

## In-line/Off-line I-V Curve Tracer for Thin-Film Solar Modules before Lamination

The Dr. Schenk I-V Curve Tracer measures the I-V curves of thin-film modules before lamination. The fully automated system is based on a proprietary LED illumination technology which enables an evaluation of the electrical characteristics of the entire thin-film panel, as well as the detection of local variations. It enables uniquely electrical characterization by:

- Space-Resolved Measurement
- Wavelength-Resolved Measurement
- Irradiance-Resolved Measurement

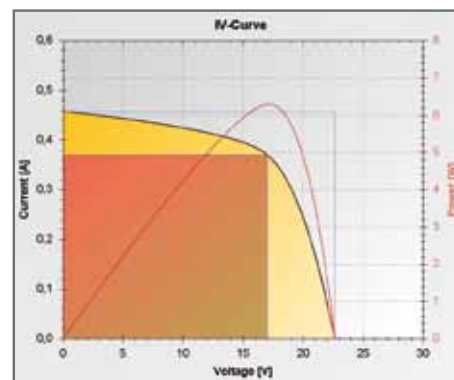
Unlike conventional flasher-tests, this measurement can be performed in-line before the lamination step and can, thus, serve as a GO/NO-GO tester to decide whether a panel is further processed.

By correlating the measurement results of the I-V Curve Tracer with data from preceding indirect optical measurements (e.g. local defects, layer thickness, haze etc.), this innovative solution serves as a valuable process control tool for the previous production steps.

The system features a three quadrant four point measurement for optimized determination of the serial and parallel resistance as well as an I-V measurement in forward direction without light. The system comes fully automated with handling and a flexible, mechanical contacting mechanism to be integrated into a production line or to be used offline as a stand-alone tool.



*The I-V Curve Tracer from Dr. Schenk*



*The I-V Curve Tracer tests the efficiency of each individual module cell before lamination*

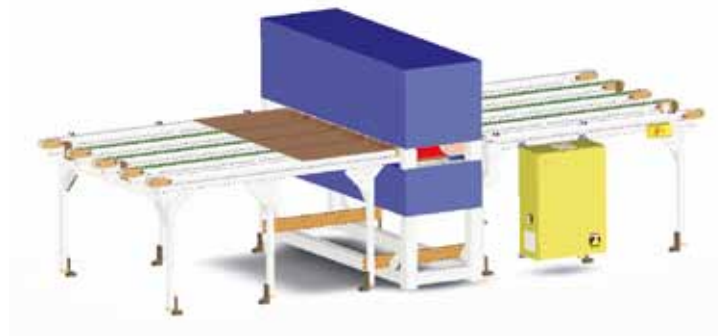
### FEATURES AT A GLANCE

- Modular system design
- Adaptable to all substrate sizes
- Adaptable to any number of cells
- Spatial resolution: e.g. 1,760 measurement areas for a panel size D 1100x1300 mm
- Three Quadrant Measurement
- Measurement Parameters: Voc, Isc, Pmax, FF, Rserial, Rparallel
- Four Point Measurement Technology
- High-performance LED units - nearly maintenance-free due to their long lifetime
- Fully automated system with handling for loading, positioning and unloading
- Mechanical contacting combs
- High durable, easy to exchange probes
- Interfacing via Ethernet or Digital I/O
- GO/NO-GO result via digital I/O (good/bad)
- Detailed measurement analysis with intuitive 3D charts
- Extensive Data Storage functions

## PROCESS CONTROL BY COMBINING OPTICAL AND ELECTRICAL TESTS

Dr. Schenk's metrology solutions SolarInspect and SolarMeasure are supporting thin-film PV module manufacturers to:

- Optimize their processes and gain higher yield
- Improve module quality and performance
- Save production costs



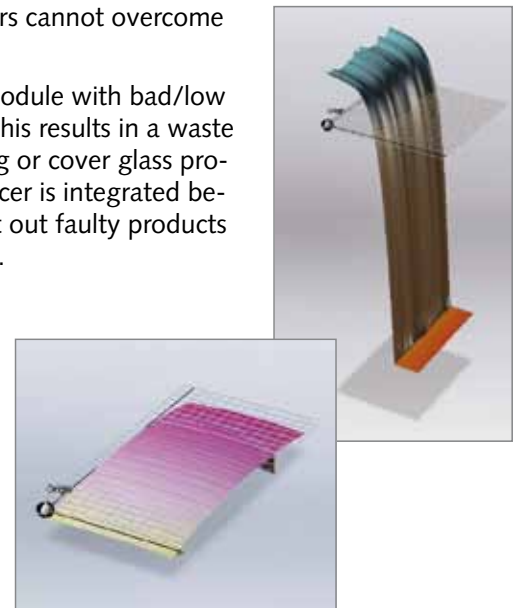
System Design of Dr. Schenk's I-V Curve Tracer

Currently, Dr. Schenk GmbH is the only "total-solution provider" of metrology systems for PV thin-film modules worldwide. Having installed more than 50 systems into running thin-film production lines within the past 3 years, Dr. Schenk's specialized solutions for virtually every processing step along the line are unmatched in the industry. With the I-V Curve Tracer from the SolarMeasure product family, Dr. Schenk GmbH has taken the next step in thin-film metrology.

"Indirect metrology tests", for example the measurement of pinhole density, layer thickness or haze monitoring, enable the manufacturer to evaluate the module quality and give an early warning as soon as a process step no longer meets the preset tolerances. These indirect measurements alone cannot make a prediction about the final electrical efficiency of the solar panel. As today's sun simulators or flashers are installed only at the very end of the production line when low quality modules have already gone through expensive back-end processing, Dr. Schenk has developed a unique innovation that is complimentary to flashers but enables an early feedback on the module efficiency!

Dr. Schenk's I-V Curve Tracer meets three challenges that flashers cannot overcome and is therefore the perfect addition to every thin-film line.

- As flashers are installed at the end of the production line, a module with bad/low efficiency can only be sorted out after complete processing. This results in a waste of expensive process capacity and material, e.g. for laminating or cover glass processing. In order to avoid this loss, Dr. Schenk's I-V Curve Tracer is integrated before the lamination step and enables the manufacturer to sort out faulty products before the module is sent on to cost intensive back-end steps.
- Whereas a flasher test can only deliver one efficiency result for the entire panel, the I-V Curve Tracer measures space-, wavelength- and irradiance-resolved and can, thus, identify the exact position or cell of an irregularity.
- By matching these detailed efficiency results with data from the indirect measurements of the SolarInspect and SolarMeasure systems along the production line, manufacturers can make immediate and long-term correlations between local defects and panel efficiency. These correlations enable manufacturers to define and optimize process criteria as well as quality rules for each production step. Corrective actions can be taken as early as possible and production costs can be reduced.



Next to the 2D display of I-V curves per measurement point, the analysis software offers intuitive 3D charts of the results - cell by cell or for a cell row.

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