supported cells. However, unlike zirconia, ceria can be reduced when exposed to a reducing atmosphere at elevated temperature, with the $Ce^{4+}$ ions partially reducing to $Ce^{3+}$ ions. This is known to result in an expansion of the crystal lattice of the material, which eventually results in the development of stresses in the ceramic electrolyte which are high enough to result in the failure of the electrolyte through cracking. This characteristic of ceria-based electrolytes precludes the use of reducing atmospheres to enable sintering of the electrolyte at very high temperatures without oxidising the steel, as has been reported for the production of metal-supported SOFCs with zirconia-based electrolytes. In addition, in order to facilitate low-cost volume manufacture and avoid problems with interaction between the nickel in the anode and the stainless steel support, it is highly desirable to sinter the electrolyte in air.

[0013] It is known that the densification of doped-ceria can be significantly enhanced by low-level addition of certain metal oxides, particularly cobalt oxide, copper oxide and lithium oxide.

[0014] The green density of a ceramic powder compact may be enhanced by the application of high pressure to the compact, to compact the powder as tightly as possible. Typical green densities of powder compacts after pressing are in the range 35-60% of theoretical density, depending upon the morphology and surface area of the powder.

[0015] The invention is intended to overcome or ameliorate at least some aspects of the above problems. Such that it can provide a process for producing an electrolyte which is dense, gas-tight, and may be fabricated on a ferritic stainless steel support using low-cost volume manufacturing methods.

Summary

[0016] Accordingly, in a first aspect of the invention there is provided a process for forming an electrolyte for a metal-supported solid-oxide fuel cell, the process comprising one or more of steps a - d:

a. combining a doped-ceria powder optionally with a sintering aid and solvent to form a slurry;

b. applying the slurry to an anode layer that is supported on a metal substrate;

c. drying to form a green electrolyte; and

d. firing the green electrolyte to form a sintered electrolyte at a sintering temperature of less than 1100°C;

wherein the slurry in step b. comprises doped-ceria powder with a physical property selected from bimodal particle size distribution, a BET surface area in the range 15 - 40 $m^2/g$, a spherical morphology, or combinations thereof.

[0017] Often the process will comprise steps a and b and optionally one of steps c or d, often a combination of two or three or more of any of steps a to d or all of steps a to d will be used to provide a dense, gas-tight doped ceria electrolyte. In addition, the doped-ceria powder present in the slurry of step b. will often have more than one physical property selected from bimodal particle size distribution, a BET surface area in the range 20 - 40 $m^2/g$, and a spherical morphology, often all three of these physical properties will be present to provide optimum densification of the electrolyte.

[0018] More specifically, it is possible to produce an electrolyte with a density of greater than 95% theoretical density, for instance in the range 95 - 100%, often 95.1, 97 or 98 - 100% density can be achieved using the process claimed. This reduces porosity and hence gas permeability, thus the electrolyte is gas-tight. Further, achieving an electrolyte density which is at such a high percentage of theoretical density ensures that the electrolyte has only very low levels of microscopic porosity, and hence is less prone to cracking (and so failure) during sintering

[0019] The doped-ceria green electrolyte will often be formed from a doped-ceria with high oxygen conductivity, such as a gadolinium doped-ceria (such as $Ce_{0.9}Gd_{0.1}O_{1.95}$ (CGO10)) or a samarium doped ceria (such as $Ce_{0.9}Sm_{0.1}O_{1.95}$). Often the doped-ceria green electrolyte will be formed from CGO (gadolinium doped-ceria). In many cases the doped-ceria will initially be in the form of a powder, such that an initial process step could be the provision of a doped-ceria powder. Often the powder will have a bimodal particle size distribution, with a peak at around 0.45 μm and a peak at around 1.6μm.

[0020] The doped-ceria powder will often be of defined surface area, to ensure good sintering of the green electrolyte layer that will be formed. Often the doped-ceria powder will have a BET surface area in the range 15 - 40$m^2/g$, more often 20 - 35$m^2/g$, still more often 24 - 28 $m^2/g$. It will generally be the case that, even where milling is used, the BET surface area of the powder will be in this range. The thermodynamic driving force for

Claims

1. A process for forming an electrolyte for a metal-supported solid-oxide fuel cell, the process comprising:

a. combining a doped-ceria powder with a sintering aid and solvent to form a slurry;

b. applying the slurry to an anode layer that is supported on a metal substrate;

c. drying to form a green electrolyte; and

d. firing the green electrolyte to form a sintered electrolyte at a sintering temperature of less than 1100°C;

wherein the slurry in step b. comprises doped-ceria powder with a physical property selected from bimodal particle size distribution, a BET surface area in the range 15 - 40 $m^2/g$, a spherical morphology, or combinations thereof.

2. A process according to claim 1, comprising the additional step of attrition milling the slurry prior to application to the anode layer.

3. A process according to claim 1 or claim 2, wherein the bimodal particle size distribution comprises particles forming a peak in the range 0.1 - 0.4μm and a peak in the range 0.5 - 1.5μm.

4. A process according to any preceding claim wherein the sintering aid is present in the range 0.5 - 5 mol % total cations; and/or comprising the additional step of forming the green electrolyte from a screen-printable ink.

5. A process according to any preceding claim, wherein the green electrolyte comprises multiple layers of electrolyte formed by applying the slurry in layers over the anode layer, with drying between the application of each layer.

6. A process according to any preceding claim, wherein the anode layer is a sintered anode layer.

7. A process according to claims 1 to 5, wherein the anode layer is a green anode layer and the green anode layer and green electrolyte are sintered in a single firing step.

8. A process according to any preceding claim, wherein the electrolyte covers the anode layer and the metal substrate.

9. A process according to any preceding claim, wherein the sintering step d. is performed in air.

10. A process according to any preceding claim further comprising a pressing step after application of the slurry to the anode layer, but prior to firing of the green electrolyte.

11. A process for forming a fuel cell comprising forming an electrolyte on a metal-supported anode layer using the process of any preceding claim, and applying a cathode material to the electrolyte.

12. An electrolyte obtained by the process according to any of claims 1 to 10.

13. A fuel cell comprising an electrolyte according to claim 12.

14. A fuel cell stack comprising at least two fuel cells according to claim 13.

15. Use of a fuel cell or fuel cell stack according to claim 13 or claim 14, respectively, in the generation of electrical energy.