Microstructural and electrical properties of gadolinium doped ceria thin films prepared by ALD (Atomic Layer Deposition)

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Reducing the operating temperature of solid oxide fuel cells (SOFC) is an important challenge in order to commercialize this important electrochemical device. When decreasing the temperature, the ohmic drop through the electrolyte is one of the major problems. Even if the ionic conductivity of YSZ (Yttria-Stabilised Zirconia), the most commonly used electrolyte material, is not sufficient below 800°C, its replacement by a better ionic conductor is difficult because of its chemical stability and its good mechanical properties. At present, several works are focused on the research of a new material which would be able to replace YSZ as electrolyte for the SOFC working at reduced temperature between 600-800°C. Among the most promising materials, we can mention La2Mo2O9 whose oxide-ion conductivity is around 6.10-2 S.cm-1 at 800°C (1), apatite silicates such as La10(SiO4)6O3 which exhibits a total conductivity around 10-3 S.cm- 1 at 700°C (2) and strontium and magnesium doped lanthanum gallate LSGM having an ionic conductivity equal to 7.5 10-2 S.cm-1 at 800°C (3). However, gadolinia- doped ceria (CGO) still remains the most studied alternative electrolyte material because of a very suitable ionic conductivity below 800°C (8.3 10-2 S.cm-1 at 800°C (3)). Therefore, CGO thin layers of less than 1-2 μm were deposited allowing to combine the interest of thin layer technology to the high ionic conductivity of CGO and to minimize losses of electrochemical perfomances due to the ohmic drop through the electrolyte.

For the first time, Atomic Layer Deposition (ALD) (4), a well-suited method for binary compounds and their doping, was used for the elaboration of SOFC components. CGO thin layers less than 1 mm-thick were achieved by this technique. SEM analysis, EDS measurements and XRD have been carried out in order to determine the microstructural characteristics of the ALD layers. Dense, uniform and well-covering layers have been deposited onto several kinds of substrates, in particular on porous SOFC electrodes. Furthermore, the electrical properties of CGO thin films were investigated by means of Impedance Spectroscopy. In particular, the ionic conductivity of the deposited material was determined and compared with the litterature data. SEM cross-sectional micrographs enabled to estimate the of the CGO thin films thickness, around 200 nm and 1 μm, as shown in the Figure below. For the 1 μm ALD layer, SEM micrographs revealed adherent, dense, uniform and well-covering films, despite the porosity of the substrates. The film strictly follows the shape of the substrate without penetrating into its porous structure.

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Figure 2. Cross-sectional view of a 1 μm CGO layer deposited on porous LSM substrate.