In-situ imaging for the strain-engineering of deformable electrodes

Abdarahmane Thiam , Christophe Rousselot , Yves Gaillard , Marina Raschetti , Marion Vieira , Frédéric Kanoufi , and Fabien Amiot*[1]

[1]Franche-Comté Électronique Mécanique, Thermique et Optique - Sciences et Technologies (UMR 6174) – Université de Franche-Comté, Centre National de la Recherche Scientifique, Ecole Nationale Supérieure de Mécanique et des Microtechniques, Université de Technologie de Belfort-Montbeliard, Centre National de la Recherche Scientifique : UMR6174, Université de Technologie de Belfort-Montbeliard : UMR6174 – France

Abstract

Hydrogen is today mainly obtained by hydrocarbon steam reforming, which produces large CO2 quantities. Because of the rising concern about greenhouse gas emissions, the widespread use of hydrogen as an energy carrier requires the development of a carbon-free production chain. In case it makes use of renewable electricity sources, hydrogen production by electrolysis may be the key to trigger the expansion of this promising sector. However, only a few percent of the total hydrogen production comes today from water electrolysis, mainly because of its cost, which is about four times higher than the cost of hydrogen obtained by steam reforming. Electrolysis requires an electrocatalyst, typically platinum, which is rare and expensive.
Electrolytic production of H2 is thus handicapped by its dependence on platinum and by the adverse role played by the hydrogen bubbles produced at the electrode surface in the hydrogen production itself. It is therefore crucial, in order to minimize the cost and energy losses, to avoid materials like platinum as much as possible, and to limit the adverse effects of bubbles production.

It has already been demonstrated that elastic strains can modulate the electrocatalytic activity of metals (1-3), so that more abundant materials could be strained in order to compare with platinum in terms of electrocatalytic activity. The question of the optimal position in the 6-dimensional strain space is however open, and we propose an experimental approach based on an original imaging technique to address this issue.

This imaging technique is applied to monitor in-situ, in-operando the early stages of the hydrogen production at the surface of deformable micro-cantilevers made of much more abundant materials. This first reveals that the hydrogen production is very non-uniform along the cantilever. An initial deformation could also be imposed to the micro-cantilevers, so that the imaging technique has been applied to cantilevers with varied external mechanical loadings. This reveals that the hydrogen production is significantly altered on the surface under tension of the bent cantilever. Contrarily, the hydrogen production is enhanced when the surface is under compression.

*Speaker

(1) *Mavrikakis et al.* Phys. Rev. Lett. 81 (13), 1998.

(2) *Kibler et al.* Angew. Chem. Int. Ed. 44, 2005.

(3) *Martinez-Alonso et al.* PCCP 24, 2022.