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Towards Membrane-less Electrolysis

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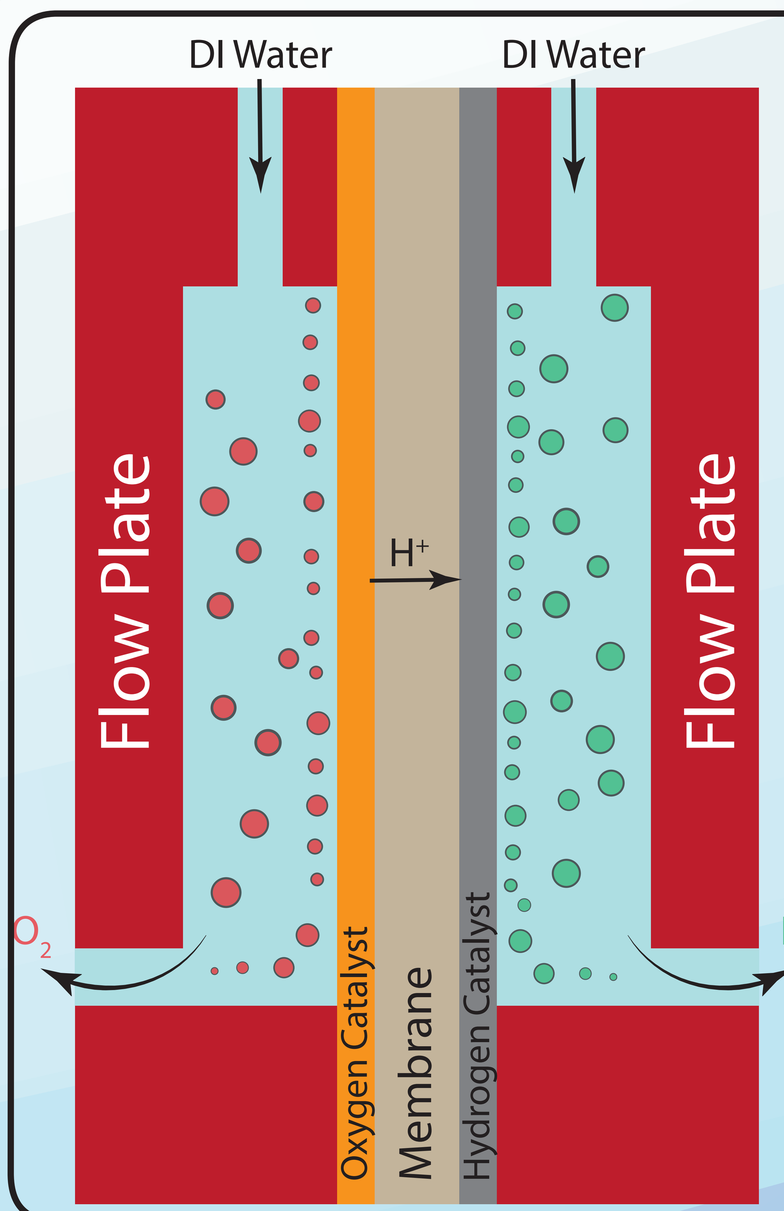
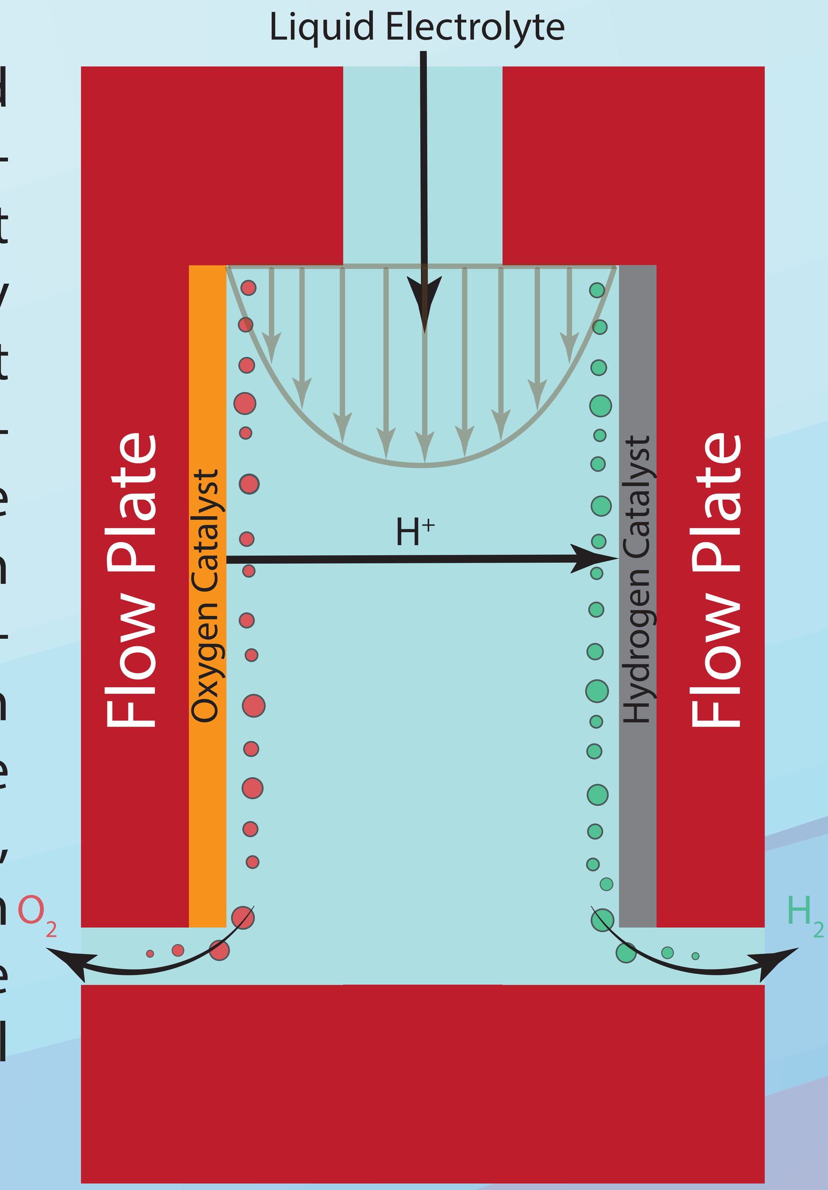
Renewable hydrogen has the potential to reshape our fossil fuel based energy infrastructure as it would allow the integration of a larger share of clean energy sources. Electrolysis of water is one of the most promising pathways toward clean hydrogen production. Although high efficiency electrolyzers are commercially available, their high cost has been a major obstacle for their large scale deployment. Design simplifications of these devices could trigger the deployment of clean-hydrogen production. Here, we demonstrate a proof-of-concept device for water splitting which the need for the integration of an ion conductive membrane between its two half cells has been removed. The efforts to scale up this device through 3D printing is the current focus of this project.

MOTIVATION



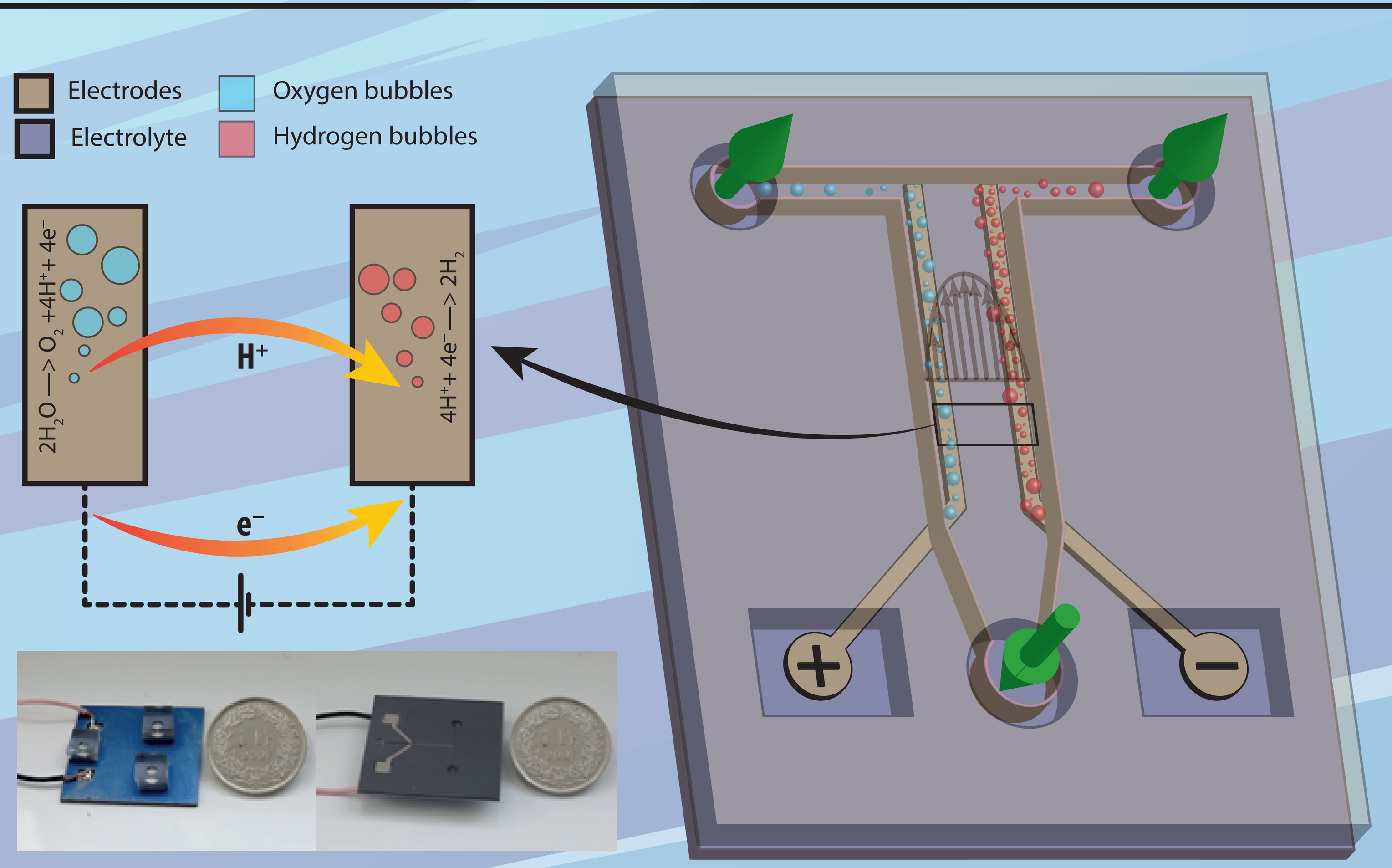
More than 150 years has passed since the discovery of water molecule splitting into its constituent hydrogen and oxygen molecules by means of electrical energy. In recent years, due to the environmental concerns resulting from excessive usage of fossil fuels, the interest has been renewed in designing efficient devices capable of delivering hydrogen gas as a chemical fuel at competitive prices. At the heart of these devices, lies a membrane/separator which contributes to the high costs of these systems and imposes some practical limitations also.



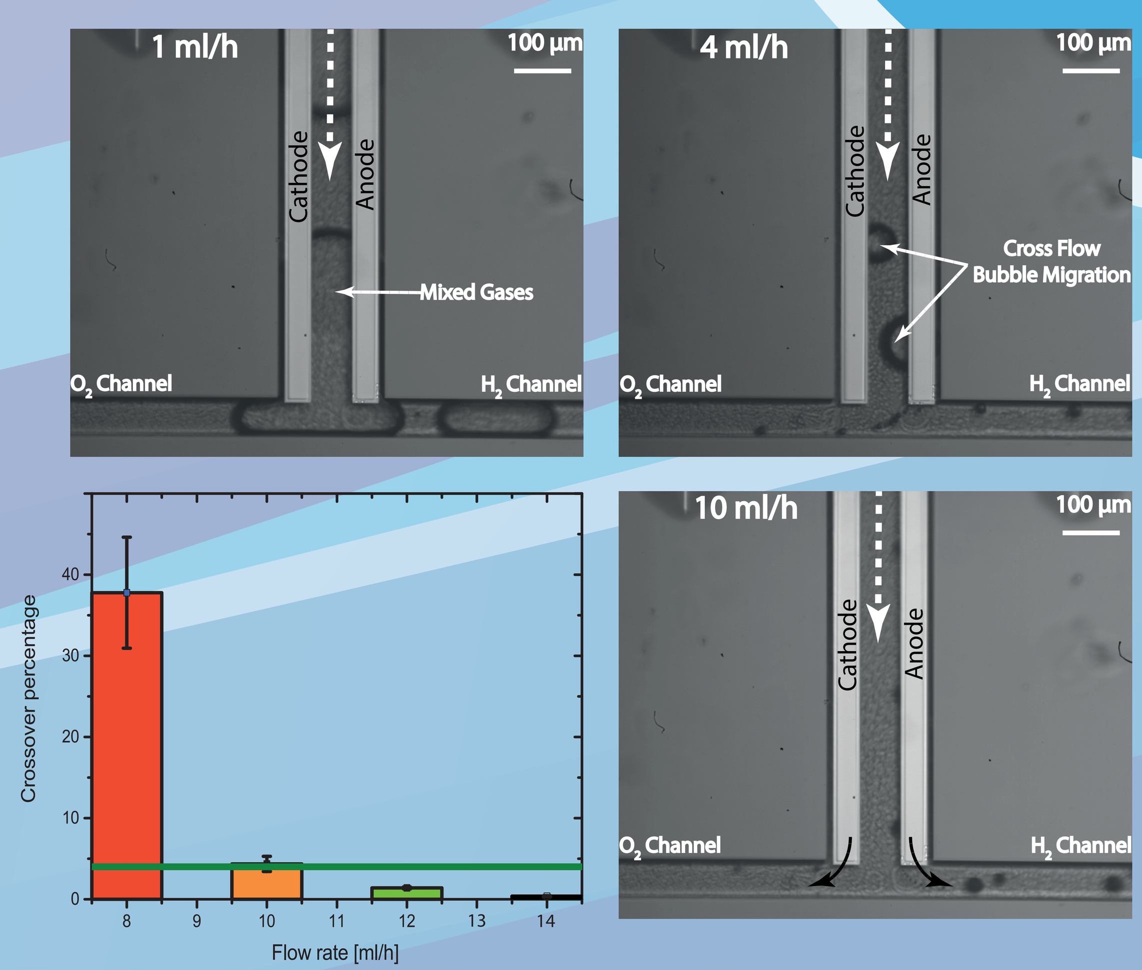
The ion conduction in the membrane can be also delivered by liquid electrolytes. The problem with liquid electrolytes is that it cannot suppress the gas crossover. In this project, we have shown that if the speed of electrolyte flow is large enough in the laminar regime, the flow can exert forces on the bubbles and keep them close to the side walls.

This concept has been shown successfully in a microfluidic demonstrator and there are ongoing efforts for scaling up the device and make a larger prototype with an affordable technology and higher throughput.

MICROFLUIDIC PROTOTYPE

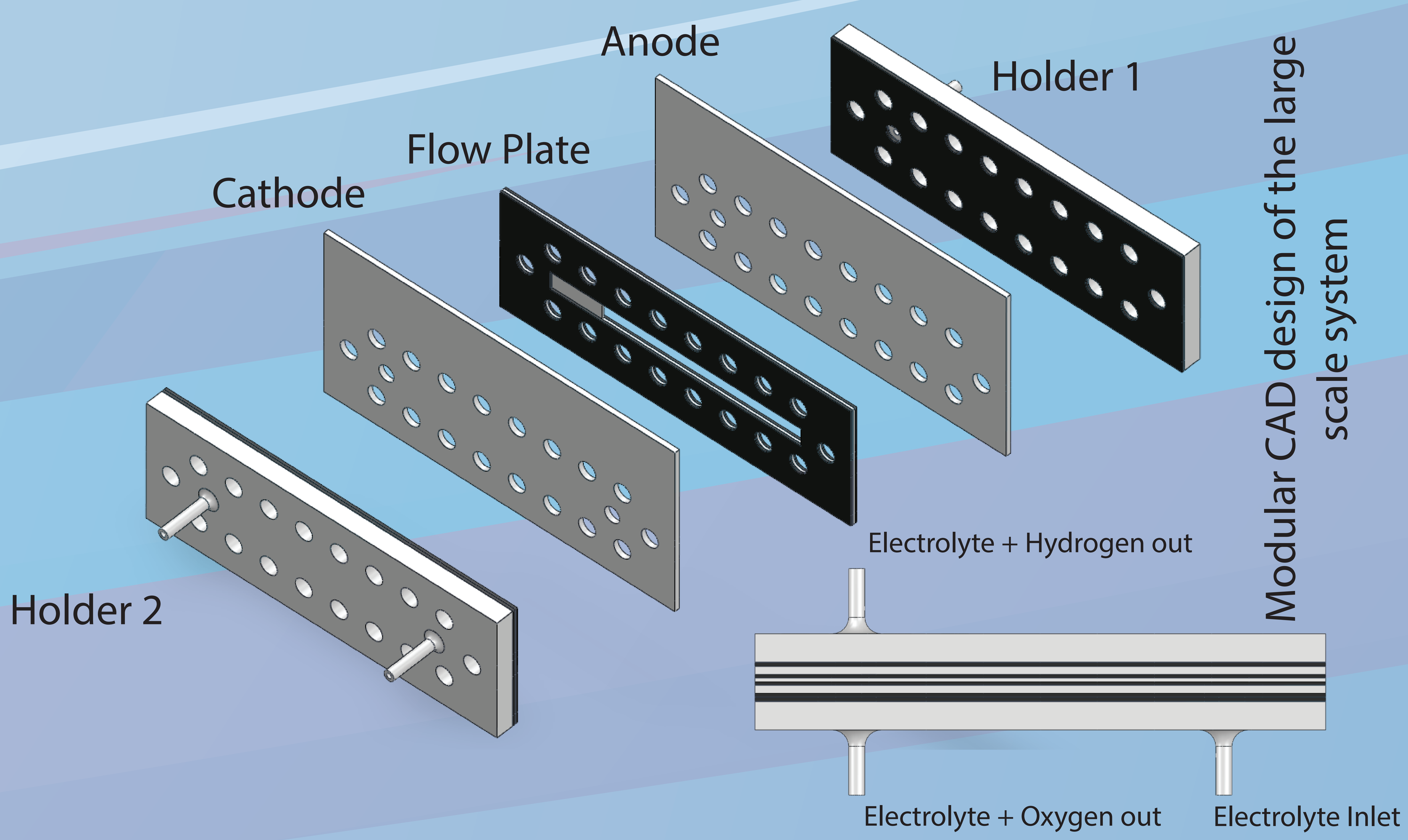


Schematic of the microfluidic device

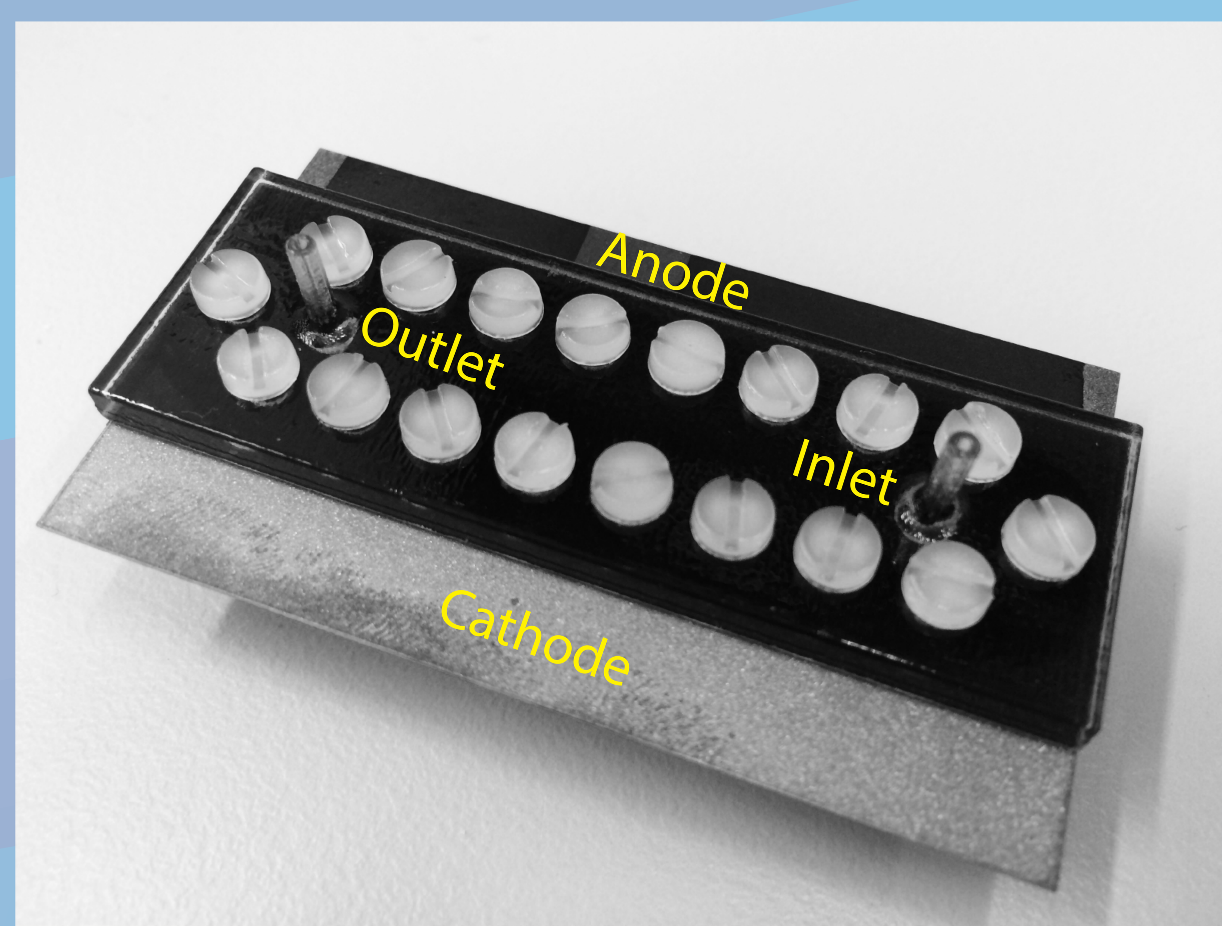


Effect of flow rate on gas crossover

3D PRINTED PROTOTYPE



Modular CAD design of the large scale system



Picture of the assembled, scaled up, 3D printed device

Hosseini Hashemi, S. M., Modestino, M. A., & Psaltis, D. *Energy and Environmental Science*. 2015