High yield hydrogen production enabled by macroporous silicon monoliths

Vega D.[a], Divins N.[b], Trifonov T.[a], **Rodriguez A.[a],** Llorca J.[b]
a Department of Electronic Engineering, Universitat Politècnica de Catalunya, Campus Nord
b Department of Chemical Engineering , Universitat Politècnica de Catalunya, Campus EEBE
Contact@E-mail: angel.rodriguez@upc.edu

Abstract

A macroporous silicon (MPS) membrane of 210 µm thickness was functionalized and evaluated for hydrogen production by steam reforming of various fuels. Performance is comparable to conventional reactors, but in a much compact device thanks to process intensification [1]. No blockage or damage was observed after extensive testing. MPS technology [2] is well suited for applications as demonstrated in [3], as it allows the fabrication of large arrays of regular pores in a silicon substrate. The fabricated samples consist of an array of ordered pores of $3.3\,\mu\mathrm{m}$ in diameter and $210\,\mu\mathrm{m}$ length, with a straight profile; the array periodicity is $4\,\mu\mathrm{m}$. The as-etched sample was post-processed to create an open membrane, and later, it was conformally covered with a $\mathrm{CeO_2}$ film, which was then coated with a layer of RhPd nanoparticles. Different fuels were studied for hydrogen generation at high temperatures (up to $1023\,\mathrm{K}$): ethanol, propanol, acetone, acetic acid, 2-methoxythanol, and a diesel surrogate [4]. Total tests duration was 80 h. The results show that no structural damage nor channel blockage is present. Results of $\mathrm{H_2}$ production are shown in **Fig. 1.** The reaction hydrogen yield and selectivity show the best results for 2-methoxyethanol at $923\,\mathrm{K}$, with $53\,\%$ selectivity, $\theta_{\mathrm{H_2}} = 0.4$ yield, and a $\mathrm{H_2}$ production density of $110\,\mathrm{L_N}\,\mathrm{H_2}/\mathrm{mL_{fuel,liq.}}\,\mathrm{cm^3_{react}}$.
Comparable results in hydrogen production with respect to conventional ceramic honeycombs have been obtained, but in a much smaller volume. Good performance was obtained and no damage or blockage was observed after extended testing, making this technology an outstanding candidate for energy production in embedded applications.

Acknowledgements

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References

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Figures

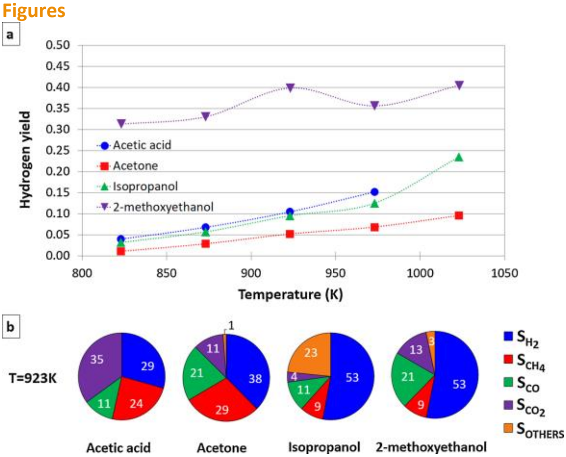

Figure 1: (a) Hydrogen yield and (b) selectivity at 923 K for different tested fuels.