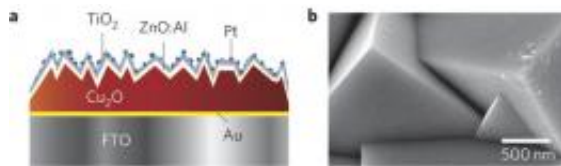


Harnessing the energy of the sun: New technique improves artificial photosynthesis

May 10 2011



a, Schematic representation of the electrode structure. b, Scanning electron micrograph showing a top view of the electrode after ALD of 5×(4 nm ZnO/0.17 nm Al₂O₃)/11 nm TiO₂ followed by electrodeposition of Pt nanoparticles. Image: Nature, DOI: 10.1038/NMAT3017

Transforming solar energy into a usable form is a real challenge. One technique is to use semiconductors to store the energy as hydrogen. Unfortunately, the most efficient semiconductors are not the most stable. An Ecole Polytechnique Federale de Lausanne (Switzerland) team has just discovered that it is possible to protect the semiconductor with a uniform layer just a few nanometers thick.

This discovery will make it possible to improve [photoelectrochemical cells](#). In the same way that plants use [photosynthesis](#) to transform sunlight into energy, these cells use sunlight to drive [chemical reactions](#) that ultimately produce hydrogen from water. The process involves using a light-sensitive semi-conducting material such as cuprous oxide to provide the current needed to fuel the reaction. Although it is not expensive, the oxide is unstable if exposed to light in water. Research by

Adriana Paracchino and Elijah Thimsen, published May 8, 2011 in the journal [Nature Materials](#), demonstrates that this problem can be overcome by covering the semiconductor with a thin film of atoms using the [atomic layer deposition](#) (ALD) technique.

Under the supervision of Professor Michael Grätzel in EPFL's Laboratory of Photonics and Interfaces, the two scientists achieved this remarkable feat by combining techniques used at the industrial scale, and then applying them to the problem of producing hydrogen. With their process, cuprous oxide can be simply and effectively protected from contact with water, making it possible to use it as a semiconductor. The advantages are numerous: cuprous oxide is abundantly available and inexpensive; the protective layer is completely impermeable, regardless of the roughness of the surface; and the process can easily be scaled up for industrial fabrication.

A promising technique

The research team developed the technique by "growing" layers of zinc oxide and titanium oxide, one atom-thick layer at a time, on the cuprous oxide surface. By using the ALD technique, they were able to control the thickness of the protective layer down to the precision of a single atom over the entire surface. This level of precision guarantees the stability of the semiconductor while preserving all of its hydrogen-producing efficiency. The next step in the research will be to improve the electrical properties of the protective layer.

Using widely available materials and techniques that can be easily scaled up brings the "green" photoelectrochemical production of [hydrogen](#) closer to the industrial interest.

More information: Highly active oxide photocathode for

photoelectrochemical water reduction, Adriana Paracchino, Vincent Laporte, Kevin Sivula, Michael Grätzel and Elijah Thimsen, *Nature Materials*, 8 mai 2011. [DOI: 10.1038/NMAT3017](https://doi.org/10.1038/NMAT3017)

Abstract

A clean and efficient way to overcome the limited supply of fossil fuels and the greenhouse effect is the production of hydrogen fuel from sunlight and water through the semiconductor/water junction of a photoelectrochemical cell, where energy collection and water electrolysis are combined into a single semiconductor electrode. We present a highly active photocathode for solar H₂ production, consisting of electrodeposited cuprous oxide, which was protected against photocathodic decomposition in water by nanolayers of Al-doped zinc oxide and titanium oxide and activated for hydrogen evolution with electrodeposited Pt nanoparticles. The roles of the different surface protection components were investigated, and in the best case electrodes showed photocurrents of up to -7.6 mA cm^{-2} at a potential of 0 V versus the reversible hydrogen electrode at mild pH. The electrodes remained active after 1 h of testing, cuprous oxide was found to be stable during the water reduction reaction and the Faradaic efficiency was estimated to be close to 100%.

Provided by Ecole Polytechnique Federale de Lausanne

Citation: Harnessing the energy of the sun: New technique improves artificial photosynthesis (2011, May 10) retrieved 25 April 2024 from <https://phys.org/news/2011-05-harnessing-energy-sun-technique-artificial.html>

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