INNOVATE. CONTROL. YIELD.

NEW!
2014 MEASUREMENT & ANALYSIS UPGRADE PACKAGES FOR THE LIS-R2 & LIS-R1



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1. Cell IV package:

- Dark IV and light IV (using monochromatic laser illumination) data acquisition, reporting of common IV curve parameters.
- Suns-Voc;
  - Full area monochromatic illumination of 6” cells with up to 1.2 Suns equivalent illumination intensity.
  - Generation of arbitrary light pulse profiles, enabling optimization of pulse duration to minimize thermal or capacitive effects.
  - Instant feedback on measurement errors resulting from thermal or capacitive effects from hysteresis analysis.
  - Reporting of common implied IV curve parameters (iFF, iVoc, etc). Superior accuracy due to precise control of laser pulse parameters over a wide range.
  - Global series resistance analysis from comparison of Suns-Voc and light IV measurement data.

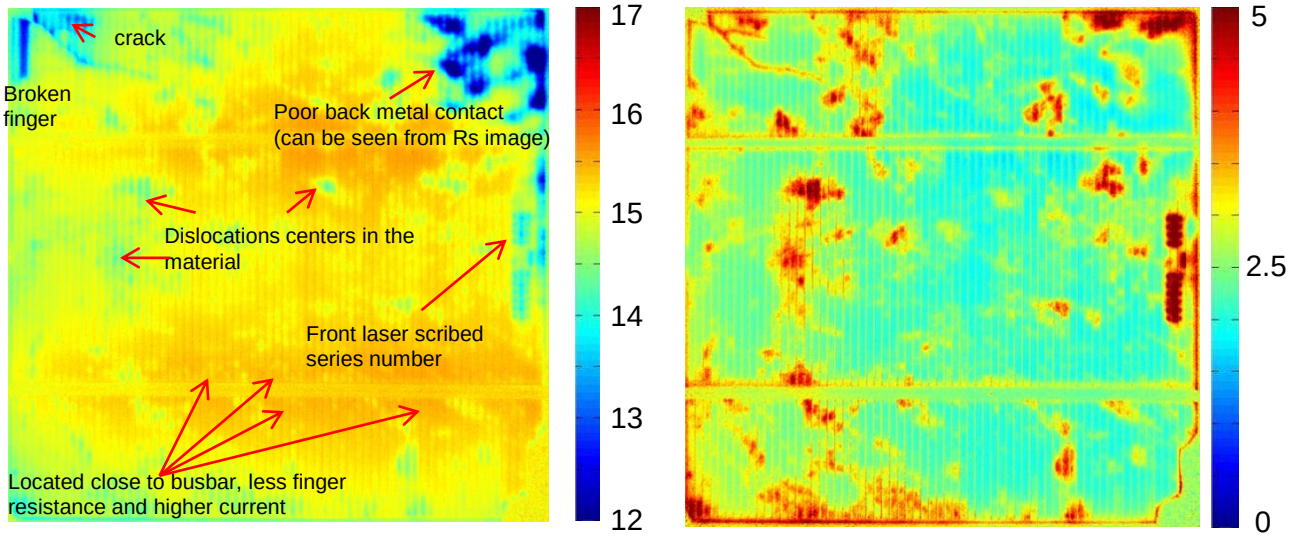


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2. Advanced cell measurement package (beta):

- New measurement methods enable quantitative analysis of local cell parameters and to quantify the impact of local defects on final cell performance.
  - Efficiency image. Although a solar cell only have one overall efficiency value, for each point on the cell, the local efficiency contribution varies. This efficiency image enables quantifying the impact of individual defects on device performance.
  - J_{mpp} image: Local contribution of each cell area to the total current density at the maximum power point. Intuitive quantification of current losses.
  - J_0 image: Local dark saturation current density analysis, separates recombination from other loss mechanisms (e.g. Rs effects).

Example: Efficiency image and J_0 image of an industrial screen printed multi crystalline solar cell.



Efficiency [%]

J_0 [10^{-12} A/cm^2]

Images such as local MPP voltage Vmpp, local open circuit voltage Voc, local power density Pmpp can also be generated simultaneously with customer's special request.

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When the cell efficiency image is viewed with J_0 and R_s image, the power loss due to the following problems can be found and estimated. Root cause can then be backtracked.

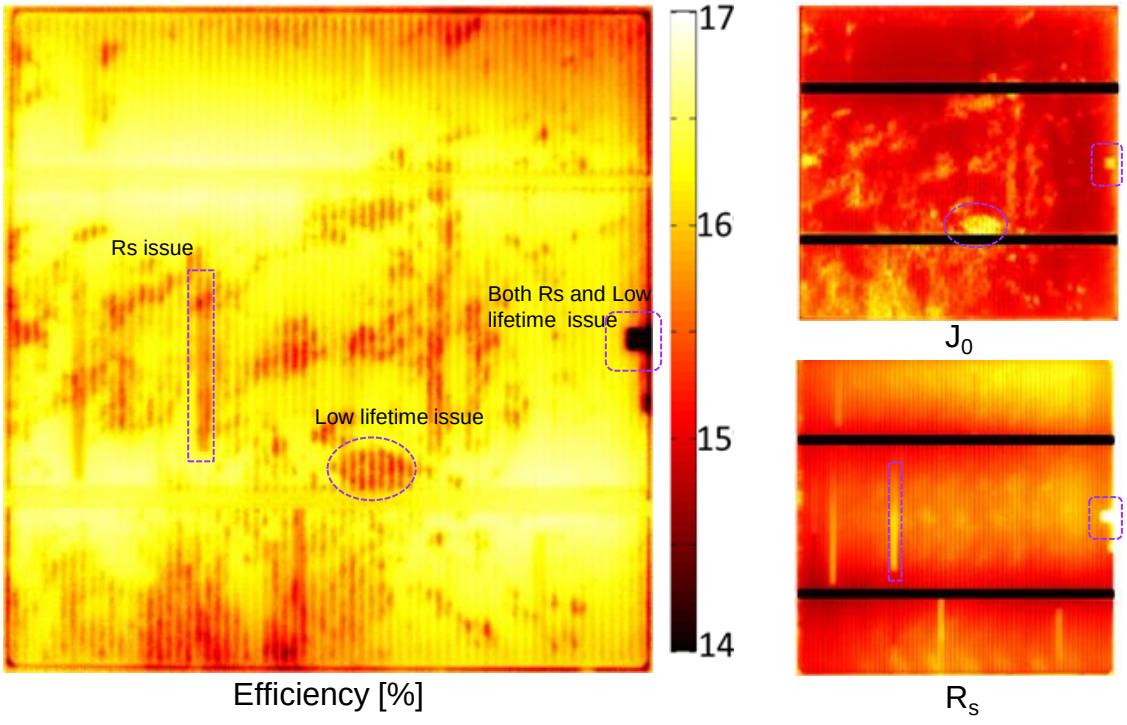
The resistive loss caused issues (can be clearly seen in R_s image)

- Broken finger
- Bad back metal contact (belt print etc.)
- Bad front metal contact
- Finger resistance (long distance current travel within the finger)
- Cell edges
- Non-uniform diffusion
- Etc.

The electrical loss caused issues (can be clearly seen in J_0 image)

- Bad passivation
- Defects in bulk material, such as grain boundaries, recombination centers and etc,
- Bad emitter/junction quality
- Non-uniform diffusion
- Etc.

- Find efficiency reduction issue types and backtrack the root cause.
- Compare how severe each problem is and decide troubleshoot priority
- Fine tuning the processing parameters to push the efficiency limit.

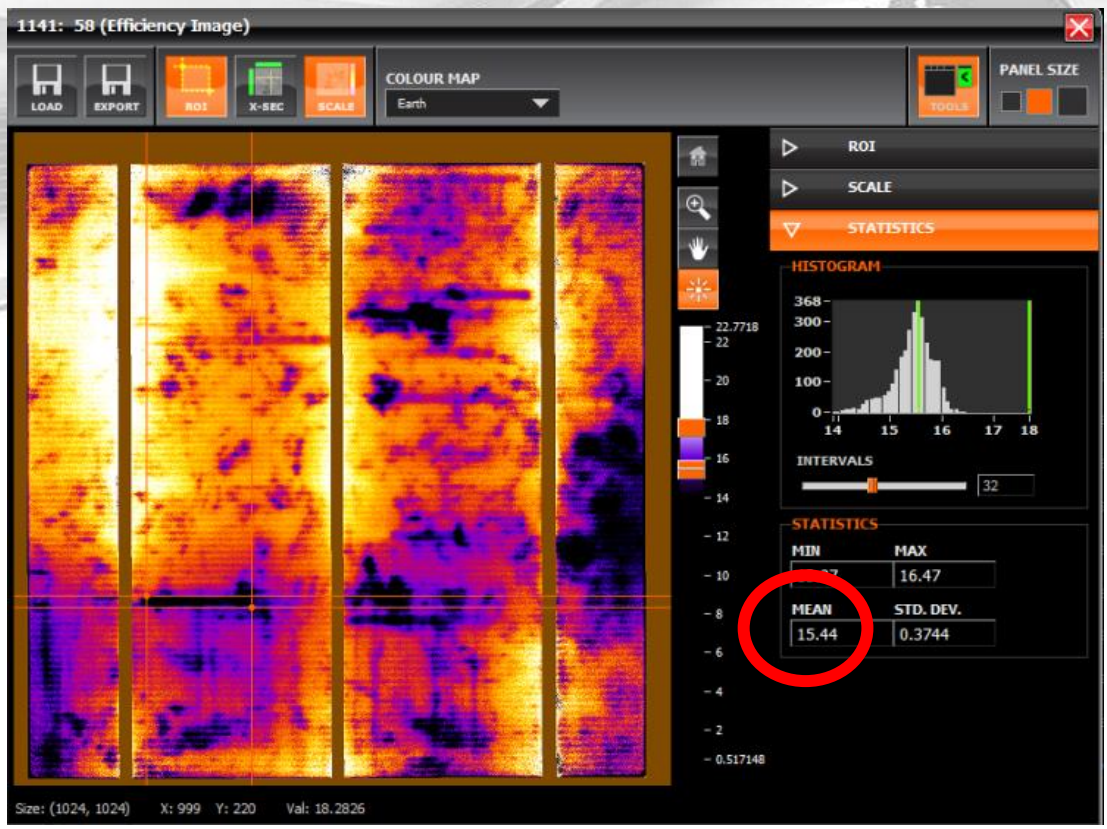


Efficiency [%]

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Easily find the efficiency loss of each problem. For example, the selected area below is a broken finger area. This area only has an average efficiency of 15.44% compared to an efficiency of 17.24% of a good area in this cell. Therefore, the absolute efficiency loss in this area is 1.8%.



By this, efficiency loss caused by different problems on the cell can be compared. The manager can decide

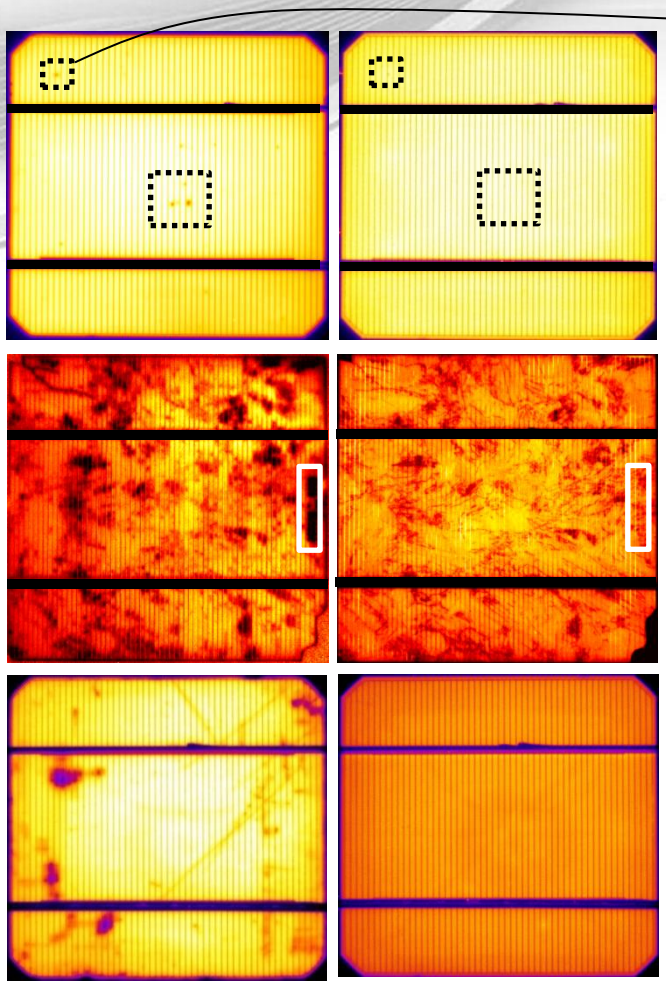
1. which problem should be solved first.
2. whether it is worth to solve this problem by understanding how much efficiency can be saved from solving this problem.

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3. Front and bulk separation package:

By comparing the two images we calculate, the front and bulk quality can be separated. Three samples are given below. It can be seen at the bottom that the left and right image measure different vertical the regions of the cell.





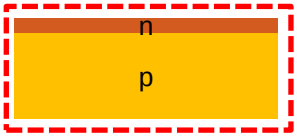
Microscope front view with a magnification of 200. Contaminants can be seen.

The two images measures two different regions, the difference represents the front quality. The extra points in the left image is caused by defects in the front.

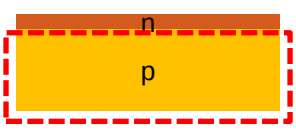
The defects in the right image represents the bulk and rear quality. The extra obvious defect in the left box is located in the front. In fact it is caused by laser tagged series number.

The extra defects in the left box are caused by processing since they don't exist in the right image. Also from the right image we know that the wafer didn't have obvious defects.

front + bulk + rear quality



bulk + rear quality



The region each image measures is in red box.

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Front and bulk separation explanation

As can be seen, the right image doesn't include the junction. Therefore, For researchers, it is helpful to know where exactly the defects are.

In the production line, the rear quality for most of the cells are very uniform, therefore, in some situations, the right image can also be called wafer quality reverse image. It finds the wafer quality of the cell before it was made.

Also, the front defects that is represented by the difference of the two images are usually caused by processing. This is because most of the processing such as diffusion, anti-reflection coating, passivation, screen printing and metal grid firing happen in the front. The rear back surface field are usually very uniform and not as critical.

So in conclusion, for most of the cases, the difference between two images is usually caused by processing. The right image usually checks the raw wafer quality.

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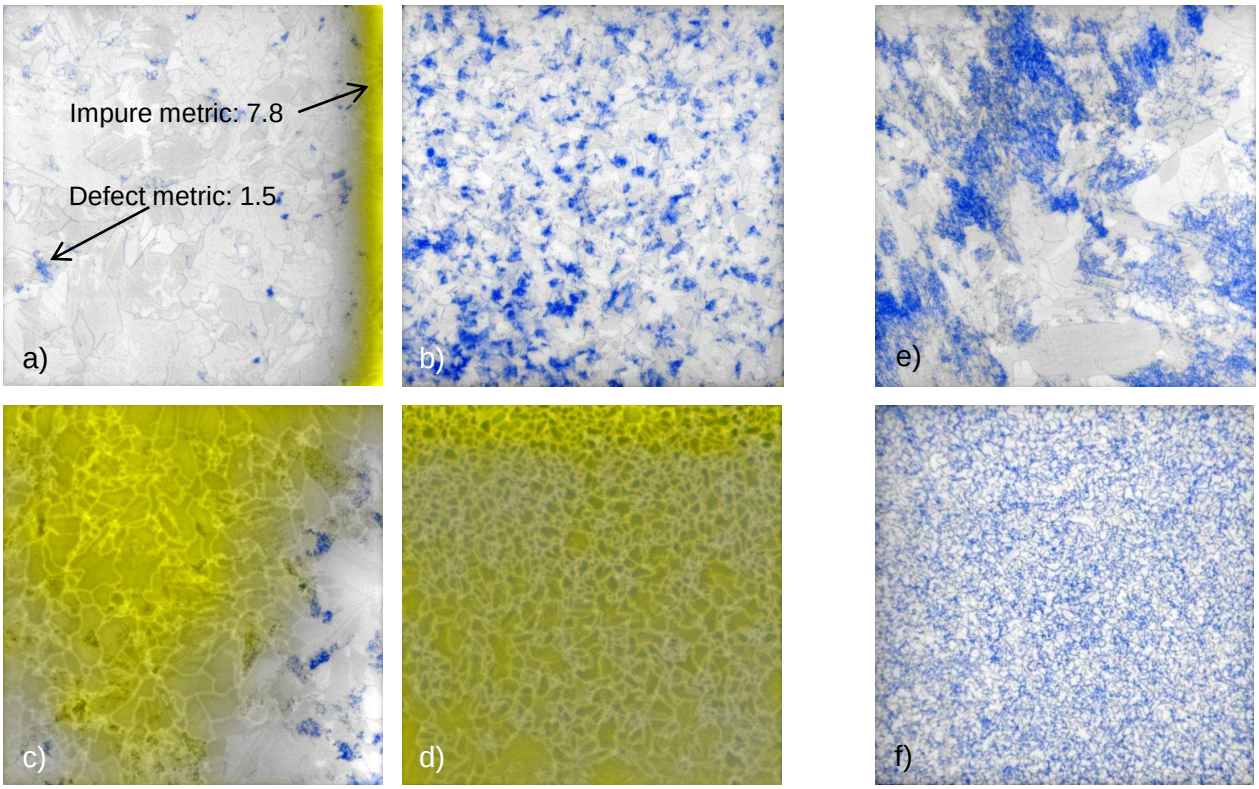
4. Multi-crystalline wafer algorithm package:

- Use the latest algorithms from our market-leading inline wafer inspection systems for analyzing as-cut wafer quality on your LIS-R1 or LIS-R2.
- Quality control and systematic process improvement for wafer manufacturers.
- Incoming wafer quality control and line optimization for cell manufacturers.
- Evaluation of BTi's automated PL imaging based wafer sorting solutions using your existing LIS-R1 or LIS-R2.
- Reporting of defect metric and impure metric for multi crystalline and for high performance multi-crystalline wafers.
- Batch export of analysis results.
- Export of PL images as JPGs with color overlays.

Find the impure and defect metrics to determine the wafer quality

Yellow: impure
Blue: defects

High performance multi-crystalline wafers



a) Edge wafer with low defect density, b) centre wafer, c) transition wafer, d) fully impure wafer.

e) Normal multi wafer, f) cast mono wafer

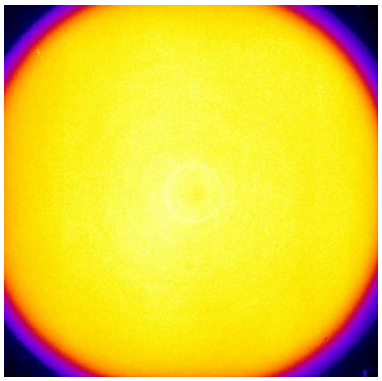
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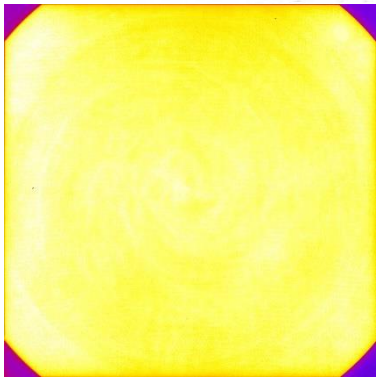
5: Mono-crystalline Wafer Analysis Package:

- Cropping of pseudo-square wafers and calculation of metrics for active cell area.
- Ring defect strength (RDS) metric[1] to quantify dark centers or dark corner wafers.
- Dark Corner area (DCA) metric.
- Striation metric.
- Crack detection (total number, position, length).
- Customizable automated report generation.

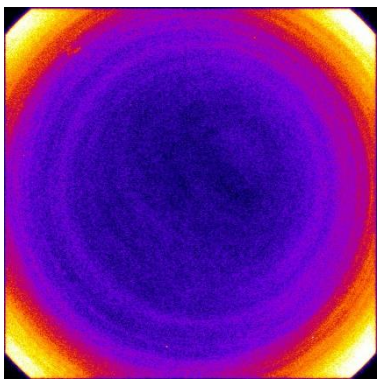
Examples: Ring defect strength (RDS)



Dark rings near wafer edge, RDS < 0



Uniform wafer: RDS ~ 1



Dark centre: RDS > 1



Crack detection

[1] J. Haunschild et al., "*Cz-Si wafers in solar cell production: Efficiency limiting defects and material quality control*", Photovoltaics International **15**, 40-46 (2012).

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