Revisiting classical superior ionic conducting materials for low temperature µSOFC

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Micro Solid Oxide Fuel Cells (µSOFC) are emerging alternatives to current portable power sources, due to their high power density and instantaneous charge capacity. One of the main challenges to overcome for a broad deployment of this technology is the design of cells able to be easily integrated in real handable devices. In this sense, one possible approach is lowering the operating temperature, permitting a facile encapsulation of the cell and an easy integration into the final device. The most widely studied electrolyte for µSOFC is Yttria-stabilized Zirconia (YSZ), which as self-sustained membranes of nanometric thickness allows an operating temperature down to 400°C, clearly insufficient for simple device incorporation. Therefore, materials with higher ionic conductivity at low-to-intermediate temperatures are targeted.

In this work, superior oxide-ion conducting materials belonging to the aurivillius ($Bi_2V_{0.9}Cu_{0.1}O_{5.35}$, hereafter BICUVOX) and apatite family ($La_{9.33+x}Si_6O_{26+1.5x}$, hereafter LSA) are investigated in thin film form. Aurivillius compounds present a tetragonal phase with a high ionic conductivity, which can be stabilized by substituting the Vanadium with a metal atom (e.g. Cu). Lanthanum silicates are characterized by a hexagonal symmetry that promotes high oxygen diffusion at low temperatures because of a low transport energy of activation. Nonetheless, both these materials present limitations in the utilization as electrolyte in classical bulk SOFC, such as poor stability and low compatibility with other components at high temperature. These limitations can be overcome using them as nanometric thin film electrolyte in low-temperature µSOFC. BICUVOX and LSA thin films of less than 300 nm thick were deposited by pulsed laser deposition (PLD) method. The films grown under different deposition conditions are characterized by X-ray diffracion (XRD), Scanning electron microscopy (SEM) and Raman spectroscopy. The ionic transport is analyzed by electrochemical impedance spectroscopy (EIS), showing the potential of using these materials at temperatures below 200ºC (Area-Specific Resistance < 0.15 Ωcm^2 for the electrolyte film). These results open new prospects in the application of this technology in a completely new range of temperatures, with great potential for easy integration in real devices.

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