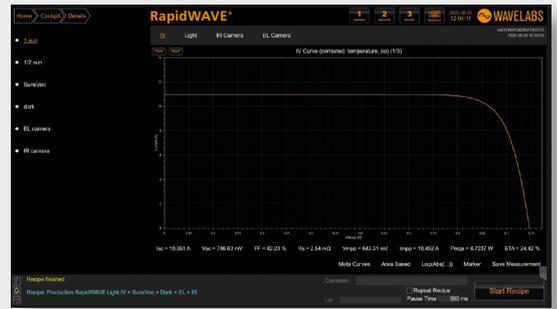




RapidWAVE®

# LED's ENHANCE YOUR SOLAR SIMULATOR



## RapidWAVE®

Precise and fast I-V characterization of high-capacity cells

RapidWAVE® is the patented WAVELABS solution to ensure the fast, precise and accurate I-V measurement of high-capacity solar cells (HJT, TopCon, PERC, IBC, HBC) in production lines.

RapidWAVE® enables companies to maintain and even further accelerate throughput rates in modern cell fabs in a simple and economical way despite the capacitance hysteresis of high-performance cells.

### FEATURES

**Fast high-precision I-V measurement**

**Easy implementation and upgrade**

**Ensuring high throughput of high-efficiency cells in production**

“ RapidWAVE® is the first reported solution that achieves I-V classification of a 745 mV solar cell in less than 30 ms with verified accuracy. ”



Dr. Bernhard Mitchell, Deputy Director Product Development

WAVELABS is a proud partner of:



## THE CHALLENGE: HOW TO ENSURE PRECISE I-V MEASUREMENTS OF HIGH-CAPACITY CELLS?

**HJT, TopCon, PERC, IBC and HBC are high-voltage cell designs that enable the PV industry to produce solar cells with efficiencies beyond the natural threshold of conventional c-Si cells of approximately 30%. But their advanced designs come with a challenge for commercially profitable and scalable production:**

Cells with open-circuit voltages greater than 680 mV cannot be measured accurately with a steady-state I-V sweep without strongly compromising throughput and thus increasing costs. The precise and accurate measurement of their I-V curves requires longer voltage sweep times of several hundred milliseconds. For commercial manufacturing, this entails critical questions of profitability. However, to ignore this requirement would result in incorrect measurements, sorting and very likely complaints from customers (see Fig. 1).

Over the years, several work-arounds have been introduced to address the problem, including diode fitting, voltage pulses, slow dark I-V sweeps as well as multiple flashes. While these achieved the precision needed, they lacked two fundamental capabilities required under modern manufacturing conditions: simplicity and speed.

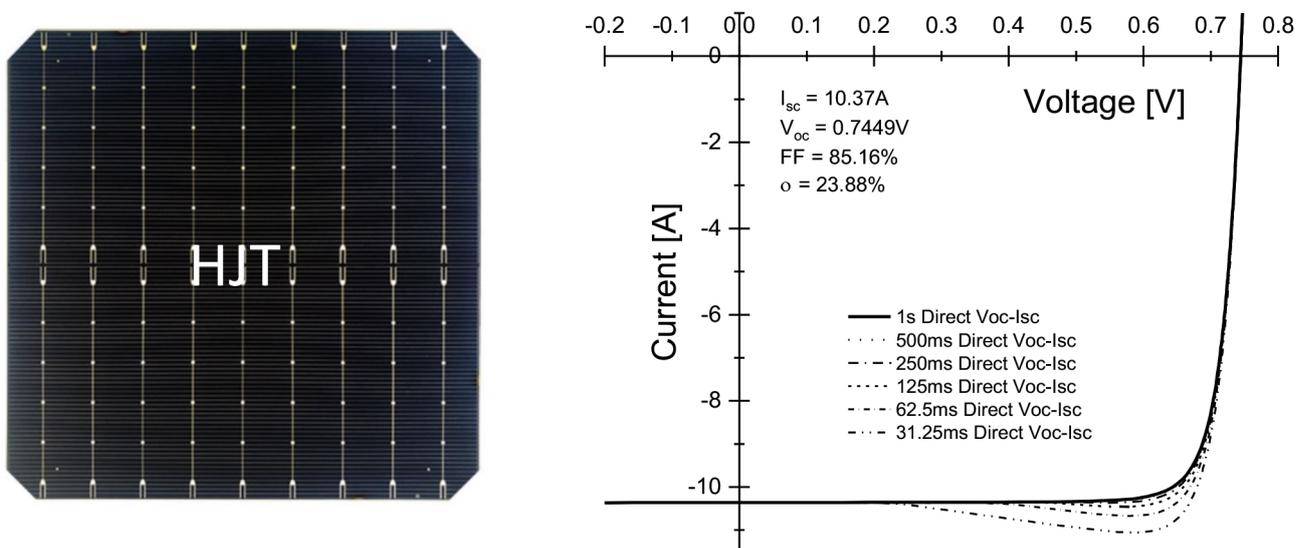
Thus, to ensure correct efficiency sorting as well as profitability of high-capacity cells, manufacturers need a flasher solution that provides precise I-V curve measurement without increasing the sweep time.



## BACKGROUND: WHY DOES SWEEPING HIGH-CAPACITY CELLS TAKE SO LONG?

To measure the exact and reproducible I-V curves of solar cells, which determine a cell's efficiency class and thus its price, the cells need to reach a steady state. A steady-state sweep is achieved when the distribution of excess carrier profiles within the cell arrives in their equilibrium state regarding the respective terminal voltage applied.

The lifetime of excess carriers in the increasingly popular n-type cell designs is particularly long. As a result, the time required to reach a steady state rises and with it the measurement times and flash times of those cell types.



» **Fig. 1:** With standard flashers, high-capacity solar cells like HJT cells (left) require longer I-V sweep times of about 1 second (right), resulting in unacceptable delays in production and reduced cell throughput per hour. The dotted curves highlight that shorter standard flashing of high-capacity cells results in non-steady-state I-V curves that are undesired for efficiency rating and binning.

## THE SOLUTION: EFFORTLESS AND ECONOMICAL I-V MEASUREMENTS WITH RAPIDWAVE

**RapidWAVE**® is the only commercially available solution for the precise I-V measurement of high-capacity solar cells with verified accuracy. That reduces the steady-state sweep time to the industry standard for mass production (Fig. 2). High-voltage solar cells that otherwise would need I-V sweeps of 1000 ms to measure the steady-state efficiency can be accurately classified within only 30 ms with the **RapidWAVE**® solution (Fig. 3).

While methods like equivalent circuit modeling, eqz voltage pulses, slow dark I-V sweeps and multiple flashes are mere work-arounds that require a change in measurement design and longer sweep times, **RapidWAVE**® is an enterprise-ready software solution that calculates the I-V curve by integrating the specific behavior of high-capacity cells into its algorithm.

In a nutshell, WAVELABS' patented **RapidWAVE**® directly encodes cell physics in its advanced algorithm, achieving a precise and consistent mapping of high-capacity cell properties to I-V curve measurements.

**RapidWAVE**® works for all high-efficiency solar cells, including the highest voltage heterojunction cells (HJT). It will also be available for cut-cell measurements, utilizing new patent-pending WAVELABS innovation in 2023.

By the way, **RapidWAVE**® is not only valuable to mass manufacturing, but also provides for an easier way to derive accurate STC I-V parameters of high-voltage cells without the need for advanced temperature stabilization typically used in laboratories.

## RAPIDWAVE IS AVAILABLE FOR THE FOLLOWING WAVELABS SOLAR SIMULATORS:



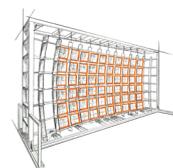
SINUS-300



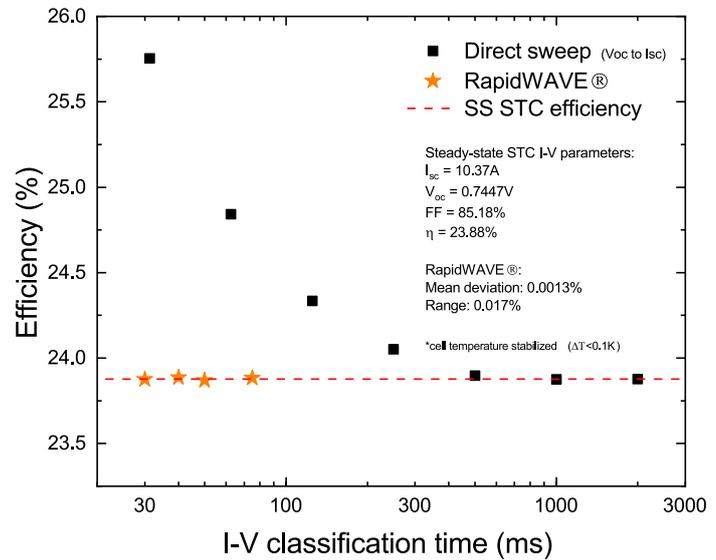
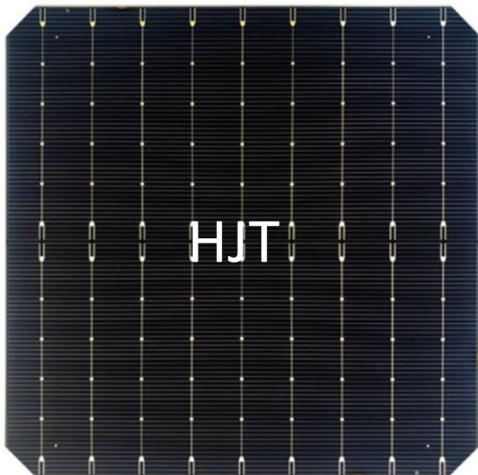
REAR SIDE FLASHER



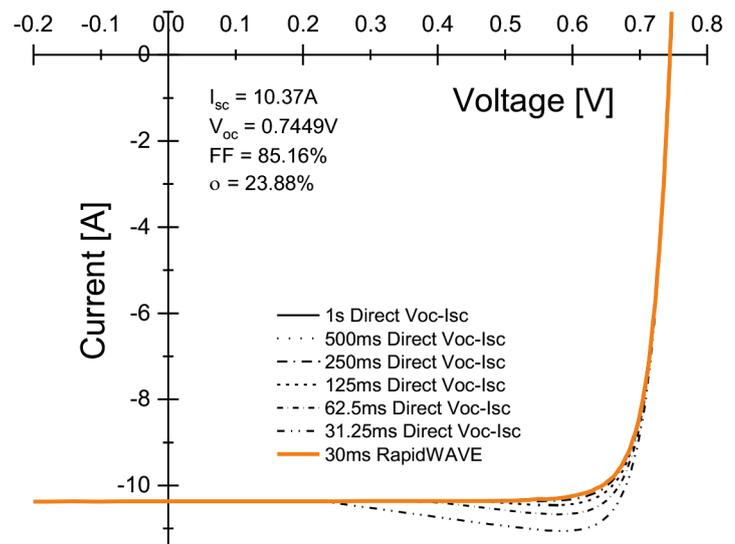
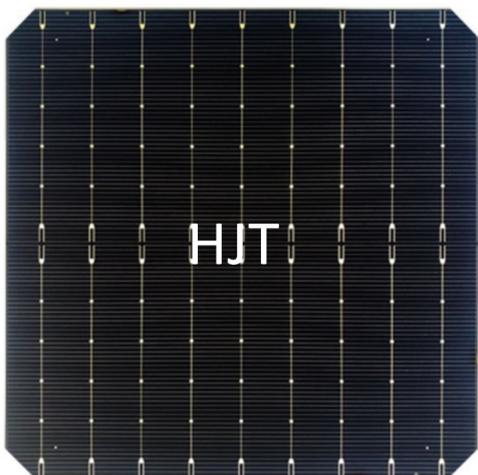
PRODUCTION  
MODULE FLASHER



SINUS-2100



» **Fig. 2:** While the direct sweep with standard flasher technology (black dots) would require a sweep time of 1000 ms, **RapidWAVE®** (orange stars) achieves the same accuracy almost two orders of magnitude faster.



» **Fig. 3:** The I-V curve achieved with **RapidWAVE®** in 30 ms perfectly matches the I-V curve achieved with conventional flasher technology in 1000 ms.

“ SCALE YOUR HIGH-CAPACITY CELL PRODUCTION AND GET IN TOUCH TO ACCELERATE YOUR I-V MEASUREMENTS. ”



## CONTACT

### WAVELABS Solar Metrology Systems GmbH

 Spinnereistr. 7 – 04179 Leipzig, Germany

 +49 341 3375 560

 +49 341 3375 5696

 [info@wavelabs.de](mailto:info@wavelabs.de)