HIGHLIGHTS FROM THE FP7 PROJECT CHEETAH:
MORE POWER WITH LESS MATERIAL

Jan Kroon – Project coordinator

Berlin, 30 November 2017
Facts and Figures

• FP7-Energy-2013 Integrated Research Project (IRP)

• Grant agreement no.: 609788

• Combination of collaborative research project (CP) and coordination action (CSA)

• Total planned costs: 13.2 M€, EC Contribution 9.7 M€

• Duration 48 months: (1/1/2014 - 1/1/2018)

• Coordinator: ECN + 33 partners

• Website: www.cheetah-project.eu
History and European context

European 20-20-20 targets

Solar Europe Industry Initiative

SET plan for PV for 2020

**European Energy Research Alliance (EERA-PV):** Established 2010
- Definition of Joint Programme for PV
- Accelerate PV development in Europe through R&D alignment

First examples of joint projects in support of EERA-PV:

- **SOPHiA** 2012-2015
- **CHEETAH** 2014-2017
Link EERA PV - CHEETAH

• Activities within EERA-PV:
  • Silicon PV
  • Thin film PV
  • Emerging (OPV, perovskites)
  • Concentrated PV
  • Building Integrated PV and systems
  • Reliability (since 2017)
  • Mobility and research infrastructure

• CHEETAH executes selected part of Joint Programme
  • Total budget 13 Meuro / EC contribution 9.7 Meuro
  • Duration 48 months: (1/1/2014 -1/1/2018)
Project approach and structure

**NEEDS**

**Research**
- Cheaper and more efficient cells and modules
- Earth abundant and non-toxic materials

**Coordination**
- Structure for managing R&D & cooperation
- Exchange & communication

**CHEETAH innovations**
- New concepts for
  - Silicon PV → <100µ thick
  - thin film → light management
  - OPV → low cost barriers
- At reduced cost, environmentally friendly....

- Create tools for cooperation
- Improve exchange & communication
- Interfacing with industry
Consortium: 34 partners
Coordination activities

- **Joined actions** and **mobility exchange** actions
- **E-learning platform**
- **Training workshops, summer schools, webinars**
- **Contacts with industrial stakeholders** via workshops & web meetings
- **Standards, surveys, reports**
- **Dissemination & exploitation**
  - ‘Knowledge exchange web portal’
Website: www.cheetah-project.eu
PV Knowledge Exchange Portal

http://www.cheetah-exchange.eu/

Contains dynamic database with:

- PV Technologies
- PV R&D topics
- Overview of PV research infrastructures in Europe
- PV expert profiles
- Webinars and workshops

ULTRA-THIN AND KERFLESS SILICON WAFER DEVELOPMENT

The International Technology Roadmap for Photovoltaics (ITRPV) [1] predicts a continued reduction in the silicon wafer thickness in the coming years. However, in the last 2-3 years, the predicted reduction in the wafer thickness did not happen and wafer thickness stagnated at around 100 μm. This is because further decreases in wafer thickness are quite challenging for both the wafering process and all subsequent down-stream handling steps in solar cell and module production, with increased risk of wafer breakages and hence yield loss [2, 3]. Nevertheless, it would be very beneficial for the photovoltaic industry to go to thinner silicon substrates with a thickness below 100 μm. The first reason for this is that a better silicon utilisation and the use of thinner silicon substrates without compromising on the high cell efficiencies.

Infrastructure

- IMEC-Cell Modeling Infrastructure and software
- PHO-ISE Indoor/outdoor reliability Testing facility for PV modules

Expertise

- GORDON Ivan
- DRIESEN Marien
- BANSEN Roman
- BOECK Torsten
- FOSS Sean Erik
- VAN NIEUWENHUIZEN Kris
- DEPUWAL Valerie
- TUCCI Mario
- SLACUI Abdelilah
- SERRA Joao
- SIVARAMAKRISHNAN RACHAKRISHNAN Harish

Webinars

- Wet-chemistry deposition of semiconductor nanostructures for IR photovoltaics
- Characterization of thin film solar cell layers by x-ray based spectroscopy
PV Knowledge Exchange Portal

http://www.cheetah-exchange.eu/

- So far, only Cheetah participants and JP PV partners are listed in database
- Will be extended to non – JP PV institutes in near future
- Knowledge exchange Portal will be maintained by JP PV after Cheetah project ends under new name
- Overview of national and EC funded projects will be added
Drivers for research activities

- **COSTS** dominated by the materials, where to reduce?
  - Crystalline Si: wafer costs,
    - *Go to thin wafers < 100 micron*!!
  - Thin film PV: semiconductor + Indium
    - *Smart cell architectures (microconcentrator)*
    - *Light management*
  - OPV/Perovskite PV: encapsulation!!
    - *Intrinsic stable materials and device structures*
    - *Reduction of barrier layer requirements*
Crystalline Si research: wafer and cell production

Fabricate (ultra) thin Si kerf free wafers and cells on 40 – 80 μm

- By epitaxial growth

- Develop new technology bricks for ultra-thin wafers (40 μm)

- 17% heterojunction cells achieved on 50 μm epi foils

12.5 x 12.5 cm² 40 -50 μm epifoils

Heterojunction cells on 50 μm epifoil
Crystalline Si research: cell and module production

Develop/redesign industrially compatible cell and module processes for thin cells down to 80 μm and proof mechanical stability

Heterojunction (HJ) cell production on industrial pilot line

Heterojunction (HJ) cell production on industrial pilot line

\[ \eta_{\text{max}} > 22\% \]

at \( \sim 90 \, \mu m \)

\[ P_{\text{max}} = 313 \, \text{Wp} \]

\[ 1 \, \text{g Si/Wp} \]

60 cells IBC thin cell module

60 cells thin cell HJ module

INES, ECN, AIT
Thin film PV material research strategy

**Example:** micro concentrator approach for CIGS
- Restriction of absorber material
- Low and medium concentration of sunlight
- Proof of concepts have been demonstrated

**Top-down μ cells based on inkjet-printed CIGSSe**

**Bottom-up growth of CISe μ cells from In droplets**

**Inkjet-printed PMMA micro lenses**

**CIGSe-CZTS direct-diffuse micro concentrator**

HZB, ZSW, TUT, IKZ, ENEA, EPFL, FZ Julich
Organic/Hybrid PV materials research strategy

- *Intrinsic stable materials and device structures*
- *Reduction of barrier layer requirements ➔ reduction of costs*

**Screening organic materials on stability**

**Device design**

**R2R printing**
More detailed results on the CHEETAH achievements will be presented in the parallel sessions after the break!
Summary

CHEETAH created the means to perform part of the EERA Joint Program on PV in a “formal” collaborative project

**Coordination**

Creation of tools like dynamic database, e-learning platform…….

**Joint research**

Focus on **Lower TRL, long-term research** to generate new innovations
Thank you for your attention and I wish you a very nice event!!