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FNSNF

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

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Design of Optofluidic Components for an Integrated Electrolyzer

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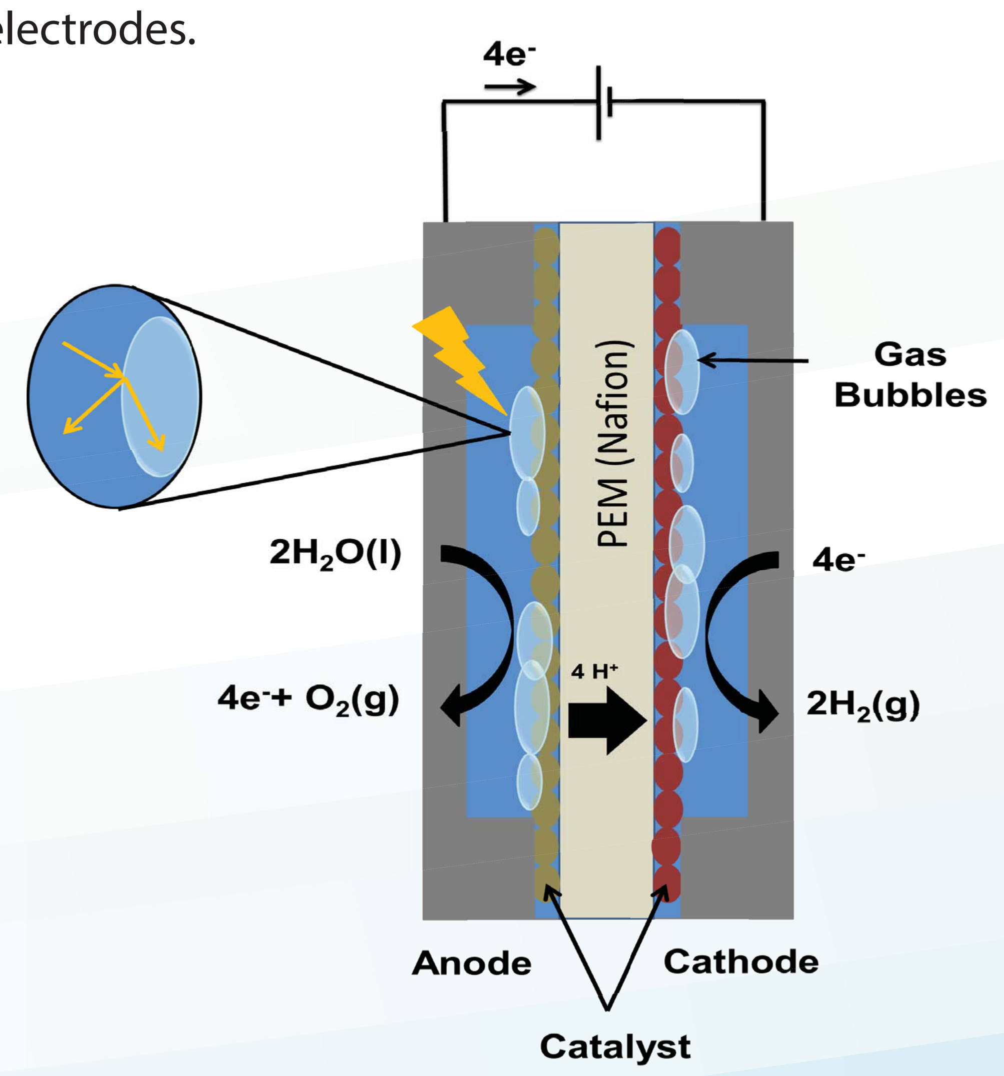
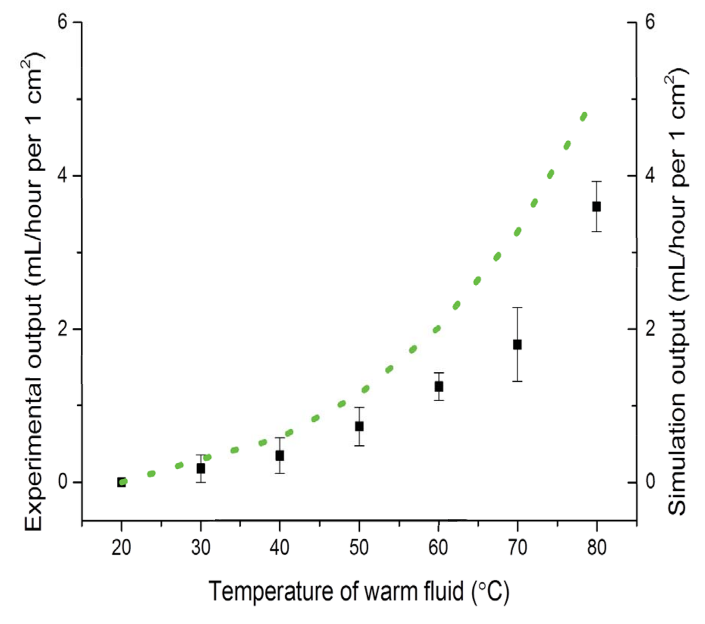
INTRODUCTION

The optofluidic part of SHINE project includes design and fabrication of three mini/microfluidics devices [1]. The first is a heat sink which cools down the solar panel close to ambient temperature. The second, an optofluidic vapor generator to feed the electrolyzer and the third is a microelectolyzer where water splitting reaction happens and the product gases are generated and separated inside. Proton Exchange Membrane (PEM) electrolyzer operated with water vapor have several advantages when compared to liquid water fed systems [2]. In the case of liquid water, gaseous products will stick on the surface of catalytic sites and impose mass transport limits to the system. Also, product gas formation in liquids can scatter and/or refract the incoming light away from photoactive electrodes.

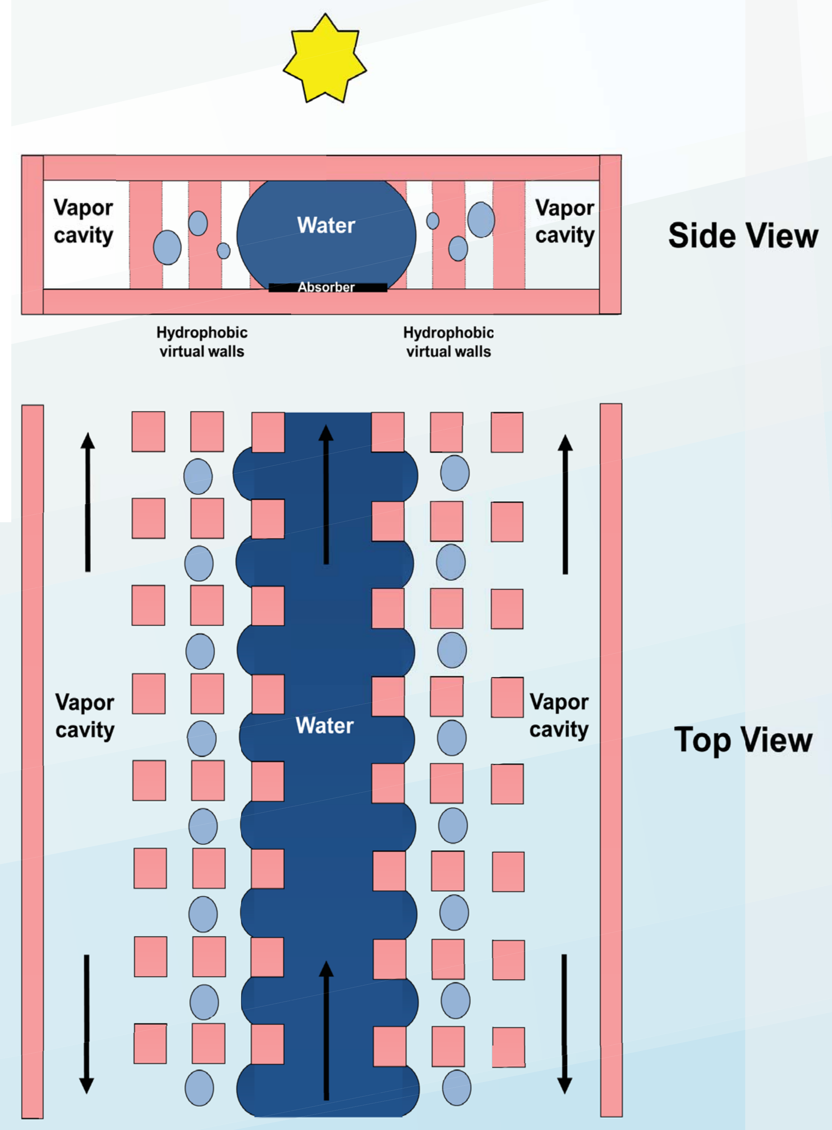


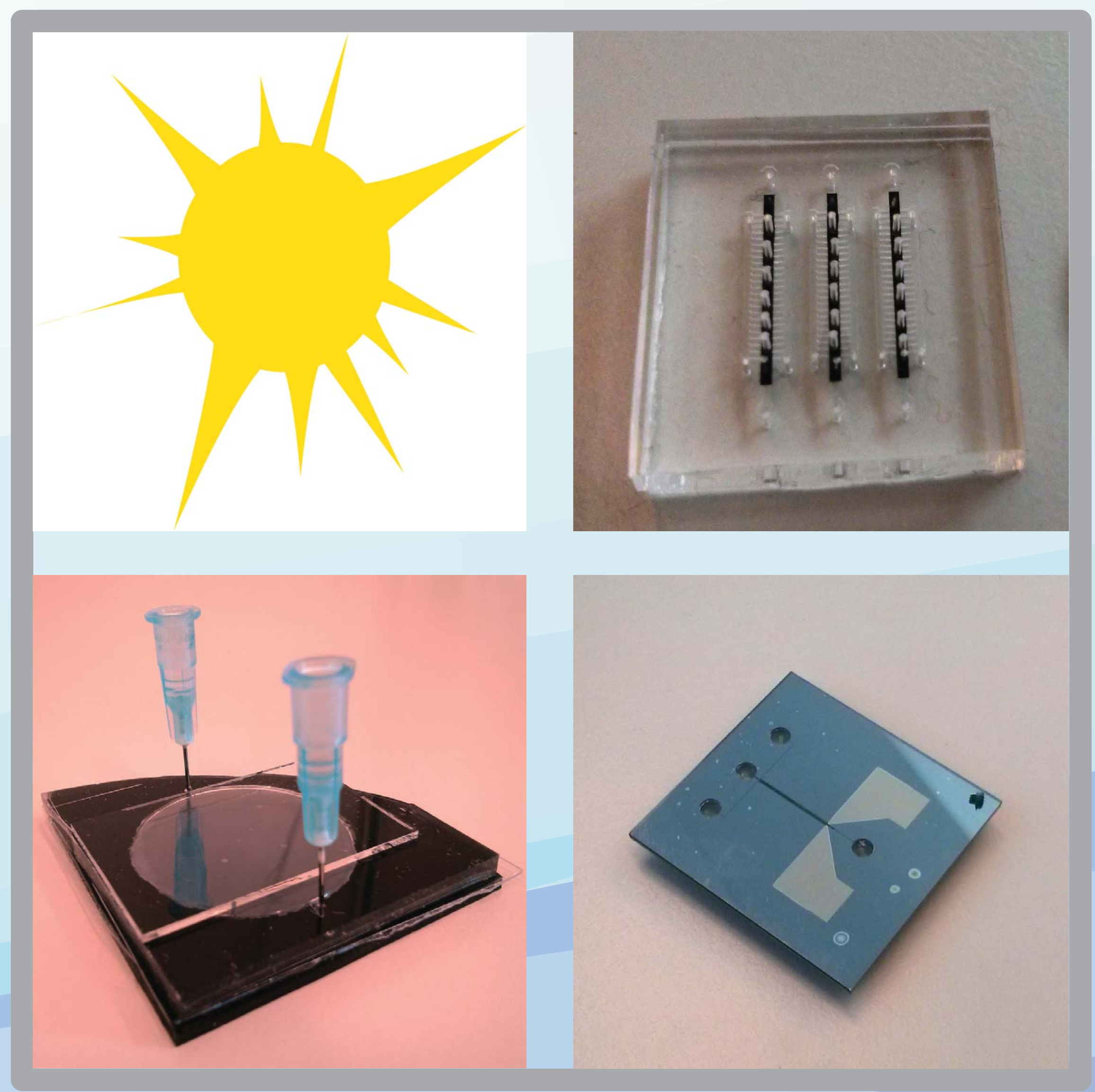
VAPOR GENERATOR

We use carbon black absorbers in microfluidic channels to heat up the input water. PDMS microstructures increase the fluidic resistance in the cross-flow direction in a way that only water vapor can escape from them and enter the side channels. In the side channels, a carrier gas will guide the vapor into the PEC cell. Water can be preheated at the back of PV before entering this device



Evaporation rate as a function of water inlet temperature

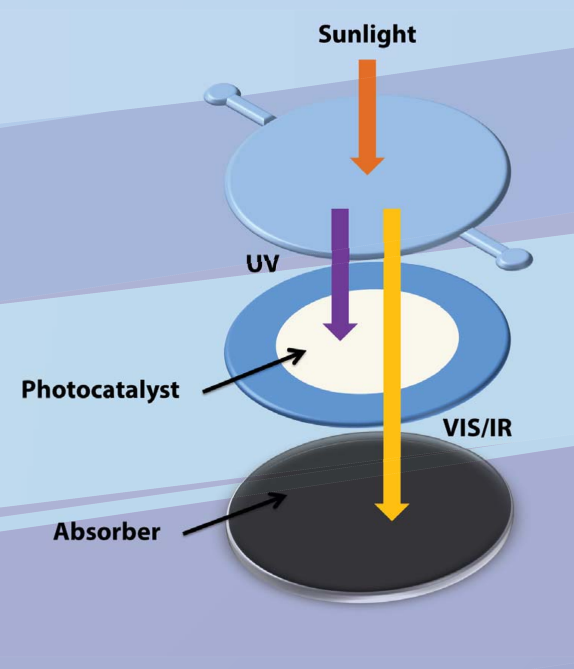


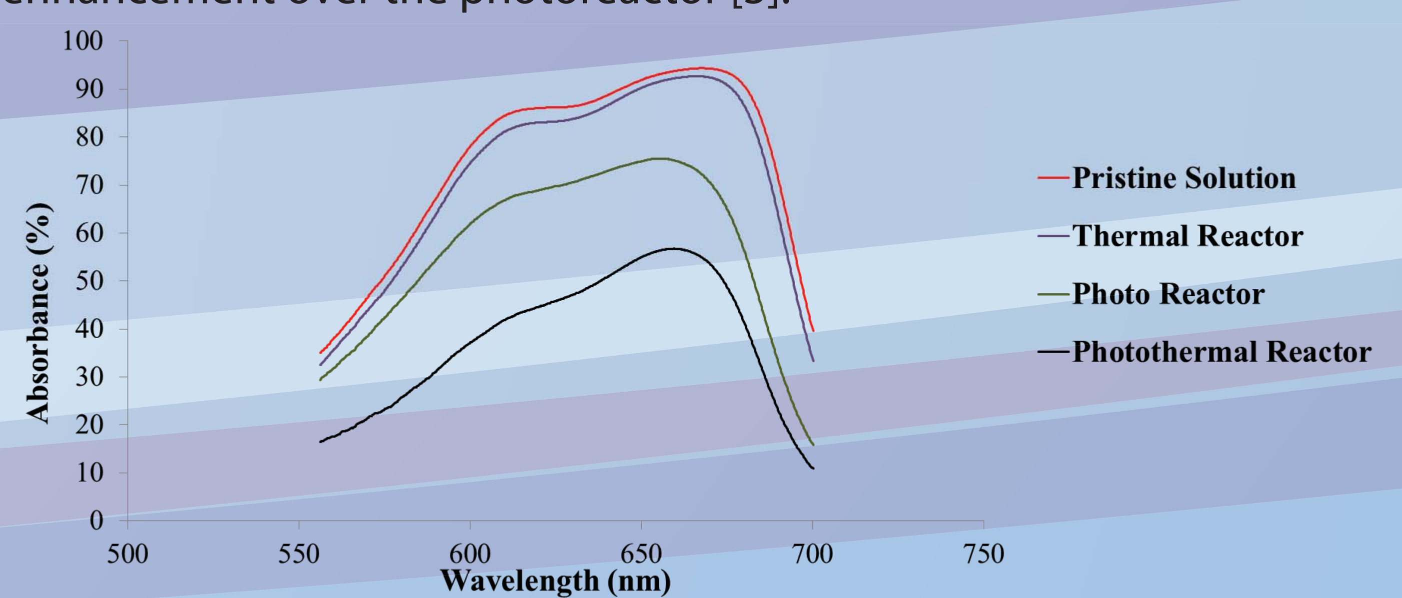


THERMAL MANAGEMENT

Some part of the solar energy is converted into heat by the solar cell, increasing its equilibrium temperature. This elevated temperature leads to an efficiency loss which can be controlled by integrating a cooling system into the PV component. Solar concentration factor determines the type of cooling system required. For low concentration factors, air cooled systems are the best choice and for high concentration factors water cooled system will be needed. If a water cooled system is used, the warm output water can be used to feed the vapor generator.

In a parallel project, the effect of this heating component on the decomposition rate of organic water pollutants is tested. Photoreactors with titania thin films as the photocatalyst are fabricated and the reaction rate for the cases with and without absorber are investigated. The photothermal reactor shows 82% enhancement over the photoreactor [3].

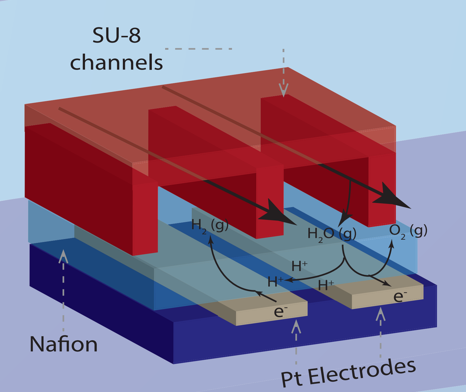


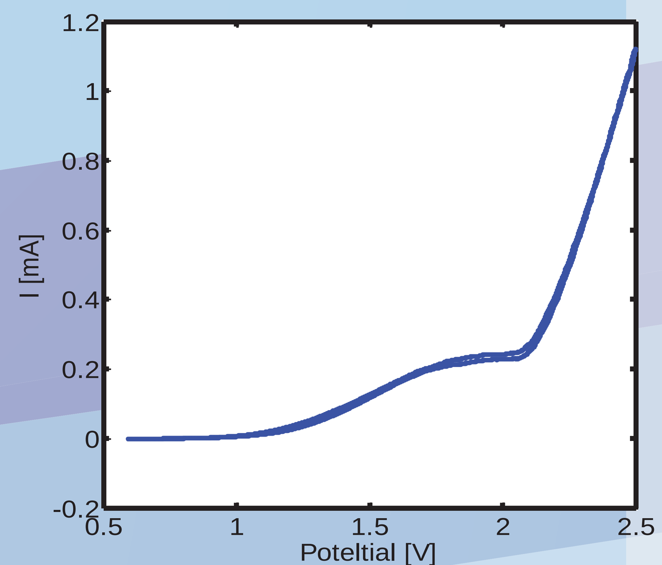


ELECTROLYZER

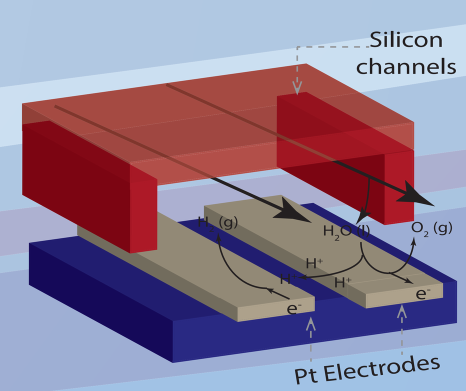
Two microelectrolyzers are being designed and fabricated: A vapor fed and a liquid fed system. The platinum electrodes are deposited on glass and fluidic channels are either etched into silicon or made out of SU8 through photolithography. Nafion is used in the vapor fed device to provide pathways for ion conduction. For liquid fed systems, integration of such a membrane is still under study.

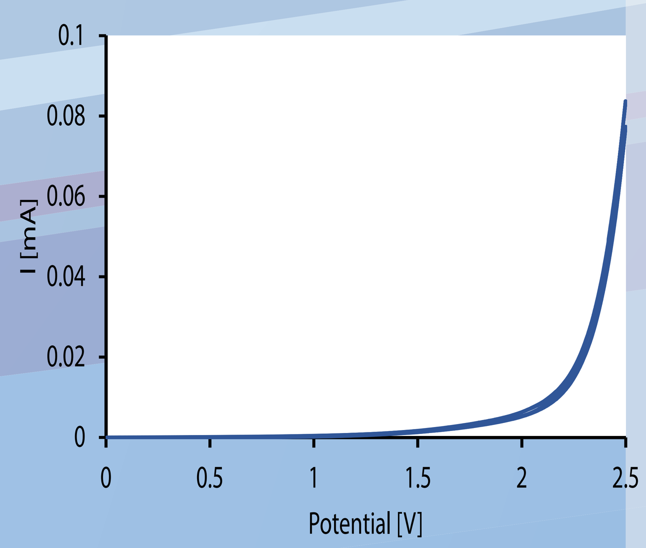
Vapor fed system





Liquid fed system





Water Splitting Components

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1. Erickson, D., Sinton, D., & Psaltis, D. (2011). Optofluidics for energy applications. Nature Photonics, 5(10), 583-590.
2. Spurgeon, J. M., & Lewis, N. S. (2011). Proton exchange membrane electrolysis sustained by water vapor. Energy & Environmental Science, 4(8), 2993-2998.
3. Hashemi, S. M. H., Choi, J. W., & Psaltis, D. (2014). Solar thermal harvesting for enhanced photocatalytic reactions. Physical Chemistry Chemical Physics.