Nanophotonics - essential ingredient for efficient and cost-effective solar cells?

Jointly with European Photovoltaic Technology Platform, Nanophotonics Europe Association and Nanophotonics for Energy Efficiency Network of Excellence, and with the support of Photonics21 and EPIC

Day: Thursday, 03 October 2013
Time: 09:00 – 12:30
Access: Open to all participants of the EU PVSEC 2013

Scope:

A forum for the Nanophotonics and Photovoltaics communities to exchange ideas, to inform one another of latest developments, issues, challenges and opportunities, and to discuss joint future activities.

Background:

The Photovoltaics community is driven by issues relating to materials, device processing and manufacturing, and mainly focusing on the $/W or $/m^2 metrics. Novel ideas emerging out of the Nanophotonics community may address these issues by increasing device efficiencies (ideally at constant cost per unit area), or by allowing a reduction in the amount of material used (and hence, a cost reduction) for the same efficiency, but these ideas are often seen as impractical and not scalable. There is a clear need for the Photovoltaics and Nanophotonics communities to inform one another of the mutual constraints and capabilities and to explore the way forward, with the goal of ensuring the long term European competitiveness. The most suitable funding sources need to be identified and brought on board.

The meeting aimed to address the following questions:

What are the material and engineering constraints that prevent the implementation of Nanophotonic concepts? Are Nanophotonics concepts scalable to square metre panels? What is the trade-off between performance and cost? What are the material issues, also in view of earth abundance?

Programme Outline

09:00 – 09:10	Welcome and Introduction Wim C. Sinke (European Photovoltaic Technology Platform) and Gonçal Badenes (Nanophotonics Europe Association, Nanophotonics for Energy Efficiency NoE)
09:10 – 09:35	Light management for ultra-high efficiency photovoltaics Albert Polman (AMOLF)
09:35 – 10:00	Nanophotonics for more efficient solar cells Franz-Josef Haug (EPFL)
10:00 – 10:25	From nanoscale to gigawatt: a possible roadmap for how photonics will empower photovoltaics Ounsi El Daif (IMEC)
10:25 – 10:45	Coffee Break
10:45 – 11:10	Thin-film photovoltaics: industrial strategies for increasing the efficiency and reducing costs Cosimo Gerardi (STMicroelectronics)
11:10 – 11:35	Photonics for high-efficiency crystalline silicon solar cells Stefan Glunz (FhG ISE)
11:35 – 12:00	Panel/Discussion Moderator: Thomas Krauss (York Univ.)
12:00 – 12:10	Conclusions & future actions

Executive Summary

The workshop yielded a lively discussion with many contributions from the floor, the main points being summarised below:

The Photovoltaics community is looking towards Nanophotonics with great expectation. The need for novel concepts is clearly recognised as a driver for future innovation and commercial competitiveness of the sector.

Photovoltaics is looking for "hero"- demonstrations that will really break new ground in order to lead the field. Whether the nanostructure is at the front or at the back of the cell, whether it includes plasmonics, Mie scatterers, or other features matters less – as long as it works convincingly and brings the field (well) beyond existing approaches and technologies. According to current understanding and proofs of principle, Nanophotonics may offer benefits for advanced solar cell and module designs, but the "killer application" still needs to be demonstrated. Moreover, the practical applicability of many of proposed concepts is a major challenge.

Nanophotonics should concern itself with what it can do well; part of the discussion is governed by ray optics arguments, but the opportunities offered by wave optics, such as exceeding the Lambertian limit for light trapping and controlling the light flow in the active layer are particularly important and therefore need to be explored further. Other ideas concerned the exploration of the photonic properties of existing electrical structures; small modifications may already yield sizeable effects without adding cost. In any case, work on photonic structures must carefully consider its impact on electrical behaviour of the devices.

On the other hand, Nanophotonics should not *overly* constrain itself with eventual manufacturability issues or manufacturing cost; as long as the concepts

provide real added value, industry will find a way to come up with workable solutions.

The Nanophotonics community is largely concerned with increased light trapping and is exploring a variety of avenues to achieve this. The real problem, however, is to demonstrate enhanced efficiency in working solar cells or maintaining efficiency while drastically reducing device thickness. Credible comparisons with state-of-the-art technologies should be pursued. The two communities need to work together to achieve this.

Most of Nanophotonics work is concerned with novel geometries for light scattering. More effort should be spent to extend the frequency range over which light can be used efficiently, e.g. using spectral slicing, or up/down-conversion.

The analogy with nanostructured LEDs was made; initial papers on enhanced extraction efficiency from photonic crystals transformed the industry to the extent that nowadays, virtually all high-performance LEDs on the market use nanostructured surfaces of some kind.

The meeting concluded with the agreement to invite experts from the Nanophotonics community to the relevant topical working groups that the European Photovoltaic Technology Platform plans to form (e.g. to prepare strategic input for H2020 or the Solar Europe Industry Initiative, or a position paper for public and/or policy use).