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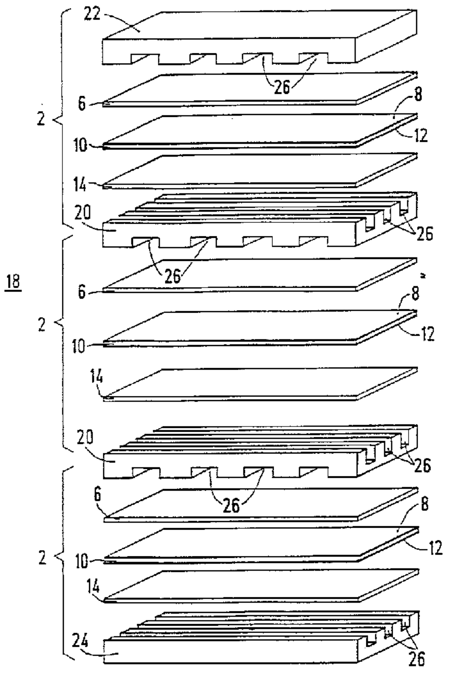
(54) CELLULES ELECTROCHIMIQUES HAUTE TEMPERATURE ET EMPILEMENT DE CELLULES ELECTROCHIMIQUES A STRUCTURES CONDUCTRICES COMPOSITES METALLIQUES

(54) HIGH-TEMPERATURE FUEL CELL AND HIGH-TEMPERATURE FUEL CELL STACK WITH METALLIC COMPOSITE CONDUCTING STRUCTURES



(57) L'invention concerne une cellule électrochimique haute température (2) dans laquelle deux électrodes (8, 12) sont disposées entre des structures conductrices composites (4, 16; 22, 20, 24) qui évacuent le courant produit dans la cellule électrochimique haute température (2) et alimentent les électrodes (8, 12) avec

(57) The invention relates to a high-temperature fuel cell (2) in which two electrodes (8, 12) are arranged between composite conducting structures (4, 16; 22, 20, 24) which remove the current produced in the high temperature fuel cell (2) and supply the electrodes (8, 12) with an operating means. At least one composite

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un moyen de fonctionnement. Au moins une structure conductrice composite (4, 16; 22, 20, 24) est constituée au moins partiellement d'un alliage à base de Fe avec une teneur en Cr comprise entre 17 et 30 % en poids, présentant un coefficient de dilatation thermique moyen dans la plage de températures comprises entre la température ambiante et 900 °C. Ledit coefficient de dilatation thermique est adapté à celui de l'électrolyte (10) et est égal à 13 à 14×10^{-6}/K, ce qui permet de réduire les coûts matière des structures conductrices composites (4, 16; 22, 20, 24) d'un facteur de 10 à 20 par rapport aux structures conductrices composites de la technique antérieure.

conducting structure (4, 16; 22, 20, 24) consists at least partially of an alloy based on Fe with a Cr content of between 17 and 30 % by weight which has an average coefficient of thermal expansion in the temperature range of room temperature to 900 °C. Said coefficient of thermal expansion is adapted to the coefficient of thermal expansion of the electrolyte (10) and is 13 to 14×10^{-6}/K, thereby reducing material costs for the composite conducting structures (4, 16; 22, 20, 24) by a factor of 10 to 20 in comparison with prior art composite conducting structures.

GR 96 P 3080 P

Abstract

High temperature fuel cell and high temperature fuel cell stack

In the present high temperature fuel cell (2), in which two electrodes (8, 12) are arranged between interconnecting conducting plates (4, 16; 22, 20, 24) for leading off the current produced in the high temperature fuel cell (2) and for supplying the electrodes (8, 12) with a working medium, at least one interconnecting conducting plate (4, 16; 22, 20, 24) consists at least in part of an alloy based on Fe with a Cr content of between 17 and 30% by weight, which in the temperature range from room temperature to 900°C has an average coefficient of thermal expansion that is matched to that of the electrolyte (10) and has a value from 13 to 14×10^{-6}/K. This measure reduces the material cost for the interconnecting conducting plate (4, 16; 22, 20, 24) by a factor from 10 to 20 in comparison with the interconnecting conducting plates known from the prior art.

FIG 1

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Description

High temperature fuel cell and high temperature fuel cell stack

The invention relates to a high temperature fuel cell and to a high temperature fuel cell stack.

In a fuel cell stack consisting of high temperature fuel cells, a fuel cell stack also being abbreviated to "stack" in the specialist literature, a contact layer, an electrolyte/electrode element, a further interconnecting conducting plate, etc. are arranged in this order on one another and below an upper interconnecting conducting plate which covers the high temperature fuel cell stack. In this case, the electrolyte/electrode element comprises two electrodes and an electrolyte which is arranged between the two electrodes. The interconnecting conducting plates within the high temperature fuel cell stack are in this case designed as bipolar plates. In contrast to an interconnecting conducting plate arranged at the edge of the high temperature fuel cell stack, these plates are provided on both sides with channels for supplying the electrolyte/electrode elements with a respective working medium.

In this case, each electrolyte/electrode element lying between two neighboring interconnecting conducting plates, including the contact layer directly adjoining the electrolyte/electrode element on both sides, and those sides of each of the two interconnecting conducting plates which adjoin the contact layer, together form a high temperature fuel cell.

This and other types of fuel cells are, for example, disclosed by the "Fuel Cell Handbook" by A.J. Appelby and F.R. Foulkes, 1989, pages 442 to 454, or the article

"Brennstoffzellen als Energiewandler" [Fuel cells as energy converters], Energiewirtschaftliche Tagesfragen, June 1993, Vol. 6, pages 382 to 390. As a rule, a high temperature fuel cell stack is composed of a large number of high temperature fuel cells. Accordingly, a large number of electrolyte/electrode elements must be connected with interconnecting conducting plates in gas-tight fashion, that is to say, in other words, integrally. The interconnecting conducting plates within the high temperature fuel cell stack, that is to say the bipolar plates, thus have the purpose of connecting the electrolyte/electrode elements electrically in series with one another, and of supplying the electrodes of the electrolyte/electrode elements with working media. The interconnecting conducting plates for closing off the high temperature fuel cell stack differ from the bipolar plates in that these interconnecting conducting plates are provided only on one side with channels for supplying the electrolyte/electrode elements with working media, and in that the current produced in the high temperature fuel cells is led off from the high temperature fuel cell stack via these interconnecting conducting plates, rather than being fed to a further high temperature fuel cell.

High temperature fuel cells with a similar structure are further disclosed by Laid-Open German Patent Specifications 44 06 276, 41 32 584, 39 35 722, 39 22 673, from German Patent 44 00 540, and from European Patent Application 05 78 855.

In order to avoid mechanical stresses in the high temperature fuel cell stack, in particular during thermal cycles which unavoidably occur, materials for the interconnecting conducting plates have been developed, the average coefficient of thermal expansion of which approximately coincides with that of the electrolyte sheets. Ceramic materials have been developed in the

$LaCrO_3$ system, as well as metallic materials based on Cr. Both materials are expensive to obtain. Because of the large proportion of volume occupied by the interconnecting conducting plates in a high temperature fuel cell stack, the cost of the interconnecting conducting plates is a dominant factor in the total cost of the high temperature fuel cell stack.

The object of the invention is therefore to provide a high temperature fuel cell, in which the material costs for the interconnecting conducting plate is reduced considerably in comparison with those known from the prior art. A further object is to provide a high temperature fuel cell stack composed of high temperature fuel cells of this type.

The first object is achieved according to the invention by a high temperature fuel cell, in which two electrodes are arranged between interconnecting conducting plates for leading off the current produced in the high temperature fuel cell and for supplying the electrodes with a working medium, at least one interconnecting conducting plate consisting at least in part of an alloy based on Fe with a Cr content of between 17 and 30% by weight, which in the temperature range from room temperature to 900°C has an average coefficient of thermal expansion that is matched to that of the electrolyte and has a value from 13 to 14×10^{-6}/K.

The second object is achieved according to the invention by a high temperature fuel cell stack which is composed of a number of these high temperature fuel cells.

When this alloy is used as a material for the interconnecting conducting plate, the material cost for the interconnecting conducting plate is reduced by a factor of from 10 to 20 in comparison with the materials used in the prior art for the production of interconnecting conducting plates for the high temperature fuel cell.

Preferably, one of the two electrodes is at least 100 μm thick, and the other is about 30 μm thick. A different choice of thickness for the two electrodes increases the stability of the electrolyte/electrode element.

In particular, the electrode provided as the cathode consists of $LaSrMnO_3$.

In a further refinement, the electrode provided as the anode consists of Ni/ZrO_2 cermet.

Preferably, an electrolyte arranged between the two electrodes contains stabilized ZrO_2 and has a thickness of between 5 and 30 μm. The electrolyte/electrode element, which comprises the two electrodes and the electrolyte, is thus supported by one of the two electrodes on account of its thickness. These electrolyte/electrode elements afford technical advantages. On account of the low electrolyte density, which results in a low electrolyte resistance, it is in particular possible to reduce the operating temperature of the high temperature fuel cell to 750°C without serious power losses. Advantages in terms of cost also result, since the cost-intensive proportion of electrolyte mass is reduced in comparison with the thicker electrolytes used in the prior art.

In order to explain the invention further, reference will be made to the illustrative embodiment in the drawing, in which:

FIG 1 shows a cross-section through a high temperature fuel cell in a schematic representation;
FIG 2 shows a cross-section through a high temperature fuel cell stack, which is composed of a large number of high temperature fuel cells, in a schematic representation.

According to FIG 1, a high temperature fuel cell 2 comprises an interconnecting conducting plate 4, a contact layer 6, an electrode 8 provided as the cathode, an electrolyte 10, an electrode 12 provided as the anode, a contact layer 14 and a further interconnecting conducting plate 16, these being stacked on one another in the specified order. The two electrodes 8, 12 and the electrolyte 10 form the electrolyte/electrode element 8, 10, 12.

The interconnecting conducting plates 4, 16 are in this case used as cover plates for the components 6, 8, 10, 12, 14 arranged between them. The current produced in the high temperature fuel cell 2 is led off therefrom via the interconnecting conducting plates 4, 16. The interconnecting conducting plates 4, 16 also supply the cathode 8 and anode 12, respectively, each with a working medium.

At least one of the interconnecting conducting plates 4, 16 consists at least in part, in other words in a subregion, of an alloy based on Fe with a Cr content of between 17 and 30% by weight. Amongst other things, the contact layers 6, 14 prevent the chromium Cr evaporating from the interconnecting conducting plates 4, 16.

The average coefficient of thermal expansion of the interconnecting conducting plates 4, 16 in the temperature range from room temperature to 900°C is from 13 to 14×10^{-6}/K. The average coefficient of thermal expansion of the interconnecting conducting plates 4, 16 is therefore higher than in the interconnecting conducting plates known from the prior art. Consequently, the assembly which consists of the components 6, 8, 10, 12, 14 and is arranged between the interconnecting conducting plates 4, 16 is, in its combination in terms of composition and thickness of the various components 6, 8, 10, 12, 14, matched in its average coefficient of thermal expansion to the average coefficient of thermal expansion of the interconnecting conducting plates 4, 16.

For this reason, the electrode 8 provided as the cathode consists of $LaSrMnO_3$, and the electrode 12 provided as the anode consists of Ni/ZrO_2 cermet. The electrolyte/electrode element 8, 10, 12 therefore likewise has an average coefficient of thermal expansion of from 13 to 14×10^{-6}/K.

In order to prevent mechanical stresses in the high temperature fuel cell 2, the electrode 8 provided as the cathode is furthermore designed with a thickness of at least 100 μm, and the electrode 12 provided as the anode with a thickness of about 30 μm. It is also possible to reverse the thickness ratio between the anode 12 and the cathode 8. In this embodiment, the electrolyte 10 arranged between the two electrodes 8, 12 consists of stabilized ZrO_2. The electrolyte 10 is in this case designed with a thickness of between 5 and 30 μm.

FIG 2 shows a cross-section of the schematic structure of a high temperature fuel cell stack 18 which consists of high temperature fuel cells 2 and, in the embodiment which is represented, comprises three high temperature fuel cells 2, each of which has the same type of structure as the high temperature fuel cell 2 represented in Figure 1.

The fuel cell stack 18 is closed off at the top with an interconnecting conducting plate 22, and at the bottom with an interconnecting conducting plate 24. In this case, the interconnecting conducting plates 22, 24 take on the function of the interconnecting conducting plates 4, 16 represented in FIG 1.

The interconnecting conducting plates 20 which are arranged inside the high temperature fuel cell stack 18, that is to say do not close off the high temperature fuel cell stack 18 in one direction, as the cover plates 22 and 24 do, are designed as bipolar plates. The upper part of the interconnecting conducting plate 20 is assigned to the electrode 12 provided as the anode, and the lower part of the interconnecting conducting plate 20 is assigned to the electrode 8 provided as the cathode. In this case, the electrode 8 provided as the cathode and the electrode 12 provided as the anode each belong to adjacent high temperature fuel cells 2.

The interconnecting conducting plates 20, 22, 24 are each provided with channels 26 which are intended for supplying the high temperature fuel cells 2 with working media. In the case of the interconnecting conducting plates 22, 24, only one side is respectively provided with the channels 26, while the interconnecting conducting plates 20 are provided with the channels 26 on both sides.

Since the high temperature fuel cell stack 18 is generally composed of a large number of high temperature fuel cells 2, a large number of interconnecting conducting plates 20 are correspondingly also present inside the high temperature fuel cell stack 18. If, according to this embodiment, the interconnecting conducting plates 20 are made, at least in a subregion, of an alloy based on Fe with a Cr content of between 17 and 30% by weight, then the cost for the total high temperature fuel cell stack 18 is reduced in comparison with the high temperature fuel cell stacks known from the prior art by at least a factor of 10.

Patent Claims

1. A high temperature fuel cell (2), in which two electrodes (8, 12) are arranged between interconnecting conducting plates (4, 16; 22, 20, 24) for leading off the current produced in the high temperature fuel cell (2) and for supplying the electrodes (8, 12) with a working medium, in which one of the two electrodes (8, 12) is at least 100 μm thick and the other is about 30 μm thick, and an electrolyte (10) arranged between the two electrodes (8, 12) contains stabilized ZrO_2 and has a thickness of between 5 and 30 μm, at least one interconnecting conducting plate (4, 16; 22, 20, 24) consisting of an alloy based on Fe with a Cr content of between 17 and 30% by weight, which in the temperature range from room temperature to 900°C has an average coefficient of thermal expansion of between 13 and 14×10^{-6}/K which is matched to the coefficient of thermal expansion of the electrolyte (10) and to that of the electrodes (8, 10).

2. The high temperature fuel cell (2) as claimed in claim 1, wherein the electrode (8) provided as the cathode consists of $LaSrMnO_3$.

3. The high temperature fuel cell (2) as claimed in claim 1 or 2, wherein the electrode (12) provided as the anode consists of Ni/ZrO_2 cermet.

4. The high temperature fuel cell (2) as claimed in one of claims 1 to 3, wherein the average coefficient of thermal expansion of the electrolyte/electrode element (8, 10, 12) is between 13 and 14×10^{-6}/K.

5. A high temperature fuel cell stack (18) in which the interconnecting conducting plates (20) are designed as bipolar plates, and which stack is composed of a number of high temperature fuel

cells (2) as claimed in one of the preceding claims.

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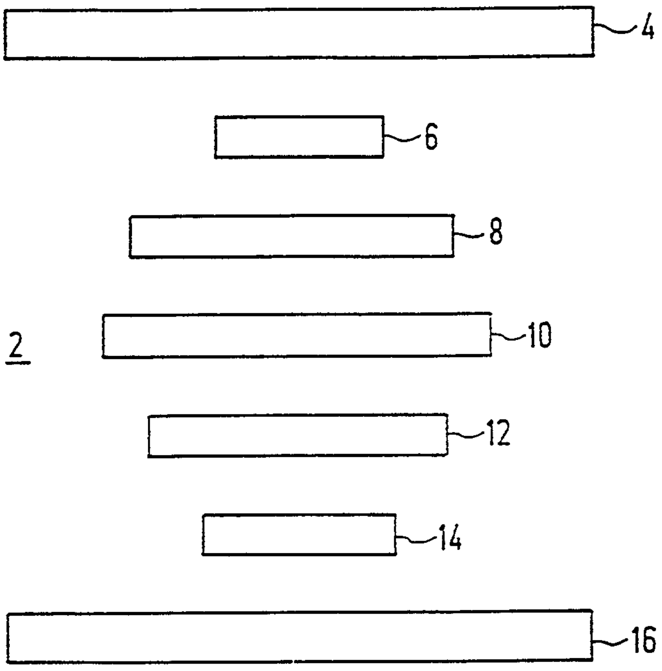


FIG 1

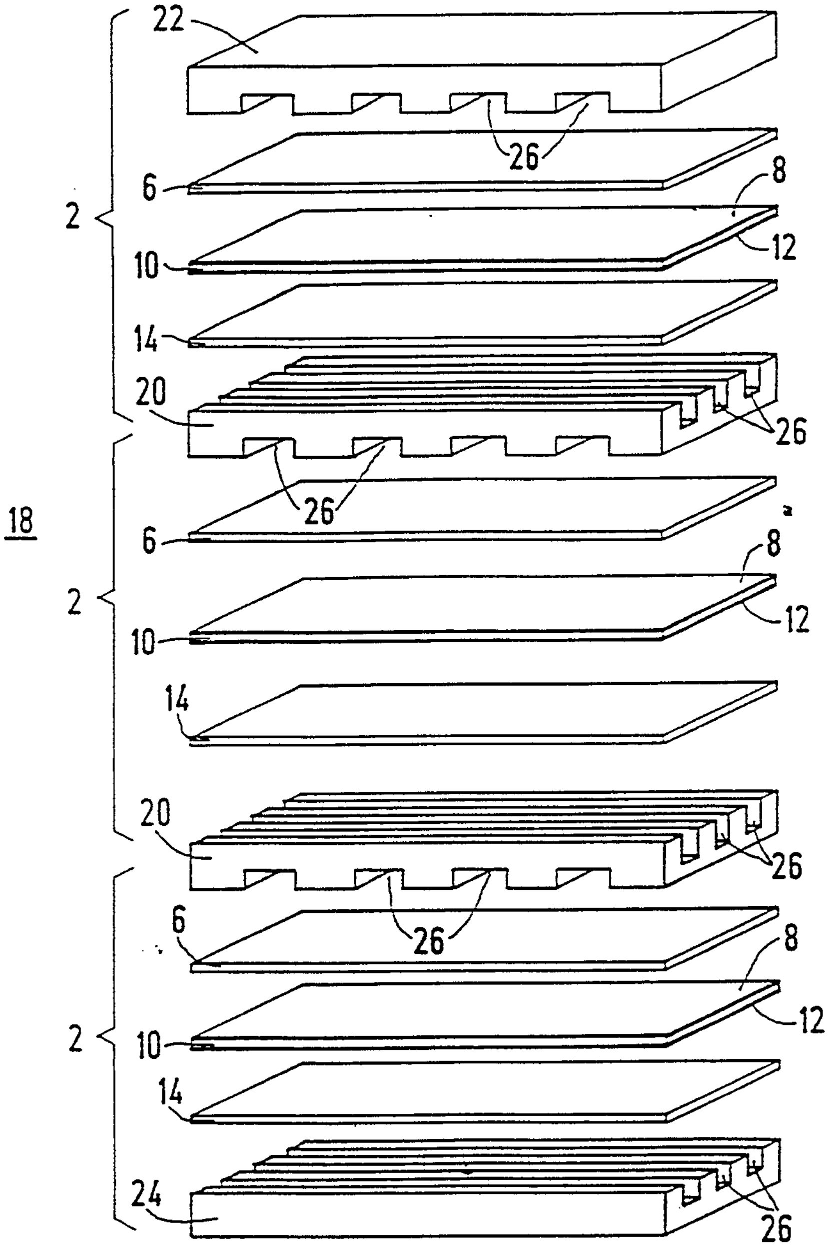
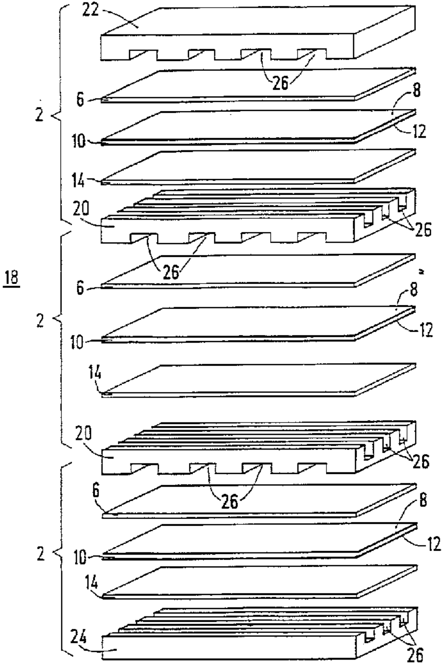


FIG 2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