CALL FOR PhD CANDIDATES

Atomic Layer Deposition (ALD) functionalized porous silicon membrane for Solar fuel production by CO_2 reduction reaction.

Background

Primary energy consumption and more particularly fossil energies such as coals, oil, gas is constantly growing, and it could lead to energy shortage in some parts of the world. Furthermore, strict control of carbon dioxide (CO_2) emission is required and new technologies enable its use to produce high added value chemicals or fuels. To date, the best CO_2-to-methane (CH_4) conversion yield is rather low (about 1.1 $\mu mol.g_{catalyst}^{-1}.h^{-1}$) [1]. Major improvement of such technologies could be of interest but the approach is generally always the same. During this study, we propose an original approach allowing the fabrication of conversion devices on large areas porous materials, giving hope for an increase the of fuel production quantity.

CO_2 reduction for solar fuel production is generally based on a two-electrode system. This implies two separated design and fabrication steps for the anode and the cathode (Figure 1a), increasing the complexity and production cost of the final system. Monolithic Photoelectrochemical Cells (PECs) (Figure 1b) integrate the whole conversion system in a single assembly. However, a better integration of these cells are necessary to push the outstanding phenomenon called "artificial photosynthesis".

Among all the semi-conductors that have been studied for PEC fabrication, silicon is a material of choice since it is easy to pattern and it is possible to homogeneously deposit materials on its surface using large area substrates thanks to microelectronics industry. Moreover, silicon presents a dominant role in the field of solar energy to electric energy conversion (photovoltaics) thanks to its excellent light absorption properties. Consequently, porous silicon (PSi) functionalization seems to be a promising approach to perform CO_2 reduction reaction (CO2RR) thanks to its high specific surface area and the possibility to conformably deposit ALD catalysts inside the pores. Moreover, this functionalization layer can passivate the PSi [2], often pointed out as prone to photocorrosion [3]. The obtained device could present the architecture proposed on Figure 1c. To date, the most promising catalyst is titanium dioxide (TiO_2) [1] but others, such as wide gap semiconductors, whose deposition is mastered by our laboratory will be investigated. [4-5].

In order to tackle these different challenges, the study will consist in the design and fabrication of a large-area (>50 cm^2) PEC able to perform the CO_2 reduction by combining porous silicon, ALD catalyst and solar energy in order to produce methane.

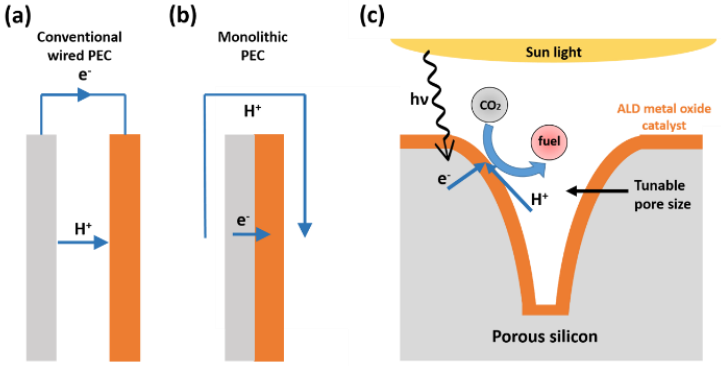

Figure 1. Schematic of a typical two-wired PEC (a) compared with a monolithic PEC (b). Proposed architecture in the frame of this project (c).

Works will be performed under the supervision of Dr. Brice Le Borgne and Pr. Gaël Gautier.

References

[1] Zhao, H., et al. (2017). *Applied Surface Science*, 404, 49-56.

[2] Ao, X., et al. (2012). *Applied Physics Letters*, 101(11), 111901

[3] Santinacci, L. et al. (2016). *ACS Applied Materials & Interfaces*, 8(37), 24810-24818.

[4] García-López, E. et al. (2018). *Catalysis Today*, 313, 100-105.

[5] Akimov, A. V. et al. (2015). What makes the photocatalytic CO2 reduction on N-doped Ta_2O_5 efficient: insights from nonadiabatic molecular dynamics. *JACS*, 137(35), 11517-11525.

Profile

The PhD candidate should hold a Master's degree in Electronics, Material Science or Electrochemistry. He or she should be autonomous, motivated and well organized. The contract duration is 3 years (October 2022 to August 2025). The salary is about €1,400/month and includes access to the French healthcare system. Access to low-fees restaurant for lunch is possible. The candidate should be aware that traveling abroad will be part of the job (conferences, collaboration, etc.). It is also required to speak, write and read English properly in order to communicate and to disseminate the team's work.

Contact

If you are interested, please contact the following people:

Dr. Brice LE BORGNE Maître de Conférences Université de Tours GREMAN – Site STMicroelectronics 16 rue Pierre & Marie Curie – BP 7155 37071 TOURS Cedex 2 brice.leborgne@univ-tours.fr	**Pr. Gaël GAUTIER** Professeur INSA-CVL GREMAN – Site STMicroelectronics 16 rue Pierre & Marie Curie – BP 7155 37071 TOURS Cedex 2 gael.gautier@univ-tours.fr

More about our laboratory:

https://greman.univ-tours.fr/english-version/about-us