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**FZ Jülich:** A. Gerber, B. Pieters, J. Noll

# Application of thin-film Cu(In,Ga)Se2 modules in PV roads

## Feasibility tests and installation

1/20/2022

# OUTLINE

- Introduction Rolling Solar project
- Motivations Thin Film Solar in Road
- Activities during preparation phase
  - Design support and verification
  - Pilot production
  - Installation
- Status and perspectives

# INTRODUCTION ROLLING SOLAR

- Interreg project 2019-2022 with 23 partners from Germany, Belgium and The Netherlands
- 5,7 M€ project budget, project leader Peter Toonssen

Public research partners

Private company partners

Advisory committee members

# INTRODUCTION ROLLING SOLAR

- **Main goals:** Develop and accelerate approaches for PV integration in infrastructure
  - At TNO part of Solliance: Develop pilots integrating thin film CIGS into noise barriers and SolaRoad elements
  - Compared with Si-based pilots during monitoring

# MOTIVATIONS FOR THIN FILM FOR SOLAR IN ROAD

Current approach for installation SolaRoad

- Standard Si modules integrated into elements with anti-skid layer in factory
- Heavy (6000 kg) single elements transported to installation site

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- Large rolls of flexible PV transported to site and rolled out over existing layer of asphalt/concrete
- Anti-skid layer deposited afterwards on-site, or beforehand and rolled-up

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***Requirements still to be met***

- *Mass customisation line for TF laminates (in progress)*

- *Anti-skid layer that can be deposited on site or beforehand*

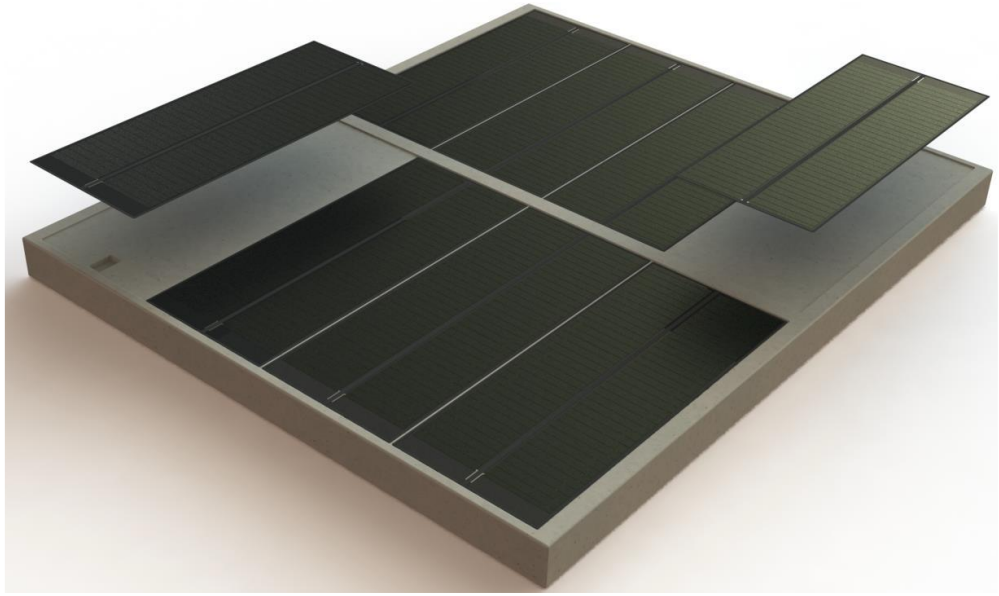
Approach envisioned here not possible yet, but first study on feasibility for using TF PV in Solar in Road application can be done.

# APPROACH FOR THIN FILM ROLLING SOLAR

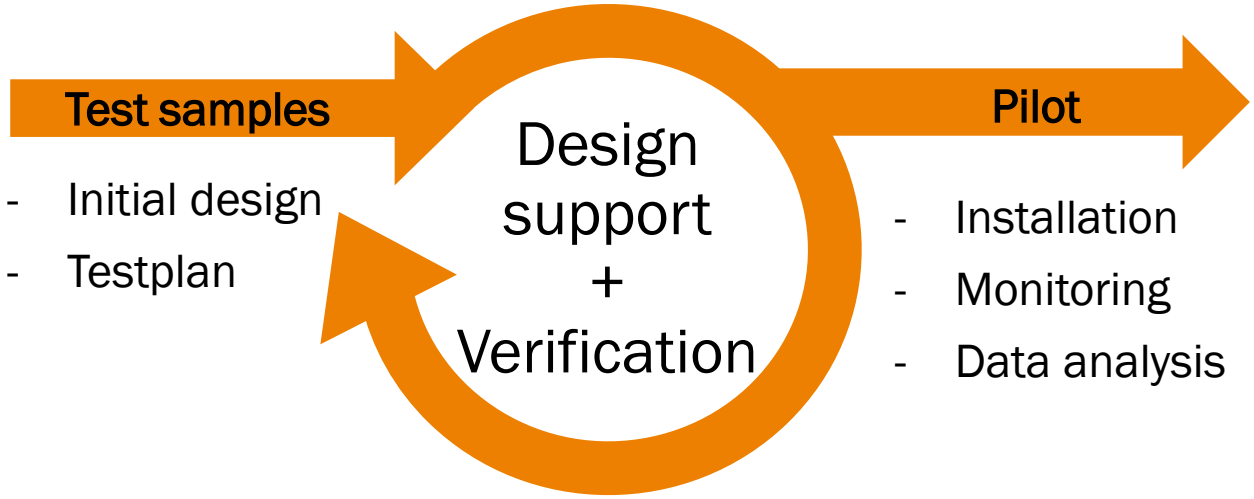
## Analogous to ‘phase A’ with Si

- CIGS modules prepared beforehand
- Modules glued to concrete element with bitumen
- Deposition of anti-skid layer in factory
- Placed as single element directly on site

Designed to have similar power ouput (voltage and current) as Phase A for fair comparison between demonstrators.



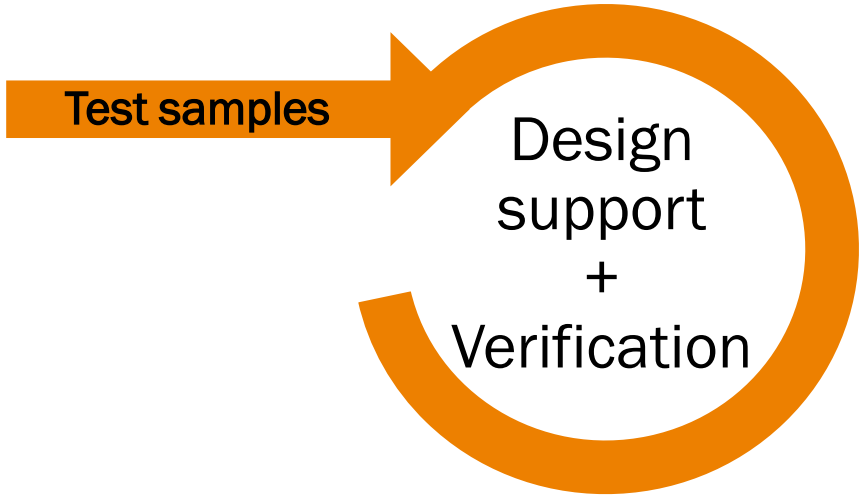
# ACTIVITIES PHASE B




- Multiscale modelling
- Mechanical testing
- Lifetime testing
- Electrical modelling

# ACTIVITIES PHASE B DEVELOPMENT

## 1. DESIGN SUPPORT AND VERIFICATION

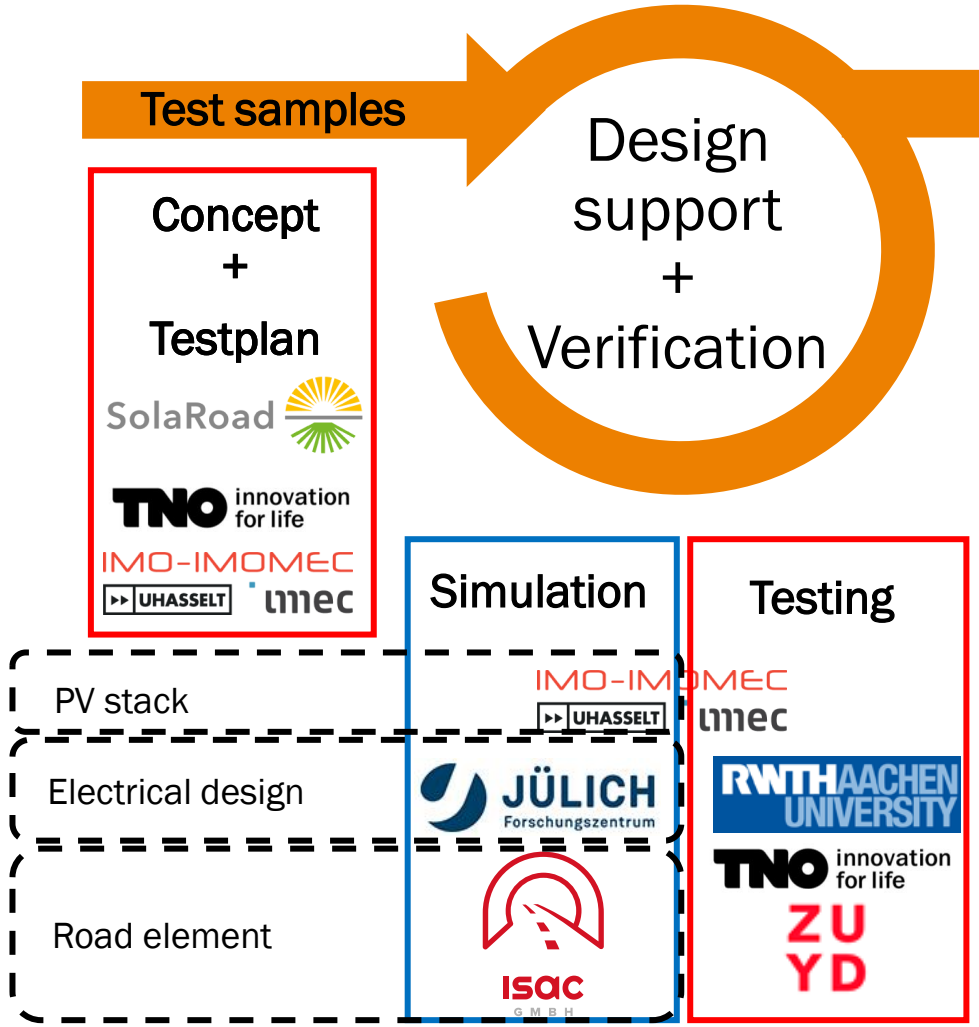



| | |
|---|---|
| SolaRoad | Material and knowledge supply |
| TNO innovation for life | PV laminate production and testing |
| RWTH AACHEN UNIVERSITY | Mechanical testing |
| ZUYD | In-situ thermal cycling |
| IMO-IMOMEC, UHASSELT, imec | PV laminate modelling |
| ISAC GMBH | Road element modelling |
| JÜLICH Forschungszentrum | Simulation electrical design for pilot |

Rolling Solar

# ACTIVITIES PHASE B DEVELOPMENT

## 2. PILOT PRODUCTION




TNO innovation for life — PV laminate production + testing

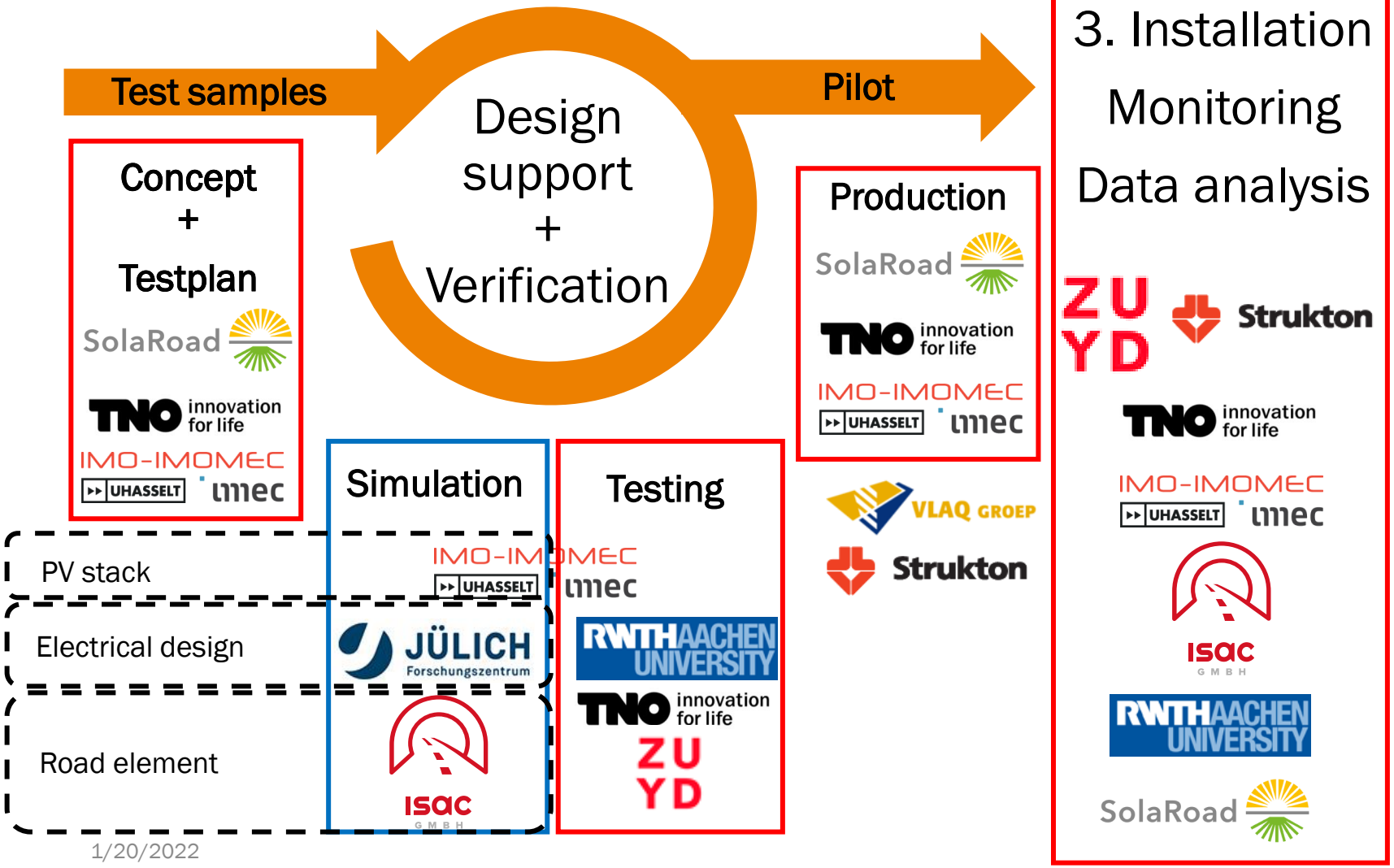
IMO-IMOMEC / UHASSELT / imec — Sensor incorporation

SolaRoad, Strukton, VLAQ GROEP — Pilot production

# ACTIVITIES PHASE B DEVELOPMENT

Interreg Euregio Meuse-Rhine
European Regional Development Fund
EUROPEAN UNION

## 3. INSTALLATION AND MONITORING

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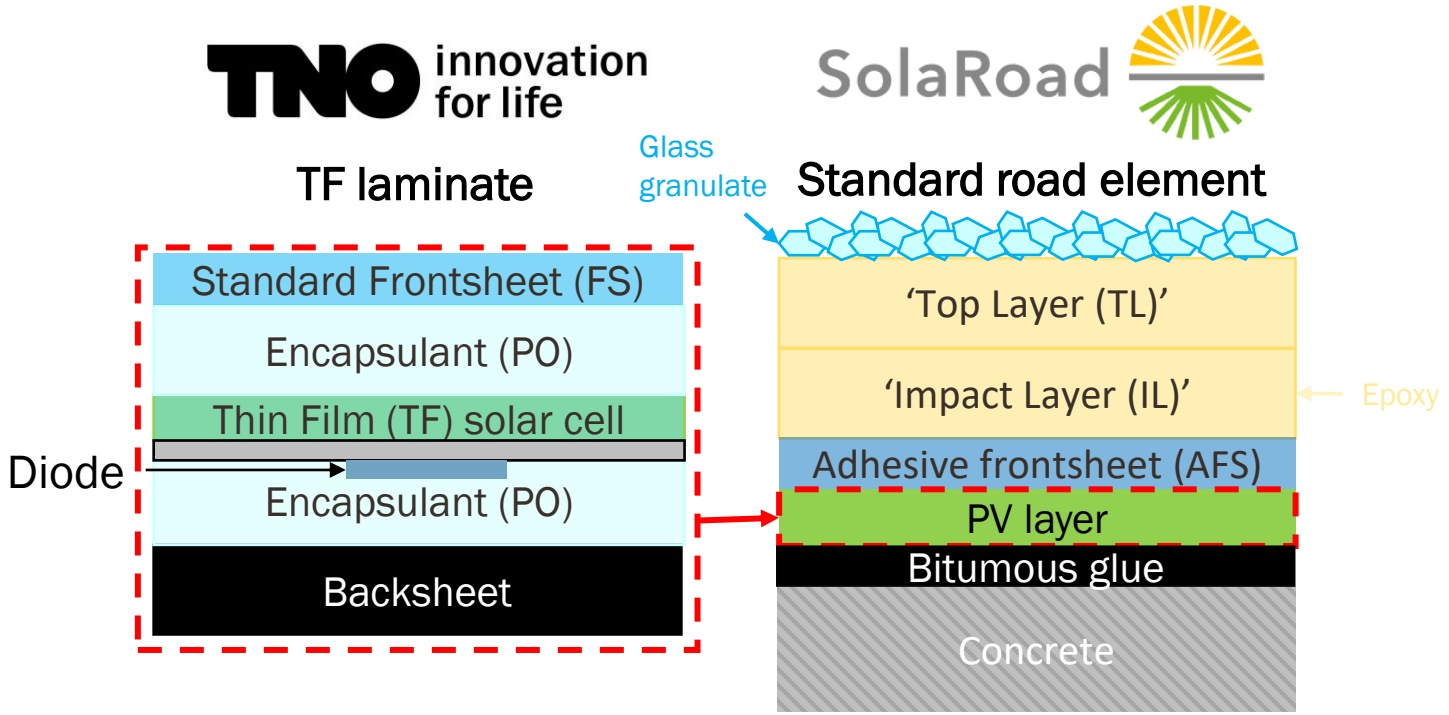
# DESIGN SUPPORT AND VERIFICATION

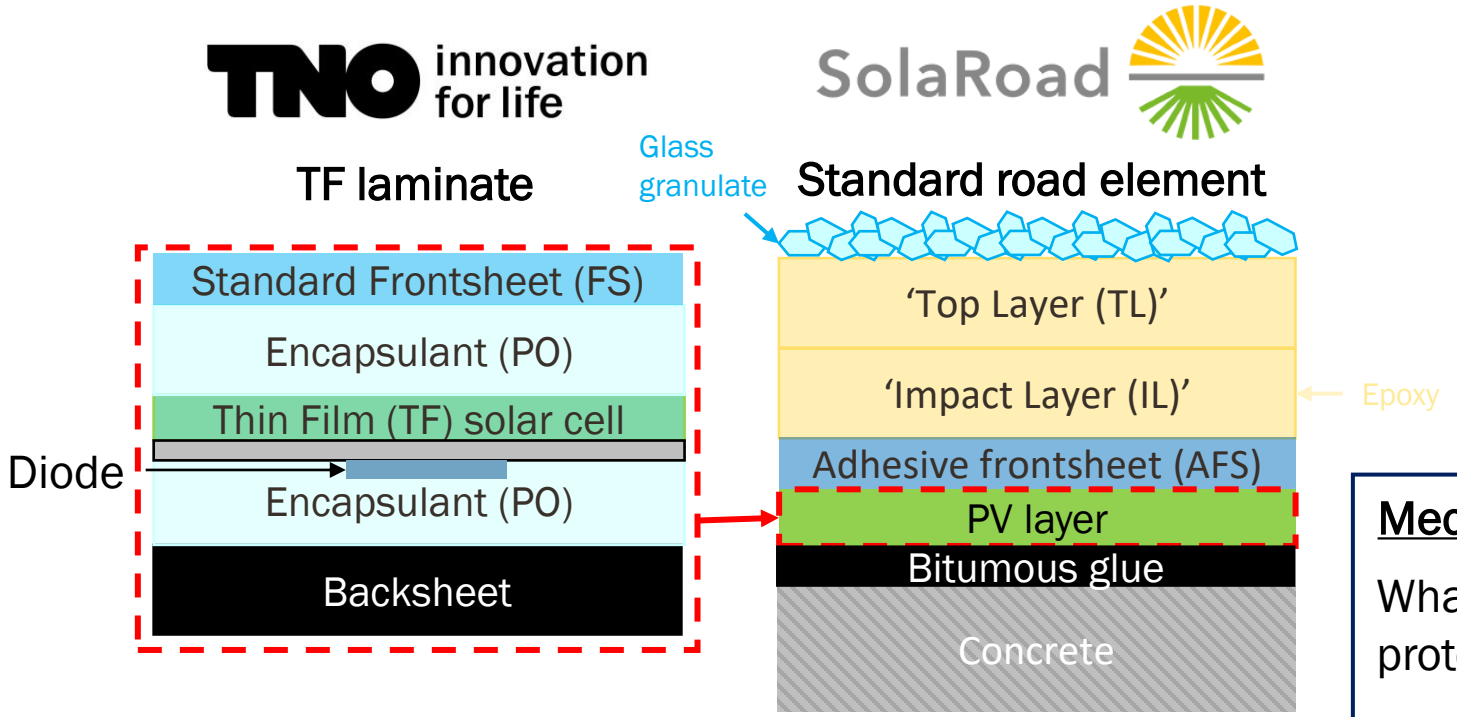



**Adhesion**

Is adhesion sufficient between:

- Standard backsheet and concrete?
- Standard FS and anti-skid layer?

# DESIGN SUPPORT AND VERIFICATION

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## Mechanical resilience

What stack build-up of the TF laminate offers best protection against traffic loading?

Variables: thickness epoxy and PO, AFS, diodes

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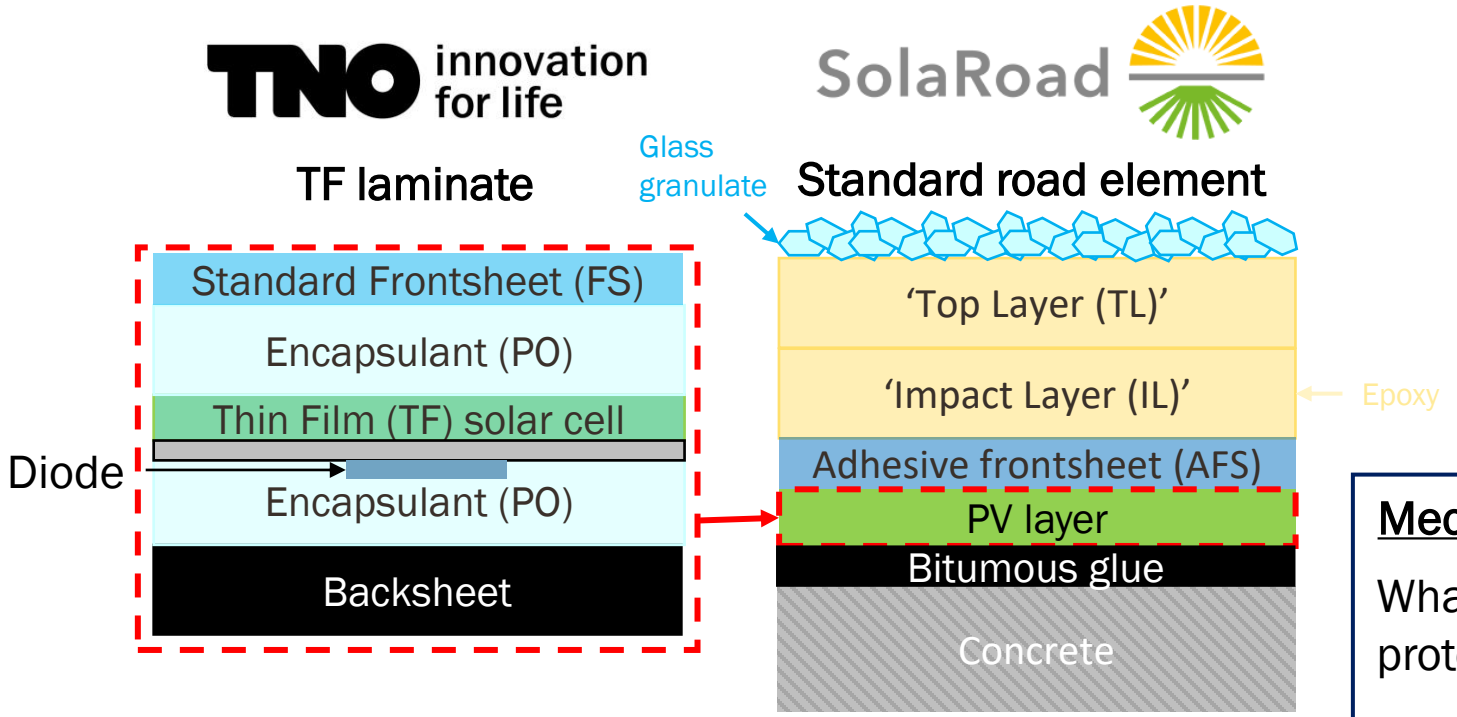


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What stack build-up of the TF laminate offers best protection against traffic loading?

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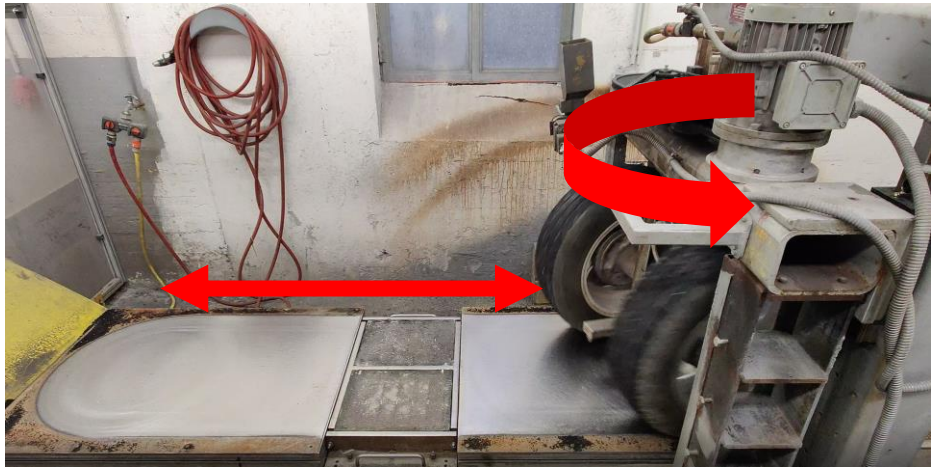
Which dominant degradation modes are observed in accelerated lifetime tests?

# MECHANICAL RESILIENCE TESTS

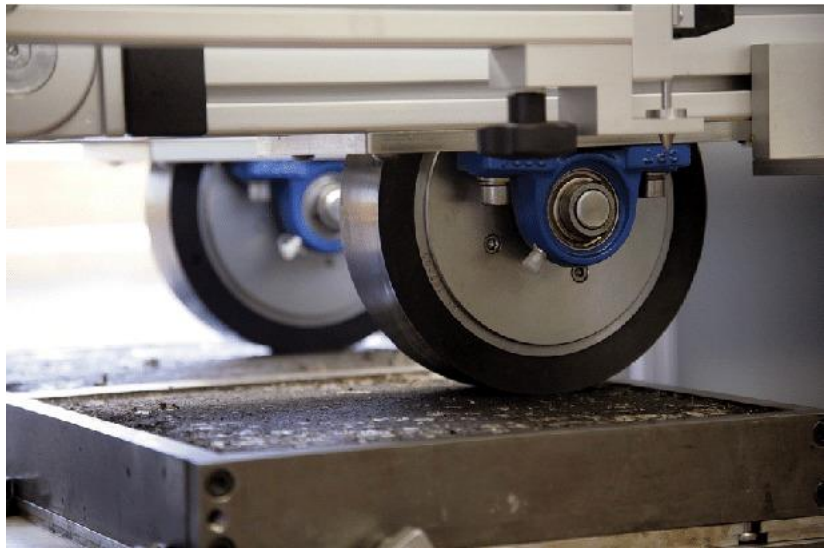
## ARTE AND WHEEL TEST

### ARTe (Ravelling test)



Room temperature (uncontrolled)
Non-reproducible loading

### Wheel test



Controlled temperature (standard 60°C)
70 kg load on axis
Loading along single line

### Tested samples

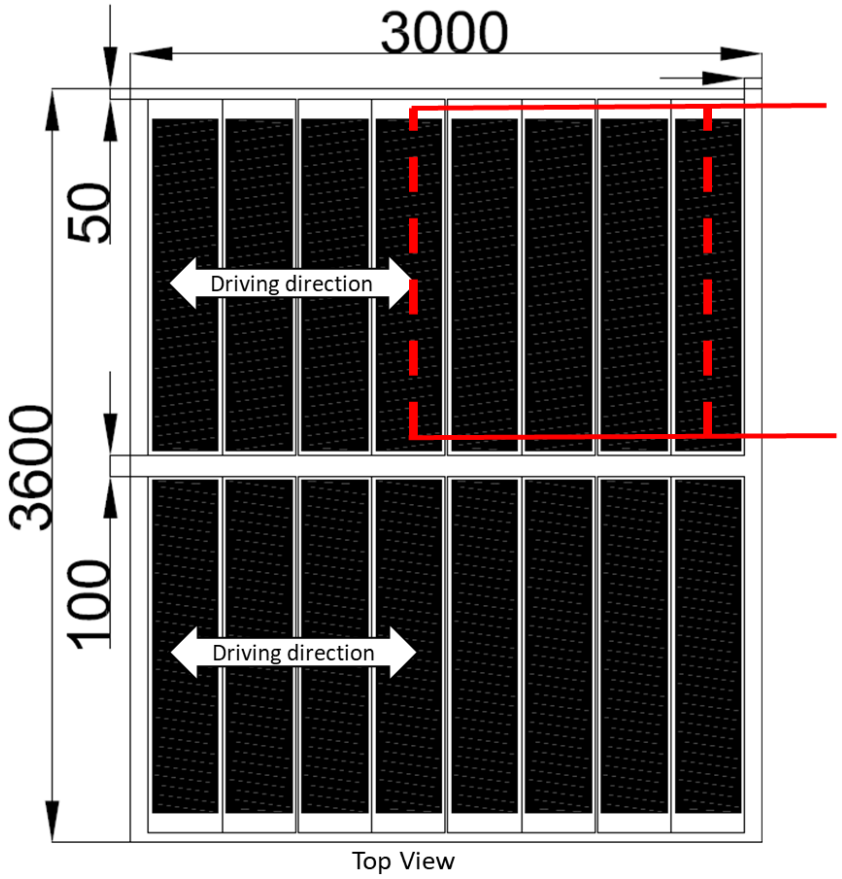
32 x 26 cm
6 cells in series

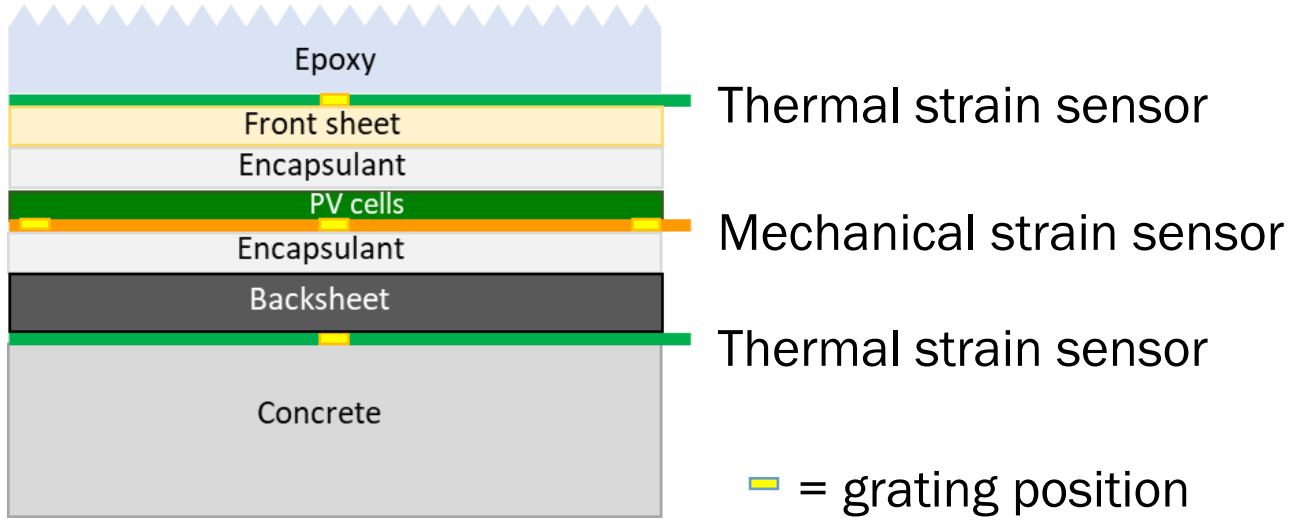
# OBSERVATIONS

- Initial efficiencies of test samples ~15-16% (15.7% ± 0.3)
- No change in average efficiency after toplayer deposition
- Mechanical loading resulted in ~ 8% (rel.) efficiency loss. Mainly due to soiling, in some cases (2/9) due to delamination
- After 1000 h damp heat, non-delaminated samples had up to 20% efficiency loss

# APPROACH FOR PHASE B ROLLING SOLAR

One element with FBG sensors for temperature and strain, at two locations



# PILOT PRODUCTION AND INSTALLATION

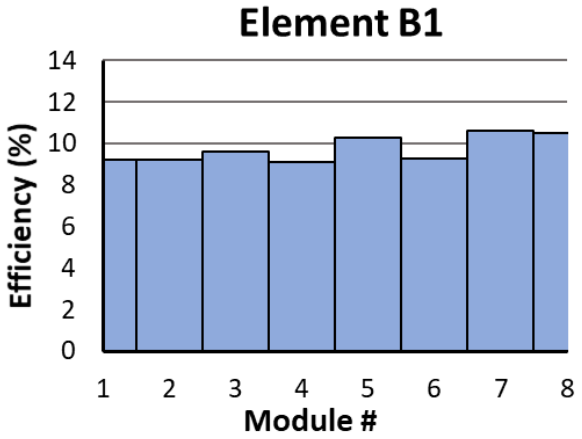
- Element preparation at Strukton prefab (September/October 2021)

# PILOT PRODUCTION AND INSTALLATION

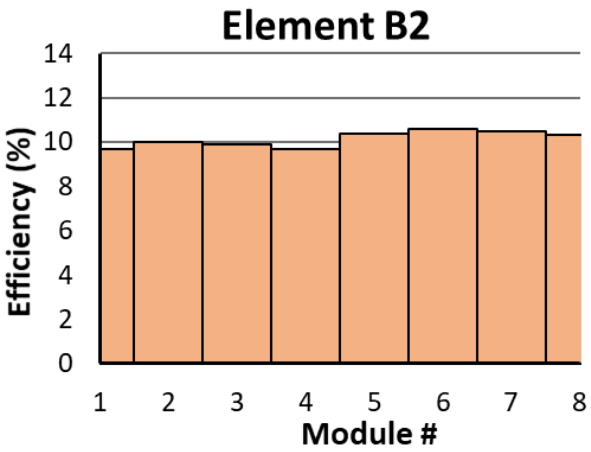
Interreg Euregio Meuse-Rhine European Regional Development Fund

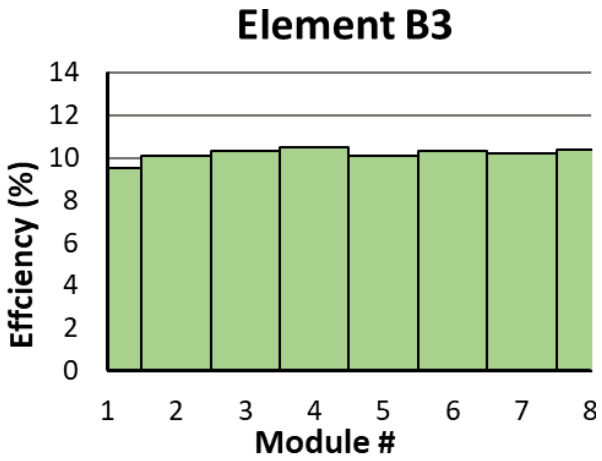
EUROPEAN UNION

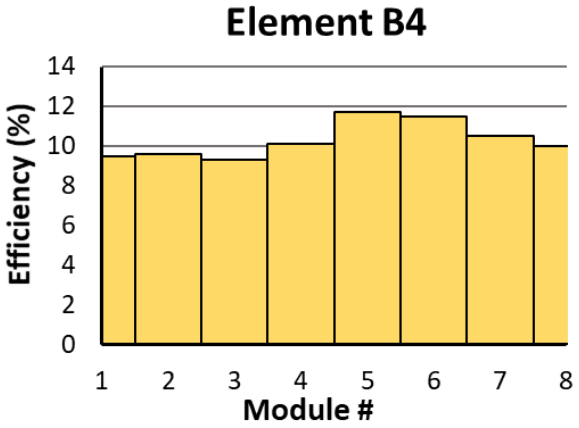
- Transport to Chemelot, installation and measurement on site (October 2021)









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# WHAT IS NEXT

## PILOT 2 (THIN FILM): SETTING UP MONITORING, FIRST TEST SEQUENCE

- **Tests of monitoring system** – done November-December 2021
- **Power measurements without traffic** – in progress, until end of January 2022
- **IV measurements on site** – planned by end of January 2022
- **'Live' measurements during loading with pedestrians, cyclsists and cars** – January/February 2022
- **Tests with increasing number of cars: 20, 100, 250, 500, 750, 1000** – February/March 2022

# THANK YOU FOR YOUR ATTENTION!