


# Cost-Effective Production of Thin-Film Solar Modules

## Allegro Laser Scriber by LPKF SolarQuipment





In musical terminology, Allegro means fast. LPKF Allegro systems perform at high speed with absolute precision. Imagine a solar fab to be a great orchestra. LPKF Allegro laser scribing systems would be world class players perfectly contributing to the overall goal, the 'grid parity.' LPKF strives to provide the most productive and reliable equipment to the solar industry – all while keeping on the cutting edge of development. LPKF's engineers and technicians are committed to reaching this goal.

# Commitment to Results

## Profitability Counts

Producing ultra precise structures on large, damageable substrates is a challenging task. Thermal deformations arising between laser scribing steps only increase the level of difficulty.

Ultra precise structuring with the Allegro laser scriber allows module efficiencies to be increased as much as physically possible.

Allegro laser scribers are exceptionally economical in terms of investment and operation, and offer the highest possible throughput. Innovative, field-tested

concepts compensate for virtually any deviations from the optimal cell geometry across the entire process chain and establish the basis for solar modules with maximum efficiency.

As part of the LPKF group, LPKF SolarEquipment benefits from recognized competences in laser, control and drive technology, extensive knowledge in laser micromachining and access to a worldwide service and distribution network. Many Allegro series laser scribers are already successfully being used in 24/7 manufacturing.



### Highest Throughput

A compact, multi-beam head enables maximum acceleration and speed, reducing the laser scriber cycle time. One scribing head move produces

multiple structures at the same time. Substrate handling processes are parallelized to the greatest possible extent, which increases the machine's throughput and reduces production costs.



### Optimum Availability

Allegro laser scribers are designed to be robust, low-maintenance and easy to service. The systems feature maintenance-free air bearings for

feeding glass and the movement of the machining head, long-life laser sources and pre-aligned optical and mechanical components. This effectively minimizes both scheduled and unscheduled downtimes, increasing system availability.



### Maximum Module Efficiency

The weakest cell greatly impacts the overall performance of the module. Producing an ultra precise layout with uniform cell size distribution in the

P1 step is critical. The subsequent P2 and P3 lines are accurately aligned and positioned based on this master. Using an ultra precise Allegro system for the P1 scribing and Allegro's Dynamic Path Tracking technology for the P2 and P3 scribing significantly extend the active module area for maximum module efficiency.



### Cost Efficiency

Optimized machine dynamics, precision laser scribing and the minimum-cost machine concept make Allegro laser scribers an exceedingly

cost-effective solution for producing thin-film solar modules.



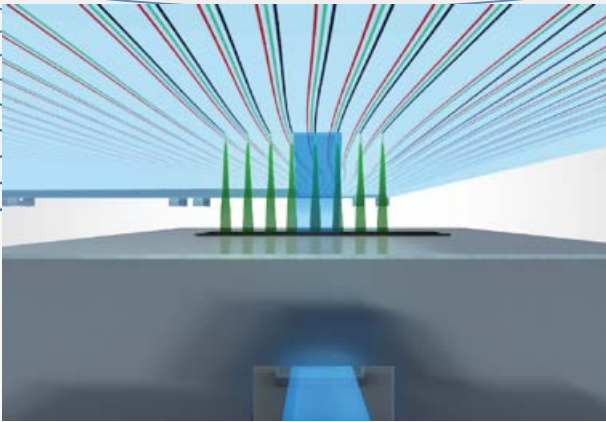


## The Heart of the System – the Scribing Head

A solid machine base provides precision, dynamics and reliability. The actual laser scribing is done by the moving laser machining head, the heart of the Allegro system.

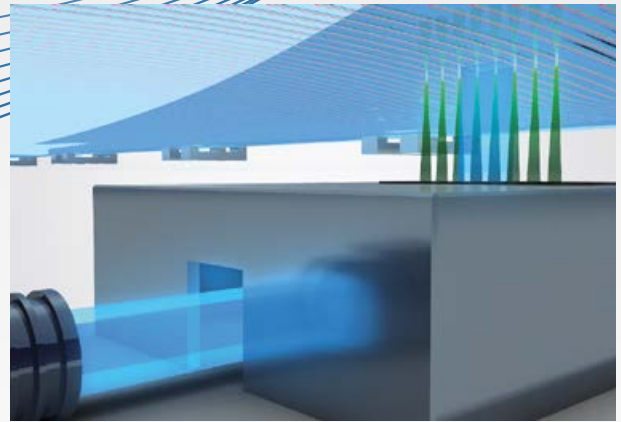
The Allegro implements the concept of moving the dynamically optimal component and combines key functions in a compact design. It arranges several parallel laser beams and focuses them on the film to be laser scribed.

This approach allows an array of intelligent and cost-effective solutions to maximize the module's efficiency, minimize the so-called dead zone and stabilize the scribing process.



### Dynamic Path Tracking

Dynamic tracking in steps P2 and P3 minimizes the spaces between individual scribing tracks. During scribing a sensor determines the position of the previous track and corrects all beams in the scribing head. The close spacing of the laser beams in the machining head allows exact scribing using only one sensor to determine the previous track position. Dynamic Path Tracking reduces the safety clearance required and maximizes module efficiency at minimal technical expense.



### Dynamic Focus Tracking

Wavy substrates from thermal processing or small process windows impair laser scribing results by reducing module efficiency and process stability. Dynamic Focus Tracking keeps every laser beam in its focal plane on the module during scribing. This leads to optimal scribing results on wavy substrates or small process windows without increasing system complexity.

Allegro laser scribers tolerate changes in the shape of the glass within the manufacturing chain. They compensate for distortion and warping due to thermal factors. This eliminates time-consuming and costly substrate conditioning steps prior to laser scribing.



### The SolarMaster GUI

In addition to the Allegro's hardware, the system's graphical user interface (GUI) is a key factor impacting ease of use. The SolarMaster features an intuitive GUI developed based on multiple ergonomic aspects. This facilitates operation and setting of production recipes while helping avoid operating errors. Furthermore, the tool setter is equipped with special supporting functions to quickly determine optimal process parameters. The SolarMaster offers three different user levels to help manage access: operator, tool setter or service level.

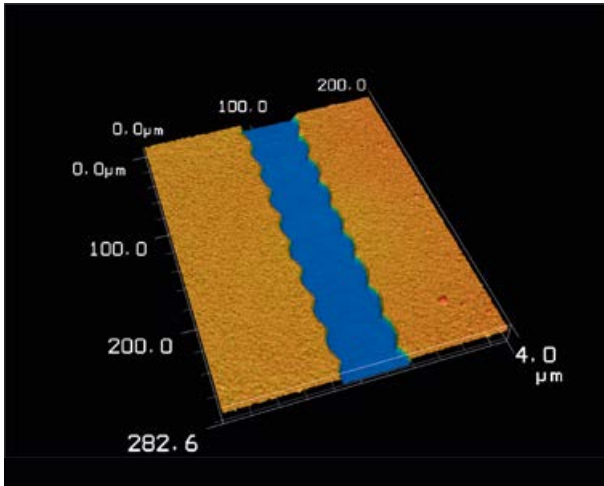
# Application Development

A specialized LPKF SolarQuipment GmbH team develops processes and optimizes parameters for all scribing tasks in CdTe, aSi, aSi/ $\mu$ Si, CIS, CIGS technologies, taking into account cost-efficiency and technological aspects. The applications lab features a variety of laser sources, near-production system technologies and analytical systems such as SEM and Laser Scanning Microscope in order to implement customer applications. The application team also helps further develop the Allegro laser scriber.

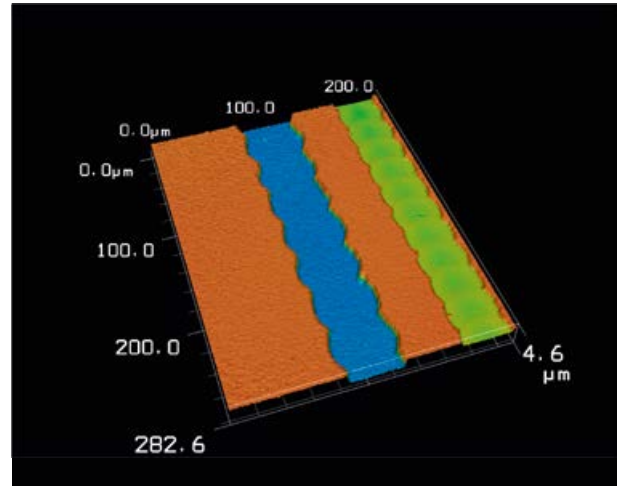




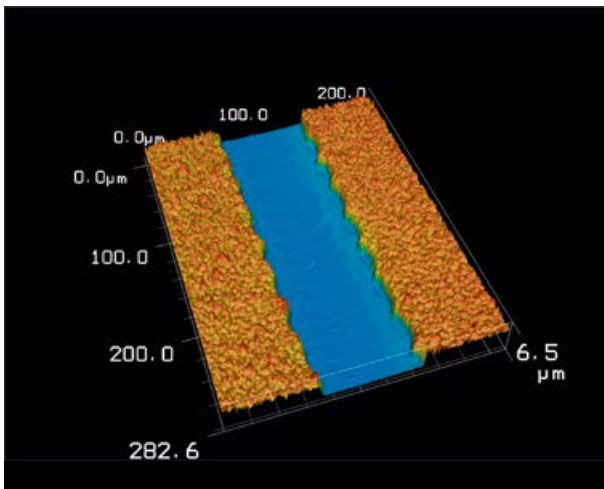
## Application Examples



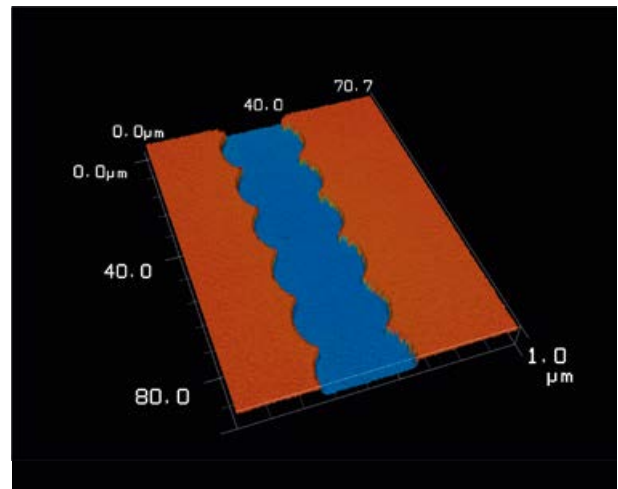
Zinc oxide (ZnO) UV-machining in aSi/μSi: No burr at the track edge or glass damage at track widths of about 30 μm.



Selective absorber removal with 532 nm during the P2 scribing step in aSi/μSi: No flaking, no damaging of the TCO.



Selective absorber and back contact removal with 532 nm in CdTe P3: No TCO damage.



Molybdenum processing with optimized pulse duration in CIGS P1: No glass damage, no cracks in the glass or molybdenum, no burr at the track edge.

LPKF SolarEquipment GmbH provides highly sophisticated products. It combines specialized skills in laser technology, control and drive technology with extensive experience in micromachining materials by laser.

The company belongs to the LPKF network with branches and agencies throughout the world. Four production plants in Europe, additional subsidiaries in the USA, China, Hong Kong and Japan as well as efficient partners in various countries ensure the company is able to provide customers with technical support worldwide.

<b>Technical Data: LPKF Allegro Series</b>	
<b>Thin-film technologies</b>	CdTe, aSi, aSi/ $\mu$ Si, CIS, CIGS
<b>Laser wavelength</b>	1064 nm, 532 nm or 355 nm
<b>Laser pulse lengths</b>	Picoseconds to Nanoseconds
<b>Scribing line width</b>	20 $\mu$ m – 70 $\mu$ m (depending on wavelength and optical configuration)
<b>Line to line distance</b>	Motor-driven and self-calibrating
<b>Processing</b>	From film or non-film side of glass
<b>Processing beams</b>	Multiple according to customer requirements
<b>Substrate dimensions</b>	Customer specific
<b>Substrate thickness</b>	2 mm – 6 mm (0.08" – 0.24")
<b>Substrate material</b>	Float glass
<b>Particle extraction</b>	LPKF HighVacuum 500*
<b>MES interface</b>	OPC server or SECSGem
<b>Software</b>	LPKF SolarMaster
<b>Additional features</b>	Process integrated quality inspection Dynamic Path Tracking Dynamic Focus Tracking

\* High-vacuum extraction and filtration system with filter cleaning, dust collection in a barrel, filter and barrel exchange optimized for harmful dusts, HEPA filter optional.

**LPKF SolarEquipment GmbH**

Mittelbergstraße 17 98527 Suhl Germany

Phone +49 (0) 3681-8924-0 Fax +49 (0) 3681-8924-44

info.solar@lpkf.com www.lpkf-solarequipment.com



Made in Germany