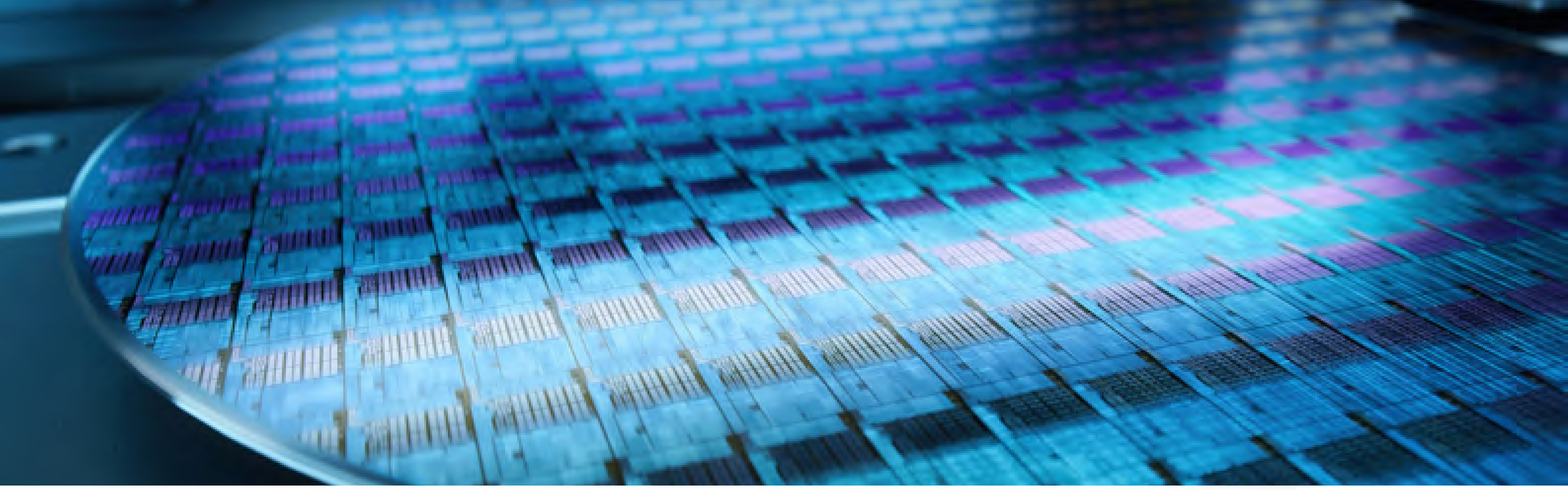
RAYLASE
THE POWER OF WE

SCALING UP SOLAR:
Overcoming the Hurdles in Laser Processing for M12 Size Solar Cells

RAYLASE.COM

RAYLASE USE CASE



AT A GLANCE

The solar industry aims to increase the efficiency of solar cells while keeping costs down. A promising strategy is using larger M12 solar wafers, but these come with their own challenges, especially in laser-based processes. The current standard f-theta optics with f=255mm focal length do not allow a field size Typo cover the new wafer size. Longer focal lengths could be an option, but they require adaptions in wavelength and mirror size, pushing on the beam deflection units into focus. To provide a solution for this challenge, RAYLASE has introduced the SUPERSCAN IV 20 SOLAR, a specialized tool tailored for these bigger wafers.

It is designed for 343nm wavelength and offers large 20 mm mirrors, both factors compensating for the longer focal length. Still thanks to an optimized line scanning tuning, the SUPERSCAN IV SOLAR provides scanning speeds of up to 200 rad/ which are necessary for the solar industry's fast production cycles.

By ensuring both speed and quality in production, this advancement offers solar cell producers a competitive edge. Thanks to the SUPERSCAN IV 20 SOLAR they can continue to produce cost-effective solar cells, and stay ahead in the ever-evolving solar market.

KEY POINTS

- **Increasing Wafer Sizes:** M12 size solar cells, with a side length of 210mm, are gaining traction. They can **enhance efficiency and reduce manufacturing costs** due to fewer solar cells per module and reduced busbar and wiring needs.
- **New Challenges in laser production:** Larger wafers introduce **higher complexities in laser processing**, e.g. in the Laser Contact Opening (LCO), a process which is crucial for PERC and TOPCon technology efficiency.
- **Optimized Scanning System for M12 wafers:** RAYLASE's system is tailored for M12 wafers, with careful selection of laser source, lens combination, and **optimized beam deflection** components.
- **SUPERSCAN IV 20 SOLAR:** The newly developed beam deflection unit from RAYLASE offers solutions for growing processing fields in the photovoltaic industry. It ensures small focus diameters in the required large image fields. At the same time, it delivers high repeatability, consistent spot sizes and fast line scanning, which both are crucial for processing larger wafers.
- **Industry Implications:** With the adoption of such scanning systems, **solar cell producers can transition to larger wafers** without sacrificing production rates. This not only **makes solar energy more affordable** and accessible but also fortifies the global move towards renewable energy sources.

> TACKLING COST AND EFFICIENCY: THE TRANSITION TO BIGGER SOLAR WAFERS

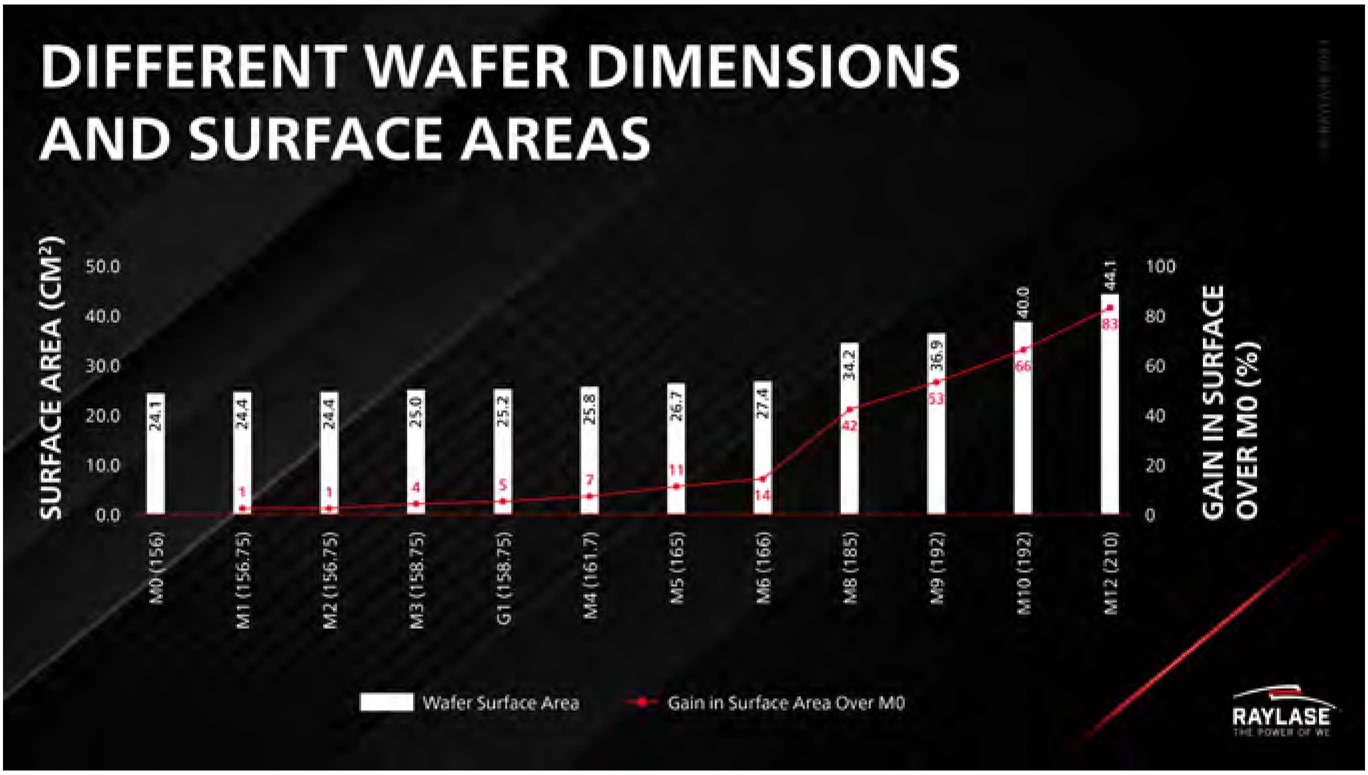
As the **efficiency of Passivated Emitter and Rear Cell (PERC)** solar cells has reached its limit, the question "How can we improve the efficiency of solar cells while reducing their production costs?" is bothering many companies in the solar industry.

So, they are **exploring various cost-reduction methods** trying to stay competitive in the market. This includes alternative types of solar cells like Heterojunction (HJT) or TOPCon (Tunnel Oxide Passivated Contact) solar cells, but also **increasing the size of the wafers** comes into their focus.

So far, the size of solar cells was growing only at a slow rate and the producers of solar cells now see an opportunity to optimize their production.

Clark Lee
VP Sales Asia at RAYLASE

Increasing the wafer sizes can **reduce manufacturing costs** and **increase efficiency at the module level**, as fewer solar cells are required per module and less busbars and wiring is needed for the connection of the solar cells. As a result, the side length of the used wafers has increased by almost 35% leading to current M12 size solar cells, with a side length of 210mm. However, this solution is not without its challenges.



△ *Figure 1: Overview over the gain in surface area with an increasing wafer size.*

HOW TO SCALE THE SIZE OF SOLAR CELLS

Bigger solar wafers are more challenging to handle due to their increased size and weight, leading to a higher risk of breakage. This requires new careful handling technologies that minimize the damage of the bigger wafers. But other **process steps face challenges due to the increased wafer size**, too. One of these is Laser Contact Opening (LCO), a vital step for achieving high efficiencies with PERC technology.

“When transferring laser processing to larger wafer sizes, longer focal lengths become necessary to cover the complete wafer in the process,” explains Clark Lee. “But longer focal lengths result in bigger spot sizes and render the process impossible.”

Achieving the necessary small spot sizes around 15 microns would require either shorter wavelengths, which present challenges in designing and producing optics for large processing fields, or larger mirrors in the beam deflection units, which then are typically too slow to keep up with current production speeds.

INNOVATIVE SCANNING SYSTEM FOR LARGER WAFERS

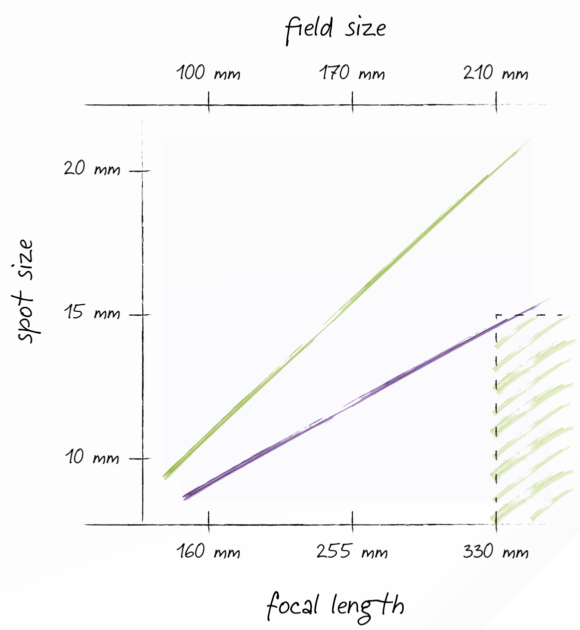
“To tackle the challenges associated with larger solar wafers, **you need a specialized scanning system** that combines deep knowledge about the photovoltaic process and beam deflection components,” explains Wolfgang Lehmann, Head of Product Management at RAYLASE.

For an optimized system to process large M12 wafers, he lists three critical aspects:

Matched optical components for a reliable laser process

When configurating an optimized laser scanning system, **selecting the right laser source and lens combination is a crucial step**. To cover the large M12 wafers with a side length of 210 mm, an F-theta lens with **an f = 330 mm focal length** becomes necessary. But if you want to keep your spot size identical to the existing process with an f = 255 mm lens, you need to compensate for the increasing spot size:

One option **is a laser source with a wavelength of 343 nm** that enables smaller spot sizes compared to traditional 532nm solutions. Additionally, larger beam diameters before the focusing optics can help to reduce the spot sizes in the field.



◁ *Figure 2: Correlation between focal length, field size and spot size for different laser wavelengths*

However, at the wavelength of 343nm, this becomes challenging. Only **a highly optimized f-theta design and very plane and stiff scanning mirrors** can ensure the consistent spot sizes across the entire working field, which are mandatory for LCO and other laser processing steps in the photovoltaic industry.

Reliable Electronics and Scanners for highest precision

For high-precision tasks like laser contact opening and other photovoltaic processes, it is **essential to achieve high repeatability and low drift.** To accomplish this, the scanning system should incorporate **optimized electronics and reliable galvanometer scanners**. These components work together to maintain consistent performance across the entire process, reducing errors and increasing the overall quality of the solar cells being produced.

Advanced Scanning Technology for optimized Production Speed

Efficient solar cell production demands **fast production cycles** without compromising on quality. To meet these requirements, the scanning system must support **quick line scanning at speeds of up to 200 rad/s** and high scanning dynamics for **rapid turnaround between lines**. This enables the system to keep up with the necessary production rates for larger wafers. Thus, incorporating **lightweight mirrors and special tuning optimized for fast line scanning** is essential, especially for large 20 mm apertures. Such components help minimizing processing times while maintaining precision, ensuring the system's overall effectiveness in adapting to larger solar cell sizes.

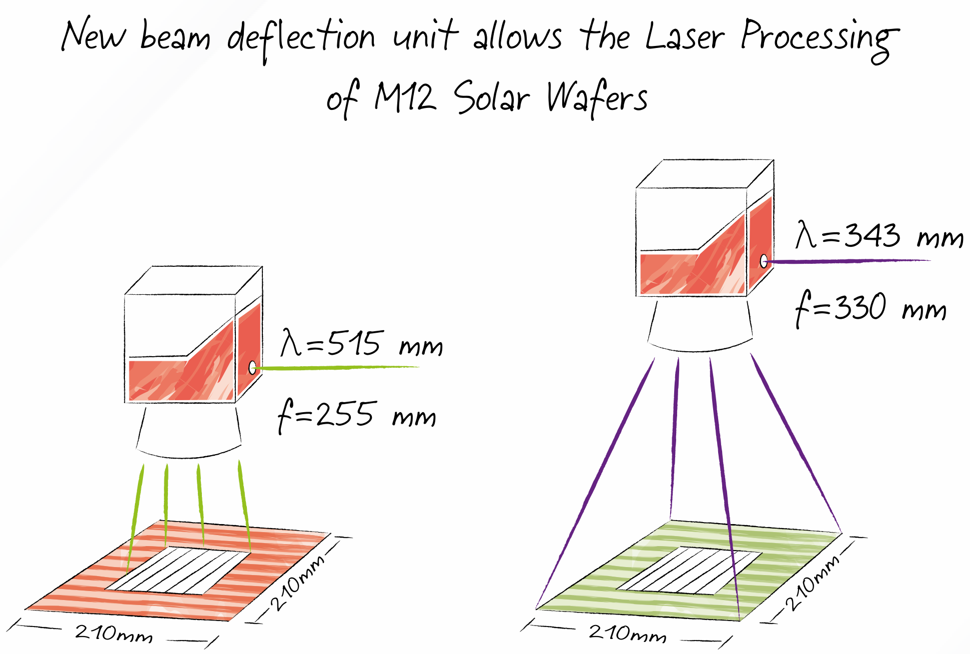
> ADVANCING M12 SOLAR CELLS: LASER TECHNOLOGY DRIVING RENEWABLE AFFORDABILITY

Luckily, due to progress in optics and beam deflection technology, such specialized laser scanning systems become possible and allow to address the unique challenges associated with larger wafer sizes.

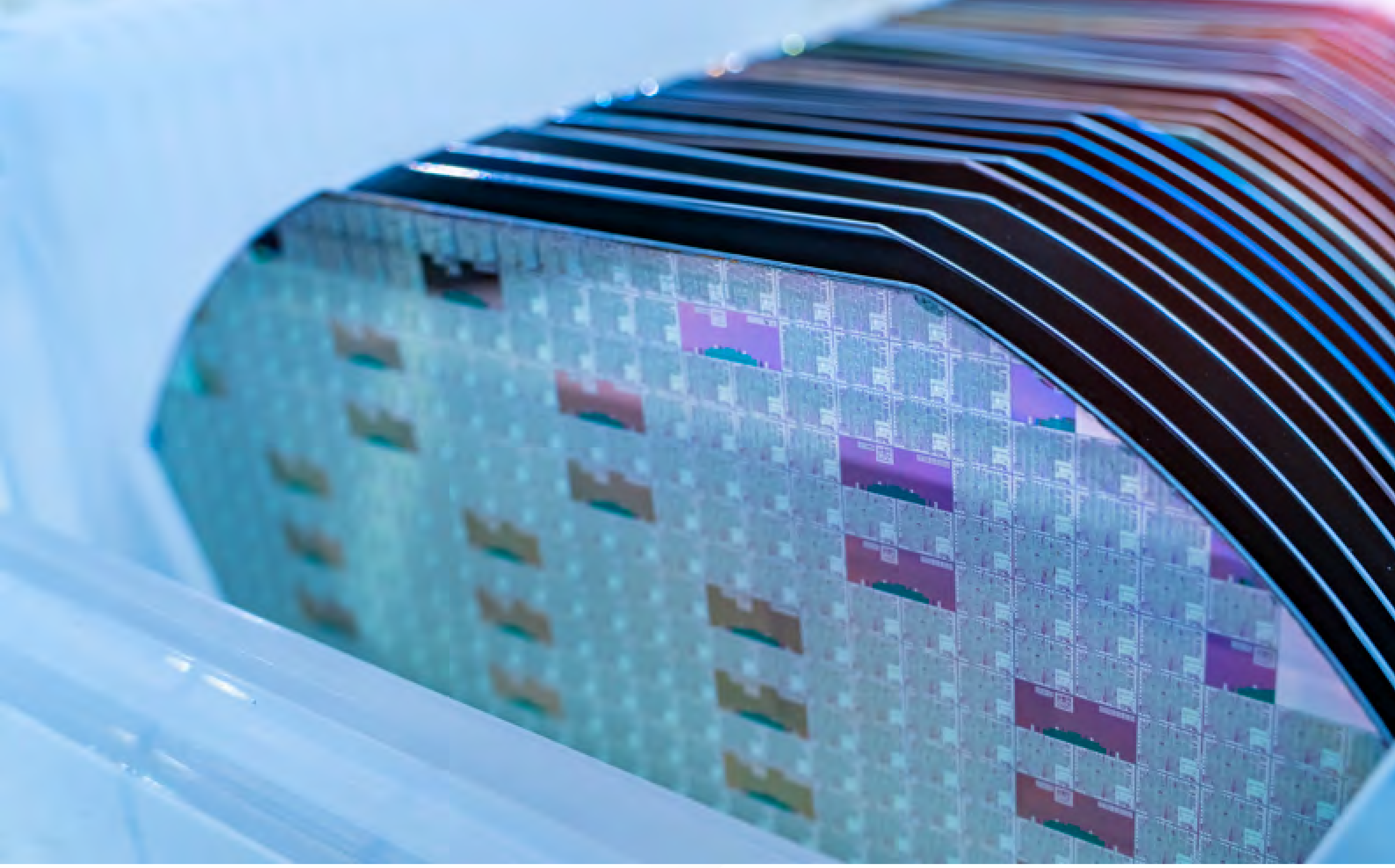
Specialized beam deflection units like our SUPERSCAN IV 20 SOLAR can offer ***an answer to the increasing field sizes of the photovoltaic industry.***

Wolfgang Lehmann
Head of Product Management at RAYLASE

Specialized beam deflection units like RAYLASE's SUPERSCAN IV 20 SOLAR can provide an answer to the growing field sizes in the photovoltaic industry. The 20mm lightweight mirrors ensure high scanning dynamics, and its specific line scanning tuning allows for a fast maximum speed of 200 rad/s. And Wolfgang Lehmann reveals: "We are in **close cooperation with renown optics manufactures and photovoltaic experts** to offer a fully matched scanning solution that covers the complete M12 wafer, while **keeping the spot size at the required 15 microns in the entire field**." This innovation enables solar cell producers to shift to larger wafers without sacrificing production rates.



△ ***Figure 3:*** *New beam deflection units enable laser processing of M12 solar wafers. (Left) Laser systems with f=255 mm focal length cannot cover the larger field sizes required for laser fabrication of M12 solar wafers. (right) With a shift to a longer focal length of f=330 mm, the larger field size becomes possible. Shorter wavelengths and the larger scanner mirrors compensate for the increased spot diameter.*



Clark Lee summarizes: "With such a system, the producers of solar cells **can upgrade their production lines to the next generation of wafers** and significantly enhance PERC and TOPCon solar cell production. The use of M12 size solar cells ultimately leads to a reduction in the price per module, supporting the ongoing demand for cost-effective solar panels and the producers of solar cells **gain a price advantage** when competing with their solar modules."

And as a result, solar energy will become increasingly affordable and accessible, further driving the global transition to renewable energy sources.

HEADQUARTERS:

RAYLASE GmbH
Wessling, Germany

+49 8153 9999 699
info@raylase.de

SUBSIDIARY CHINA:

RAYLASE Laser Technology (Shenzhen) Co.
Shenzhen, China

+86 755 28 24 8533
info (at) raylase.cn

SUBSIDIARY USA:

RAYLASE Laser Technology Inc.
Newburyport, MA, USA

+1 978 255 1672
info@raylase.com

WE ARE HIRING

FOLLOW US

STATUS 09/2023