Advances in silicon-intregrated Micro Solid Oxide Fuel Cells: Towards a new family of ultra-thin portable power sources

Iñigo Garbayo [(a)], Francesco Chiabrera [(a)], Nerea Alayo[(a)], A. Morata[(a)], A. Tarancón[(a)]*

[(a)] Department of Advanced Materials for Energy, Catalonia Institute for Energy Research (IREC), Jardí de les Dones de Negre 1, Planta 2, E-08930 Sant Adrià de Besòs (Barcelona), Spain

*E-mail of the Corresponding Author: igarbayo@irec.cat

Recent progress on the development of Micro Solid Oxide Fuel Cells (μSOFC) have positioned this emerging technology as a promising alternative to efficiently power up current energy-demanding portable devices. High instantaneous charge capacity and power density can be reached at relatively low temperatures (<600ºC) by downscaling classical SOFCs to thin films (<1μm total thickness) and integrating them in silicon micromachined substrates. Now, main challenges for a broad deployment of this technology are on the design of full cells integrable in real handable devices. We analyse here the open issues and we propose different approaches and solutions.

On one side, challenges in materials are mainly related to the still too high operating temperatures, which hinders the encapsulation of μSOFC modules into final handable devices. To solve that, operating temperatures below 300ºC are targetted. We investigate superior oxide-ion conducting materials ($Bi_2V_{0.9}Cu_{0.1}O_{5.35}$, $La_{9.33+x}Si_6O_{26+1.5x}$) in thin film form as an alternative to the most widely studied electrolyte for μSOFC, Yttria-stabilized Zirconia. Classical limitations of these materials (poor stability, reactivity) are expected to be overcome by using them as nanometric thin film electrolytes in low-temperature μSOFC. Area-specific resistances below the target 0.15 Ωcm^2 for the electrolyte were already measured in $Bi_2V_{0.9}Cu_{0.1}O_{5.35}$ films at temperatures below 200ºC, showing the potential of these materials in this new range of temperatures.

Parallel to that, great efforts are being put on the cell design for (i.) enlarging the active area versus substrate for higher power and (ii.) integrating fuel cell modules with different components of the final portable power device. First, large area μSOFC membranes have been developed supported in Si-slabs grid, increasing the active area by a factor of x200. Second, we present fuel cell stacking by Si wafer bonding and the fabrication and integration of micro evaporators, micro reformers and post-combustors, for the operation with easy-to-handle hydrocarbons.

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