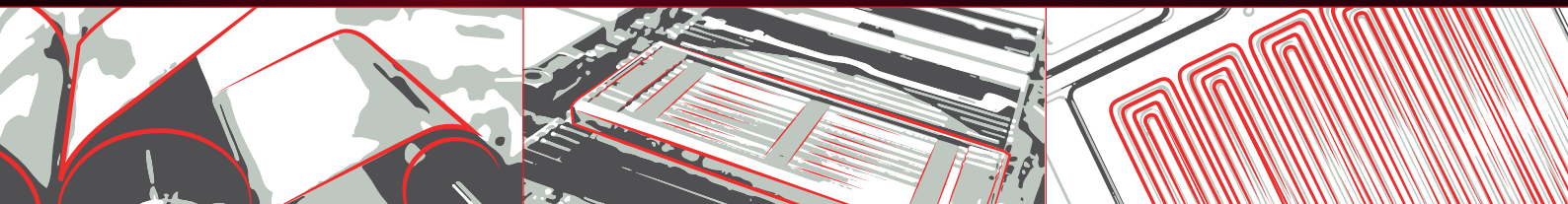


AXIALSCAN FIBER RD-50



LASER WELDING – LASER CUTTING



THE SMALLEST SPOT SIZES FOR THE LARGEST FIELDS

The AXIALSCAN FIBER RD-50 is a **highly integrated pre-focusing beam deflection unit**. It was developed to provide the **smallest spot diameters for laser welding and cutting applications**. With its large aperture, it enables the required spot diameters to be achieved even **in large processing fields**. This allows the laser processes to be implemented with only one deflection unit, even for large components, and **without extensive movement of the workpiece** or the deflection unit.

During the development of the AXIALSCAN FIBER RD-50, great focus was placed on its potential fields of application in the future. With its **dust-proof housing, integrated fiber adapter and collimator**, and a wide range of options for **coaxial inline process control**, it is optimally designed for reliable use in industrial production.

These features make the AXIALSCAN FIBER RD-50 ideal for **cutting out electrical connection points (TABs) in the battery foil**. Another application is the **welding of bipolar plates for fuel cells** with very thin stainless steel sheets of less than 100 µm thickness and extensive capillary structure. Here, the AXIALSCAN FIBER RD-50 works with high positional accuracy and produces fine welds with stable penetration depth without damaging the bipolar plate.



Smallest
spot diameter



Large
processing fields



Optimized for
industrial production

DYNAMIC LASER PROCESSING OF LARGE WORKPIECES

Due to its large **free aperture of 50 mm**, the AXIALSCAN FIBER RD-50 always shows its strength when it comes either to realizing the **smallest spot diameters** or processing **large components** between $300 \times 300 \text{ mm}^2$ and $900 \times 900 \text{ mm}^2$. With its precise lightweight mirrors, it enables high dynamics and the use of beam sources with high laser power and excellent beam quality such as **fiber lasers and ring-mode lasers** despite the large mirror dimensions.

Precisely this combination makes the AXIALSCAN FIBER RD-50 the optimal solution for your production. See for yourself:

Integrated fiber adapter and collimator for all common fiber lasers.

Ensures optimal beam configuration and simplifies integration into a production line

Highly dynamic z-focusing with RAYVOLUTION DRIVE technology

Ensures stable z-position and penetration depth independent of machining speed

Digital control with RL3-100 or SL2-100 protocol

Enables high-precision control and additionally feedback of position and status signals for process monitoring and optimization

Dust-proof housing (IP64) and clean room production

Allows the use of high laser powers up to 6 kW even under harsh production conditions

Lightweight mirrors with high power compatibility

Enable high cutting and welding speeds and higher productivity

OPTIONAL: Focus tracking camera port with RAYSPECTOR

Enables an "on-axis" vision solution with sharp imaging independent of deflection angle and z position

Second protective glass with quick-change mounting frame

Reduces maintenance times and increases productivity and process reliability

Integrated process light output without chromatic aberrations

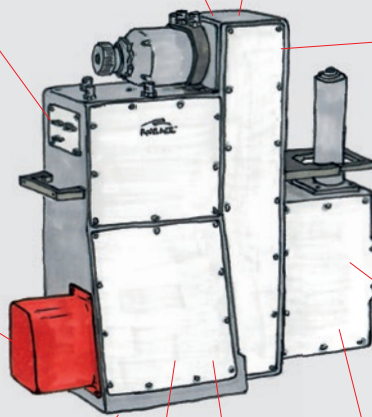
Offers a wide range of possibilities for "on-axis" process monitoring and process control such as pyrometer

Large aperture also for laser with best beam quality and beam shaping

Offers smallest focus diameters and flexible spot shapes for demanding cutting and welding applications

Flexible process field sizes

Enables processing of components in processing fields between $300 \times 300 \text{ mm}^2$ and $900 \times 900 \text{ mm}^2$



WELDING OF BIPOLAR PLATES WITH RING MODE LASERS

Adjustable ring mode lasers have established themselves as an innovative solution for welding critical components with high precision and efficiency. This is because the ring-shaped welding spot **enables a uniform energy distribution** compared to a Gaussian beam profile. This minimizes heat-affected zones and results in **better weld strength and durability**. In addition, humping, which can occur at feed rates as low as 600 mm/s, is avoided or shifted to higher speed ranges, significantly increasing productivity.

Demanding requirements for welding bipolar plates

Whenever laser welding processes depended on small spot diameters on the component, the ring-mode laser previously reached its limits. For example, **small spot diameters between 50 – 100 micrometers are used for thin bipolar plates**. These are often not achievable with a ring mode, because the combination of moderate beam quality of the ring's multimode fibers and the maximum beam diameters in typical deflection units prevents better focusing.

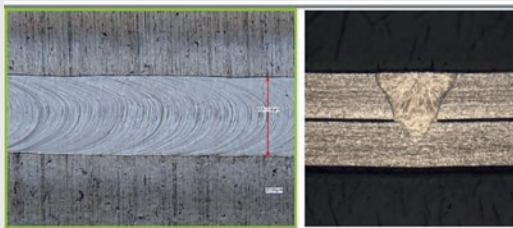
Thus, in order to use a ring mode laser for fine welds such as for bipolar plates, it **requires a special beam deflection unit** that allows a large beam diameter before focusing while providing sufficient dynamics for **efficient production**.



Gas capillaries in a fuel cell stack are close together and require high positioning accuracy during the welding process.

Large aperture enables smallest spots and large processing fields

The AXIALSCAN FIBER RD-50 was developed for exactly such applications. Its **large lightweight mirrors** allow a **free aperture of 50 mm** before focusing and the integrated collimation ensures optimal alignment of the system. This permits **spot diameters of approx. 25 µm** to be realized in a 300 x 300 mm² **with the single mode of a fiber laser**, and with a suitable laser source, even **smallest ring diameters <100 µm** are possible with the AXIALSCAN FIBER RD-50.



Surface and cross section of a weld seam during welding of bipolar plates.

Since laser welding often leads to harsh production environments with spatter and smoke, the housing of the AXIALSCAN FIBER RD-50 was designed to be **dust-proof**. An integrated fiber coupling and a double protective glass with quick-change frame also ensure that the system remains dust-free and ready for use during operation and also during maintenance.

The use of lightweight mirrors specially developed for the AXIALSCAN FIBER RD-50 enables **highly dynamic movements despite the large aperture**. This minimizes process times and even dynamically demanding scan strategies such as **processing on-the-fly** on moving components or wobble structures for optimized welding remain possible.

More efficient production of fuel cells thanks to ring mode laser and AXIALSCAN FIBER RD-50

In summary, the AXIALSCAN FIBER RD-50 makes it possible to **use a ring mode laser for welding bipolar plates** and other high-precision applications. In this way, the advantages of **precise control of the welding process**, a reduced heat-affected zone (HAZ) and minimal thermal distortion can also be used in the manufacture of fuel cells. And the resulting **high-quality laser welds** enable longer product life and improved performance of the fuel cells produced.

SP-ICE-3 - CARD

FLEXIBLE CONTROL OF LASER POWER IN WELDING PROCESS

In laser welding, **control over the melt pool** is crucial for a high-quality result. For example, abruptly switching on the laser often leads to spattering and a poorly controllable welding result. To prevent this, power ramps can help that **increase the laser power** in a controlled manner and **prevent the laser from piercing**. Here, it is important to synchronize the control of the laser power with the movements of the mirrors, especially at higher welding speeds.



Visualization of a welding ramp in the RAYGUIDE software.

To support our users in this aspect, we have integrated a **function for welding ramps** in our SP ICE 3 control card. It automatically and reproducibly increases the laser power at the start of each weld according to the user's specification, thus ensuring an **optimal and consistent welding result**.

In addition, **dynamic ring mode lasers** can be easily integrated via the SP ICE 3 card. Thanks to two individually controllable channels of the SP ICE 3 card, the **laser power and power distribution between center and ring can be varied synchronously with the scanner movements**. In this way, the melt pool can be effectively controlled by the dynamic ring mode and, as a result, higher welding speeds can be achieved with less spatter in the welding process.

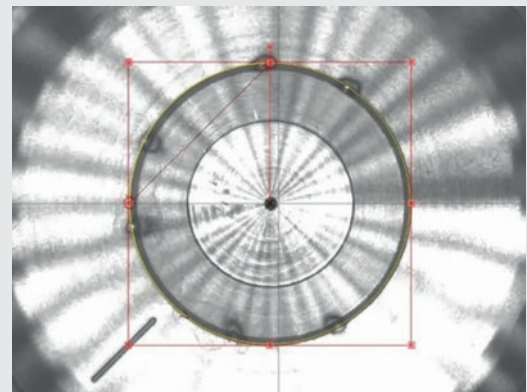
RAYGUIDE CLICK&TEACH

CONVENIENT PRODUCTION PREPARATION BY CAMERA

In many production processes, the **work preparation** is a step that can **take up a lot of time**. In high-precision production processes, this adjustment can even take more time than the subsequent laser processing.

To simplify this part of the preparation, we have developed RAYGUIDE CLICK&TEACH. Because often it is much **easier to recognize the position of the workpiece** and to adapt the movement of the deflection unit to it.

Via a camera on the AXIALSCAN FIBER RD-50, **images of the processing field are acquired and displayed as background in the RAYGUIDE software**. The RAYSPECTOR's dynamic focus tracking ensures a sharp image throughout the entire image field. In the RAYGUIDE software, the **laser processing can then be adjusted to the real positions and dimensions**. This enables precise laser processing without the need for time-consuming alignment of the component in advance. The user thus saves valuable process time.



Alignment of the laser processing on the workpiece detected by camera

OTHER SUITABLE ACCESSORIES

RAYSPECTOR

FOCUS TRACKING CAMERA PORT

Enables on-axis process monitoring with high-speed cameras and other z-position sensitive sensors. It also allows parallel use of a pyrometer at the integrated achromatic process light output.



POSITION RECOGNITION ON AUTOPILOT

Extends the manual position correction of RAYGUIDE CLICK&TEACH with automatic feature recognition on the workpiece. This conveniently enables the automation of precise laser processes.

THIS MAKES RAYLASE SPECIAL

Technical specifications are important and often decisive. But at RAYLASE, we believe that there is more to it than pure technology that matters. For this reason, we are your partner for reliable and successful laser processes and offer more than just technical components.



Systems view instead of components

Modern production systems for laser processing are usually designed specifically for one process step and are highly optimized. It is therefore important to consider the interplay with the other machine components when selecting suitable beam deflection units. At RAYLASE, we therefore always have the entire solution in mind and offer our customers assistance in putting together suitable components.



Broad application knowledge

For many processes, the beam deflection unit is a decisive component. Often it determines whether the desired spot parameters and processing speeds can be implemented on the component. To identify the optimal solution here, we support our customers in selecting the right beam delivery components and sensor technology, and perform simulations of the laser processes developed by our customers. In addition, we provide support in the parameterization of the laser and deflection unit or software functionality through the experts at our Technical Competence Center TCC.



On-site support for implementation and service

Our customers are the experts for their application – we are the experts for our beam deflection units. That's why we support our customers during the commissioning of our products – if necessary also directly on site. In this way, we at RAYLASE ensure that our system is optimally adjusted and permanently delivers what it is capable of.



Education & training on the system

Modern laser deflection units are complex systems. Therefore, it is important to have a good knowledge of their characteristics. Because only when users know how the various parameters interact the optimum process becomes possible. For this reason, we at RAYLASE put a high priority on training for our products. In addition, we also offer our customers on-site training directly on the system, if required, to enable users to operate the system independently.



The POWER OF WE

Together you achieve more. At RAYLASE, we are convinced about this. That's why we place great value on cooperation in a spirit of partnership and open communication at equal level – from expert to expert. Because only when we jointly find the best solution and successfully integrate it into the machine, everyone involved benefits in the end – our customers, us and also the end users.

GENERAL SPECIFICATIONS

Power Supply	Voltage [V]	+ 48
	Current (RMS) [A]	4
	Current (max.) [A]	8
	Ripple / Noise @ 20 MHz bandwidth [mV pp]	Max. 300
Ambient temperature [°C]		+15 to +35
Storage temperature [°C]		-10 to +60
Relative humidity non condensing [%]		≤ 80
IP Code ¹		64
Interface signals	Digital	RL3-100 protocol 20 Bit SL2-100 protocol 20 Bit
Typical deflection (optical) [rad]		± 0.393
Resolution RL3-100 / SL2-100 20-Bit [μrad]		0.76
Repeatability (RMS) [μrad]		< 2.0
Positioning noise (RMS) [μrad]		< 3.2
Temperature drift	Max. Gain drift [ppm/K]	15
	Max. Offset drift [μrad/K] ²	10
Long-term drift 8 h without water temperature control [μrad] ²		< 60
Long-term drift 8 h with water temperature control ^{2, 3}		< 40

¹ When actively using cooling air. ² Angles optical. Drift per Axis, after 30 min. warm-up, at constant ambient temperature and process stress.

³ After 60 min. warm-up, under varying process loads, with water temperature control set for ≥ 2 l/min and 22°C water temperature.

APERTURE DEPENDING SPECIFICATIONS – MECHANICAL DATA

Deflection Unit		AXIALSCAN FIBER RD-50	
Laser fiber socket		QBH	
Position of fiber socket		in front	
Weight [kg] approx.		25	
Dimensions excluding fiber socket and electrical plug connections (L x W x H) [mm]		379.0 x 200.0 x 494.0	
		Typ. beam divergence	Max. beam divergence
Typical collimator focal lengths available ¹		1/e ² full angle [mrad]	1/e ² full angle [mrad]
f = 63 mm		136	150
f = 85 mm		100	110
f = 104 mm		82	96
f = 165 mm		52	58
f = 50 mm	Fiber core ²	115	125
for Multi-Core Laser	Fiber ring ²	170	200
Free beam version (without collimator), Position of beam entrance: top with 14.4 mm full beam		–	–

¹ Optical sets optimized for maximum beam divergence. Other available collimator focal lengths on request.

² Measured with 2nd moment method.

TYPE DEPENDENT SPECIFICATIONS – TUNINGS

Tuning	Description
Vector-Tuning (VC)	Optimized tuning with a wide range of applications with emphasis on processing speed.
Microstructuring Tuning (M)	Optimized tuning for high precision beam deflection and fastest beam direction change during hatching.

TYPE DEPENDENT SPECIFICATIONS – DYNAMIC DATA

Deflection unit	AXIALSCAN FIBER RD-50 SC	
Tuning	VC	M
Processing speed [rad/s] ¹	30	10
Positioning speed [rad/s] ¹	30	10
Tracking error [ms]	0.58	0.38
Acceleration time approx. [ms]	1.28	0.84
Step response time at 1% of full scale [ms] ²	1.5	1.4
Tracking error focusing unit [ms]	1.1	1.1
Speed of moving lens [mm/s]	900	900

¹ See "Calculation of speed".

² Settling to 1/5,000 of full scale.

Calculation of speed:

1 rad/s @ ± 0.393 rad deflection (45°) 0.12 m/s for 100 mm processing field size.

Example: Processing field 400 x 400 mm² corresponds to field factor 4, processing speed 30 rad/s,
processing speed [m/s] = 30 x 0,12 m/s x 4 = 14.4 m/s

Option of air cooling:

The AXIALSCAN FIBER RD-50 deflection units offer the possibility of air cooling for the deflection mirrors.

Note: From 4 kW laser power air cooling is required to protect the mirror system from damage.

This ensures constant working conditions as well as excellent long-term stability and guarantee reliable operation of high-power applications.

Option of additional protective window:

Each AXIALSCAN FIBER RD-50 can be equipped with an optional extra protective window. This external protective window is housed under a flap and is quickly replaced. This ensures fast and easy replacement of the protective window under harsh conditions in dusty environments. This means that all cleaning of the protective window is done externally and the system is operational again after a very short time.

AIR COOLING

Specifications	
Compressed air ¹	Clean air free of water and oil
Flow rate	0l/min–4 kW, 30 l/min–6 kW

¹ ISO 8573-1:2010 [1:4:0(0,005)]

WATER TEMPERATURE CONTROL

Specifications	
Cooling water ¹	Clean tap water with additives
Water hardness [ppm]	< 10
ph value	7 – 8.6
Bacterial content [cfu/ml]	< 1,000
Recommended cooling temperature [°C]	22 – 28
Temperature stability [K]	± 1
Max. water pressure at deflection unit [bar]	< 3
Min. water flow [l/min] and pressure drop [bar]	2 / 0.4
Tube outer diameter [mm]	8

¹ **Caution:** When using cooling water including deionised water, suitable additives must be used to prevent the growth of algae and protect the aluminium and copper components of the cooling circuit against corrosion.

Additive recommendations (Please consult your additive supplier for dosage information):

Standard industrial applications: Products of company NALCO, e.g. CCL 105 (Premix) oder TRAC105A_B (Additive)

Food & beverage, packaging applications: Polypropylene glykol of company Dow Chemicals, e.g. DOWCAL N

Note: Water cooling is strongly recommended for the AXIALSCAN FIBER RD-50, as the collimator can heat up considerably at high powers and high beam divergences.

In addition, the water cooling ensures a uniform temperature control of the system and thus guarantees excellent long-term stability and reliable operation of high power applications.

CONFIGURATION EXAMPLES – AXIALSCAN FIBER RD-50

Processing field size [mm x mm]	300 x 300	400 x 400	500 x 500	600 x 600
Working distance [mm] ¹	291	415	539	663
Spot diameter 1/e ² [µm]	23	30	36	43
Free Focus range [mm]	2	24	60	110

¹ From the bottom edge of deflection unit to the processing field.

OPTICS SPECIFICATIONS

Wavelength and coatings	Mirror substrate	Maximum permissible laser power [W] ¹
1,060 nm – 1,090 nm + AL	SC	6,000

¹ Valid for single-mode and multi-mode continuous wave (CW) lasers

PROCESS-MONITORING

AXIALSCAN FIBER RD-50	
Process light broadband output wavelength [nm]	400 – 900 + 1,300 – 2,100

Every AXIALSCAN FIBER RD-50 is equipped with a dust-proof optical output for process light radiation. Both very short wavelengths below the laser wavelength and long-wave thermal radiation are transferred externally. This means that various sensors can be connected, e.g. cameras for position detection, weld quality monitoring and pyrometers.

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