Composite Interconnect and Method for Forming Composite Interconnects

Technical Field

This invention relates to a composite interconnects and a method for forming composite interconnects and more particularly, though not exclusively, to composite interconnects and a method for forming composite interconnects, for solid oxide fuel cells ("SOFC").

Background

In an SOFC stack, the anode of one fuel cell is physically and electrically connected to the cathode of an adjacent fuel cell in the stack via an interconnect. This allows the fuel cells to be operated in series so that the electricity generated by each fuel cell can be combined. Material used for the interconnect needs to be electrically conducting and chemically stable with fuel cell materials. As SOFC stacks undergo thermal cycling and the operating temperatures can go above 900°C for high power generating efficiency, the interconnects also need to be able to withstand such high temperatures. In addition, the interconnects must be extremely stable because they are exposed to both the oxidizing and reducing side of the cell at high temperatures.

Besides the traditional $LaCrO_3$-based interconnects, precious metals such as platinum (Pt) and palladium (Pd) can be added to ceramics to form a composite interconnect that has excellent electrical conductivity as well as chemical stability at temperatures over 900°C. Currently, more than 90 wt.% of the precious metal is needed in a ceramic matrix in order for the interconnect to be conducting. However, Pt and Pd are very expensive metals and the cost of using them is thus prohibitively high.

Summary

According to one exemplary aspect, there is provided a method for forming a composite interconnect for a solid oxide fuel cell. The method comprises mixing high aspect ratio metal particles with a matrix powder and an organic vehicle to form a paste. The paste is fired to form the composite interconnect.

Before firing, the paste may be disposed between electrodes of adjacent solid oxide fuel cells by a process preferably selected from the group consisting of: printing, spraying, dispensing and ink-jetting. Firing is preferably at a temperature in the range 1000 °C to 1200 °C.

According to a further exemplary aspect, there is a composite interconnect formed by the method of the first exemplary aspect.

According to another exemplary aspect, there is provided a composite interconnect for a solid oxide fuel cell comprising a matrix and high aspect ratio metal particles.

For all aspects, the high aspect ratio metal particles may be obtained by milling a metal powder to obtain flaked metal particles or by direct metal wire growth to obtain wired metal particles. The metal powder may be selected from: platinum, and palladium. The flaked metal particles may have grain sizes ranging from 100nm to 50μm. The wired metal particles may have diameters ranging from 2nm to 500nm and lengths ranging from 1μm to 200μm. Weight percentage of the high aspect ratio particles in the

composite interconnect may range from 10 to 50 wt%, more preferably from 20 to 30 wt%.

The matrix powder may be one of: ceramic powder, ceramic glass powder, and high temperature conductive powder. Where the matrix is a ceramic powder, the ceramic powder may be selected from: $La_{1-x}Sr_xMnO_3$ with La being any one of the Lanthanide elements Pr, Nd, Sm, Gd, Yb and Y, with x being less than 0.5, yttrium-stabilized zirconia, $LaCrO_3$, doped $LaCrO_3$, and $La_{1-x}Sr_xCoO_3$ (LSC).

Preferably, the organic vehicle comprises a common flux which comprises rosin, an activator, a thrixotropic agent and a solvent. From 5 to 30 wt.% of the organic vehicle may be used.

Brief Description of the Drawings

In order that the invention may be fully understood and readily put into practical effect there shall now be described by way of non-limitative example only preferred embodiments of the present invention, the description being with reference to the accompanying illustrative drawings.

In the drawings:

Fig. 1 shows a flowchart of a first exemplary embodiment of the method; and

Fig. 2 shows a flowchart of a second exemplary embodiment of the method.

Detailed Description of Exemplary Embodiments

According to one aspect, there is provided a composite interconnect and a method for forming a composite interconnect for a solid oxide fuel cell.

In a first exemplary embodiment, referring to Fig. 1, a metal powder is milled to form flaked metal particles. Before milling, the metal powder typically comprises spherical grains having grain sizes of about 50nm to 5μm. After milling, the flaked particles have grain sizes of about 100nm to 50 μm.

In a second exemplary embodiment, referring to Fig. 2, metal wire is grown to form wired metal particles. The wired metal particles have diameters ranging from 2nm to 500nm and lengths ranging from 1μm to 200μm.

Both the flaked and the wired metal particles are high aspect ratio metal particles. The high aspect ratio metal particles have lengths more than ten times greater than their breadth or diameter. Preferably, their lengths are more than a hundred times greater than their breadth or diameter. More preferably, their lengths are more than a thousand times greater than their breadth or diameter. The metal can be Pt or Pd.

A paste is then formed by mixing the high aspect ratio metal particles with a matrix powder and an organic vehicle. Preferably, the paste comprises 10 to 50 wt.% of the high aspect ratio metal particles. More preferably, the paste comprises 20 to 30 wt.% of

the high aspect ratio metal particles. The mixing disperses the high aspect ratio metal particles relatively uniformly through the paste.

By using high aspect ratio metal particles, this amount of precious metal Pt or Pd is sufficient for the resulting interconnect to be conducting. Compared to the greater than 90 wt.% needed when using normally available unprocessed metal powder, this is a significant reduction in the amount of precious metal needed, and results in a significant cost saving.

The matrix powder is preferably a ceramic powder such as $La_{1-x}Sr_xMnO_3$ (LSM), with La being any one of the Lanthanide elements Pr, Nd, Sm, Gd, Yb and Y, and x being less than 0.5. Alternatively, the ceramic powder can be yttrium-stabilized zirconia (YSZ), $LaCrO_3$, doped $LaCrO_3$, or $La_{1-x}Sr_xCoO_3$ (LSC), or any other suitable ceramic powder.

The organic vehicle can be common flux which comprises rosin, an activator, a thrixotropic agent and a solvent. Preferably, 5 to 30 wt.% of the organic vehicle is used.

The paste is preferably formed by stirring, milling, shaking or ultrasonically vibrating the high aspect ratio metal particles and the ceramic powder together to form a composite powder, and then mixing the composite powder with the organic vehicle. Alternatively, the high aspect ratio metal particles, ceramic powder and organic vehicle can be directly mixed together to form the composite paste.

To form the composite interconnect, the paste is disposed between electrodes of adjacent solid oxide fuel cells and fired at temperatures ranging from 1000 °C to 1200°C for about 1 to 2 hours. The paste can be disposed on the SOFCs by any suitable process, for example, such as printing, spraying, dispensing, ink-jetting.

The composite interconnect displays a resistivity of about 0.05 to 4 m-Ohm.cm. The maximum operating temperature is about 1000°C. Coefficient of thermal expansion was found to be about 13-16 ppm/°C from room temperature to 600°C, about 400 ppm/°C from around 700°C to 800°C, and about 6-10 ppm/°C above 830°C. The minimum screen printing mesh size is about 20-30 μm.

Whilst there has been described in the foregoing description exemplary embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations in details of design, construction and/or operation may be made without departing from the present invention. For example, other than flakes or wires, the high aspect ratio metal particles can have any other suitable high aspect ratio shape, such as ribbons. Mixtures of flakes and wires and other shapes of metal particles can also be used to form the composite interconnect.. Also, besides a ceramic powder, the matrix powder can be a ceramic glass powder or other suitable high temperature conductive powder.

The Claims

1. A method for forming a composite interconnect for a solid oxide fuel cell, the method comprising:
   - mixing high aspect ratio metal particles with a matrix powder and an organic vehicle to form a paste; and
   - firing the paste to form the composite interconnect.

2. The method of claim 1 wherein the high aspect ratio metal particles comprise flaked metal particles obtained by milling a metal powder.

3. The method of claim 2, wherein the flaked metal particles have grain sizes ranging from 100nm to 50μm.

4. The method of claim 1 wherein the high aspect ratio metal particles comprise wired metal particles obtained by metal wire growth technique.

5. The method of claim 4, wherein the wired metal particles have diameters ranging from 2nm to 500nm and lengths ranging from 1μm to 200μm.

6. The method of claim 1, claim 2 or claim 3, wherein the high aspect ratio metal particles comprise at least one metal selected from the group consisting of: platinum and palladium.

7. The method of any one of the preceding claims, wherein a weight percentage of the high aspect ratio metal particles in the composite interconnect ranges from 10 to 50 wt%.

8. The method of any one of claims 1 to 6, wherein a weight percentage of the high aspect ratio metal particles in the composite interconnect ranges from 20 to 30 wt%.

9. The method of any one of the preceding claims, wherein the matrix powder is selected from the group consisting of ceramic powder, ceramic glass powder and high temperature conductive powder.

10. The method of any one of the preceding claims, wherein before firing the paste is disposed between electrodes of adjacent solid oxide fuel cells.

11. The method of claim 10, wherein the paste is disposed on the solid oxide fuel cells by a process selected from the group consisting of: printing, spraying, dispensing and ink-jetting.

12. The method of any one of the preceding claims, wherein the firing is at a temperature in the range 1000 °C to 1200 °C.

13. The method of any one of the preceding claims, wherein the matrix powder is a ceramic powder selected from the group consisting of:

$La_{1-x}Sr_xMnO_3$ with La being any one of the Lanthanide elements Pr, Nd, Sm, Gd, Yb and Y, with x being less than 0.5,

yttrium-stabilized zirconia,

$LaCrO_3$,

doped $LaCrO_3$, and

$La_{1-x}Sr_xCoO_3$ (LSC).

14. The method of any one of the preceding claims, wherein the organic vehicle comprises a common flux which comprises rosin, an activator, a thrixotropic agent and a solvent.

15. The method of claim 14, wherein 5 to 30 wt.% of the organic vehicle is used.

16. A composite interconnect formed by the method of any one of the preceding claims.

17. A composite interconnect for a solid oxide fuel cell comprising a matrix and high aspect ratio metal particles.

18. The composite interconnect of claim 17, wherein the high aspect ratio metal particles comprise flaked metal particles, the flaked metal particles being a milled metal powder.

19. The composite interconnect of claim 18, wherein the flaked metal particles have grain sizes ranging from 100nm to 50μm

20. The composite interconnect of claim 17, wherein the high aspect ratio particles are wired metal particles, the wired metal particles being grown metal wire.

21. The composite interconnect of claim 20, wherein the wired metal particles have diameters ranging from 2nm to 500nm and lengths ranging from 1μm to 200μm.

22. The composite interconnect of any one of claims 17 to 21, wherein the high aspect ratio metal particles comprise at least one metal selected from the group consisting of: platinum and palladium.

23. The composite interconnect of any one of claims 17 to 22, wherein a weight percentage of the high aspect ratio metal particles in the composite interconnect ranges from 10 to 50 wt%.

24. The composite interconnect of any one of claims 17 to 22, wherein a weight percentage of the high aspect ratio metal particles in the composite interconnect ranges from 20 to 30 wt%.

25. The composite interconnect of any one of claims 17 to 24, wherein the matrix is selected from the group consisting of ceramic, ceramic glass and high temperature conductive material.

26. The composite interconnect of any one of claims 17 to 25, wherein the matrix comprises a matrix powder and an organic vehicle.

27. The composite interconnect of claim 26, wherein the matrix powder is a ceramic powder selected from the group consisting of:

$La_{1-x}Sr_xMnO_3$ with La being any one of the Lanthanide elements Pr, Nd, Sm, Gd, Yb and Y, with x being less than 0.5,

yttrium-stabilized zirconia,

$LaCrO_3$,

doped $LaCrO_3$, and

$La_{1-x}Sr_xCoO_3$ (LSC).

28. The composite interconnect of claim 26 or claim 27, wherein the organic vehicle comprises a common flux which comprises rosin, an activator, a thrixotropic agent and a solvent.

29. The composite interconnect of claim 28, wherein 5 to 30 wt.% of the organic vehicle is used.

30. The composite interconnect of any one of claims 17 to 29, wherein composite interconnect is disposed between electrodes of adjacent solid oxide fuel cells.

31. The composite interconnect of any one of claim 17 to 30, wherein the composite interconnect is fired at a temperature in the range 1000 °C to 1200 °C.