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SHINE RTD 2013

FNSNF

Sun to Fuel

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
csem

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EMPA Materials Science & Technology
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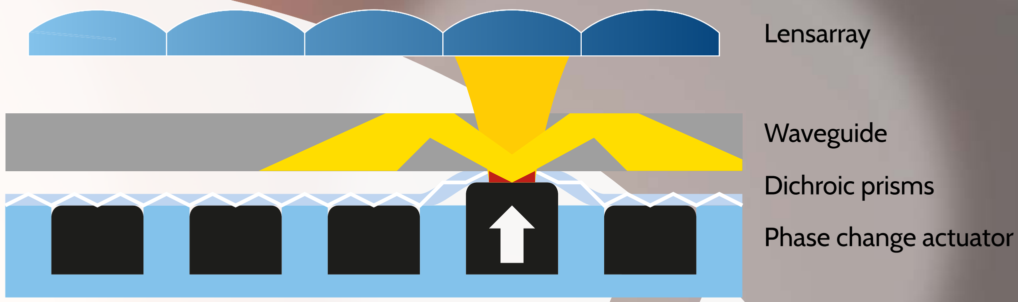
Aim of the Project

This project aims to develop a hydrogen production system using sunlight in an integrated manner with earth abundant materials mimicking natural photosynthesis. We aim to pursue a system level approach to provide an optimal sun to fuel conversion efficiency.

The approach is to use concentrated sunlight to decrease the amount of solar cell area and a water vapour feedstock in a reverse fuel cell design. The full spectrum of sunlight is utilized: the visible part is used for the photovoltaic cell and the infrared part to provide the energy for passive tracking and for water heating. Microfluidics will be used to manage heat in the solar concentrator, for cooling the Photovoltaic cell and generating water vapour. A theoretical multi-physics model will be developed to optimize the parameters of the system.

Solar Concentration (LAPD)

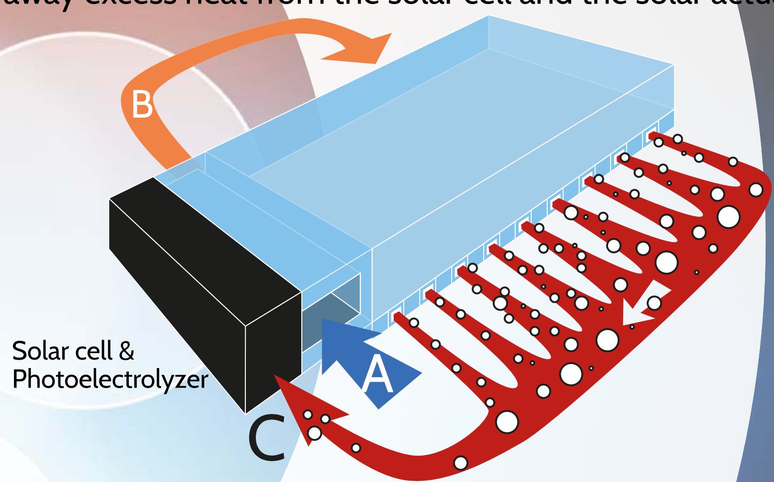
Concentrating sunlight allows for a higher possible efficiency at the PV cell. Using a self-adaptive concentrator eliminates the energy required to power it and therefore corresponds to an overall system efficiency increase.



The self-adaptive mechanism uses the infrared light in the sunlight to create a local coupling feature by thermally expanding paraffin wax. Using a dichroic prism array in a flexible membrane visible light is reflected and coupled into the waveguide on contact between the membrane and the waveguide.

Microfluidics (LO)

Microfluidic structures will efficiently deliver input fluids to the catalysts and mobilize the gaseous byproducts away from the catalytic sites. In addition water vapor is generated as an input feed for the photoelectrolyzing cell by taking away excess heat from the solar cell and the solar actuator.

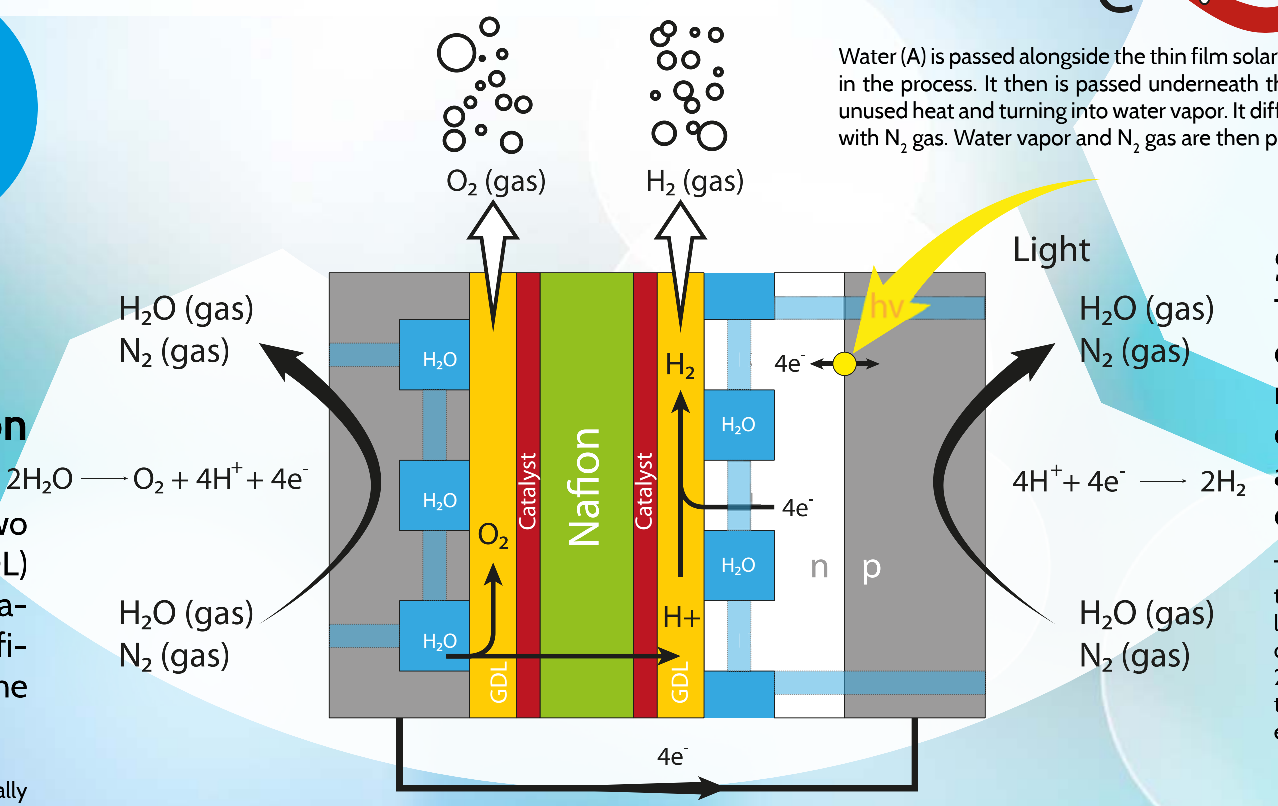


Water (A) is passed alongside the thin film solar cell, absorbing its heat and cooling it down in the process. It then is passed underneath the self-adaptive mechanism (B), taking up unused heat and turning into water vapor. It diffuses into a vapor flow channel pressurized with N_2 gas. Water vapor and N_2 gas are then pumped into the PEC micro-reactor (C).

SHINE

Solar Hydrogen Integrated Nano Electrolysis

H_2



Catalyst and gas diffusion layers (EMPA)

Assembly and development of two kinds of gas diffusion layers (GDL) with integrated nano sized catalyst particles. These will be specifically tailored to the needs of the cathode and anode side.

The cathode side (PV side) GDL will be commercially available carbon based materials that are functionalized using Pt black particles. On the anode side the high potential (1.2V and 2.6V) prevents the use of a carbon based GDL. The material of choice here will be titanium alloy grid or foam.

Solar cell (CSEM)

The solar cell will be fabricated using earth abundant materials (mainly silicon) and designed to provide the voltage to break the water molecules.

The solar cell will consist of a multiple junction cell with an open-circuit voltage of at least 1.4 V. If a triple junction cell is used the open circuit voltage can be increased to over 2V. Using concentrated PV further increases the open-circuit voltage and therefore the efficiency of the solar cell.

Photoelectrolyzer (LRESE)

The hydrogen generation is performed by a H_2 generating microreactor with the solar cell providing the necessary voltage to drive the microreactor. The main focus lies on the design and optimization of the microreactor.

The microreactor itself consists of a catalyst coated on a proton membrane (Nafion). Using the energy provided by the solar cell, two reactions are driven in the microreactor: Reduction of H_2O to O_2 and H^+ on the one side and Oxidation of the H^+ protons (which diffuse through the membrane) to H_2 on the other side.