

Description

The present invention relates to electrochemical cells and, more particularly, to nonaqueous cells utilizing a polymer electrolyte.

Solid-state cells having a lithium anode, a finely-divided metal oxide cathode and a polymer electrolyte possess many advantages over other types of electrochemical cells. For example, such cells provide a long useful service life, possess a relatively high power density, a relatively high specific energy -- on the order of 200 to 300 Wh/kg -- and a relatively high specific power -- on the order of 600 W/kg. Such cells are also desirable in that their polymer-based electrolyte component can be readily and inexpensively formed with greatly reduced thickness, and the entire cell can be shaped in a number of desirable configurations thereby making the cell useful in a wide variety of applications.

An example of such a cell is disclosed in the publication Advanced Battery Development, published in 1984. That cell comprises a lithium foil anode, a cathode of finely divided vanadium oxide with carbon black additions mixed with electrolyte material, termed a "composite electrode," and an electrolyte comprising an ion-conducting polymer consisting of poly(ethylene oxide) complexed with the lithium salt LiCF_3SO_3 deposited in a thin layer on a nickel foil.

A laminate, comprising elongate strips of anode material, polymer electrolyte, cathode material and current conductor layers is formed into a cell by folding the laminate in a "fan-folded" or "concertina" configuration. However, in the fan-folded configuration disclosed, the stacked segments of the laminate overlap each other such that the segments of current conductor contact each other, and the segments of anode material contact each other on successive segments of the fan-folded laminate.

In another embodiment, a cell comprises a spiral or "jelly roll" configuration in which a laminate comprising a strip of insulator material, a strip of anode material, a strip of polymer electrolyte, a strip of composite cathode material and a strip of current collector are wound into a spiral shape. Successive windings of the aforementioned laminate are isolated from each other by the strip insulator segment of the laminate.

Another battery cell construction is disclosed in the article "The Magic of MOLI" in the June 1987 issue of QST. That cell includes a molybdenum disulfide cathode, a polymer electrolyte and a lithium anode. A laminate comprising an anode sandwiched between two electrode layers which, in turn, contact two cathode layers is wound in jelly-roll fashion and encased in a steel can to form the cell.

Strips of metal foil extend transversely of the anode and cathode layers and are connected to the negative and positive electrodes, respectively, of the resulting battery.

However, the aforementioned cell designs possess some disadvantages. For example, the lithium/vanadium oxide cell designs disclosed show a single cathode laminated to each anode strip, and a single current conductor for each cathode. Consequently, a portion of the anode strip opposite the electrolyte layer is largely unused and adds unnecessarily to the cost, weight, and thickness of the resultant cell. It is not currently practicable to manufacture lithium anode strips which are sufficiently thin to overcome this disadvantage.

The disadvantage with the MOLI cell is that each cathode requires its own current conductor, again adding to the overall weight thickness and cost of the resultant cell. Accordingly, a need exists for a lithium battery which is relatively inexpensive to manufacture, is efficient in operation in that it uses substantially the entire anode strip and is light in construction.

According to a first aspect of the present invention, there is provided an electrochemical cell comprising a relatively thin strip of anode material having flat opposing surfaces; first and second layers on said opposing surfaces; first and second relatively thin strips of cathode material superposed to said first and second layers, respectively; and a cathode current conductor strip; the anode strip, first and second layers, and first and second strips of cathode material being deformed such that both said first and second strips of cathode material contact said cathode current conductor strip along substantially the entire lengths of said strips of cathode material; characterised in that said first and second layers are layers of solid polymeric electrolyte coated on said anode material, thereby forming a cell laminate with said anode and cathode material, and in that said cell further comprises one or more projections protruding outwardly from a longitudinal edge of one of said anode and cathode current conductor strips.

In one embodiment, a single cathode current conductor strip is superposed to a laminate strip comprising a single anode strip sandwiched between two electrolyte layers and two cathode strips, and the combination is wound into a spiral. As a result of the spiral winding, the single cathode conductor strip contacts both cathode layers and therefore serves a double duty.

In a second embodiment, the aforementioned cell laminate is fan-folded into a stack having a plurality of laminate sections. The cathode conductor strip is also fan-folded into a stack which is interleaved between the folded segments of the laminate strip and oriented such that the folds of

the conductor strip are at right angles to the folds of the laminate strip.

With both embodiments, the cathode conductor strip may be provided with tabs protruding sidewardly from a longitudinal edge of the strip and spaced along its length. Similarly, the anode may be of lithium and be provided with a protruding strip of metal foil, such as nickel, which extends from a side of the anode strip opposite that of the cathode tabs. The resultant structures are fitted with positive and negative electrodes which are made of a conductive material and attached to the appropriate set of tabs.

In a preferred method of fabricating the spiral or jelly-roll cell, a mandrel of nonconducting material is connected to the leading edge of a strip of metallic foil, and the foil is wound about the mandrel. Simultaneously, a strip of cell laminate is inserted into the nip of the roll of foil. As the foil strip continues to be wound about the mandrel, it forms the cathode current conductor strip with the cell laminate as well as a protective casing.

The invention provides, in a second and alternative aspect thereof,

a method for forming an electrochemical cell comprising the steps of:

- (a) selecting a relatively thin strip of anode material having flat, opposing surfaces;
- (b) coating first and second solid polymer electrolyte layers on said opposing surfaces;
- (c) attaching first and second relatively thin strips of cathode material to said first and second electrolyte layers, respectively, thereby forming a laminate strip with said electrolyte layers and said anode strip;
- (d) attaching a single cathode current conductor strip to a nonconductive, elongate mandrel, one of said cathode current conductor strip and anode strip being provided with one or more projections protruding outwardly from a longitudinal edge thereof;
- (e) winding said conductor strip about said mandrel in a spiral; and
- (f) simultaneously with step (e), inserting an end of said laminate strip in a nip of said spiral and winding said laminate in a spiral to be concentric with and in between windings of said conductor strip.

The invention is hereinafter more particularly described by way of example only with reference to the accompanying drawings, in which:-

Fig. 1 is an exploded perspective view of a cell laminate strip of an embodiment of cell in accordance with the present invention;

Fig. 2 is an exploded perspective view of the cell laminate of Fig. 1 superposed to a current collector strip and including a cathode current collector strip;

Fig. 3 is a perspective view of a spiral or "jelly-roll" configuration of the cell shown in Fig. 2;

Fig. 4 is an end view of the cell of Fig. 3;

Fig. 5 is an opposite end view of the cell of Fig. 3;

Figs. 6(A) and 6(B) are perspective views showing the formation of a preferred embodiment of cell in accordance with present invention utilizing the laminate of Fig. 1;

Fig. 6(c) is a side elevation, in section, of the cell formed in Figs. 6(A) and 6(B);

Fig. 7 is an exploded, perspective view of a second preferred embodiment incorporating the cell laminate of Fig. 1; and

Fig. 8 is a perspective view of an assembled cell utilizing the embodiment of Fig. 7.

As shown in Fig. 1, an electrochemical cell includes a cell laminate, generally designated 10, which comprises an anode strip 12, first and second layers of polymer electrolyte 14, 16, respectively, and first and second cathode strips 18, 20, respectively. In the preferred embodiment, the cell laminate 10 comprises a portion of a secondary cell having an alkali metal foil anode with a thickness of about 75 microns (75×10^{-6} m), an ionically conducting polymeric electrolyte layer containing an ionizable alkali metal salt with a thickness of about 25 microns and an intercalation cathode layer of a finely divided transition metal oxide with a thickness of about 75 microns.

In a particularly effective embodiment, the anode strip 12 comprises a lithium foil and the cathode strips comprise a composite of finely divided vanadium oxide (V_6O_{13}), carbon black or an electronically conductive polymer and solid electrolyte material. The polymer electrolyte 14, 16 preferably comprises a lithium salt, such as $LiCF_3SO_3$, dissolved in poly(ethylene oxide), PEO. Alternatively, the active cathode component may comprise metal chalcogenides such as $NbSe_3$, V_2O_5 , MnO_2 , TiS_2 or electronically conducting organic polymers such as polypyrrole and polyacetylene. Both the electrolyte layers 14, 16 and the cathode strips 18, 20 may be coated onto the anode strip 12 by the "doctor blade" continuous casting, solvent evaporation technique or by extrusion.

Although element 10 in Figs. 1 and 2 is referred to as a cell laminate, it should be noted that there are in fact two "cells" in the strict sense of the term, each having a cathode in an ion exchange relation with an anode. However, in the electrochemical cell shown in the figures, the two cathode layers are always joined by a single current conductor.

As shown in Figs 1 and 2, the cell laminate 10 preferably includes an anode current collector strip 22 which is embedded in the anode strip 12 along a longitudinal edge thereof and extends sidewardly

therefrom. Appropriate materials for the strip 22 are nickel, copper other conductive metals, conductive polymers and metal-coated polymers. The cell laminate 10 is superposed to and is joined to a cathode current conductor strip 24, which is sized to protrude sidewardly beyond the longitudinal edge 26 of the cell laminate 10 opposite the edge containing the anode current conductor strip 22. The protruding portion 28 is separated from the remainder of the cathode conductor strip 24 by a broken line 30 for purposes of illustration. An appropriate material for the strip 24 is aluminum, other conductive metals, polymers and metal-coated polymers.

When placed in position as shown in Fig. 2, the cell laminate 10 and cathode strip 22, which together comprise a cell 32, are preferably rolled lengthwise to form a "jelly-roll" or spiral configuration, as shown in Figs. 3, 4 and 5. With this configuration, the single cathode current conductor strip 24 is able to contact both cathode strips 18, 20 along substantially their entire lengths and therefore conduct current from both cells to the positive electrode of the associated battery.

The protruding part 28 of the cathode strip 24 provides a convenient positive electrode 33 at one end of the cell 32, and the anode conductor strip 22 protrudes from the opposite end of the cell to provide a negative electrode 34.

As shown in Figs. 3-5, it is also preferable to fabricate the cathode conductor strip 24 so that it is longer in length than the cell laminate 10. Consequently, the cathode conductor strip 24 forms an outer protective covering for the cell 32 when formed into the spiral shown in the figures.

As shown in Figs. 6(A)-6(C), an alternate spiral cell structure 32' may be fabricated utilizing a cylindrical mandrel 35 made of a nonconductive material such as nylon. To form the spiral cell 32', the cathode conductor strip 24' is attached at an end to the mandrel 35 and wound in a spiral about it. The cell laminate 10, with a protruding anode strip 22, is inserted into the nip 36 and the cathode conductor strip 24' continues to be wound around the mandrel 35 so that the cell laminate 10 itself forms a spiral in between the windings of the cathode conductor strip.

Again, it is preferable that the cathode conductor strip 24' be longer in length than the cell laminate 10 so that the finished product, shown in Fig. 6(C), includes an outer protective covering of metal. Once the cathode conductor strip 24' has been wound about the mandrel 35, and the cell laminate 10, the resulting structure includes protruding positive and negative electrodes 33', 34' respectively.

A more conventional positive electrode is formed by slitting the protruding portion 28' of the

cathode conductor strip 24' into a plurality of tabs 42, then folding the tabs radially inwardly and connecting them to a button 44 made of a conductive material such as nickel and having a cylindrical head 46 and shank 48. The shank 48 is attached to the ends of the tabs 42 and secured within the mandrel 35. The head 46 then becomes the positive electrode 33' of the cell 32'.

The opposite end of the cell 32' includes a spiral of protruding end 22 in which the windings are sealed and separated by an insulating polymer 50. A layer of conducting polymer 52 is applied to form a flat negative electrode surface. Similarly, the windings of the cathode are sealed and separated by an insulating polymer 50. The cell is encased in a jacket 54 made of a nonconductive polymer.

An alternate design of the cell 32" is shown in Figs. 7 and 8. In Fig. 7, the cell laminate 10' is fan-folded along its length, thereby forming a series of segments 56 joined by creases 58. The anode conductor strip has been modified to form a series of protruding tabs 22' extending along one longitudinal side of the cell laminate 10', and spaced to extend from every second segment 56.

Similarly, the cathode conductor strip 24" is fan-folded to form a plurality of segments 60 in which every other segment has a protruding tab 28'. Sequential segments 60 are joined by creases 62.

As shown in Fig. 8, the cell 32" is formed by interleaving the segments 60 of the cathode conductor strip 24" with the segments 56 of the cell laminated 10'. Consequently, the cathode conductor strip 24" contacts both faces of each segment 56 of the cell laminate 10' and therefore contacts the surfaces of both cathode strips 18, 20 substantially along their entire lengths.

The resultant structure is substantially in the form of a cube. The creases 58 of the cell laminate 10' are oriented at right angles to the creases 62 of the cathode conductor strip 24" and the tabs 22' of the anode strip 12 are longitudinally aligned with each other, as are the tabs 28' of the cathode conductor strip. Accordingly, the anode and cathode tabs 22', 28', respectively, may be joined together to form the negative and positive electrodes of the resultant cell 32".

Claims

1. An electrochemical cell comprising a relatively thin strip of anode material having flat opposing surfaces; first and second layers on said opposing surfaces; first and second relatively thin strips of cathode material superposed to said first and second layers, respectively; and a cathode current conductor strip; the anode strip, first and second layers, and first and



therefrom. Appropriate materials for the strip 22 are nickel, copper other conductive metals, conductive polymers and metal-coated polymers. The cell laminate 10 is superposed to and is joined to a cathode current conductor strip 24, which is sized to protrude sidewardly beyond the longitudinal edge 26 of the cell laminate 10 opposite the edge containing the anode current conductor strip 22. The protruding portion 28 is separated from the remainder of the cathode conductor strip 24 by a broken line 30 for purposes of illustration. An appropriate material for the strip 24 is aluminum, other conductive metals, polymers and metal-coated polymers.

When placed in position as shown in Fig. 2, the cell laminate 10 and cathode strip 22, which together comprise a cell 32, are preferably rolled lengthwise to form a "jelly-roll" or spiral configuration, as shown in Figs. 3, 4 and 5. With this configuration, the single cathode current conductor strip 24 is able to contact both cathode strips 18, 20 along substantially their entire lengths and therefore conduct current from both cells to the positive electrode of the associated battery.

The protruding part 28 of the cathode strip 24 provides a convenient positive electrode 33 at one end of the cell 32, and the anode conductor strip 22 protrudes from the opposite end of the cell to provide a negative electrode 34.

As shown in Figs. 3-5, it is also preferable to fabricate the cathode conductor strip 24 so that it is longer in length than the cell laminate 10. Consequently, the cathode conductor strip 24 forms an outer protective covering for the cell 32 when formed into the spiral shown in the figures.

As shown in Figs. 6(A)-6(C), an alternate spiral cell structure 32' may be fabricated utilizing a cylindrical mandrel 35 made of a nonconductive material such as nylon. To form the spiral cell 32', the cathode conductor strip 24' is attached at an end to the mandrel 35 and wound in a spiral about it. The cell laminate 10, with a protruding anode strip 22, is inserted into the nip 36 and the cathode conductor strip 24' continues to be wound around the mandrel 35 so that the cell laminate 10 itself forms a spiral in between the windings of the cathode conductor strip.

Again, it is preferable that the cathode conductor strip 24' be longer in length than the cell laminate 10 so that the finished product, shown in Fig. 6(C), includes an outer protective covering of metal. Once the cathode conductor strip 24' has been wound about the mandrel 35, and the cell laminate 10, the resulting structure includes protruding positive and negative electrodes 33', 34' respectively.

A more conventional positive electrode is formed by slitting the protruding portion 28' of the

cathode conductor strip 24' into a plurality of tabs 42, then folding the tabs radially inwardly and connecting them to a button 44 made of a conductive material such as nickel and having a cylindrical head 46 and shank 48. The shank 48 is attached to the ends of the tabs 42 and secured within the mandrel 35. The head 46 then becomes the positive electrode 33' of the cell 32'.

The opposite end of the cell 32' includes a spiral of protruding end 22 in which the windings are sealed and separated by an insulating polymer 50. A layer of conducting polymer 52 is applied to form a flat negative electrode surface. Similarly, the windings of the cathode are sealed and separated by an insulating polymer 50. The cell is encased in a jacket 54 made of a nonconductive polymer.

An alternate design of the cell 32" is shown in Figs. 7 and 8. In Fig. 7, the cell laminate 10' is fan-folded along its length, thereby forming a series of segments 56 joined by creases 58. The anode conductor strip has been modified to form a series of protruding tabs 22' extending along one longitudinal side of the cell laminate 10', and spaced to extend from every second segment 56.

Similarly, the cathode conductor strip 24" is fan-folded to form a plurality of segments 60 in which every other segment has a protruding tab 28'. Sequential segments 60 are joined by creases 62.

As shown in Fig. 8, the cell 32" is formed by interleaving the segments 60 of the cathode conductor strip 24" with the segments 56 of the cell laminated 10'. Consequently, the cathode conductor strip 24" contacts both faces of each segment 56 of the cell laminate 10' and therefore contacts the surfaces of both cathode strips 18, 20 substantially along their entire lengths.

The resultant structure is substantially in the form of a cube. The creases 58 of the cell laminate 10' are oriented at right angles to the creases 62 of the cathode conductor strip 24" and the tabs 22' of the anode strip 12 are longitudinally aligned with each other, as are the tabs 28' of the cathode conductor strip. Accordingly, the anode and cathode tabs 22', 28', respectively, may be joined together to form the negative and positive electrodes of the resultant cell 32".

Claims

1. An electrochemical cell comprising a relatively thin strip of anode material having flat opposing surfaces; first and second layers on said opposing surfaces; first and second relatively thin strips of cathode material superposed to said first and second layers, respectively; and a cathode current conductor strip; the anode strip, first and second layers, and first and



second strips of cathode material being deformed such that both said first and second strips of cathode material contact said cathode current conductor strip along substantially the entire lengths of said strips of cathode material; characterised in that said first and second layers are layers of solid polymeric electrolyte coated on said anode material, thereby forming a cell laminate with said anode and cathode material, and in that said cell further comprises one or more projections protruding outwardly from a longitudinal edge of one of said anode and cathode current conductor strips.

2. A cell according to Claim 1, further characterised in that said cell laminate and said cathode current conductor strip are superposed to each other and are rolled to form a spiral.

3. A cell according to Claim 1, further characterised in that said cell laminate is fan-folded lengthwise to form a plurality of segments arranged in a stack; and in that said cathode current conductor strip is fan-folded to form a plurality of segments arranged in a stack which intersects said fan-folded cell laminate stack such that creases of said folded strip of current conductor are positioned at right angles to creases of said folded laminate strip and each intermediate segment of said folded current conductor strip extends between adjacent segments of said cathode material of said folded cell laminate.

4. A cell according to Claim 3, further characterised in that said projection(s) are provided on said strip of anode material in the form of a plurality of conductive tabs spaced along said longitudinal edge thereof and positioned such that when said strips of anode and cathode materials are deformed, said tabs extend therefrom in a common direction.

5. A cell according to Claim 4, further characterised in that projection(s) are also provided on said cathode current conductor strip in the form of a plurality of conductive tabs spaced along said longitudinal edge thereof and positioned such that, when said strips of anode and cathode materials and said current conductor strip are deformed, said tabs extend therefrom in a common direction different to the direction of said anode material tabs.

6. A cell according to Claim 5, further characterised in that said tabs of said strip of anode material and said current conductor strip each

extend only from every other segment thereof.

7. A cell according to Claim 6, further characterised in that said tabs of said strip of anode material and said current conductor strip each extend from common edges thereof.

8. A cell according to Claims 1 or 2, further characterised in that it comprises a mandrel made of a nonconductive material; in that said cathode current conductor strip is attached proximate an end thereof and wound about said mandrel in a spiral; and in that said laminate is wound about said mandrel in a spiral positioned between windings of said cathode current conductor strip.

9. A cell according to Claim 8, further characterised in that said projection(s) are provided on said anode strip forming a current conductor therefor.

10. A cell according to Claim 9, further characterised in that said projection(s) includes common connector means for forming a negative electrode of said cell.

11. A cell according to Claim 10, further characterised in that said common connector means comprises a metallic pin inserted in an end of said mandrel and connected to said projection(s).

12. A cell according to Claims 10 or 11, further characterised in that said cathode current conductor strip includes a longitudinally extending portion protruding sidewardly therefrom beyond said laminate in a direction opposite said projection(s) of said anode strip.

13. A cell according to any of Claims 8 to 12, further characterised in that said cathode current conductor strip has sufficient length to form an outer covering of said spiral and thereby enclose said laminate strip.

14. A cell according to any preceding claim, further characterised in that said strip of anode material comprises a strip of lithium foil; in that said electrolyte layer comprises a lithium salt dissolved in poly(ethylene oxide); and in that said strip of cathode material comprises a composite of finely divided vanadium oxide, carbon black and solid electrolyte material.

15. A cell according to any preceding claim, further characterised in comprising a polymer coating encapsulating said laminate strip and



said cathode current conductor strip.

16. A method for forming an electrochemical cell comprising the steps of:

- (a) selecting a relatively thin strip of anode material having flat, opposing surfaces;
- (b) coating first and second solid polymer electrolyte layers on said opposing surfaces;
- (c) attaching first and second relatively thin strips of cathode material to said first and second electrolyte layers, respectively, thereby forming a laminate strip with said electrolyte layers and said anode strip;
- (d) attaching a single cathode current conductor strip to a nonconductive, elongate mandrel, one of said cathode current conductor strip and anode strip being provided with one or more projections protruding outwardly from a longitudinal edge thereof;
- (e) winding said conductor strip about said mandrel in a spiral; and
- (f) simultaneously with step (e), inserting an end of said laminate strip in a nip of said spiral and winding said laminate in a spiral to be concentric with and in between windings of said conductor strip.

17. A cell according to Claim 19, further characterised in that said protruding portions of said cathode current conductor strip include a plurality of transverse slits forming tabs therebetween, said tabs being folded radially inwardly; and in that said cell further comprises a button connecting said tabs to form a positive electrode.

18. A cell according to Claim 20, further characterised in that said button includes a head and a shank extending into said mandrel.

Patentansprüche

1. Elektrochemische Zelle, die einen relativ dünnen Streifen aus Anodenmaterial umfaßt, der ebene gegenüberliegende Oberflächen aufweist; eine erste und eine Zweite Schicht auf den genannten gegenüberliegenden Oberflächen; einen ersten und einen zweiten relativ dünnen Streifen aus Kathodenmaterial, der über der genannten ersten bzw. zweiten Schicht liegt; und einen Kathodenstromleiterstreifen; wobei der Anodenstreifen, die erste und die zweite Schicht und der erste und zweite Streifen aus Kathodenmaterial so verformt sind, daß sowohl der erste als auch der zweite Streifen aus Kathodenmaterial mit dem genannten Kathodenstromleiterstreifen entlang im

wesentlichen den gesamten Längen der genannten Streifen aus Kathodenmaterial in Kontakt stehen; dadurch gekennzeichnet, daß die genannte erste und zweite Schicht Schichten aus polymerhaltigen Trockenelektrolyt sind, die auf das genannte Anodenmaterial aufgetragen sind, wodurch ein Zellenlaminat mit dem genannten Anoden- und Kathodenmaterial gebildet wird, und dadurch, daß die genannte Zelle weiters eine oder mehrere Vorsprünge aufweist, die aus einer Längskante eines der genannten Anoden- und Kathodenstromleiterstreifen nach außen hervorragen.

2. Zelle nach Anspruch 1, die weiters dadurch gekennzeichnet ist, daß das genannte Zellenlaminat und der genannte Kathodenstromleiterstreifen übereinandergelegt und zusammengerollt sind, um eine Spirale zu bilden.
3. Zelle nach Anspruch 1, die weiters dadurch gekennzeichnet ist, daß das genannte Zellenlaminat der Länge nach im Zickzack gefaltet ist, um eine Vielzahl von Segmenten zu bilden, die in einem Stapel angeordnet sind; und dadurch, daß der genannte Kathodenstromleiterstreifen im Zickzack gefaltet ist, um eine Vielzahl von Segmenten zu bilden, die in einem Stapel angeordnet sind, der sich mit dem genannten im Zickzack gefalteten Zellenlaminatstapel überschneidet, so daß Falten bzw. Knicke des genannten gefalteten Streifens aus Stromleiter im rechten Winkel zu Knicken des genannten gefalteten Laminatstreifens angeordnet sind und jedes Zwischensegment des genannten gefalteten Stromleiterstreifens sich zwischen angrenzenden Segmenten aus genanntem Kathodenmaterial des genannten gefalteten Zellenlaminats erstreckt.
4. Zelle nach Anspruch 3, die weiters dadurch gekennzeichnet ist, daß der/die genannte(n) Vorsprung/-sprünge auf dem genannten Streifen aus Anodenmaterial in der Form einer Vielzahl von leitenden Lappen vorgesehen ist/sind, die entlang der genannten Längskante davon im Abstand angeordnet sind und so angeordnet sind, daß, wenn die genannten Streifen aus Anoden- und Kathodenmaterialien verformt werden, die genannten Lappen sich davon in einer gemeinsamen Richtung erstrecken.
5. Zelle nach Anspruch 4, die weiters dadurch gekennzeichnet ist, daß der/die Vorsprung/-sprünge auch auf dem genannten Kathodenstromleiterstreifen in der Form einer Vielzahl von leitenden Lappen vorgesehen ist/sind, die im Abstand entlang der genannten Längskante



davon angeordnet sind und so angeordnet sind, daß, wenn die genannten Streifen aus Anoden- und Kathodenmaterialien und der genannte Stromleiterstreifen verformt werden, die genannten Lappen sich davon in einer gemeinsamen Richtung erstrecken, die sich von der Richtung der genannten Anodenmateriallappen unterscheidet.

6. Zelle nach Anspruch 5, die weiters dadurch gekennzeichnet ist, daß die genannten Lappen des genannten Streifens aus Anodenmaterial und der genannte Stromleiterstreifen sich jeweils nur von jedem zweiten Segment davon erstrecken.

7. Zelle nach Anspruch 6, die weiters dadurch gekennzeichnet ist, daß die genannten Lappen des genannten Streifens aus Anodenmaterial und des genannten Stromleiterstreifens sich jeweils von gemeinsamen Kanten davon erstrecken.

8. Zelle nach Anspruch 1 oder 2, die weiters dadurch gekennzeichnet ist, daß sie einen Dorn aus nichtleitendem Material umfaßt; dadurch, daß der genannte Kathodenstromleiterstreifen nahe einem Ende davon befestigt und in einer Spirale um den genannten Dorn gewickelt ist; und dadurch, daß das genannte Laminat in einer Spirale um den genannten Dorn gewickelt ist, die zwischen Windungen des genannten Kathodenstromleiterstreifens angeordnet ist.

9. Zelle nach Anspruch 8, die weiters dadurch gekennzeichnet ist, daß der/die genannte(n) Vorsprung/-sprünge am genannten Anodenstreifen angeordnet ist/sind, der einen Stromleiter dafür bildet.

10. Zelle nach Anspruch 9, die weiters dadurch gekennzeichnet ist, daß der/die genannte(n) Vorsprung/-sprünge gemeinsames Verbindermittel zum Bilden einer negativen Elektrode der genannten Zelle einschließt/einschließen.

11. Zelle nach Anspruch 10, die weiters dadurch gekennzeichnet ist, daß das genannte gemeinsame Verbindermittel einen Metallzapfen umfaßt, der in ein Ende des genannten Dorns eingefügt und mit dem/den genannten Vorsprung/-sprünge verbunden ist.

12. Zelle nach Anspruch 10 oder 11, die weiters dadurch gekennzeichnet ist, daß der genannte Kathodenstromleiterstreifen einen sich in Längsrichtung erstreckenden Abschnitt ein-

schließt, der davon seitwärts über das genannte Laminat hinaus in eine Richtung vorragt, die dem/den genannten Vorsprung/-sprünge des genannten Anodenstreifens entgegengesetzt ist.

13. Zelle nach einem der Ansprüche 8 bis 12, die weiters dadurch gekennzeichnet ist, daß der genannte Kathodenstromleiterstreifen eine ausreichende Länge aufweist, um eine äußere Abdeckung der genannten Spirale zu bilden und dadurch den genannten Laminatstreifen einzuschließen.

14. Zelle nach einem der vorhergehenden Ansprüche, die weiters dadurch gekennzeichnet ist, daß der genannte Streifen aus Anodenmaterial einen Streifen aus Lithiumfolie umfaßt; dadurch, daß die genannte Elektrolytschicht ein Lithiumsalz umfaßt, das in Poly(äthylenoxid) aufgelöst ist; und dadurch, daß der genannte Streifen aus Kathodenmaterial ein Verbundmaterial aus feingeteiltem Vanadiumoxid, Ruß und Trockenelektrolytmaterial umfaßt.

15. Zelle nach einem der vorhergehenden Ansprüche, die weiters dadurch gekennzeichnet ist, daß sie eine Polymerbeschichtung umfaßt, die den genannten Laminatstreifen und den genannten Kathodenstromleiterstreifen einkapselt.

16. Verfahren zum Bilden einer elektrochemischen Zelle, das folgende Schritte umfaßt:

(a) das Auswählen eines relativ dünnen Streifens aus Anodenmaterial, der ebene gegenüberliegende Oberflächen aufweist;

(b) das Beschichten der genannten gegenüberliegenden Oberflächen mit einer ersten und zweiten polymerhaltigen Trockenelektrolytschicht;

(c) das Befestigen eines ersten und zweiten relativ dünnen Streifens aus Kathodenmaterial auf der genannten ersten bzw. zweiten Elektrolytschicht, wodurch ein Laminatstreifen mit den genannten Elektrolytschichten und dem genannten Anodenstreifen gebildet wird;

(d) das Befestigen eines einzelnen Kathodenstromleiterstreifens an einem nichtleitenden, länglichen Dorn, wobei einer des genannten Kathodenstromleiterstreifens und Anodenstreifens mit einem oder mehreren Vorsprüngen versehen ist, die aus einer Längsseite davon nach außen hervorragen;

(e) das Wickeln des genannten Leiterstreifens um den genannten Dorn in einer Spirale; und



(f) gleichzeitig mit Schritt (e), das Einfügen eines Endes des genannten Laminatstreifens in einen Knick bzw. Spalt der genannten Spirale und das Wickeln des genannten Laminats in einer Spirale, sodaß es konzentrisch mit den Windungen des genannten Leiterstreifens ist und zwischen diesen liegt.

17. Zelle nach Anspruch 19, die weiters dadurch gekennzeichnet ist, daß die genannten hervorragenden Abschnitte des genannten Kathodenstromleiterstreifens eine Vielzahl von Querschlitzten aufweisen, die Lappen dazwischen bilden, wobei die genannten Lappen radial nach innen gefaltet sind; und dadurch, daß die genannte Zelle weiters einen Knopf umfaßt, der die genannten Lappen verbindet, um eine positive Elektrode zu bilden.

18. Zelle nach Anspruch 20, die weiters dadurch gekennzeichnet ist, daß der genannte Knopf einen Kopf und einen Schaft einschließt, der sich in den genannten Dorn erstreckt.

Revendications

1. Pile électrochimique comprenant une bande relativement fine de matériau de l'anode ayant des surfaces opposées plates ; des première et deuxième couches sur les surfaces opposées ; des première et deuxième bandes, relativement fines, de matériau de la cathode posées sur les première et deuxième couches, respectivement ; et une bande cathode conductrice de courant ; la bande anode, les première et deuxième couches, et les première et deuxième bandes de matériau de la cathode étant déformées de telle sorte que les première et deuxième bandes de matériau de la cathode soient en contact avec la bande cathode conductrice de courant sur sensiblement toute la longueur des bandes de matériau de la cathode, caractérisée en ce que les première et deuxième couches sont des couches d'électrolytes polymères solides recouvrant le matériau de l'anode, formant ainsi un laminé pour pile avec le matériau de l'anode et de la cathode, et en ce que la pile comprend, en outre, une ou deux saillies dépassant vers l'extérieur à partir du bord longitudinal de l'une des bandes anode et cathode conductrices de courant.

2. Pile selon la revendication 1, caractérisée en ce que le laminé pour pile et la bande cathode conductrice de courant sont superposés et enroulés en spirale.

3. Pile selon la revendication 1, caractérisée en ce que le laminé pour pile est plié en éventail longitudinalement pour former une pluralité de segments disposés de façon empilée, et en ce que la bande cathode conductrice de courant est pliée en éventail pour former une pluralité de segments disposés de façon empilée qui sont imbriqués avec l'empilement de laminé pour pile plié en éventail, de telle sorte que les plis de la bande pliée conductrice de courant sont positionnés à angle droit par rapport aux plis de la bande de laminé pliée et que chaque segment intermédiaire de bande pliée conductrice de courant s'étend entre les segments adjacents de matériau de la cathode du laminé pour pile plié.

4. Pile selon la revendication 3, caractérisée en ce que la/les saillie(s) est/sont présente(s) sur la bande de matériau de l'anode sous la forme d'une pluralité d'entailles conductrices espacées sur le bord longitudinal de celle-ci, et positionnées de telle sorte que, lorsque ces bandes anode et cathode sont déformées, ces entailles en dépassent dans une direction commune.

5. Pile selon la revendication 4, caractérisée en ce que une/des saillie(s) est/sont également prévue(s) sur la bande cathode conductrice de courant sous la forme d'une pluralité d'entailles conductrices espacées sur son bord longitudinal et positionnées de telle sorte que, lorsque ces bandes en matériau de l'anode et de la cathode et cette bande conductrice de courant sont déformées, ces entailles en dépassent dans une direction commune, différente de la direction des entailles ménagées dans le matériau de l'anode.

6. Pile selon la revendication 5, caractérisée en ce que les entailles de la bande en matériau de l'anode et de la bande conductrice de courant s'étendent chacune seulement à partir d'un segment sur deux de celles-ci.

7. Pile selon la revendication 6, caractérisée en ce que les entailles de la bande anode et de la bande conductrice de courant s'étendent chacune à partir de leurs bords communs.

8. Pile selon la revendication 1 ou 2, caractérisée en ce qu'elle comprend un mandrin en matériau non-conducteur, en ce que la bande cathode conductrice de courant est fixée à proximité d'une de ses extrémités et entourée autour du mandrin en spirale, et en ce que le laminé est enroulé autour du mandrin en une



spirale positionnée entre les couches enroulées de la bande cathode conductrice de courant.

9. Pile selon la revendication 8, caractérisée en ce que une/des saillie(s) est/sont prévue(s) sur la bande anode formant un conducteur de courant pour elle. 5
10. Pile selon la revendication 9, caractérisée en ce que la/les saillie(s) comprend/comprennent des moyens de connexion communs pour constituer une électrode négative de la pile. 10
11. Pile selon la revendication 10, caractérisée en ce que les moyens de connexion communs comprennent une tige métallique insérée dans une extrémité du mandrin et connectée à la/aux saillie(s). 15
12. Pile selon la revendication 10 ou 11, caractérisée en ce que la bande cathode conductrice de courant comprend une partie s'étendant longitudinalement dépassant sur le côté de celle-ci au-delà du laminé dans une direction opposée à la/aux saillie(s) de la bande anode. 20
13. Pile selon l'une quelconque des revendications 8 à 12, caractérisée en ce que la bande cathode conductrice de courant a une longueur suffisante pour constituer une enveloppe extérieure de la spirale et entourer ainsi la bande de laminé. 25
14. Pile selon l'une quelconque des revendications précédentes, caractérisée en ce que la bande de matériau de l'anode comprend une bande de feuille de lithium, en ce que la couche électrolyte comprend un sel de lithium dissous dans un polyoxyde d'éthylène, et en ce que la bande de matériau de la cathode comprend un composé d'oxyde de vanadium finement divisé, du noir de carbone et un matériau électrolyte solide. 30
15. Pile selon l'une quelconque des revendications précédentes, caractérisée en ce qu'elle comprend un revêtement polymère recouvrant la bande de laminé et la bande cathode conductrice de courant. 35
16. Procédé de fabrication d'une pile électrochimique comprenant les étapes suivantes : 40
 - (a) sélection d'une bande relativement mince de matériau de l'anode ayant des surfaces opposées plates ; 45
 - (b) revêtement de première et deuxième couches d'électrolyte polymère solide sur

ces surfaces opposées ;

(c) fixation des première et deuxième bandes relativement fines de matériau de la cathode sur les première et deuxième couches d'électrolyte, respectivement, formant ainsi une bande de laminé avec les couches d'électrolyte et la bande anode ;

(d) fixation d'une seule bande cathode conductrice de courant sur un mandrin allongé, non-conducteur, une de ces bandes cathodes conductrices de courant et une de ces bandes anodes étant pourvue d'une ou plusieurs saillies dépassant vers l'extérieur à partir d'un de ses bords longitudinaux ;

(e) enroulement en spirale de la bande conductrice autour du mandrin ; et

(f) simultanément à l'étape (e), insertion d'une extrémité de la bande de laminé dans un étranglement de ladite spirale et enroulement en spirale dudit laminé pour que celui-ci soit concentrique avec et entre les couches enroulées de la bande conductrice.

17. Pile selon la revendication 19, caractérisée en ce que les parties en saillie de la bande cathode conductrice de courant comprennent une pluralité de fentes transversales formant des entailles entre elles, ces entailles étant pliées radialement vers l'intérieur, et en ce que la pile comprend, en outre, un bouton reliant les entailles pour former une électrode positive. 25
18. Pile selon la revendication 20, caractérisée en ce que le bouton comprend une tête et une tige s'étendant dans le mandrin. 30