WAVELABS

FLASHBOARD

LED's OPTIMIZE YOUR CELL PRODUCTION

WAVELABS Flashboard

Gain production insights and find the sweet spot of parameter settings

WAVELABS **Flashboard** is the first intelligent, automated big data solution for solar cell production. It enables manufacturers to pinpoint root causes for cell efficiency losses and calculate optimum parameter settings to increase efficiency and reduce variances. The machine-learning-based solution enables rapid and advanced analysis of thousands of data points from across the production line. It is the key to gaining new insights into your production and optimizing processes.

HIGHLIGHTS

- **Gain new production insights**
- **Optimize parameter settings**
- **Automate big data analysis**

> "WAVELABS Flashboard helps cell manufacturers of any size to find out what really affects their cell efficiency losses during production and mitigate the root causes."

Bernhard Klöter,
Lead Data Analysis,
WAVELABS

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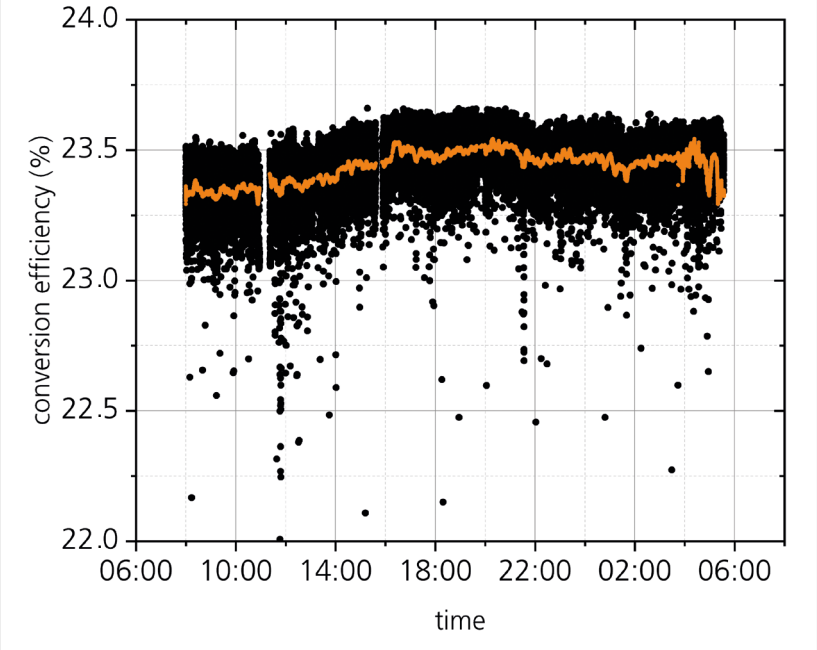
THE CHALLENGE: HOW TO MAKE USE OF YOUR DATA TO OPTIMIZE YOUR SOLAR CELL PRODUCTION?

Solar cell manufacturers have two questions in mind:
1. How do I reduce the costs of production?
2. How do I maximize the efficiency of my cells?

In an ideal world, manufacturers would be able to pinpoint the root cause of strong efficiency variance or insufficient cell efficiency measured at the end-of-line testing. As of today, even while there are hundreds of data points measured during cell production, it is difficult to combine, consolidate and analyze them in a meaningful and insightful way. They are often merely used as a monitoring tool to stay within fixed boundaries defined by either the machine vendor or complicated experiments. In fact, typically only end-of-line data is utilized to address insufficiencies. This is not enough to make production more cost-effective, reduce variance and increase cell efficiency.

Manufacturers generally have sufficient data at their disposal. Analyzing this data from various stages of the production process will enable them to identify patterns and trends that can indicate potential problems or areas for improvement.



» **Fig. 1:** The conversion efficiency of a typical solar cell production day featuring outliers at specific times and an overall changing mean value. The challenge is to understand what triggered those changes.

BACKGROUND: WHY IS IT SO DIFFICULT TO PINPOINT THE ROOT CAUSE OF INEFFICIENCIES AND VARIANCE?

During the production of one solar cell, hundreds of data points are created to monitor the production process. Each data point represents a process step or material characteristic that can have an influence on the final cell efficiency. This data provides the key to optimizing production settings and materials for the best possible cell efficiency outcomes. Still, the devil is in the details because there are many questions to be answered:

- Which parameters are relevant and how strong is their influence?
- What is the real parameter variance (in comparison to the assumption)?
- What is the optimum value for a parameter?
- How do cell physics affect all this?
- How do I prevent getting lost in data?

While the analysis of hundreds of parameters is generally possible, it is very time-consuming and complex due to high dimensionality and multiple interacting variables. To utilize this data, manufacturers need the capabilities to aggregate, correlate and analyze data in an automated, fast and easy-to-handle way. A large amount of data calls for big data solutions and machine-learning-based approaches. So why settle for traditional methods when you can take your data analysis to the next level?

Wafer	Texturing	Emitter diffusion	Selective emitter formation	Clean and rear polish	Front passivation & anti-reflection	Rear passivation & reflection	Metallic contact formation
• Resistivity • Bulk lifetime	• Optics • S_{front} • S_{rear}	• Series resistance • S_{front} • $J_{o,front}$ • Bulk lifetime • Optics	• Series resistance • $J_{o,front}$ • Optics	• Rear optics • S_{front} • S_{rear} • Parallel resistance	• Front optics • $J_{o,front}$ • Bulk lifetime	• Rear optics • $J_{o,rear}$ S_{rear} • Bulk lifetime	• Optics • Series resistance • S_{front} S_{rear} • Bulk lifetime

» **Fig. 2:** There are many parameters that might influence a cell's efficiency. The question is: Which is the most significant?

THE SOLUTION: MAKE PRODUCTION DATA ANALYSIS EASY AS PIE WITH WAVELABS FLASHBOARD

WAVELABS **Flashboard** is a software solution for WAVELABS solar simulators that gives manufacturers the upper hand over their cluttered and overwhelming production data points. Using machine learning allows for the fast analysis of hundreds of parameters and thousands of data points.

It supports the import of any production and parameter data in standard .csv and SQL, making it fit for every production line.

WAVELABS **Flashboard** uses a refined hierarchical 3-step analysis to separate the wheat from the chaff in production big data. This enables manufacturers of solar cells to:

- pinpoint root causes,
- analyze production conditions and settings,
- calculate real parameter variance during production,
- match production parameters to cell technology[1] and
- calculate optimum parameters for the best efficiency outcomes of your cell production.

WAVELABS **Flashboard** provides tried-and-tested automated algorithms that ensure both precise outcomes and easy handling of production data. The time for smart production has come.

WAVELABS FLASHBOARD IS AVAILABLE FOR THE FOLLOWING WAVELABS SOLAR SIMULATORS

SINUS-300

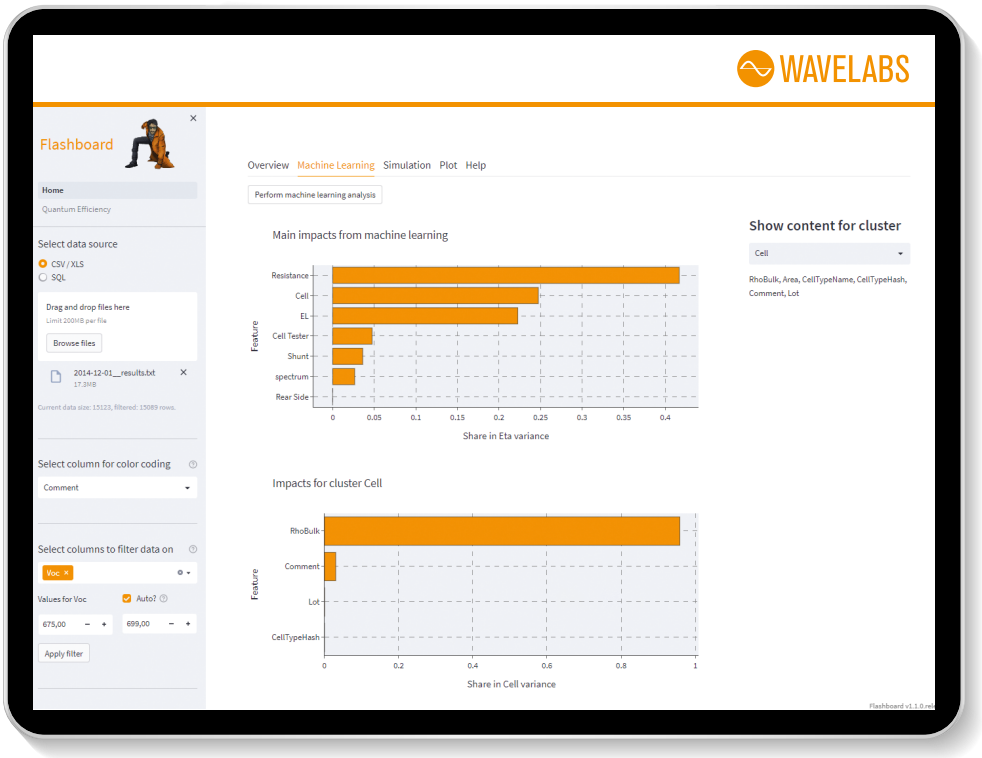
SINUS-360 PRO

SINUS-360 ADVANCED

[1] Basic models for PERC, HJT and TOPCon are available. WAVELABS can also support for individual simulation models in Flashboard.

WAVELABS SOLUTION

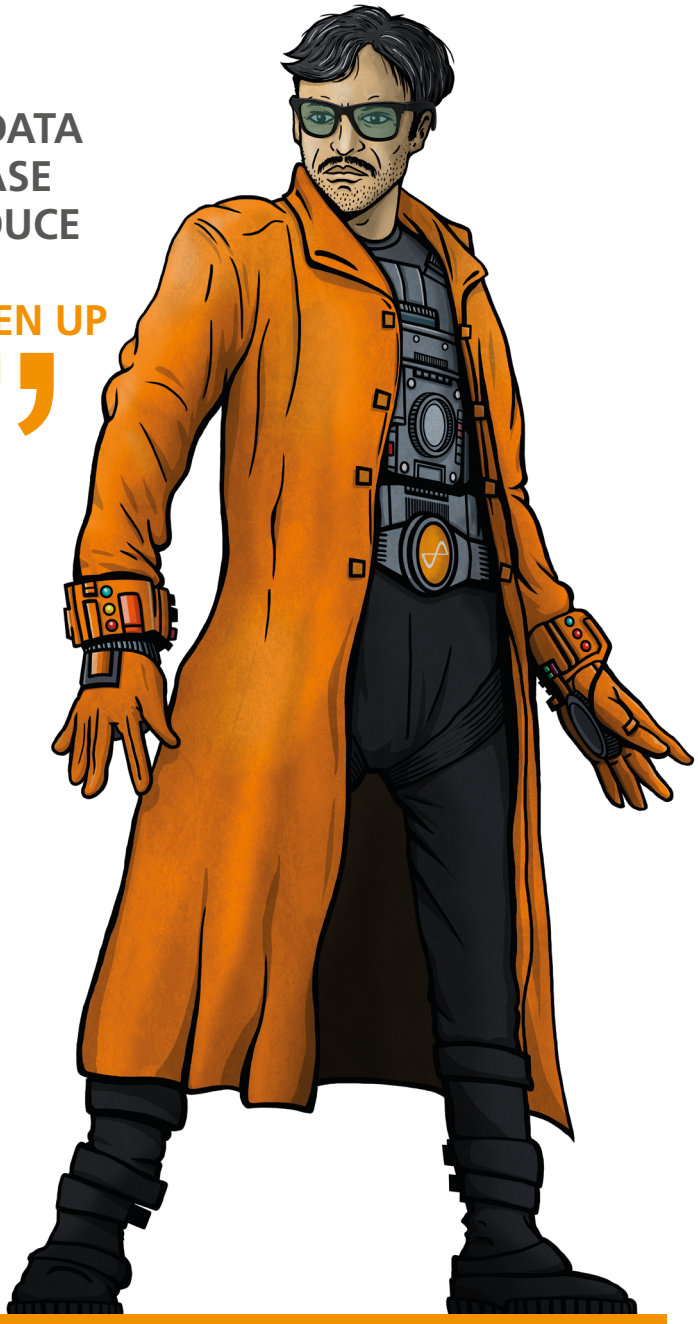
WAVELABS Flashboard enables manufacturers to pinpoint the most significant impact factor in their cell efficiency in respect of the produced cell technology.



WAVELABS Flashboard can also be used on mobile devices.

WAVELABS

"USE YOUR PRODUCTION DATA INTELLIGENTLY TO INCREASE CELL EFFICIENCY AND REDUCE PRODUCTION COSTS. GET IN TOUCH TO SMARTEN UP YOUR PV PRODUCTION."



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