Scalability and feasibility of photoelectrochemical H$_2$ evolution - DTU Orbit (29/12/2018)

Scalability and feasibility of photoelectrochemical H$_2$ evolution: the ultimate limit of Pt nanoparticle as an HER catalyst

The recent surge in investigating electrocatalysts for the H$_2$ evolution reaction is based on finding a cheap alternative to Pt. However platinum's excellent catalytic activity means very little catalyst needs to be used. The present study combines model experiments with numerical modeling to determine exactly how little catalyst is needed. Specifically we investigate ultra-low Pt loadings for use in photoelectrochemical H$_2$ evolution using TiO$_2$–Ti-pn$^+$Si photocathodes. At a current density of 10 mA cm$^{-2}$, we photocathodically evolve H$_2$ at +465, +450, +350 and +270 mV vs., RHE at Pt loadings of 1000, 200, 50, and 10 ng cm$^{-2}$ corresponding to HER overpotentials of $\eta_{1000\text{ng}} = 32$ mV, $\eta_{200\text{ng}} = 46$ mV, $\eta_{50\text{ng}} = 142$ mV, and $\eta_{10\text{ng}} = 231$ mV. To put this in perspective, if 30% of the world's current annual Pt production was used for H$_2$ evolution catalysis, using a loading of 100 ng cm$^{-2}$ and a current of 10 mA cm$^{-2}$ would produce 1 TW average of H$_2$. The photoelectrochemical data matched the modeling calculations implying that we were near the fundamental maximum in performance for our system. Furthermore modeling indicated that the overpotentials were dominated by mass transfer effects, rather than catalysis unless catalyst loadings were less than 1000 ng cm$^{-2}$.

**General information**

State: Published
Organisations: Department of Physics, Experimental Surface and Nanomaterials Physics, Department of Micro- and Nanotechnology, Silicon Microtechnology, Aalto University
Number of pages: 9
Pages: 2991-2999
Publication date: 2015
Peer-reviewed: Yes

**Publication information**

Journal: Energy & Environmental Science
Volume: 8
Issue number: 10
ISSN (Print): 1754-5692
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 30.87 SJR 14.59 SNIP 4.819
Web of Science (2017): Impact factor 30.067
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 26.39 SJR 12.283 SNIP 4.325
Web of Science (2016): Impact factor 29.518
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 19.28 SJR 7.769 SNIP 4.001
Web of Science (2014): Impact factor 20.523
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 14.81 SJR 6.019 SNIP 2.996
Web of Science (2013): Impact factor 15.49
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 11.84 SJR 5.868 SNIP 2.599
Web of Science (2012): Impact factor 11.653
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes