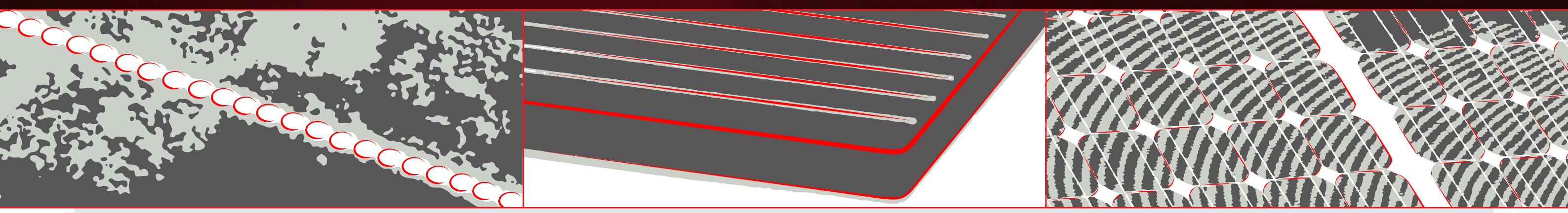
SUPERSCAN IV SOLAR *NEW*

LASER CONTACT OPENING – SELEKTIVES LASER DOPING



FAST AND PRECISE LASER PROCESSING OF SOLAR CELLS

Laser processes are an important part of the **production of modern solar cells.** In PERC solar cells, for example, the laser enables backside contacting of the cell by **laser contact opening or selective laser doping of the semiconductor.** In all these applications, it is usually necessary to laser very **fine structures** of a few micrometers **with high precision.** At the same time, **productivity remains a key issue,** because PV production only runs economically at the highest quantities. As a result, the cycle rate demanded by the solar industry is is over 3,600 wafers per hour.

To reliably accomplish this task, it requires **specialized high-speed scanners** such as our SUPERSCAN IV-SOLAR series. With an **accuracy of ± 10 µm, a marking speed of more than 60 m/s** and highest dynamics due to the SiC mirrors, the **100 and 300 laser-written lines per wafer** can be generated **in less than 500 ms** and thus the SUPERSCAN IV-SOLAR ensures high production throughput and thus lower production costs.

With the SUPERSCAN IV-20 SOLAR, it is also possible to implement the necessary spot and speed requirements in **larger process fields up to 210 x 210 mm².** This is an important aspect for **the production of M12 solar wafers** with larger dimensions.

Highest processing speed

Large processing fields

Smallest spot diameter

www.raylase.com

OPTIMIZED SOLUTION FOR SOLAR PRODUCTION

The SUPERSCAN IV SOLAR is **specially designed to meet the requirements of wafer processing in photovoltaics.** It is important to select the **optimum configuration for the deflection unit** consisting of aperture, mirror substrates, coating and control electronics. Only this way the high requirements for **speed, accuracy and dynamics** can be achieved.

And it is precisely this combination that makes the SUPERSCAN IV-SOLAR series the optimal solution for your photovoltaic production. See for yourself:

Digital control optimized for long vectors in solar applications

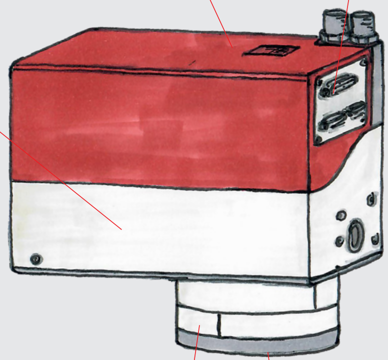
Enables extremely fast processing speed of up to 240 rad/s optical

Digital control with XY2-100 or SL2-100 protocol

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

Lightweight mirrors with high dynamics even at large apertures

Enable highly dynamic processing at smallest spot diameters



Mirror substrates and coatings suitable for short wavelengths

Allow smallest spot diameters even at long focal lengths

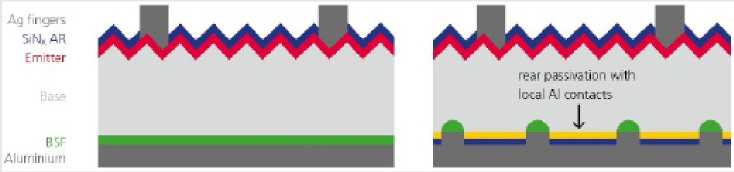
Suitable lenses also for large process fields

Allow processing of wafers up to 210 x 210 mm² (M12 Wafer)

LASER CONTACT OPENING IN SOLAR CELL PRODUCTION

Solar wafer technology has been developing steadily for years. And especially in agile photovoltaic markets such as China, solar wafers produced with **innovative processes** like PERC ("Passivated Emitter Rear Contact") are used in large quantities. This is because such wafers are in some cases more than 20% more efficient in energy conversion than predecessor architectures such as BSF.

In the case of PERC solar cells, the higher energy conversion efficiency is enabled by a dielectric passivation layer (mostly Al_2O_3, SiO_2, SiNx). Small contact openings are then created in this layer via laser ablation. This is done during **Laser Contact Opening (LCO)** by selectively removing the passivation layers via a dashed dot or line pattern.



Schematic drawing of a PERC solar cell and the Laser Contact Opening (LCO) process step. Source: T. Dullweber et al., Photovoltaics International, vol. 13 (2011), p. 77

High requirements on accuracy and throughput

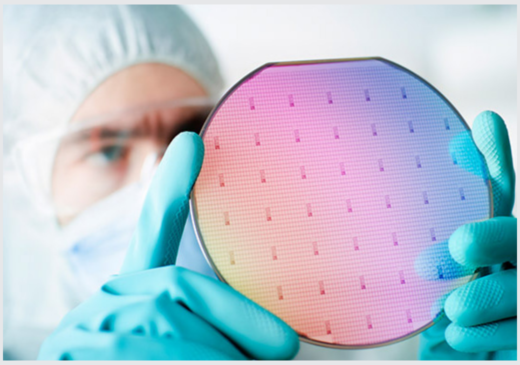
In order to achieve **optimum solar cell efficiency,** the contact aperture must measure only a few 1/100 mm. This ensures that they do not unnecessarily expose silicon, which could lead to increased electron recombination. The **placement of the contacts must be very precise** to ensure correct alignment with the front contacts on the one hand and to avoid damaging the structure of the cell on the other. **Repeatability of a few micrometers** is required here. At the same time, the process step including handling time must not take longer than 1 second per wafer in order to optimally fit into the production process, which is typically designed for at least 3600 wafers per hour.

Specialized scanning solutions enable efficient production

For existing M0-M6 wafers, the **SUPERSCAN IV 15 is an established solution.** In combination with a 532 nm laser and an f = 255 mm f-theta objective, it achieves spot sizes smaller than 20 µm and accuracies < ± 10 µm. Thanks to a tuning optimized for long vectors, the SUPERSCAN IV-15 reaches speeds of up to 240 rad/s or over 60 m/s in the field. This makes it possible to mark 100-300 lines per wafer in less than 500 ms and thus meet the requirements of the photovoltaic industry.

Larger wafers M12 wafers require new scanning solutions

However, the increasing size of solar wafers poses challenges for laser production. This is because existing scan systems cannot achieve the necessary **processing fields of at least 210 x 210 mm²** without increasing the spot size. And scan systems with larger apertures typically do not offer the necessary dynamics and high speed.



The manufacturers of photovoltaic modules are relying on ever larger wafers. This allows solar modules to be produced more cost-effectively.

To support manufacturers in their shift towards larger wafers and thus cheaper solar modules, the SUPERSCAN IV-20 SOLAR was developed. With its lightweight SiC mirrors, optimized electronics and its special tuning, the SUPERSCAN IV-20 SOLAR offers **speeds of 200 rad/s,** just like the smaller deflection units. Additionally, the mirrors are optimized for use at **a wavelength of 343 nm,** enabling even finer structures.

At the same time, a combination of the SUPERSCAN IV-20 SOLAR **with a suitable f = 330 mm F-Theta lens** provides the necessary larger processing fields for the production of M12 wafers and still allows a **cycle rate of at least 1 wafer / second.**

This allows the solar industry to further **reduce production costs** and ensures that the high demand for low-cost PV modules can be further met.

SP-ICE 3 CONTROL CARD

HIGHEST SPEED THANKS TO INTELLIGENT CONTROL

The high scan speeds in wafer production pose challenges for scan systems. Because, **only if the velocity is kept constant,** the **individual pulses can be cleanly positioned** on the wafer.

For this reason, the mirrors are only accelerated outside the processing area. A **"skywriting"** provides a **very fast direction change of the beam outside the processing area without active laser power.** Since these turn-around times can become quite relevant with up to 300 lines, it is important here to use a deflection unit with lightweight mirrors and low tracking distortion.

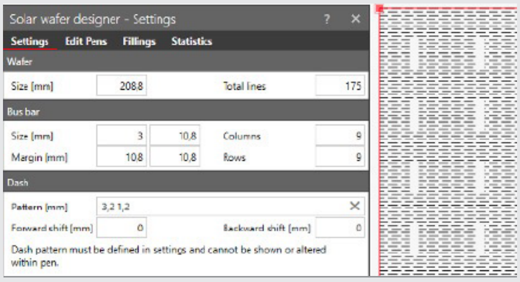
In addition, process time can be saved via intelligent software functions. At the windows of the "passivation layer", **line segments can be combined into a line using the "dashed line" feature** of the SP-ICE-3. As a result, the laser is only modulated at the corresponding points and there is **no deceleration or acceleration** at all. This prevents valuable time from being wasted and increases the productivity of the process.

RAYGUIDE SOFTWARE

QUICK AND EASY OPTIMIZATION OF THE SCANNING PATTERN

A special plus for wafer manufacturers is the RAYGUIDE software with its **special solar wafer plug-in.** Typically, a solar wafer laser process requires a pattern consisting of dash lines for structuring. It is interrupted by rectangular areas – "bus bars", which are evenly distributed over the wafer. Often these patterns are created using a DXF file and loaded into the laser process software, which results in thousands of individual dashes when imported conventionally. The software solution RAYGUIDE can import or designthe customer's own individual pattern for wafer and optimize its laser processing strategy.

The **RAYGUIDE solar wafer plug-in combines individual dash lines into a dash line pattern.** This way, the gaps in the **pattern are precisely created by modulating the laser power** instead of marking individual vectors. In addition, the software also allows **faster and more direct adaptation of the patterns.** As a result, ad hoc changes to the wafer layout can be made easily and conveniently with it. Furthermore, the "Designer" offers a fundamental streamlining of the workflow, since the detour via DXF files is eliminated.



The software solution RAYGUIDE can import or design the customer's own individual pattern for wafers.

OTHER SUITABLE ACCESSORIES

CAMERA ADAPTER

FOR ON-AXIS PROCESS MONITORING

With our camera adapter and the Machine Vision Control components, the deflection unit can be expanded to include process monitoring.

LENSES & MORE

SUITABLE OPTICS FOR EVERY APPLICATION

F-theta lenses, protective glasses, mirror substrates and coatings are available for all common laser types, wavelengths, power densities, focal lengths and processing fields.

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 successful integrate it into the machine, everyone involved benefits in the end – our customers, us and also the end users.

GENERAL SPECIFICATIONS

Energy supply	**Voltage [V]**	+48
	Current (RMS) [A]	2
	Max. current [A]	5
	Riple / Noise] [mV pp] [1]	300
Ambient temperature [°C]		+15 … +35
Storage temperature [°C]		-10 … +60
Humidity [%] (non-condensing)		80
IP Code		IP64
Control signals digital, Auflösung [µrad]	**SL2-100, 20-Bit**	0.76
	XY2-100-E, 16-Bit	12
Typical deflection [rad]		± 0.393
Repeatability (RMS) [µrad]		< 2.0
Position noise (RMS) [µrad]		< 4.5
Temperature drift	**Max. Gaindrift [ppm/K]** [2]	15
	Max. offset drift [µrad] [2]	10
Long-term drift 8 h with water temperature control [µrad] [2]		40
Long-term drift 8 h without water temperature control [µrad] [2, 3]		60

1 At 20 MHz bandwidth
2 Angle optical. Drift per axis. After 30 minutes of warm-up time, at constant ambient temperature and process load.
3 After 30 minutes of warm-up time, even at changing process load with water cooling at ≥ 2 l/min and water with 22°C.

APERTURE-DEPENDENT SPECIFICATIONS – MECHANICAL VALUES

Spezifikation	SUPERSCAN IV-15	SUPERSCAN IV-20
Input aperture [mm]	15	20
Beam displacement [mm]	18.1 (QU [1]), 18.0 (SC [2])	26.0 (SC)
Dimensions (Length x Width x Hight) [mm]	170 x 125 x 117.5	203 x 159 x 150
Weight [kg]	3.2	5.5

1 Quartz
2 Silicon carbide

MIRROR VERSIONS

Wavelength	Substrate 15 mm	Substrate 20 mm
343 nm	-	SC
355 nm	QU [1], SC [2]	SC
515 nm	SC	SC
532 nm	QU, SC	SC
1,030 nm	SC	-
1,070 nm	SC	-
1,064 nm	QU, SC	SC
1,060-1,080 nm	QU	-

[1] Quartz
[2] Silicon carbide

TYPE-DEPENDENT SPECIFICATIONS – TUNING

Tuning	Description
Wafer tuning (W)	Optimized tuning for long vectors at highest speeds and precise beam deflection
Wafer enhanced tuning (WE) [1]	Innovative tuning for long vectors with ultra-high speed and precise beam deflection.

[1] Only intended for full-surface wafer markings.

TYPE-DEPENDENT SPECIFICATIONS – DYNAMIC BEHAVIOR

Deflection unit	SUPERSCAN IV-15 QU	SUPERSCAN IV-15 SC		SUPERSCAN IV-20 SC
Tuning	W	W	WE [1]	W
Proceeding speed [rad/s] [2]	200	200	240	200 [3]
Positioning speed [rad/s] [2]	200	200	240	200 [3]
Acceleration time (approx.) [ms]	0.69	0.52	0.55	0.80
Tracking error [ms]	0.30	0.20	0.25	0.40
Step response at 1 % full scale [4]	0.65	0.50	0.55	0.80

[1] Only intended for full-surface wafer markings.
[2] See "Calculation of the maximum speed in the processing field”.
[3] When using SP-ICE-3 control card and RAYGUIDE software
[4] Regulated to 1/5,000 full amplitude.

Calculation of the maximum speed in the processing field

Speed in the processing field = F-Theta lens focal length x positioning speed:
Example 1:
SUPERSCAN IV-15 SC with F-Theta lens f = 254 mm, positioning speed 200 rad/s
v = 254 / 1000 x 200 = 50 m/s
Example 2:
SUPERSCAN IV-20 SC with F-Theta lens f = 330 mm, positioning speed 200 rad/s
v = 330 / 1000 x 200 = 66 m/s

Deflection mirrors and lens

Lenses with optimized lens holders and scan mirrors are available for all common laser types, wavelengths, power densities, focal lengths and processing fields. Customized designs are also possible.
For more information on possible combinations, please contact the RAYLASE Support Team at:
Tel.: +49 8153 9999 297 or E-Mail: support@raylase.de.

WATER TEMPERATURE CONTROL

Specifications	
Water	Clean tap water with additive
Temperature [°C]	22 … 28
Max. water pressure [bar]	< 3
Min. flow rate and pressure drop	2 / 0.4

Caution!
In order to prevent the growth of algae and protect the aluminum parts from corrosion, suitable additives must be used when using cooling water (including deionized water).

Additive recommendations
Please follow the dosing and application instructions of the manufacturer.
Standard industrial applications: Products from NALCO, e.g. CCL105 (finished mixture) or TRAC105 (additive)
Applications in the food / packaging industry: Propylene glycols from Dow Chemical, e.g. DOWCAL N.

Headquarters:
RAYLASE GmbH
Wessling, Deutschland
+49 8153 9999 699
info@raylase.de

Subsidary China:
RAYLASE Laser Technology (Shenzhen) Co.
Shenzhen, China
+86 199 25 48 3946
info@raylase.cn

Subsidary USA:
RAYLASE Laser Technology Inc.
Newburyport,MA, USA
+1 (313) 552-7122
info@raylase.com