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Recent advances in materials, shaping and characterization tools for efficient SOFC and SOEC devices operating at intermediate temperatures

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The mandatory need of an energy sources diversification leads to a current great interest for the research areas related to hydrogen technologies. In particular, with a high efficiency Solid Oxide Cells produce either hydrogen when used in the electrolysis mode (Solid Oxide Electrolysis Cell, SOEC) or electricity and heat when used in the Fuel Cell mode (Solid Oxide Fuel Cell, SOFC). However, the durability in operation (especially in the SOEC mode) needs to be improved by reaching less than 1% degradation per 1000 h. To reach this objective, a solution is to decrease the working temperature (i.e. down to 600°C), without decreasing the power density. Approaching these objectives is really challenging.

For this purpose, ICMCB-CNRS follows several routes from long time in close collaboration with partners belonging to the French Research Federation on hydrogen (FRH2, <https://frh2.cnrs.fr/>), CEA and industrial partners. The French program of research PEPR-H2 (<https://www.pepr-hydrogen.com/>) led by CNRS and CEA is a favorite frame.

In this presentation, I will detail the most recent developments performed at ICMCB in collaboration with IRCER-CNRS laboratory and CEA-Liten, following three main axis. The first one concerns the research of new materials of electrodes, mainly oxygen electrodes, recently we had focused on some materials belonging to the upper terms ($n=2, 3$) of the series $\text{Ln}_{n+1}\text{Ni}_n\text{O}_{3n+1\pm d}$ ($\text{Ln} = \text{La}, \text{Pr}$), as well as doping on the anionic site (oxygen) by fluorine, for instance regarding reference electrodes such as LSFC (La-Sr-Fe-Co). The second axis concerns the development of innovative shaping routes of such multi-layered cells. A first goal was to produce a Solid Oxide Cell entirely composed of Gd-doped ceria with functionalized (impregnated) porous electrodes. The second goal was to develop a simple and low cost shaping process, i.e. the tape casting. Then we have developed a combined tape casting and infiltration (of solution) method in order to prepare new architectures of SOC(s). Finally, to bear our research we have developed several measurements tools, such as for instance IEDP (Isotopic Exchange Depth Profiling) measurements performed under oxygen pressure, i.e. close to the usual conditions of the SOEC devices.