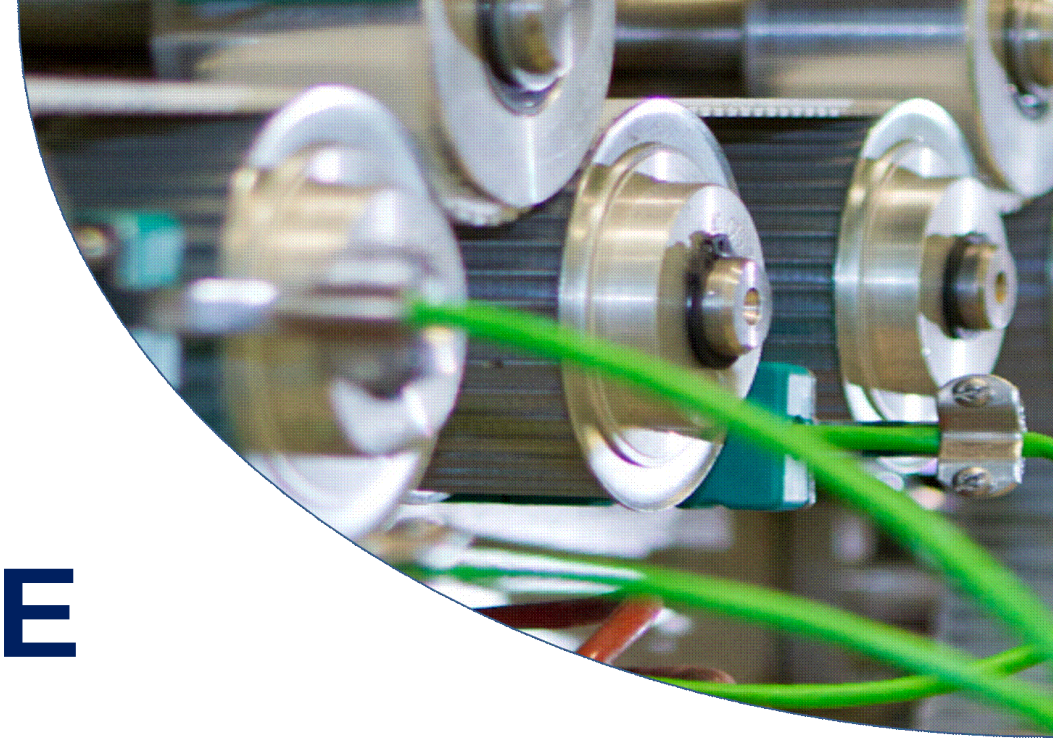

SOLLIANCE

An R&D cluster bringing thin film solar energy technology to excellence

SOLAR RESEARCH
SOLLIANCE

IN-SITU MONITORING OF THE DEGRADATION OF CIGS SOLAR CELLS

Mirjam Theelen

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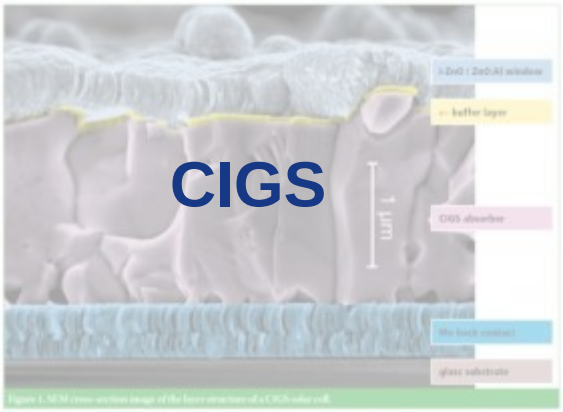
On behalf of Hielkema Testequipment

tim@hielkematest.nl

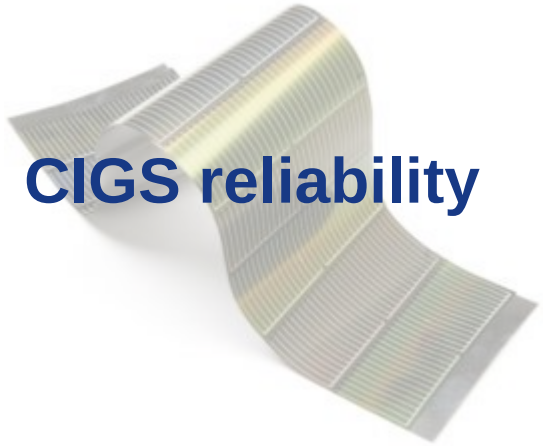
hielkema TESTEQUIPMENT B.V.
Temperature (& humidity) chambers

SOLAR RESEARCH
SOLLIANCE

Solliance

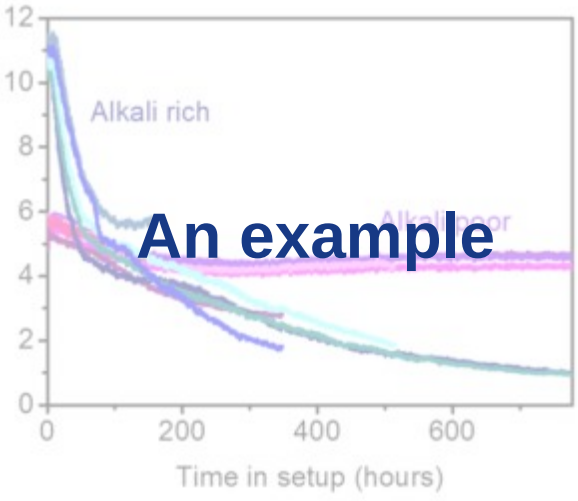


CIGS



CIGS reliability

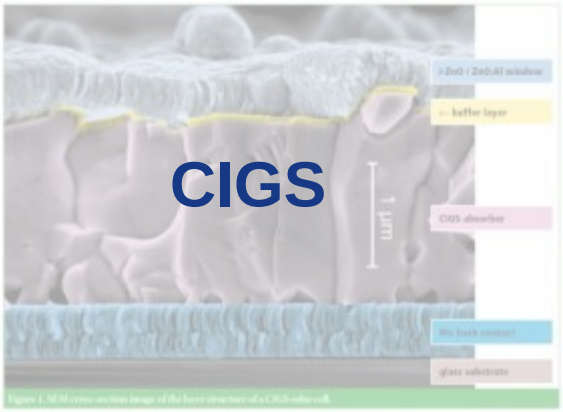
In-situ monitoring



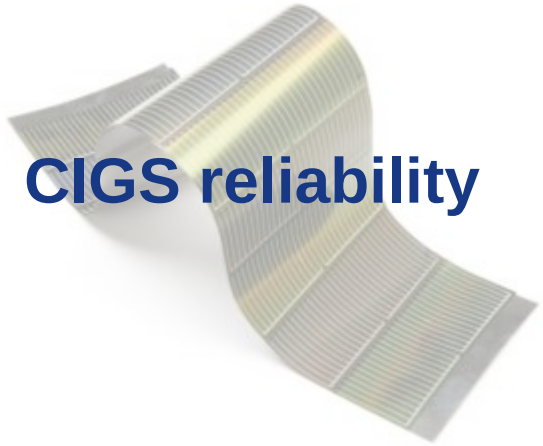
An example

Conclusions & outlook

Solliance

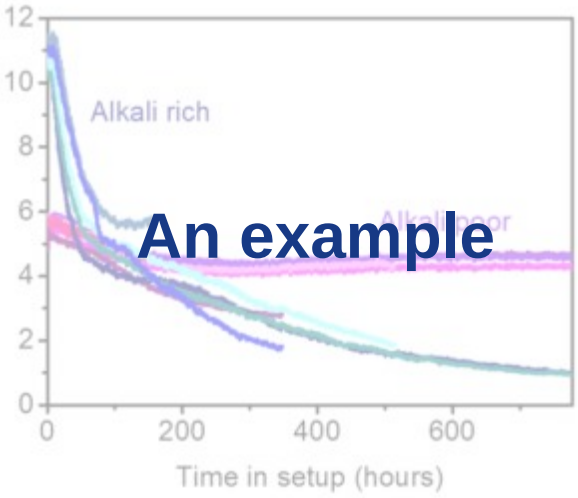


CIGS



CIGS reliability

In-situ monitoring



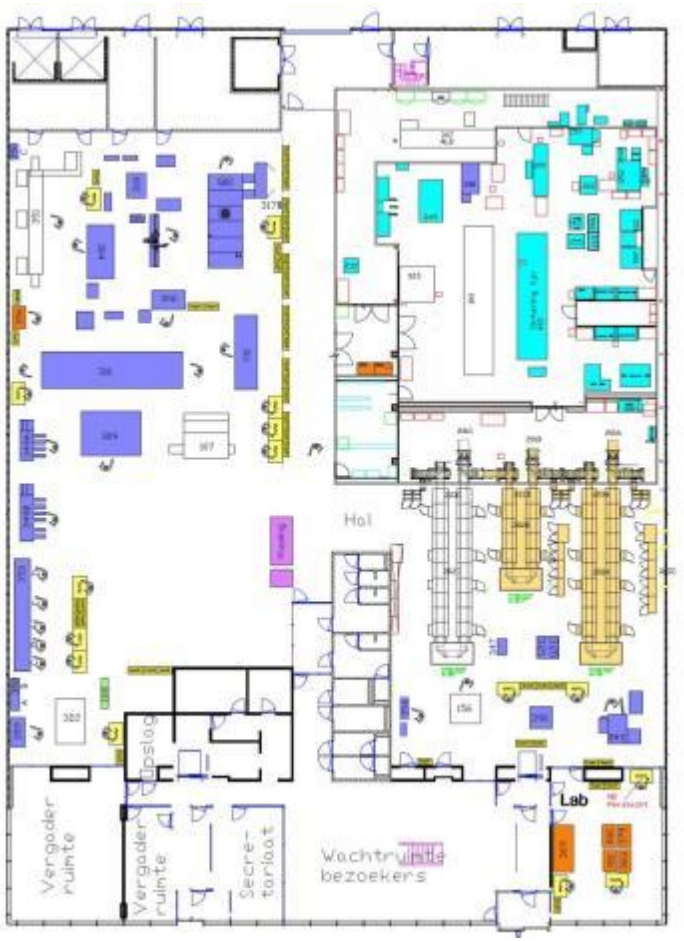
An example

Conclusions & outlook

Solliance: Cross border PV collaboration

- Thin film PV R&D
- Over 250 researchers
- Close collaboration with industry

Solliance Facilities



- >6000m^2 TF-PV Labs
- Coevap, Sputtering and ECD for CIGS
- Stable CIGS reference-line 15% @ 10x10cm
- R2R process line for OPV/OLED/Perovskites
- Analysis equipment
- Ability to exchange process steps

R&D

CIGS

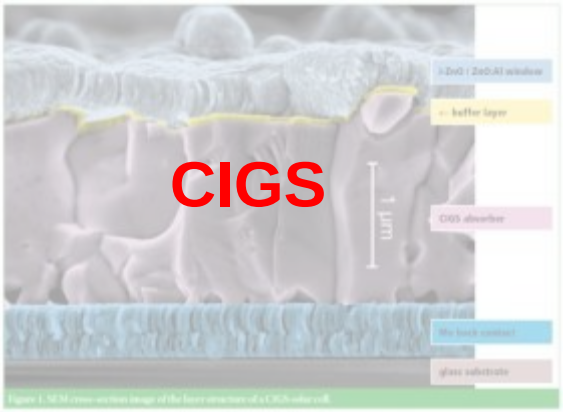
Spatial ALD

Back-end interconnection

OPV/perovskite printing

Reliability

Solliance



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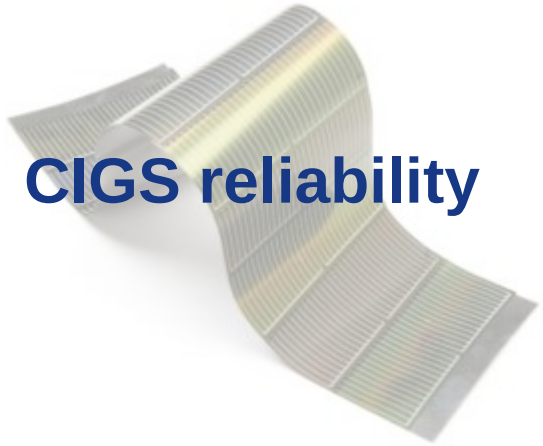
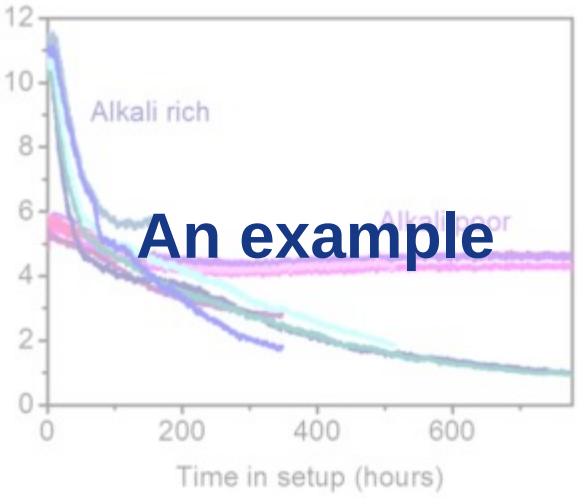


CIGS reliability

In-situ monitoring



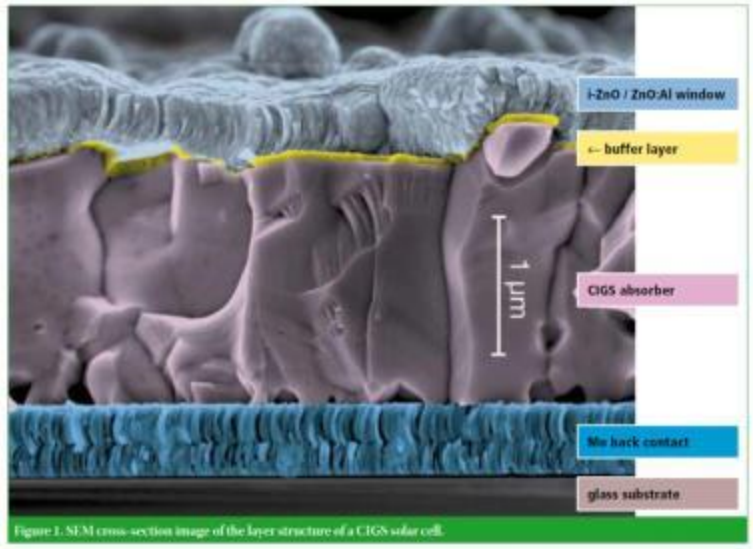
An example

Conclusions & outlook

CIGS solar cells

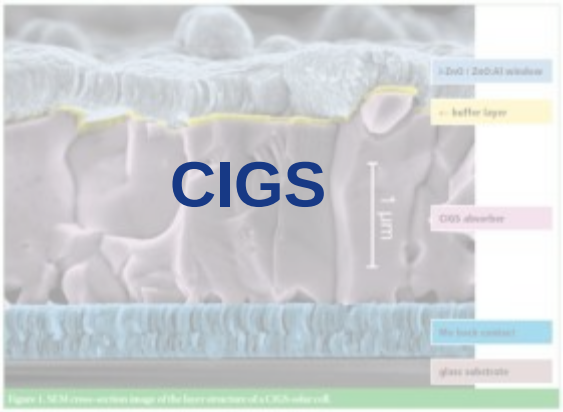
- Material of copper indium gallium selenide / sulphide – $Cu(In,Ga)(Se,S)_2$
- Thin film ‘flexible’ PV
- High efficiencies (21.7%)

3-5 micron



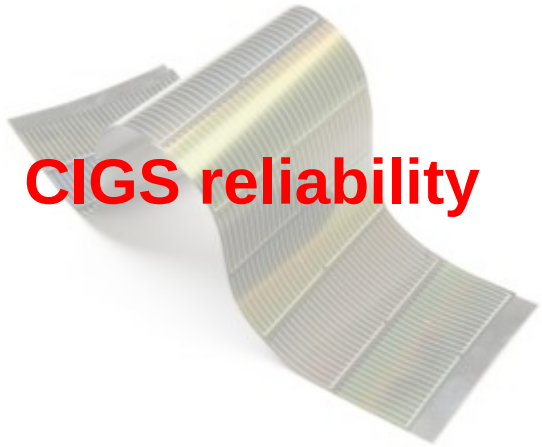
Friedlmeyer 2010

Solliance

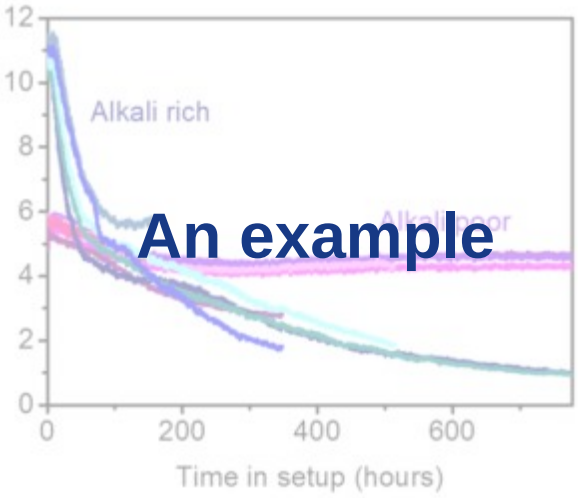


CIGS

CIGS reliability



In-situ monitoring



An example

Conclusions & outlook

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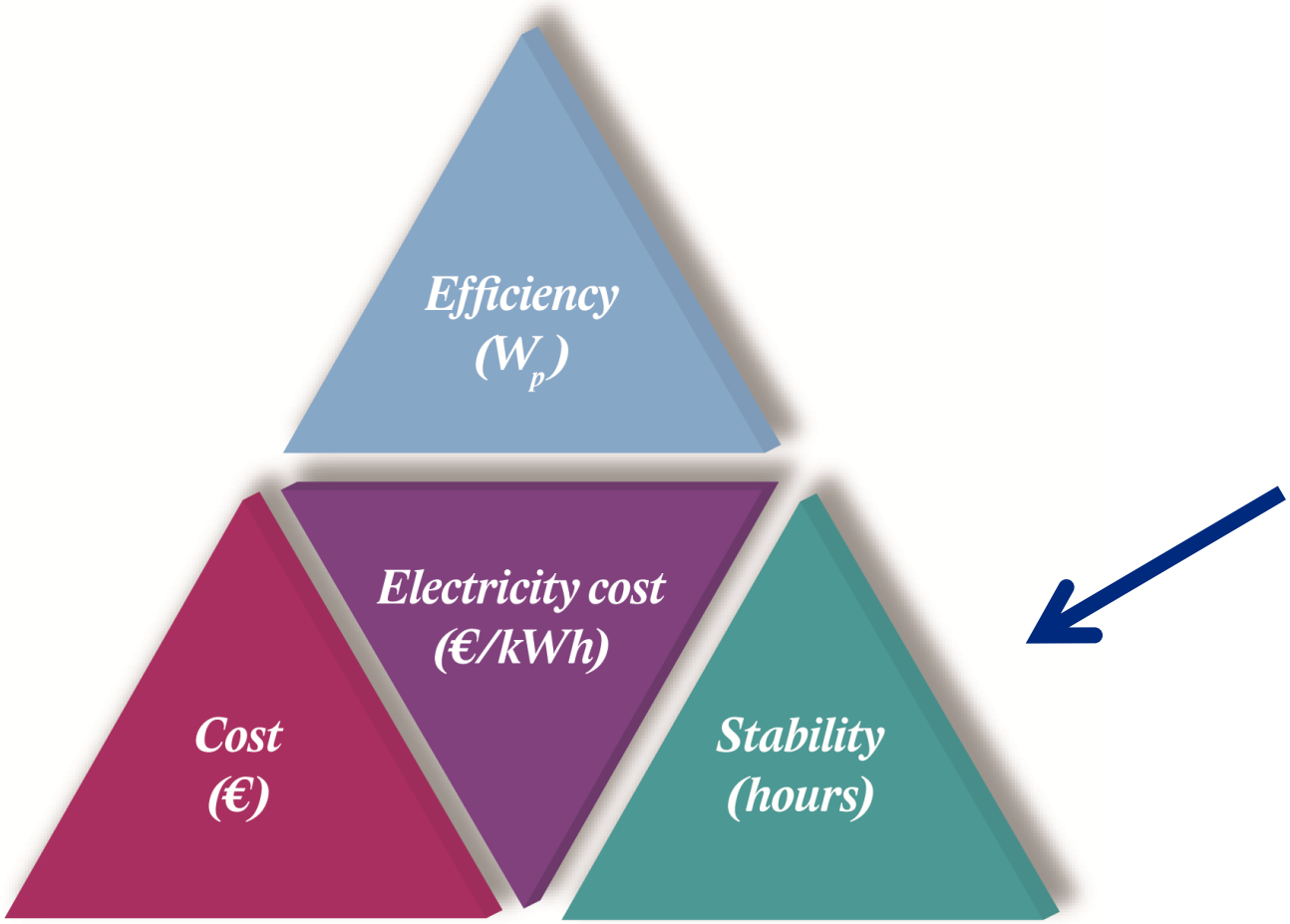
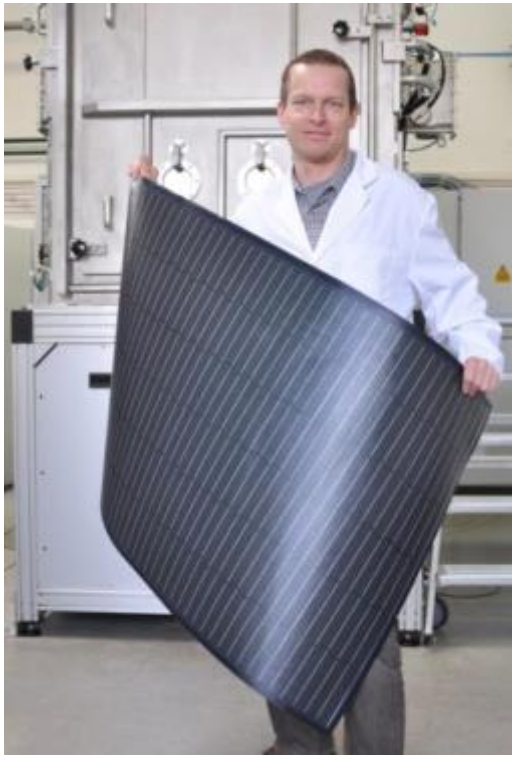
SOLLIANCE

What is the lifetime?

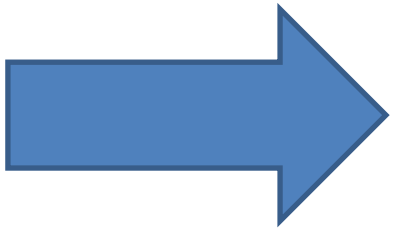


Limited field testing for thin film PV



New types of thin film PV, like CIGS, are coming to the market

ALT for CIGS: Is it valid?



The environment conditions stay the same

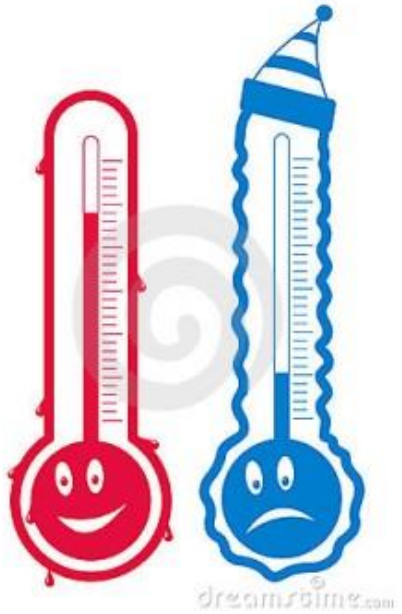
The degradation mechanisms might change

CIGS: degradation enhanced by moisture

Degradation driven by moisture ingress

IEC: 1000 h @ 85ºC/85% RH = 25 y Miami

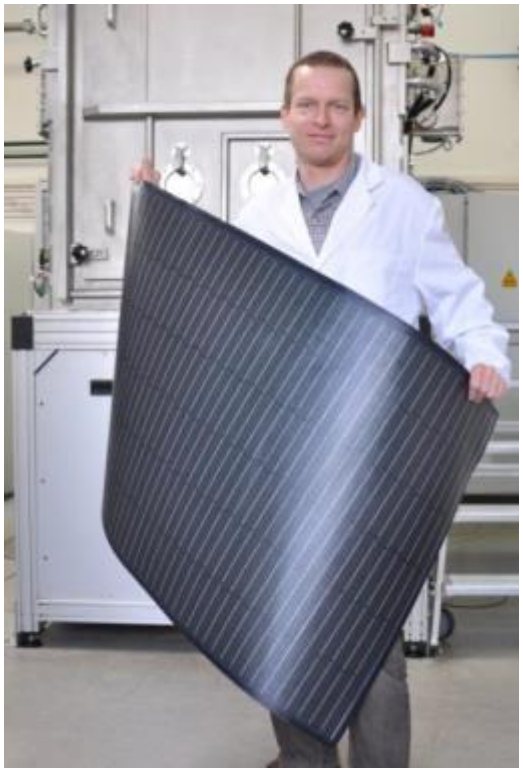
Also impact of temperature and bias



CIGS: degradation enhanced by moisture

The lifetime of CIGS is strongly dependent on the water barrier:

- **Glass**
- **Expensive inorganic/organic multistacks**



Braun – CIGS workshop 2011

Instead: make more stable CIGS

Find the bottlenecks in CIGS modules

Unprotected samples

3-5 micron

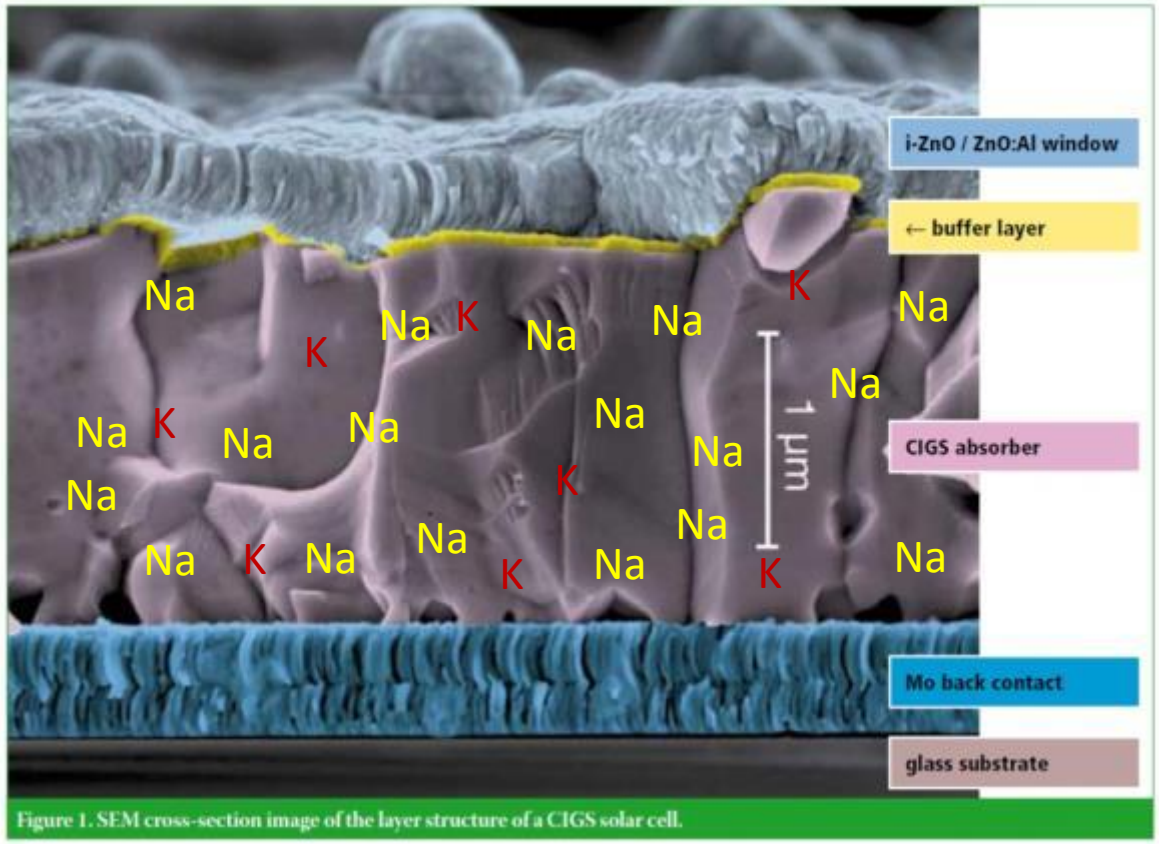
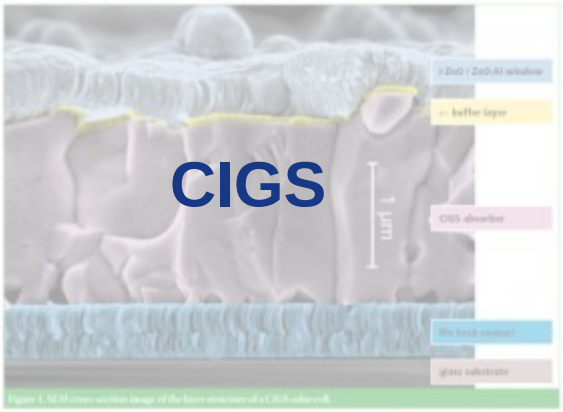


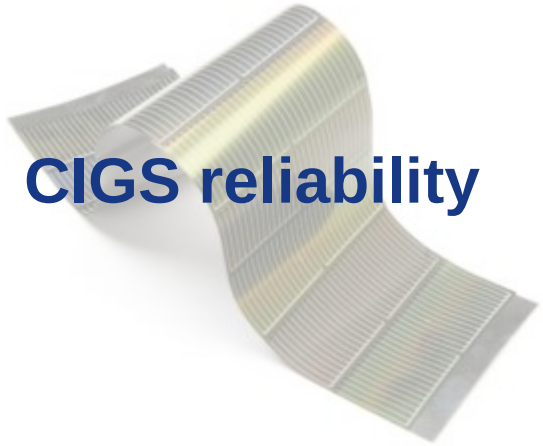
Figure 1. SEM cross-section image of the layer structure of a CIGS solar cell.

Friedlmeyer 2010

Solliance

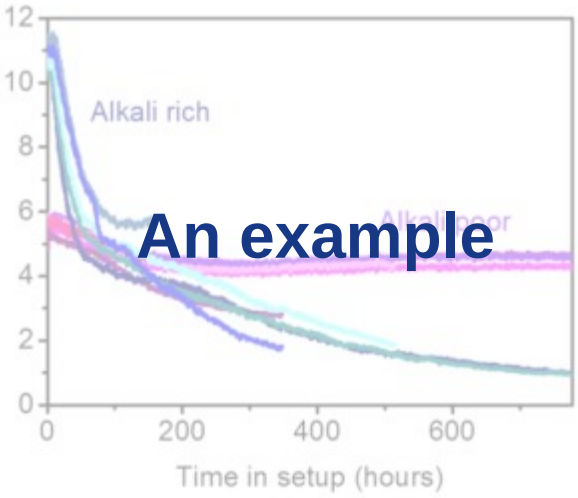


CIGS



CIGS reliability

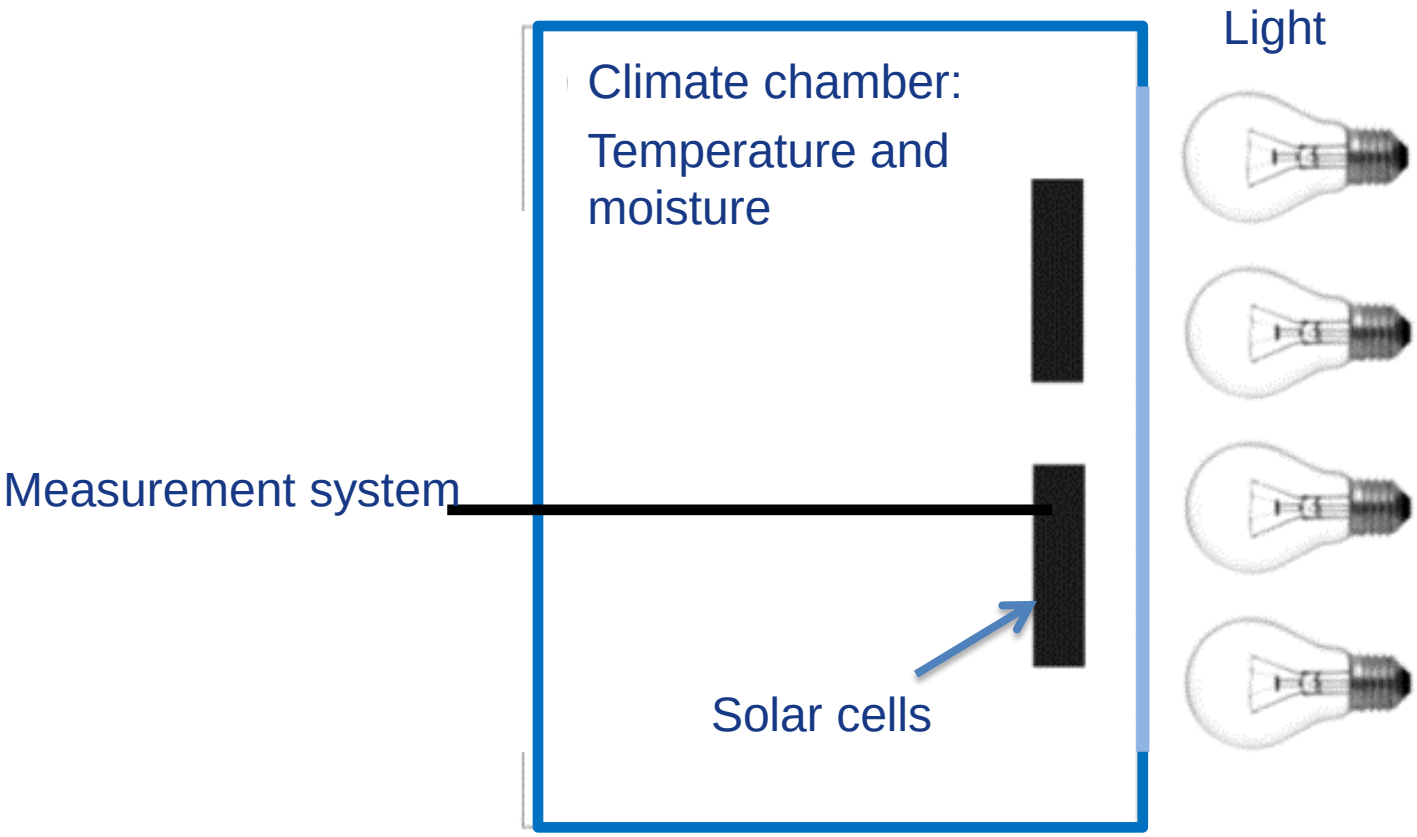
In-situ monitoring



An example

Conclusions & outlook

Real time measurement



Combining loads with real time IV testing

The setup

Climate chamber

for moisture and temperature

Solar simulator

80 x 80 cm^2 – BAA qualified

Window with shutter

For dark curves

The movie

http://www.youtube.com/watch?v=Zmy5tb-2NK8

Setup v2.0

Solar simulator and climate chamber

1x1 m² AAA illumination

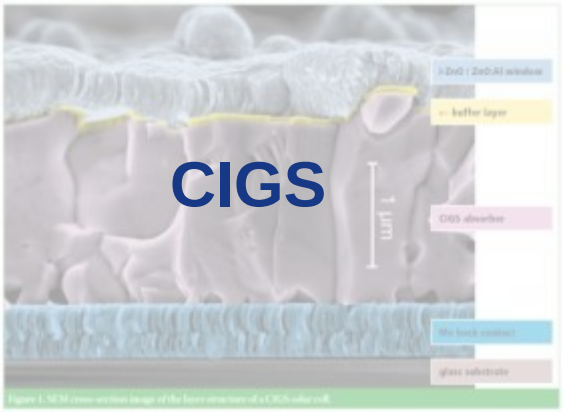
Measurement setup

Setup v2.0

Climate chamber and solar simulator

Sample holders

Solliance



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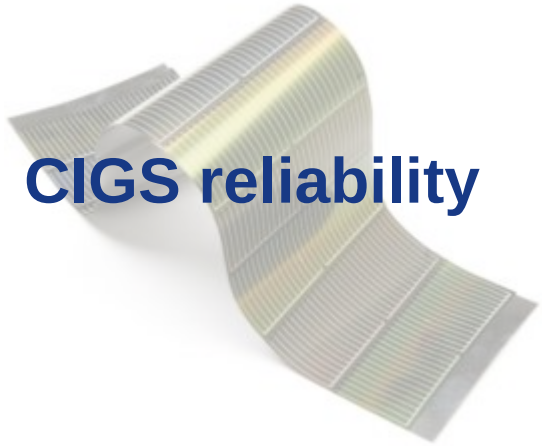
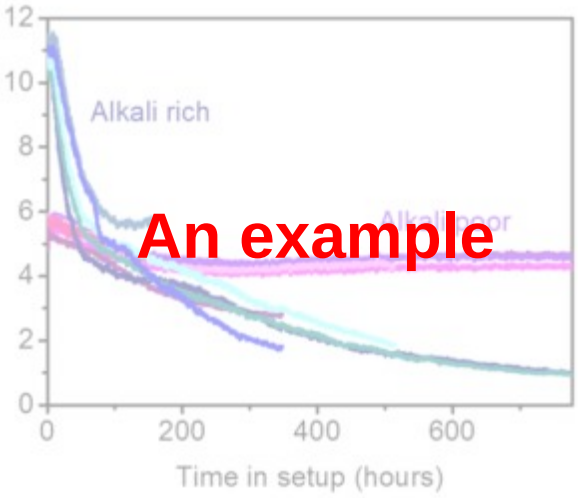


CIGS reliability

In-situ monitoring



An example

Conclusions & outlook

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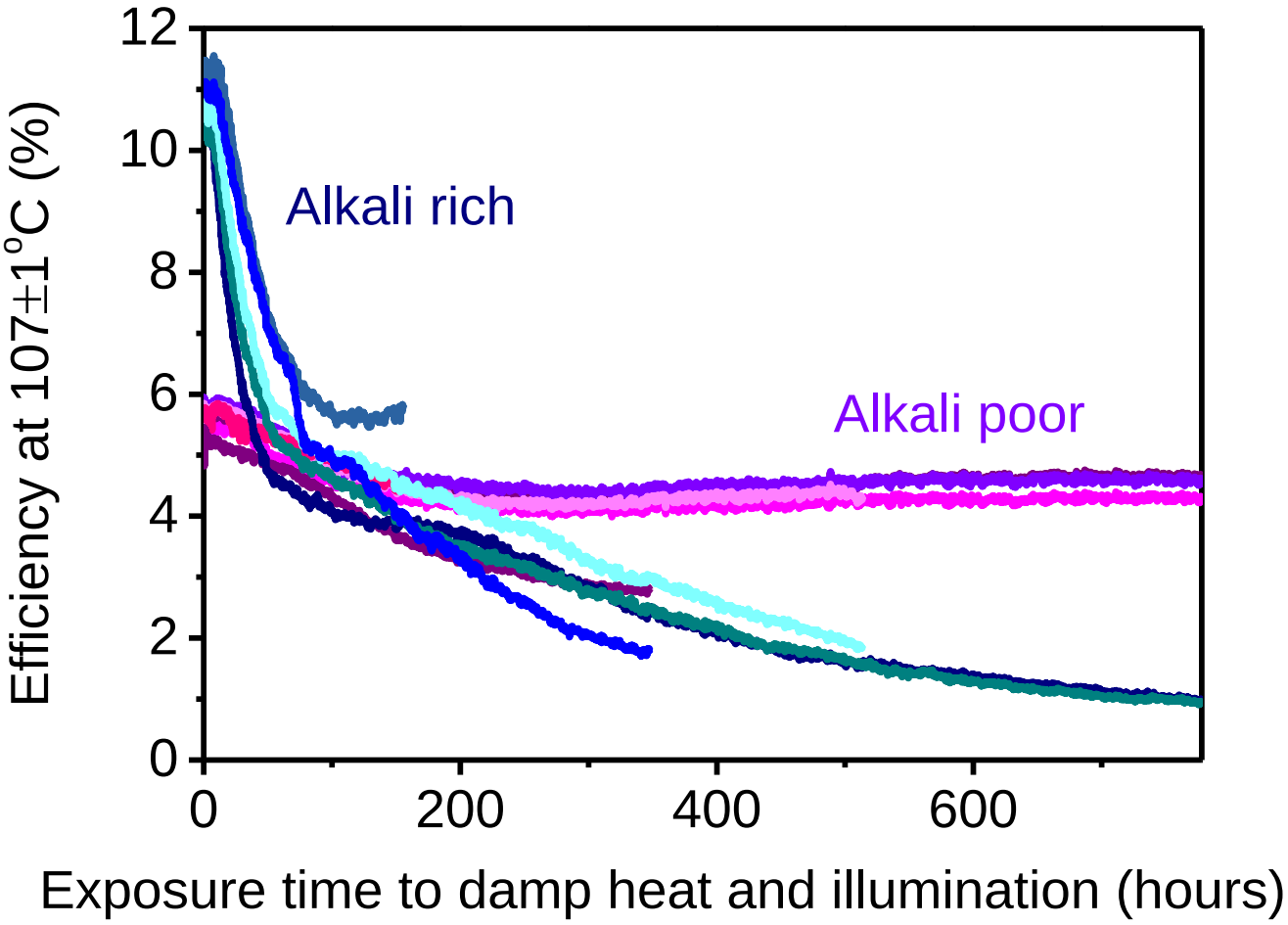
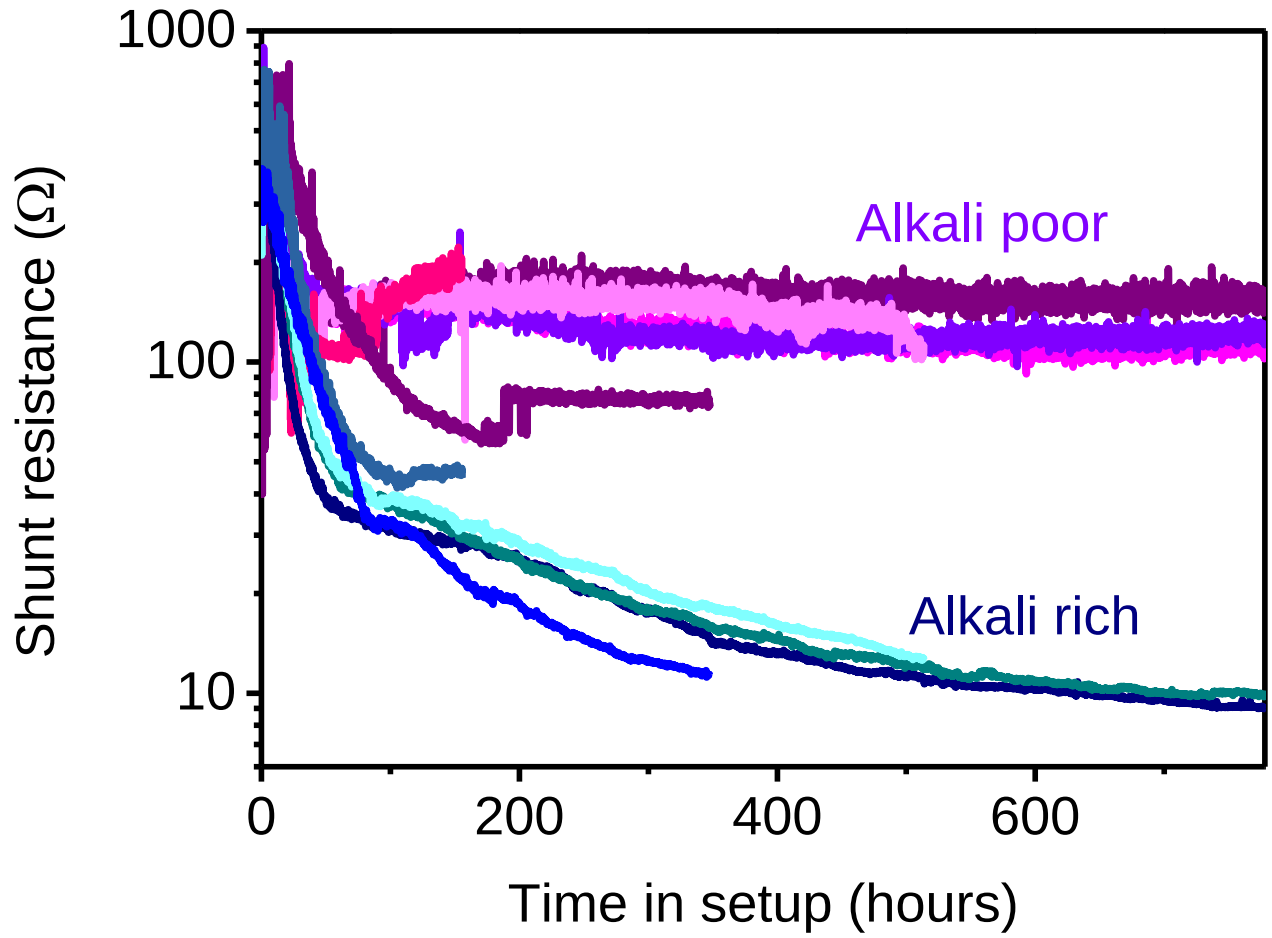
SOLLIANCE

Alkali rich: high initial η – fast decline



Efficiency loss due to shunting

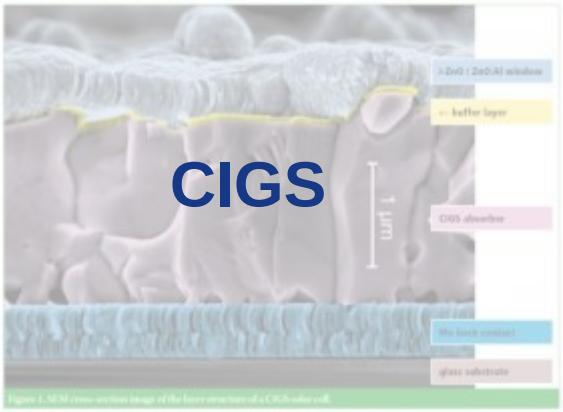


Shunting = Formation of alternative paths for the current

Learn more about long term stability

- **Alkali poor solar cells:**
  - Almost stable efficiency
- **Alkali rich solar cells:**
  - Large decrease in efficiency

Solliance



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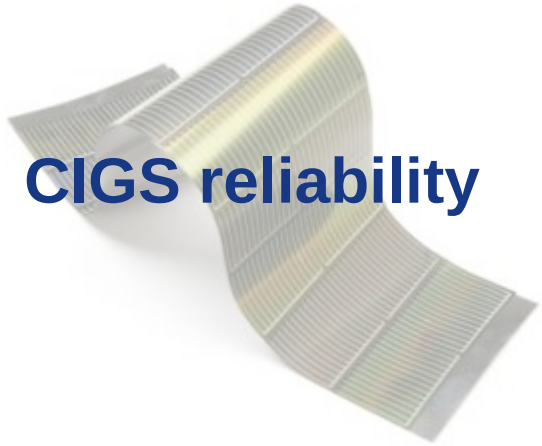
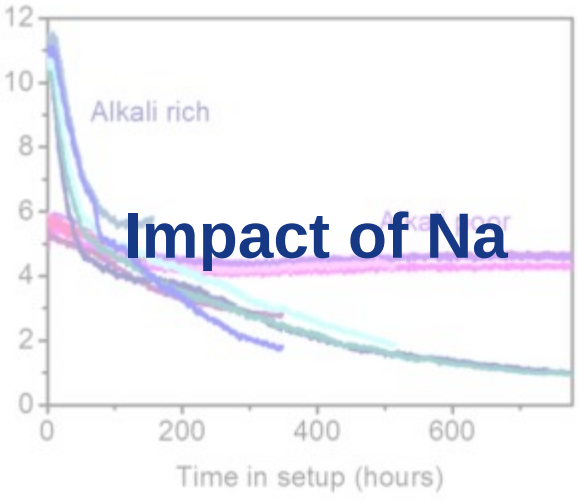


CIGS reliability

In-situ monitoring



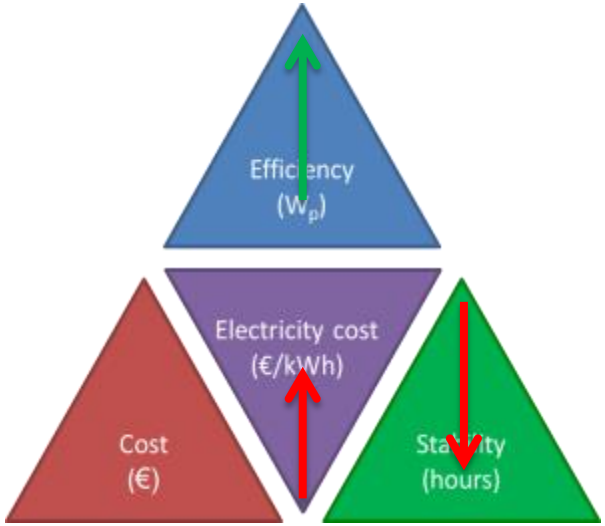
Impact of Na

Conclusions & outlook

Summary

Design and building of a setup for in-situ monitoring of PV degradation

Identification:
High initial efficiency, BUT fast degradation



Outlook

- How to obtain high efficiency and a high lifetime?
- Addition of bias voltages
- What does this mean for field exposure?
- Market penetration with commercial setup

Thanks to…





RERA SOLUTIONS
PV MEASUREMENT SYSTEMS

TU Delft

hielkema TESTEQUIPMENT B.V.
Temperature (& humidity) chambers

eternal sun

Thank you for your attention!

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