Towards an optimized and predictable lifetime of thin film solar cells

Frank de Graaf, TNO, frank.degraaf@tno.nl

8 June, 2016

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

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Content

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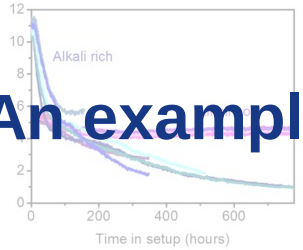

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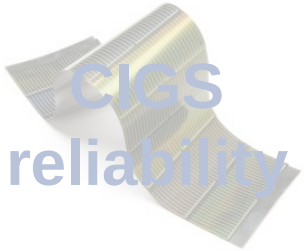

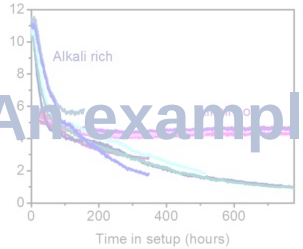

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Solliance: Cross border PV collaboration

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

R&D with collaborations across the value chain

Material Suppliers → SF-Products Suppliers → Equipment Suppliers → Manufac-turers → End-users

SOLLIANCE

Partners in research and industry

Solliance research partners

ECN, imec, TNO, Holst Centre (Open Innovation by imec and TNO), TU/e Technische Universiteit Eindhoven University of Technology, TU Delft Delft University of Technology, JÜLICH FORSCHUNGSZENTRUM, universiteit hasselt KNOWLEDGE IN ACTION

Solliance industry partners

DSM, Panasonic, DYESOL, solartek, nano-c nanostructured carbon materials that power our world, Heliatek, VDL, MEYER BURGER, 4JET LASER | SYSTEME | SERVICES, vito, morphotonics, HyET Solar Flexible lightweight solar modules, Rexroth Bosch Group, nTact Adapting to Process, TULiPPS Solar System Solutions, eternal sun, TSE TROLLER, heijmans, Meco, seac, Scheuten, ccm centre for concepts in mechatronics, SolayTec, MAAN GROUP, AVANCIS ADVANCED SOLAR POWER, calyxo, manz

SOLLIANCE

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

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Solliance: 2020 Ambition

- Demonstrate unique features of thin film PV in real projects
- Enable economically feasible zero-energy buildings with thin film solar by introducing technologies for customization
- Enable large scale industrial activity for PV integrated products

SOLLIANCE

Content

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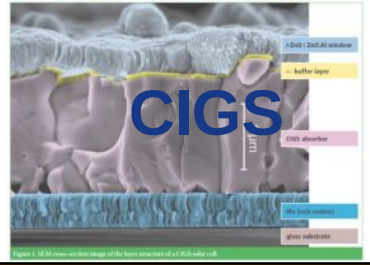

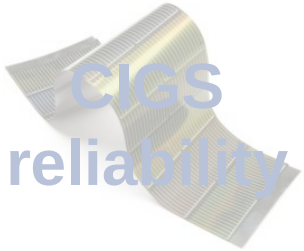

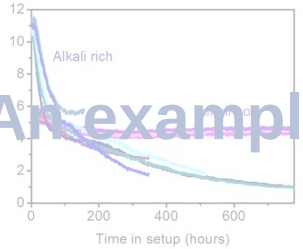

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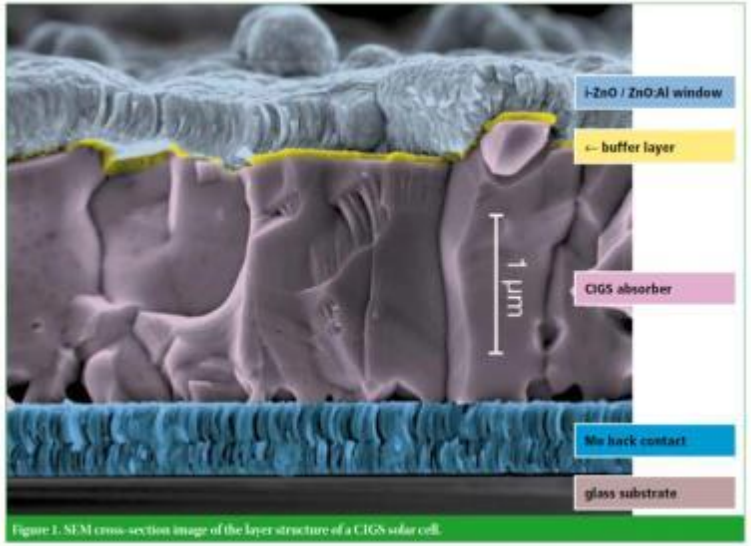
CIGS: Thin film solar cell technology

- Material of copper indium gallium selenide / sulphide – $Cu(In,Ga)(Se,S)_2$
- Thin film ‘flexible’ PV
- High efficiencies (22.3% by Solar Frontier)

3-5 micron



Friedlmeyer 2010

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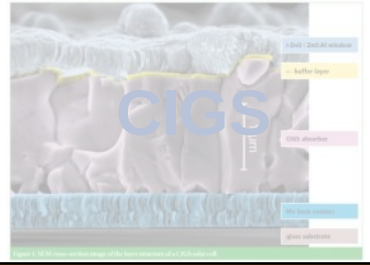
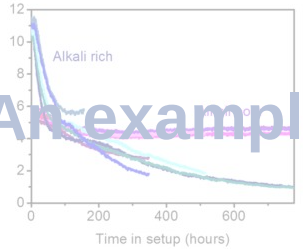


CIGS

CIGS reliability

In-situ monitoring



An example

Conclusions & outlook

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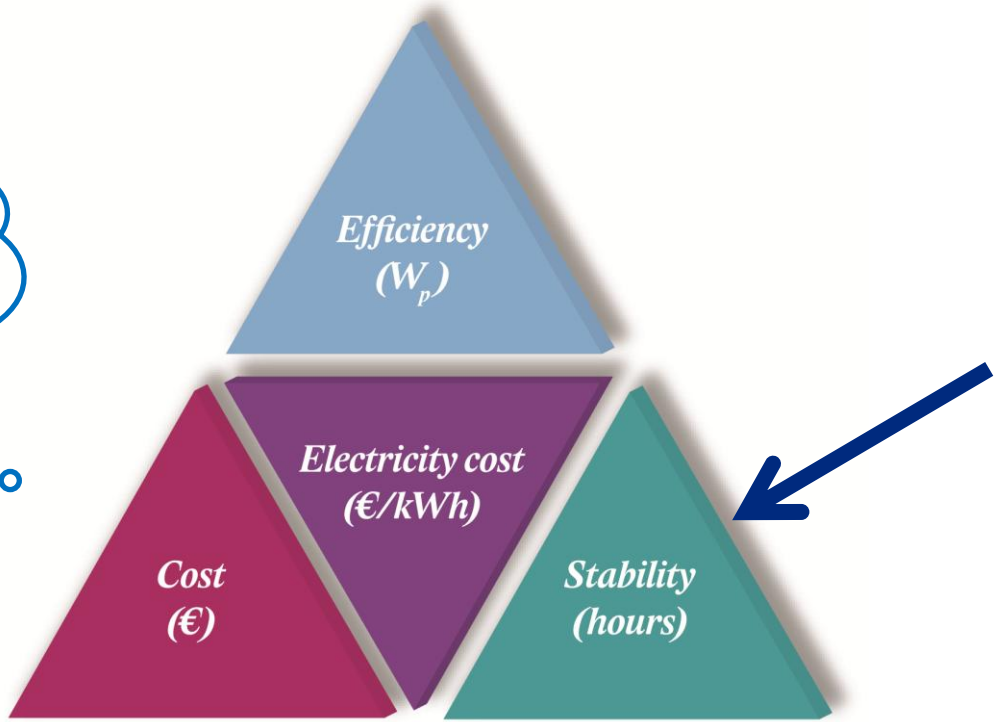
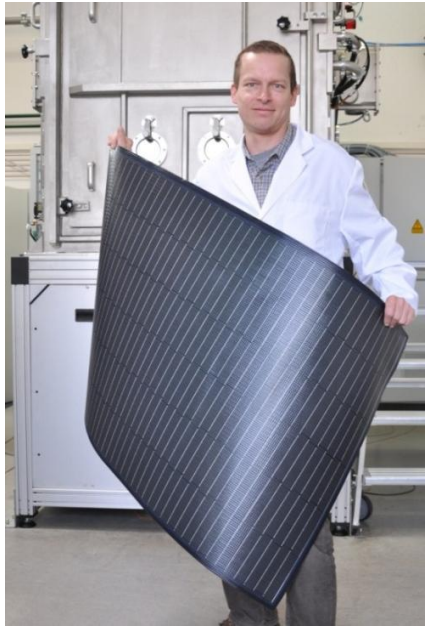
CIGS reliability: What is the lifetime?

Trade- off between stability and cost → optimized and predictable lifetime!



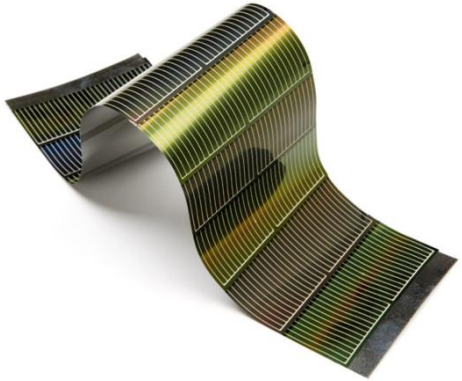
SOLLIANCE

Thin film PV: Limited field testing



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

Accelerated Lifetime Tests (ALT) for CIGS: Is it valid?



Environment conditions stay the same

Degradation mechanisms might be different

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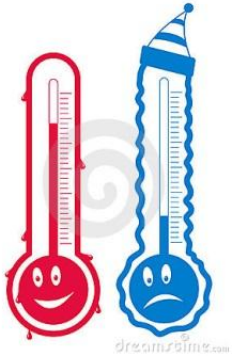
CIGS: degradation enhanced by moisture

- **Degradation driven by moisture ingress**
- **IEC: 1000 h @ 85ºC/85% RH ~~ 25 y Miami**

Also impact of illumination, temperature and electrical bias



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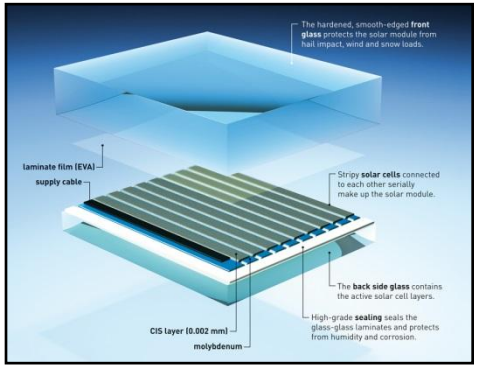
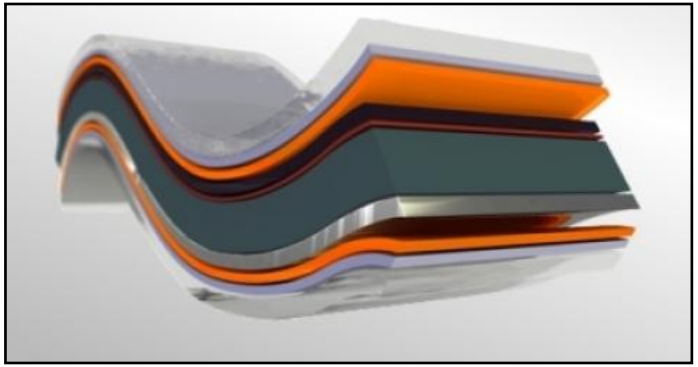
Solution: Moisture barriers





Glass

Expensive inorganic/organic multistacks

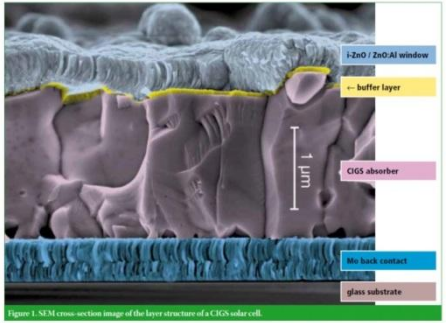


Figure 1. SEM cross-section image of the layer structure of a CIGS solar cell.

Study without package: intrinsically stable solar cells

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Alternative: Intrinsically stable CIGS

- **Find the bottlenecks in CIGS stacks, cells and modules:**

What happens during degradation?

Can we make stable CIGS modules without barrier layers?

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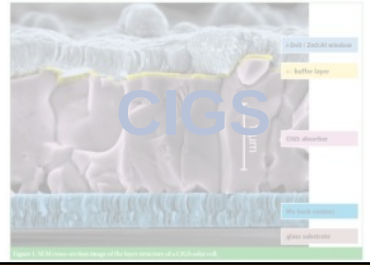
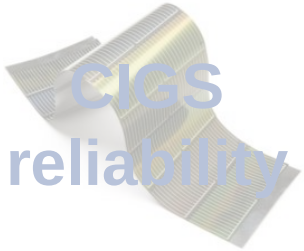
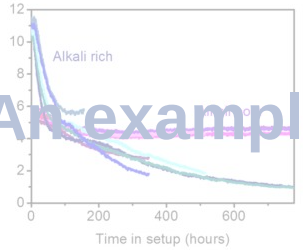


CIGS



CIGS reliability

In-situ monitoring



An example

Conclusions & outlook

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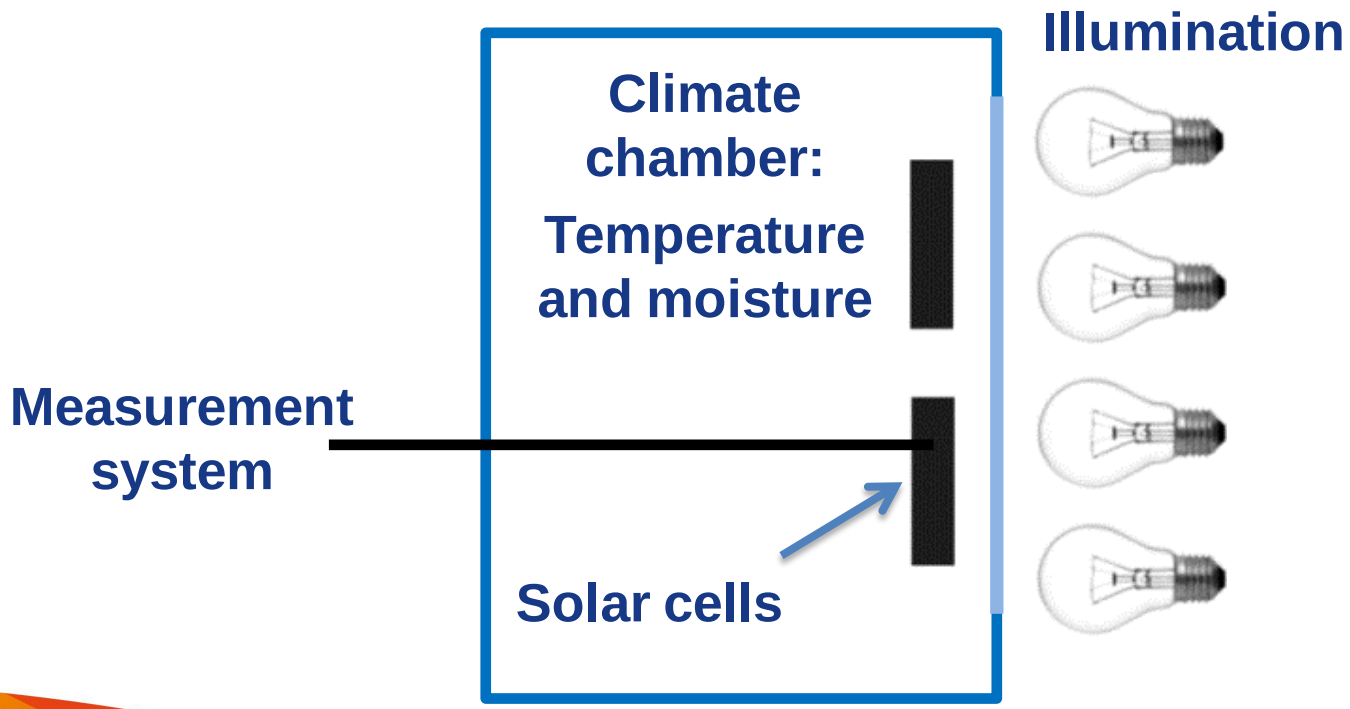
Real time measurement



Combining loads with real time IV testing

The setups

1. Climate chamber

for moisture and temperature

2. Solar simulator

1 x 1 m^2 – AAA qualified

3. Window with shutter

For dark curves

eternal sun
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RERA SOLUTIONS
PV MEASUREMENT SYSTEMS

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

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The setup:

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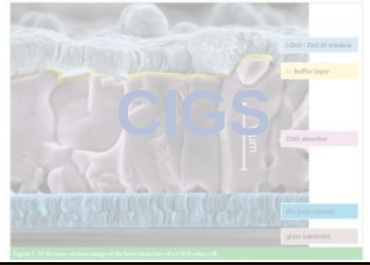

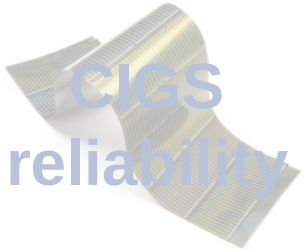

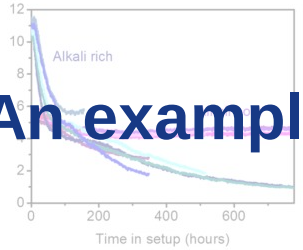

An example

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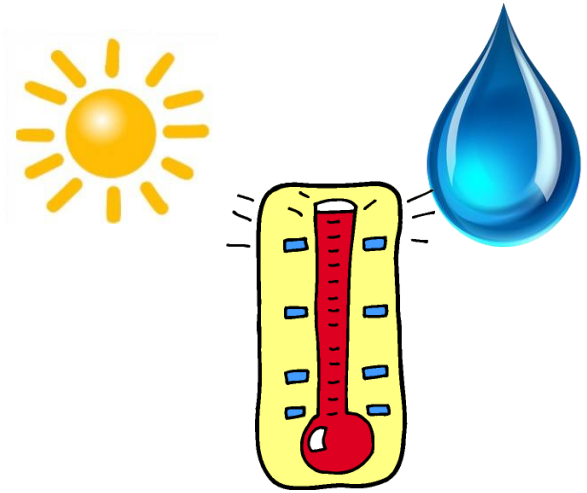
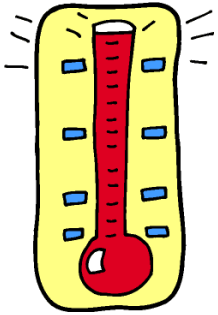
Example (1): the influence of humidity

Damp heat + light

85°C + 85% RH + 1000 W/m²



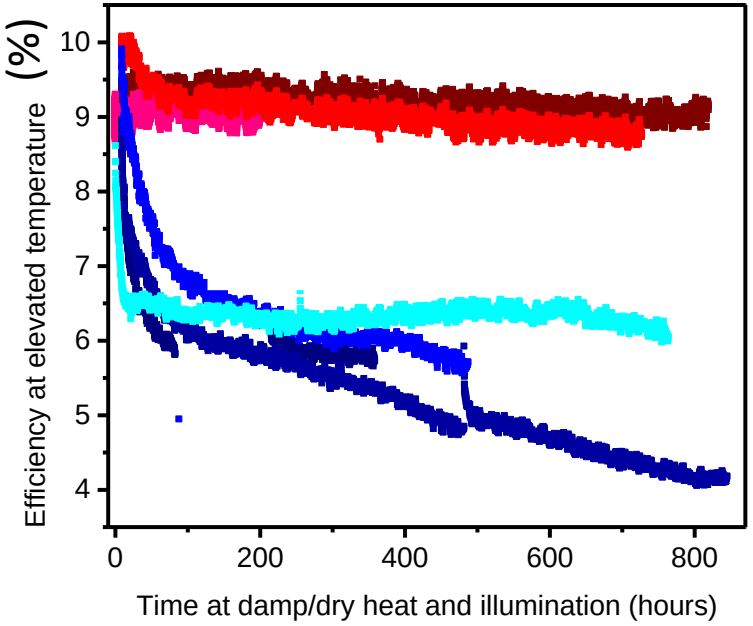


85°C + ~10% RH + 1000 W/m²

Dry heat + light

Example (1): the influence of humidity

~15% at RT

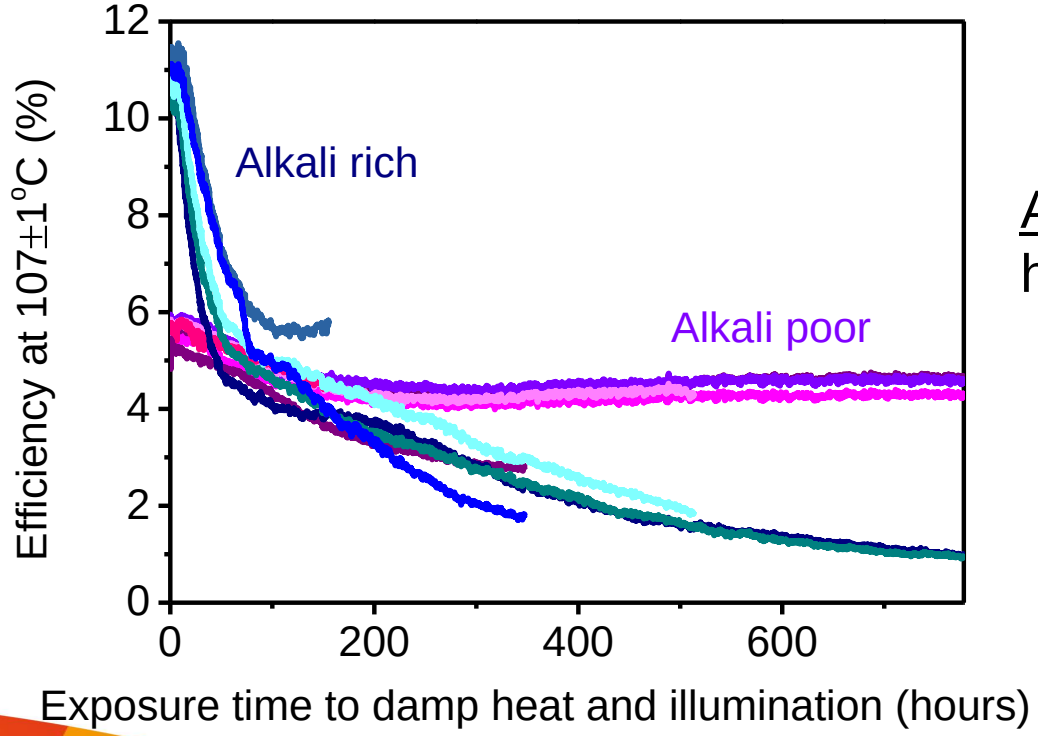


Dry heat + light

Damp heat + light

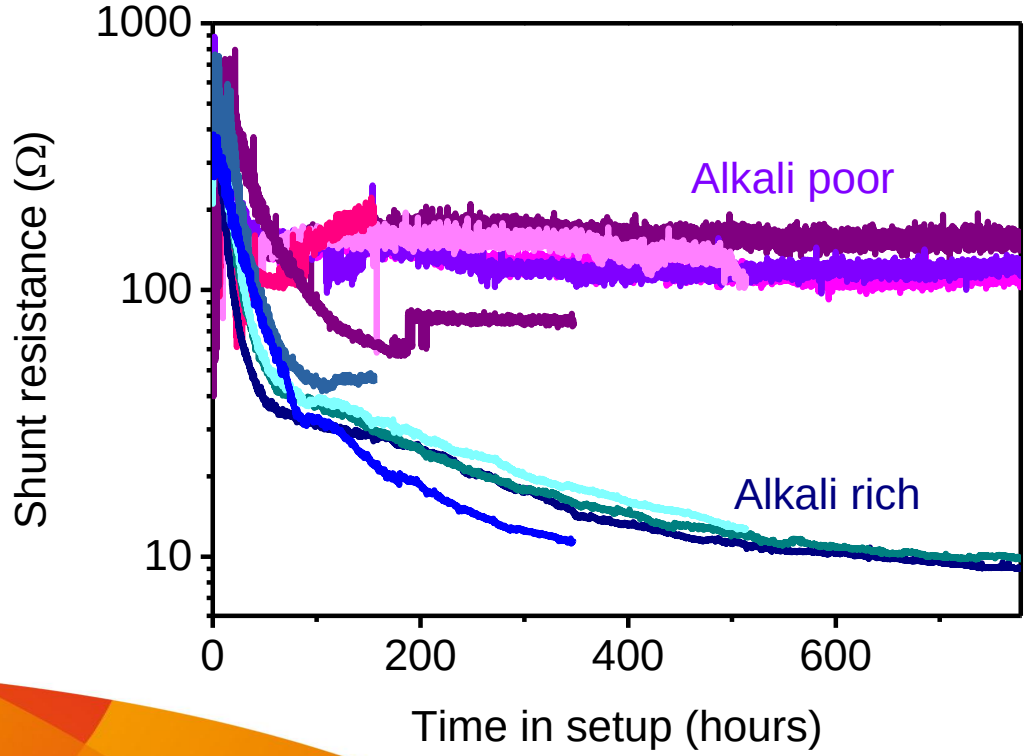
Samples are stable in dry heat + light

Example (2): influence of alkali elements



<u>Alkali rich:</u>
high initial η – fast decline

Example (2) influence of alkali elements



Efficiency loss due to shunting:

= Formation of alternative paths for the current

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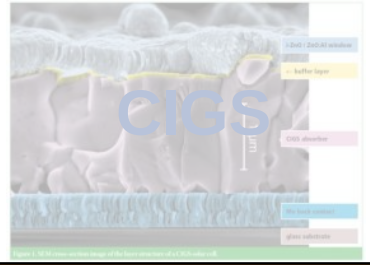

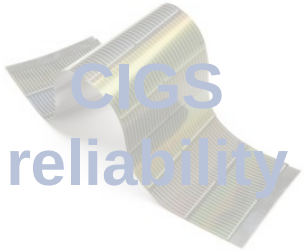

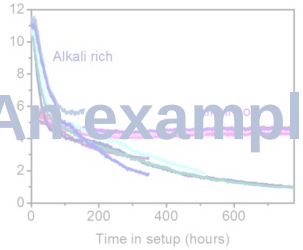

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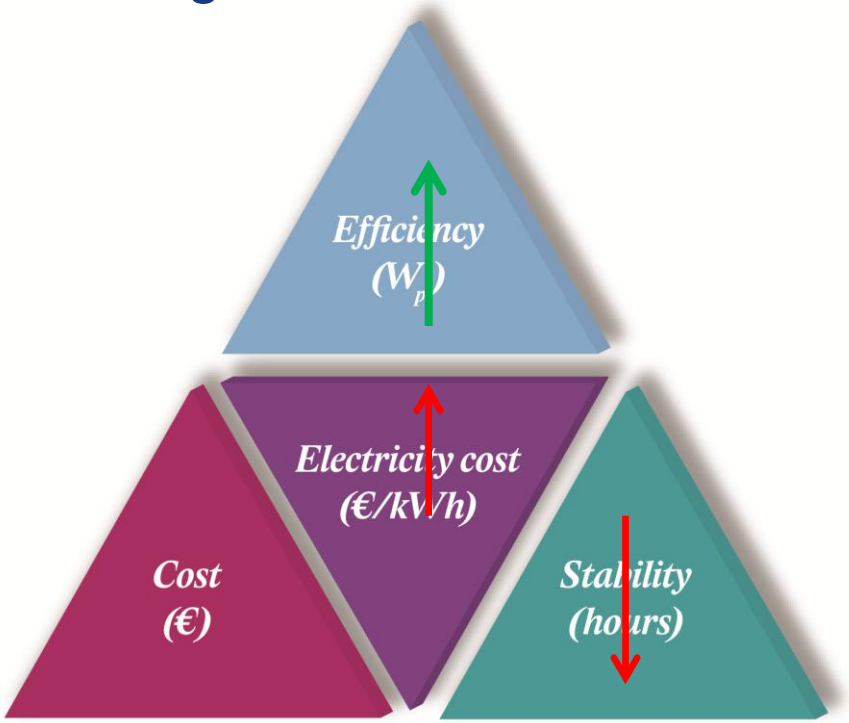
Summary

Design and building of two setups for in-situ monitoring of PV degradation

Identification:
High initial efficiency, BUT fast degradation due to moisture



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Outlook

- How to obtain high efficiency and a high lifetime?
- Learn more about the influence of electrical biases
- What does this mean for field exposure?
- Market penetration with commercial setup

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Thanks to…

TNO innovation for life

eternal sun
NEXT GENERATION SOLAR TESTING





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




INSTITUT des MATÉRIAUX JEAN ROUXEL
iMN
Physique Chimie et Génie des Matériaux

RERA SOLUTIONS
SOLAR MEASUREMENT

TU Delft

ECN

SOLLIANCE

More information:

Setup:

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

http://www.eternalsun.com/products/climate-chamber-solar-simulator/

CIGS degradation

M. Theelen and F. Daume, *Stability of Cu(In,Ga)Se_2 solar cells: A literature review*, Solar Energy 133 (2016) 586–627

Thank you for your attention

Frank de Graaf

frank.degraaf@solliance.eu

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