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PECSYS Virtual Workshop
5th November 2020

Workshop Summary

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Workshop focus and objectives

Direct production of hydrogen from sunlight

Objective
Scientific exchange between research and industry in the field of direct hydrogen production from sunlight.

Presentations

Project results by the consortium on directly electrically coupled photovoltaic + electrolyser approaches

Related topics from guest speakers on a variety of topics

1. European Hydrogen research strategy
2. Beyond Sun to H_2 to prepare synthetic zero carbon fuels for motor vehicles
3. Water splitting wireless devices
4. Thermal integration in concentrated PV+ electrolysis system
5. Scaling of III-V semiconductor based solar hydrogen systems

Some figures

Count	Country	Registered
1	Belgium	14
2	Brazil	2
3	Canada	4
4	Colombia	1
5	Cyprus	1
6	Denmark	1
7	France	2
8	Germany	29
9	Italy	7
10	Korea	2
11	Morocco	1
12	Peru	1
13	Portugal	7
14	Slovakia	1
15	Spain	5
16	Sweden	27
17	Switzerland	2
18	The Netherlands	2
19	United Kingdom	4
20	USA	8
	TOTAL	121

Average attendance:

~ 60

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Acknowledgements for the successful organization

Guest speakers

- Claudiu Pavel (FCH JU, BE)
- Hannah Johnson (Toyota Motors Europe, BE)
- Ib Chorkendorf (Technical University of Denmark, DK)
- Sophia Haussener (EPFL, CH)
- Jose Ramon Galan-Mascaros (ICIQ, ES)
- Todd Deutsch (NREL, US)

Presenters and contributors from the Consortium

HZB Helmholtz Zentrum Berlin PVcomB · JÜLICH Forschungszentrum · UPPSALA UNIVERSITET · Consiglio Nazionale delle Ricerche · enel Green Power

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PECSYS results in relation to specific objectives

1. New record PV-EC devices for thin film silicon, crystalline-Si and CIGS based approaches
   - **4%** solar to hydrogen efficiency on **64 (100) cm²** area integrated thin film silicon electrolyser
   - **4.5 %** solar to hydrogen efficiency on **2500 cm²** integrated c-Si (SHJ) electrolyser
   - **13 %** solar to hydrogen efficiency on **80 (100)** cm² integrated CIGS electrolyser
   - **14%** solar to hydrogen efficiency on **730 cm²** direct coupled SHJ PV to PEM electrolyser
   - **10 %** solar to hydrogen efficiency on **10 m²** direct coupled PV (CIGS and SHJ) to PEM electrolyser stacks
2. Sealing concepts beyond state-of-the-art
   - Materials that effectively protect photoabsorber from „corrosive“ electrolyte still elusive
3. Demonstration of 10 m² solar to hydrogen system with long lifetime – done with PV+EC but not with thermally integrated devices
4. LCOH in the range from **4 to 10 €/kg,** 6€/kg is possible with integrated devices also

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What have we learnt from the workshop – Guest Speakers

C. Pavel (FCH JU)

1. Renewable H_2 production
    - Europe has big plans for in the order of GW of electrolyser capacity and millions of tonnes of annual H2 production
    - Future research will also focus on end use which will increase demand
2. Supply chain
    - Supply chain is still fragmented
    - Critical raw materials include Si, carbon (graphite) and titatnium which have traditionally been considered as „low“ cost and abundant

H. Johnson (Toyota Motors Europe)

1. Direct sunlight to hydrogen (and other fuels) can provide fuels that significantly reduce the lifecycle emissions of motor vehicles
2. Introduction of Sun to-X: beyond renewable electrolysis for hydrogen generation – photoelectrochemical production of a „synthetic“ fuel -Hydrosil

What have we learnt from the workshop - Guests

Ib. Chorkendorff (DTU)

1. Advocated device benchmarking using hydrogen measurements rather than current
2. PV+EC shows superior performance than wireles (PEC) mainly because of optical losses
3. Wireless devices need protective layers, so far TiOx seems to be the best material with protection upto 80 hours

S. Haussener (EPFL)

1. Scaling PV + EC by concentrating the incident irradiance to > 1500 suns and taking advantage of heat transfer to the electrolyser
2. Photoactive area increased from ~ 2 cm^2 to 12 cm ×12 cm leading to hydrogen production of > 0.4 kg/day

What have we learnt from the workshop - Guests

J. R. Galan-Mascaros (ICIQ, ES)

- Overview of the a-leaf project artificial photosynthesis for CO_2 splitting
- Photo-electro-catalytic cell from earth-abundant materials for sustainable solar production of CO_2-based chemicals and fuels

T. Deutsch (NREL, US)

- Buried junction typical of PV cells achieves higher efficiency than semiconductor liquid junctions
- PV+electrolysis still superior than PEC in terms of stability
- Scale of capacity with moderate ~ 10 % solar concentration => a III-V photoabsorber of 8 cm ² achieved 3.3 L in 8 hours
- MEAs solve bubble formation issues, better for safety since they use water
- Demonstrator III-V photoabsorber + MEA+ 10 sun+ active cooling; solar to hydrogen efficiency 2-5 %
- Introduction NREL „Electrons to Molecules“ approach

Questions from the audience

- Integrated device lifetime
- Mitigation of losses from PV to electrolysis
- Bubble management
- Performance measurement – hydrogen
- Materials used – heat transfer between PV and electrolyser; electrocatalyst; photocatalytic materials

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Conclusion

There are many common points for photovoltaics+electrolysis, photoelectrochemical and photocatalytic devices

1. Scale up capacity but with the constraints of
    - Efficiency
    - Cost
    - Service lifetime
    - Sustainability
2. Using „costly“ but highly performing materials (III-V seminconductor photoabsorber and platinum group electrocatalysts) can help with finding innovations to solve engineering and practical problems with these devices including bubbles, thermal management, charge transport
3. Difficulty in comparison because of lacking standard measurements

Slides available at

https://www.helmholtz-berlin.de/projects/pecsys/news-and-events/pecsys-workshop/index_en.html

Thank you for attending

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