The solid, sodium ion-conductive electrolyte used in the battery is conventionally β-alumina. As this is a ceramic, failure of the solid electrolyte cannot be ruled out. In such an event, an uncontrolled reaction between sodium and sulfur may occur, which due to its exothermic nature may lead to an undesired temperature rise in the battery. In order to keep the temperature rise as small as possible in such a case, it is known, for example from JP-A 10270073, to use a displacer of aluminum with which the compartment for the sodium on the sodium side of the solid electrolyte is restricted to a gap with a width of 0.01 to 0.2 mm. The gap is here produced by a combination of plastic deformation and elastic rebound upon injection of the displacer into the solid electrolyte which is conventionally of annular construction. The use of a displacer made of aluminum, however, leads to an uncontrollable reaction if the solid electrolyte becomes damaged. In that case there is initially a reaction between sodium and sulfur, leading to an increase in the temperature. This temperature rise may attain temperatures at which even the aluminum begins to react with the sulfur penetrating through the fracture. This reaction is exothermic and cannot be ended. This leads to a further rise in temperature and to thermal destruction first of the electrode and, depending on the construction of the battery, of the battery as a whole as well.

Besides the use of aluminum as material for the displacer, JP-A 05266919 and JP-A 08329981 also disclose the use of stainless steel.

Since the mechanical strength of stainless steel is greater than that of aluminum and hence the plastic deformation at battery operating temperature is very much lower, the stainless steel, with a cylindrical design of the displacer, is unable to conform to the shape of the solid electrolyte. Owing to thermal expansion, therefore, there may be a fracture of the solid electrolyte if the displacer made from stainless steel is pressed nonuniformly against the solid electrolyte. Such nonuniform pressing of the displacer onto the solid electrolyte results, for example, from manufacturing inaccuracies during the production of the ceramic solid electrolyte.

The object of the ~~present invention~~embodiments disclosed herein was accordingly to provide an electrode unit having a displacer, which does not exhibit the disadvantages of the electrodes known from the prior art.

Said object is achieved by an electrode unit for an electrochemical device, comprising a solid electrolyte and a porous electrode, the solid electrolyte dividing a compartment

for cathode material and a compartment for anode material and the porous electrode being extensively connected to the solid electrolyte, with a displacer (23) being accommodated in the anode material compartment, where the displacer (23) is manufactured from a stainless steel or from graphite foil and bears resiliently against the internal geometry of the solid electrolyte (3) in such a way that the displacer (23) does not contact the solid electrolyte over its full area, or with the displacer comprising an outer shell (62) of stainless steel or graphite, and a core (64) of a nonferrous metal, the nonferrous metal being thermoplastically deformable at a temperature which is lower than the temperature at which the stainless steel is thermoplastically deformable, and where for production the shell (62) of stainless steel or graphite is pressed onto the solid electrolyte (3) by introduction and heating of the nonferrous metal, and on cooling forms a gap between solid electrolyte (3) and shell (62) of stainless steel.

In an aspect, there is provided an electrode unit for an electrochemical device, comprising a solid electrolyte and a porous electrode, the solid electrolyte dividing a compartment for cathode material and a compartment for anode material and the porous electrode being extensively connected to the solid electrolyte, with a displacer being accommodated in the anode material compartment, wherein the displacer comprising an outer shell of stainless steel or graphite, and a core of a nonferrous matal, the nonferrous metal being thermoplastically deformable at a temperature at which the stainless steel is thermoplastically deformable, and where for production of the dislplacer the shell of stainless steel or graphite is pressed onto the solid electrolyte by introduction and heating of the nonferrous metal, and on cooling forms a gap between solid electrolyte and shell of stainless steel or graphite.

In another aspect, there is provided the use of the electrode unit as defined above in an apparatus for storing electrical energy or in an electrolysis cell.

Through the use of a displacer made of stainless steel or a displacer with an outer shell made of stainless steel, in particular in the event of the fracture of the solid electrolyte, an uncontrolled thermal destruction of the battery as a whole is prevented, since the stainless steel reacts with the sulfur only at very much higher temperatures and less vigorously than does aluminum. Through this means it is possible to achieve a significant increase in the operational safety of such a battery operating on the basis of an alkali metal and sulfur. By virtue of the fact that the displacer bears resiliently against the internal geometry of the solid electrolyte, changes in length due to thermal expansion can be compensated.

For the purposes of the present invention, an anode material should be taken to mean a liquid reactant which is supplied to the anode side during discharging. The anode material is preferably electrically conductive, in particular a liquid alkali metal is used as the anode material. Suitable anode materials are for example lithium, sodium, potassium, in particular sodium or potassium.

The cathode material is a liquid reactant which is electrochemically reacted with the anode material. The cathode material conventionally forms a salt by chemical reaction with the anode material. Suitable cathode materials are for example sulfur or polysulfides. The cathode material is here used in liquid form. Also suitable as cathode material is a mixture of sodium chloride and a metal from transition group 8, as for example iron, nickel or cobalt, in combination with a liquid-melt electrolyte such as $NaAlCl_4$.

Patent claims

1. An electrode unit for an electrochemical device, comprising a solid electrolyte ~~(3)~~ and a porous electrode ~~(7)~~, the solid electrolyte ~~(3)~~ dividing a compartment for cathode material and a compartment for anode material and the porous electrode ~~(7)~~ being extensively connected to the solid electrolyte ~~(3)~~, with a displacer ~~(23)~~ being accommodated in the anode material compartment, wherein the displacer comprising an outer shell ~~(62)~~ of stainless steel or graphite, and a core ~~(64)~~ of a nonferrous metal, the nonferrous metal being thermoplastically deformable at a temperature which is lower than the temperature at which the stainless steel is thermoplastically deformable, and where for production of the displacer ~~(23)~~ the shell ~~(62)~~ of stainless steel or graphite is pressed onto the solid electrolyte ~~(3)~~ by introduction and heating of the nonferrous metal, and on cooling forms a gap between solid electrolyte ~~(3)~~ and shell ~~(62)~~ of stainless steel or graphite.

2. The electrode unit according to claim 1, wherein the outer shell comprises a base ~~(69)~~ which, with an upwardly bent edge ~~(68)~~, surrounds the cylindrically bent metal sheet ~~(61)~~ or is surrounded by the cylindrically bent metal sheet ~~(61)~~, so that the base ~~(69)~~ is movable relative to the outer shell for the production of the displacer ~~(23)~~.

3. The electrode unit according to claim 1 or 2, wherein the displacer ~~(23)~~ is constructed as a hollow body having an inner shell ~~(63)~~ and an outer shell ~~(62)~~ of stainless steel and also, between them, a core ~~(64)~~ of the nonferrous metal.

4. The electrode unit according to one of claims 1 to 3, wherein the nonferrous metal is zinc, aluminum or an alloy comprising at least one of these metals.

5. The electrode unit according to one of claims 1 to 4, wherein the outer shell ~~(62)~~ of stainless steel or graphite is a flexible sheet or comprises a cylindrically bent metal sheet ~~(61)~~ whose edge overlap in axial direction.

6. The electrode unit according to one of claims 1 to 5, wherein the displacer ~~(23)~~ comprises current conducting means ~~(39)~~.

7. The electrode unit according to claim 6, wherein the current conducting means ~~(39)~~ comprise a special steel tube ~~(41)~~ closed at both ends and with a core ~~(43)~~ of an electrically highly conductive material and are arranged in recesses ~~(37)~~ of the displacer ~~(23)~~ or wherein the current conducting means comprise a coating of an electrically highly conductive material on the inside of the displacer ~~(23)~~.

8. The electrode unit according to claim 7, wherein the current conducting means ~~(39)~~ comprising a special steel tube ~~(41)~~ closed at both ends and with a core ~~(43)~~ of an electrically highly conductive material are clamped in the recesses ~~(37)~~.

9. The electrode unit according to claim 7 or 8, wherein the electrically highly conductive material is selected from the group consisting of copper, aluminum, silver, gold, sodium, and also mixtures and alloys comprising at least one of these metals.

10. The electrode unit according to one of claims 1 to 9, characterized in that the solid electrolyte ~~(3)~~ is of cylindrical design and the porous electrode ~~(7)~~ surrounds the solid electrolyte ~~(3)~~, the compartment for the anode material being surrounded by the solid electrolyte ~~(3)~~.

11. The electrode unit according to one of claims 1 to 10, wherein a channel ~~(27)~~ is formed in the displacer ~~(23)~~ and the anode material is supplied through said channel ~~(27)~~.

12. The electrode unit according to one of claims 1 to 11, wherein the solid electrolyte ~~(3)~~ is made from β"-alumina.

13. The electrode unit according to one of claims 1 to 12, wherein the anode material is an alkali metal.

14. The electrode unit according to one of claims 1 to 13, wherein the cathode material is sulfur or polysulfide.