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Progress in Advanced Materials and Nanotechnology for Photovoltaics: from Laboratory to the Market.

The EU PV Clusters 3rd Workshop and General Assembly

Workshop Report

Introduction

This workshop was held on 25th – 26th May 2016 at the University of Barcelona, hosted by Leitat. The key objectives of the workshop were:

- Highlight key results of the research and innovation (R&I) projects supported by various programmes of FP7 and Horizon 2020 (the current EU Framework Programme for Research and Innovation 2017-2020) in the field of Photovoltaics (PV) and review their technology readiness level (TRL) in a value-chain approach.
- Give an updated overview of the portfolio of projects in the PV field to bring forward the global picture of PV research and innovation in Europe and highlight the impact of advanced materials and nanotechnology on the European PV industry.
- Identify common R&I priorities for bridging the gap between advanced materials and nanotechnology-based innovation and the successful commercialisation of innovative products and industrial technologies.
- Provide a forum for discussion, problem solving and planning of R&I activities in Europe and give key recommendations on future R&I needs in the PV domain, including cross-cutting topics (engineering and upscaling, characterisation, modelling, standardisation, safety and pilot lines for PV)
- Enable the materials, nanotechnology & PV communities in Europe to develop strategic collaborations and industrial partnerships.
- Review the existing materials, nanotechnology and PV roadmaps to support the development of European PV industry, and to implement them in Horizon 2020.

This document is a first draft report of the workshop. It highlights some of the key points against a number of these objectives. A more detailed and considered report will be prepared over the next few weeks, based on the feedback from workshop attendees on this report.

Key Results

The presentations of projects funded by the European Commission under the FP7, Horizon 2020 and several other programmes gave a very useful overview of the current portfolio of PV projects. These presentations highlighted that the European PV research community continues to be at the forefront of global research and innovation activities in several PV technologies. However the workshop also clearly highlighted that the PV industry must further develop its supply chain to improve its market presence and engage with market partners. Key results and performance achievements reported for each of the seven PV clusters can be summarized as follows:

- **Cluster 1: Wafer Based PV Cells**
  There were three project presentations in this cluster. Key points highlighted were:
  - Heterojunction modules with 330W with cells having 22.5% efficiencies in the ***Hercules*** project
  - Aims to demonstrate of circular economy approaches to end of life PV cells in the ***Cabriss*** project
- **Cluster 2: Thin Film PV Cells**
  There were six project presentations in this cluster, covering thin film silicon, CIGS and kesterite solar cells. Key achievements presented were:
  - Demonstration of 22% efficiency on CIGS cells, with a target above 24% by the end of the ***Sharc25*** project
  - Achievement of 11-12% efficiencies in kesterite solar cells and a world record 9.1% for electrodeposited kesterites in the ***Kestcells*** project
  - Optimisation of metallic substrates via intermediate layers have been validated in OPV and a-Si technologies in the ***Steel PV*** project
- **Cluster 3.1: Third Generation PV Cells – Nanostructures**
  There were three project presentations in this cluster, including:
  - ***Nano Tandem*** is developing novel methods for direct growth of III-V nanowires for implementation in silicon photovoltaics
- **Cluster 3.2: Third Generation PV Cells – OPV and DSSC**
  This was one of the most active areas with eight project presentations on OPV. These ranged from innovative materials projects to large scale pilot line projects. Key achievements to date include:
  - Over 9% efficiency in OPVs demonstrated in the ***MatHero, Mujulima*** and ***Sunflower*** projects
  - High efficiency pervoskites solar cells concepts demonstrated. Record efficiency lab scale cell >20% ***(MESO)*** and monolithic tandem perovskite/heterojunction c-Si solar cells with over 21% efficiency ***(CHEOPS)***
  - Large scale R2R produced OPV with 3.9% efficiency in the ***Smartonics*** project
- **Cluster 4: Concentrators and Tracking**
  There were 3 project presentations in this cluster:
  - ***CPV Match*** reported first prototypes of a new four-junction solar cell architecture with efficiencies above 40% in the lab
  - The first field upgradeable HCPV system with an estimated lifetime of more than 40 years has been developed and a crucial component has been improved in the SME Instrument project ***COGEM***, expecting demonstration of near-zero LCOE.
  - Efficiencies of >26% achieved in triple junction silicon cells in the ***Historic*** project

- **Cluster 5: Innovative Installations**
  There were four project presentations describing innovative installations. These described an end user perspective of the requirements of PV systems. Details of six BIPV demonstrators were presented in the ***PVSITES*** project and the development of novel composite based BIPV is being demonstrated in ***BFIRST*** project. A novel concept of prototypes lighting/PV onto ETFE architectural textile is demonstrated in ***ETFE-MFM*** project.
- **Cluster 6: Production Equipment and Processes**
  There was one presentation in this cluster, on the ***Pliant*** project but the focus was on some of the more research oriented aspects of the project. The preparation of perovskite solar cells with over 16% efficiency was reported.
- **Cluster 7: Industry Support**
  There were three project presentations in this cluster:
  - ***Solar Bankability*** is investigating the risks associated with investment in PV and how these can be reduced. A lack of track record for PV was highlighted as a significant investment risk and this project is assessing ways to reduce the risk.
  - ***EUROSUNMED*** is focusing on cooperation with North African countries and how PV systems can be optimised for the conditions in these countries.
  - ***Solar EraNet*** presented the opportunity for PV project support through the ERANET mechanism

  In addition ***KIC InnoEnergy*** presented its activities and how it can offer support to innovative PV opportunities.

<u>Common Research Priorities</u>

Analysis of the presentations highlighted a number of common research challenges and priorities. These can be listed under three themes as follows:

Improved Cost / Performance

A continued strong requirement for more ***cost effective energy generation*** was clearly highlighted for several PV technologies. This can be achieved in a number of ways:

- Higher efficiency, by using enhanced materials and processes and optimised cell designs (to optimise factors such as light capture and management and multi-layer interfaces)
- Reduced cost of materials and processes (using room temperature, atmospheric pressure, integrated processes and roll to roll processers where practical)
- Increased stability and lifetime – this can be achieved through a number of ways including optimised device design and device encapsulation (thus optimising barrier properties)

The importance of environmental impact was also strongly highlighted, with a strong emphasis on the use of sustainable materials and materials recycling

Upscaling

There is a strong need to develop the processing capability to produce large scale PV systems (e.g. full size modules, R2R manufactured products at full width) and to demonstrate "fitness for purpose" of full scale products in a range of applications. Key requirements are:

- Demonstrate "lab" performance at large scale for a range of different PV technologies
- Optimise large scale processes by, for example, "productionisation" of lab based processes
- Optimise PV module designs for relevant applications (addressing, for example transparency, flexibility, lightweight and aesthetics)
- Establish large scale demonstrators with representative end users (e.g. BIPV), accommodating end user design requirements
- Demonstrate integration in real systems / buildings and disseminate information on the value and impact of PV in these application
- Build engagement with key end users to identify and agree needs (e.g. standardisation of new PV technologies and products)
- Establish standards for novel PV technology products that are fit for purpose

Justification

One of the key issues discussed was the lack of market engagement and the lack of recognition of the value of PV as a sustainable renewable energy technology. It is important that this issue is addressed by, for example

- Showing that novel PV technologies do meet market need - essentially preparing the business justification for PV
- Develop business cases for investment, to demonstrate to investors the potential returns from PV

These common research challenges priorities are obviously the key areas for future funding and collaboration. However, it is not sufficient to consider each in isolation. It is considered that the most effective way forward is to address all three issues in and integrated way.

These activities will ensure that PV technologies are successfully developed to address the ever increasing global demand for energy.

Conclusions

This was a very positive, well organized workshop which addressed all its objectives. Furthermore, it highlighted the continuing strengths of the European PV community and also the key challenges for the future if it is going to retain its leading R&D position and begin to re-develop its industrial capability. Many of these challenges are similar to those highlighted at the 2013 EU PV Clusters workshop.

The workshop defined a number of common research priorities and identified key issues that need to be addressed and started the discussion required to progress these. These

outputs will be further discussed at the workshop at Industrial Technologies 2016 in Amsterdam on 23rd June.

Iain Weir and David Gutierrez
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