

# Chemically Stable Proton Conducting Materials for Reversible Solid Oxide Fuel Cells

Enrico Traversa

*Physical Science and Engineering Division, King Abdullah University of Science and Technology (KAUST), Thuwal 23955-6900, Saudi Arabia*

The high cost of solid oxide fuel cells (SOFCs), associated with their high operating temperatures, hampers their broad use and causes long-term stability problems. A step forward towards reducing the SOFC working temperature at 600°C or below can be the use of high temperature proton conductor (HTPC) oxides as electrolytes, due to their lower activation energy for proton conduction (0.3-0.6 eV), with respect to oxygen-ion conducting electrolytes [1]. We have recently made significant progresses following various strategies [2] in the development of chemically-stable HTPC electrolytes by improving the sinterability of Y-doped barium zirconate (BZY) [3], which offers excellent chemical stability against CO<sub>2</sub> and H<sub>2</sub>O reaction and high bulk conductivity [4], but low conductivity values for sintered pellets due to the presence of blocking grain boundaries. Co-doping BZY with Pr allowed obtaining a chemically stable, sinterable electrolyte that showed a conductivity of 0.01 S/cm at 600°C.

However, efficient cathodes need to be developed to avoid polarization losses at such a low temperature [5]. We followed a rational approach to tailor the cathode materials with low overpotential, considering that the materials should concurrently possess electron, proton and oxygen-ion conductivities, given the different species involved in the cathode reactions, and we succeeded in obtaining an area specific resistance as low as 0.157 Ω cm<sup>2</sup> at 600°C [6].

The development of these materials allowed us to start investigation on solid oxide electrolysis cells (SOECs), where the use of HTPC electrolytes can alleviate the problems encountered with oxygen-ion electrolytes, which are high working temperatures, dilution of the produced H<sub>2</sub>, and fuel electrode oxidation [7]. We were recently able to report first on the SOEC test using BZY electrolytes [8].

In this presentation, the past work on protonic SOFCs will be briefly summarized, and then the recent work on SOECs will be presented. In addition, preliminary results of the recent efforts in scaling up both planar and microtubular cells and in improving the performance through the tailoring of the nanostructure of cathode materials will be shown.

## References

- [1] E. Fabbri, D. Pergolesi, E. Traversa, *Chem. Soc. Rev.* **29**, 4355 (2010)
- [2] E. Fabbri, L. Bi, D. Pergolesi, E. Traversa, *Adv. Mater.* **24**, 195 (2012)
- [3] E. Fabbri, L. Bi, H. Tanaka, D. Pergolesi, E. Traversa, *Adv. Funct. Mater.* **21**, 158 (2011)
- [4] D. Pergolesi, E. Fabbri, A. D'Epifanio, E. Di Bartolomeo, A. Tebano, S. Sanna, S. Licoccia, G. Balestrino, E. Traversa, *Nature Mater.* **9**, 846 (2010)
- [5] E. Fabbri, D. Pergolesi, E. Traversa, *Sci. Technol. Adv. Mater.* **11**, 044301 (2010)
- [6] E. Fabbri, L. Bi, D. Pergolesi, E. Traversa, *Energy Environ. Sci.* **4**, 4984 (2011)
- [7] L. Bi, S. Boulfrad, E. Traversa, *Chem. Soc. Rev.* **43**, 8255 (2014)
- [8] L. Bi, S.P. Shafi, E. Traversa, *J. Mater. Chem. A* **3**, 5815 (2015)