

METHOD FOR MANUFACTURING BATTERIES AND BATTERY OBTAINED
BY SAID METHOD

Technical field of the invention

The present invention relates to the manufacture of batteries. It can be applied in particular to lithium ion batteries. The invention relates to a novel method for manufacturing batteries, and in particular lithium ion
5 batteries. It also relates to the batteries obtained by this method, which have a novel architecture that confers on them an improved service life.

Prior art

10 In order to increase the efficiency of production of rechargeable batteries with high energy density and high power density, such as entirely solid batteries or batteries impregnated with a liquid electrolyte, the simultaneous manufacture of a plurality of batteries can
15 be implemented using a superimposition of alternating anode and cathode sheets previously coated with a layer of electrolyte.

WO 2016/001584 (I/TEN) describes sheets comprising a conductive substrate covered successively with a layer of
20 electrode covered with a layer of electrolyte; these sheets are cut, before or after deposition, in patterns, in particular in a U shape. These sheets are stacked in alternation in order to constitute a stack of a plurality of elementary cells. The patterns of cutting of anodes and
25 cathodes are placed in an "opposite orientations" configuration so that the stack of layers of cathode and anode are offset laterally. After the stacking step, this document teaches depositing an encapsulation system in a thick layer of around ten microns and conformal, typically

a polymeric layer, on the stack and in the available cavities present within the stack. This makes it possible to ensure firstly the rigidity of the structure at the cutting planes and secondly the protection of the battery cell with regard to the atmosphere. Once the stack is produced and encapsulated in a rigid structure, it is cut along cutting planes in order to obtain unitary batteries, with the baring on each of the cutting planes of the cathode and anode connections of the batteries. It may happen that, during such cutting, the encapsulation system may be torn away, which causes discontinuity of the impermeability of the battery. Adding terminations (i.e. electrical contacts) at the point where these cathode and anode connections are visible is also known.

This prior art is explained here in greater detail with reference to figure 12, which illustrates a lithium ion battery structure described in WO 2016/001584. The battery **200** comprises a plurality of anodes **230** and a plurality of cathodes **210**, which are disposed one above the other in alternation. Each anode and each cathode comprises a layer of a respective anode or cathode active material, referred to as the anode layer and respectively the cathode layer. Moreover, a layer of an electrolyte material, not shown in figure 12, is interposed between the anode and the cathode, so that the electrolyte material separates two facing active materials. The thickness of the various layers that constitute them does not normally exceed 10 μm , and is often between 1 μm and 4 μm . The battery has, on a first lateral edge **201**, anode connections **230'** located below one another. Moreover, on the opposite lateral edge **202**, cathode connections **210'** located below one another are provided. The stack of anodes **230** and cathodes **210** is offset laterally. The cathode connections **210'** are located projecting, with respect to the free face

230" of the anode. In a similar manner, on the opposite edge **201**, the free face **210"** of the cathode is located recessed with respect to the free face of the anode, on which anode connections **230'** are subsequently deposited.

5 This known solution does however have certain drawbacks. This is because, according to the positioning of the electrodes, in particular the proximity of the edges of the electrodes for multilayer batteries and the cleanness of the cuts, a leakage current may appear on the
10 ends, typically in the form of a rampant short-circuit. It reduces the performance of the battery, and this despite the use of an encapsulation system around the battery and in the vicinity of the cathode and anode connections. Moreover, an unsatisfactory deposition of the
15 encapsulation system on the battery is sometimes found, in particular on the edges of the battery at the spaces created by the lateral offsets of the electrodes on the battery edges.

 Moreover, since the terminations, respectively anode
20 and cathode, are situated recessed from the adjacent layers, respectively cathode and anode, it is necessary to make a cutout of large dimensions. Such a cutout must then be filled by means of an insulating material. Given the large dimensions thereof, this cutout leads to a substantial
25 loss of useful materials, for producing the battery proper. Moreover, it makes it necessary to deposit great thicknesses of insulator, in the available cavities present within the stack. A thick insulator risks weakening the whole of the battery encapsulation system since, during
30 the cutting, the encapsulation system deposited in a thick layer has a tendency to delaminate.

 The architecture according to the prior art therefore has both technical and economic drawbacks.

The present invention aims at least partly to remedy some drawbacks of the prior art mentioned above.

It aims in particular to increase the efficiency of production of rechargeable batteries with high energy
5 density and high power density and to produce more efficient encapsulations at less cost.

It aims in particular to propose a method that reduces the risk of short-circuit, and which makes it possible to manufacture a battery having low self-discharge.

10 It aims in particular to propose a method that makes it possible to manufacture, in a simple, reliable and rapid manner, a battery having a very long service life.

It also aims to propose such a method that uses a cutting step of better quality than in the prior art.

15 It also aims to propose such a method that makes it possible to improve the encapsulation phases and the encapsulation itself, taking place during the production of the end battery.

It also aims to propose a method for manufacturing
20 batteries that causes less loss of materials.

Objects of the invention

At least one of the above objectives is achieved by means of at least one of the objects according to the
25 invention as presented below. The present invention proposes as a first object a battery comprising at least one anode and at least one cathode, arranged on top of one another in an alternating manner, said battery comprising lateral edges comprising an anode connection area and a
30 cathode connection area, preferably laterally opposite the anode connection area, and longitudinal edges, in which the anode comprises

- a current collector substrate,
- at least one anode layer, and

- optionally a layer of an electrolyte material or of a separator impregnated with an electrolyte, and the cathode comprises
 - a current collector substrate,
 - 5 - at least one cathode layer, and
 - optionally a layer of an electrolyte material or of a separator impregnated with an electrolyte,so that the battery comprises successively at least one anode layer, at least one layer of an electrolyte material or of a separator impregnated with an electrolyte and at least one cathode layer,
- 10 characterized in that each anode and each cathode comprises a respective main body, separated from a respective secondary body, said main bodies and secondary bodies being separated by a space free from any electrode material, electrolyte and/or current-collector substrate, said free space connecting the opposite longitudinal edges of the battery, i.e. said free space extending between the opposite longitudinal edges of the battery.
- 20 The present invention proposes as a second object a battery comprising at least one anode and at least one cathode, arranged on top of one another in an alternating manner, said battery comprising lateral edges comprising an anode connection area and a cathode connection area, preferably laterally opposite the anode connection area, and longitudinal edges, in which the anode comprises
 - a current collector substrate,
 - at least one anode layer, and
 - optionally a layer of an electrolyte material or of
 - 30 a separator impregnated with an electrolyte,and the cathode comprises
 - a current collector substrate,
 - at least one cathode layer, and

- optionally a layer of an electrolyte material or of a separator impregnated with an electrolyte,

so that the battery comprises successively at least one anode layer, at least one layer of an electrolyte material or of a separator impregnated with an electrolyte and at least one cathode layer,

characterized in that each anode and each cathode comprises a respective main body, separated from a respective secondary body by a space free from any electrode material, electrolyte and/or current-collector substrate, said free space connecting the opposite longitudinal edges of the battery, i.e. said free space extending between the opposite longitudinal edges of the battery.

Advantageously, the battery comprises an encapsulation system completely covering four of the six faces of said battery, the remaining two faces comprising an anode connection area and a cathode connection area.

Advantageously, the encapsulation system comprises:

- at least one first covering layer, preferably selected from parylene, type-F parylene, polyimide, epoxy resins, silicone, polyamide, sol-gel silica, organic silica and/or a mixture thereof, deposited on the battery,

- at least one second covering layer composed of an electrically insulating material, deposited by deposition of atomic layers on said at least one first covering layer, on the understanding that this sequence of at least one first covering layer and of at least one second covering layer may be repeated z times with $z \geq 1$.

Advantageously, the anode connection area and the cathode connection area are covered by a termination system.

Advantageously, the termination system comprises successively:

- a first layer of a material filled with graphite, preferably based on an epoxy resin filled with graphite,

- a second dense layer of metallic copper arranged on the first layer of the termination system, and

5 - optionally, a third layer based on a tin-zinc alloy of tin, arranged on the second layer,

- optionally a fourth layer based on tin or based on an alloy of silver, palladium and copper, arranged on the third layer of the termination system.

10 Advantageously, the width of the free space is between 0.01 mm and 0.5 mm.

Advantageously, the width of the secondary bodies is between 0.05 mm and 2 mm.

15 Advantageously, in plan view, the free spaces of the cathodes are superimposed.

Advantageously, in plan view, the free spaces of the anodes are superimposed.

Advantageously, in plan view, the free spaces of the cathodes and of the anodes are not coincident.

20 Another object of the invention is a method for manufacturing a battery, said battery comprising at least one anode and at least one cathode, arranged on top of one another in an alternating manner, said battery comprising longitudinal edges and lateral edges,

25 wherein the anode comprises

- a current collector substrate,
- at least one cathode layer, and
- optionally a layer of an electrolyte material or of

a separator impregnated with an electrolyte,

30 and the cathode comprises

- a current collector substrate,
- at least one cathode layer, and
- optionally a layer of an electrolyte material or of

a separator impregnated with an electrolyte,

so that the battery comprises successively at least one anode layer, at least one layer of an electrolyte material or of a separator impregnated with an electrolyte, and at least one cathode layer,

5 each anode comprising an anode connection area, located in the vicinity of a first lateral edge of the battery, whereas each cathode comprises a cathode connection area, located on a second lateral edge of the battery, opposite to said first edge,

10 said manufacturing method comprising:

 a) the provision of a stack of alternating sheets, this stack comprising first sheets or anode sheets, each of which is intended to form an anode layer of a plurality of batteries, as well as second sheets or cathode sheets,
15 each of which is intended to form a cathode layer of a plurality of batteries,

 each anode sheet comprising at least one anode slot and each cathode sheet comprising at least one cathode slot, said slot, respectively anode and cathode,
20 comprising two longitudinal parts at least partly superimposed, intended to delimit the longitudinal edges of the battery, as well as a lateral part connecting said two longitudinal parts, i.e. a lateral part extending between the two longitudinal parts of said slot, the
25 lateral part of the anode slot and the lateral part of the cathode slot being mutually offset, it being understood that each lateral part of the slots delimits a space free from any electrode material, electrolyte and current-collector substrate, said free space separating,
30 for each anode and each cathode, a main body from a secondary body, i.e. a main body with respect to a secondary body,

b) the implementation of a heat treatment and/or of a mechanical compression of the stack of alternating sheets previously provided,

c) the production of two cutouts extending at least partially inside said slots, the first cutout extending between the lateral part of the anode slot and the facing end of the longitudinal parts, whereas the second cutout extends between the lateral part of the cathode slot and the facing end of the longitudinal parts.

Advantageously, after the step c), the cut-out stack is encapsulated, by depositing:

- at least one first covering layer, preferably selected from parylene, type-F parylene, polyimide, epoxy resins, silicone, polyamide, sol-gel silica, organic silica and/or a mixture thereof, deposited on the battery,

- at least one second covering layer composed of an electrically insulating material, deposited by deposition of atomic layers on said at least one first covering layer, on the understanding that this sequence of at least one first covering layer and of at least one second covering layer may be repeated z times with $z \geq 1$.

Advantageously, after the step d) of encapsulating the cut-out stack, the cut-out and encapsulated stack is impregnated, by a phase carrying lithium ions such as liquid electrolytes or an ionic liquid containing lithium salts.

Advantageously the terminations of the battery are produced by successively depositing

- a first layer of a material filled with graphite, preferably based on an epoxy resin filled with graphite,
- a second dense layer of metallic copper arranged on the first layer of the termination system, and

- optionally, a third layer based on a tin-zinc alloy of tin, arranged on the second layer of the termination system,

- optionally a fourth layer based on tin or based on
5 an alloy of silver, palladium and copper, arranged on the third layer of the termination system.

Advantageously, the two cutouts are produced through at least a majority of the anodes and cathodes, in particular through all the anodes and cathodes.

10 Advantageously, the distances between each cutout and the facing ends of the longitudinal parts are identical. Advantageously, its distances are between 0.05 mm and 2 mm.

Advantageously, each slot has a roughly H shape, the
15 longitudinal parts forming the vertical main recesses of the H, whereas the lateral part forms the channel of the H.

Advantageously, each lateral part of the slots delimits a space free from any electrode material,
20 electrolyte and/or current-collector substrate connecting or extending between the opposite longitudinal edges of the battery, said free space separating, for each anode and each cathode, a main body from a secondary body.

Advantageously, the width of the lateral part of the
25 slots is between 0.05 mm and 2 mm.

Advantageously, each sheet belonging to said stack comprises a plurality of lines of slots arranged alongside each other. Advantageously, the two cutouts are made through all the slots on the same line.

30 Advantageously, each sheet comprises a plurality of rows of slots arranged below one another.

Advantageously, the distance separating adjacent cutouts, provided in adjoining lines, is between 0.05 mm and 5 mm.

Advantageously, the number of lines is between 10 and 500, whereas the number of rows is between 10 and 500.

Advantageously, each cutout is produced by a sawing method, by a swaging method, by guillotine, or by laser.

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Figures

The accompanying figures, given by way of non-limitative examples, show various aspects and embodiments of the invention. [Fig. 12] shows a battery according to the prior art.

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[Fig. 1] is a perspective view of the anode and cathode sheets intended to form a stack according to the battery manufacturing method in accordance with the invention.

[Fig. 2] is a front view, illustrating one of the sheets of figure 1.

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[Fig. 3] is a front view, to a larger scale, illustrating the H-shaped slots formed in adjacent sheets.

[Fig. 4] is a perspective view, also to a large scale, illustrating these H-shaped slots formed in adjacent sheets.

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[Fig. 5] is a plan view, illustrating a cutting step performed on various slots formed in the stack in the previous figures.

[Fig. 6] is a plan view, illustrating to a larger scale the cutouts formed on an H-shaped slot.

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[Fig. 7] is a view in cross section, along the line VII-VII indicated in figure 6.

[Fig. 8] is a view in cross section along the line VIII-VIII indicated in figure 6.

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[Fig. 9] is a plan view illustrating a battery according to the invention, which is able to be obtained in particular according to the method of the previous figures.

[Fig. 10] is a front view illustrating a battery according to the invention that is able to be obtained in particular according to the method of the previous figures.

[Fig. 11] is a perspective view illustrating a battery
5 according to the invention that is able to be obtained in particular according to the method of the preceding figures.

[Fig. 12] is a perspective view illustrating a battery according to the prior art.

[Fig. 13] is a plan view illustrating a cutting step
10 implemented on various H-shaped slots formed on an anode sheet or cathode sheet according to a second variant of the invention.

[Fig. 14] is a plan view illustrating to a larger
15 scale the cutouts formed on H-shaped slots according to a second variant of the invention.

[Fig. 15] is a perspective view illustrating a battery according to the invention that is able to be obtained in particular according to the second variant of the invention.

The following references are used on these figures
20 and in the following description:

[Table 1]: references used in the present application

I	stack of anode and cathode sheets		
1	cathode sheet	XH/XH ¹	horizontal median axis of slots 14 and 34, and respectively of slots 1014 and 1034
3	anode sheet	D, D', D _n , D' _n , D _{n+1} , D' _{n+1}	Cutout
10	perforated central area of the cathode sheet	100/ 1100	Battery according to the invention
12	peripheral frame of the cathode sheet	40/1040	off-cuts of material
XX	longitudinal or horizontal direction of the stack	41	off-cuts of cathode materials
YY	vertical or transverse direction of the stack	43	off-cuts of anode materials
L	line of slots	X 100 Y 100	longitudinal and transverse median axes of 100
R	row of slots	101/102	lateral edges of 100
20/ 1020	bridges of material between two lines	103/104	longitudinal edges of 100
H ₂₀ / H ₁₀₂₀	heights of the bridges	110/ 1110	cathode layers
22	bands of materials between two rows	130/ 1130	anode layers
L ₂₂	width of strips	111, 131/1111, 1131	main body of 110, respectively of 130/main body of 1110, respectively of 1130

14/ 1014	H-shaped slots in the cathode sheets	112, 132/ 1112, 1132	secondary body of 110, respectively of 130/secondary body of 1110, respectively of 1130
16/ 1016	vertical main recesses of 14	113/ 1113	Space, between 111 and 112, respectively between 1111 and 1112, free from any electrode material, electrolyte and/or current collector substrate
18/ 1018	horizontal channel of 14	133/ 1133	space, between 131 and 132, respectively between 1131 and 1132, free from any electrode material, electrolyte and/or current collector substrate
H ₁₄	total height of the slot	L ₁₁₃ /L ₁₁₁₃	width of the free space between 111 and 112, respectively between 1111 and 1112
L ₁₄	total width of the slot	L ₁₁₂ /L ₁₁₁₂	width of secondary body 112, respectively 1112
L ₁₆	width of each main recess 16	111', 112', 131', 132'	free spaces respectively of 111, 112, 131, 132
H ₁₈	height of each channel 18	200	batteries of the prior art, see figure 12
D ₁₈	distance between the top of 16 and 18	210/230	cathode/anode
34/ 1034	H-shaped slots in the anode sheets, similar to the slots 14/1014	201/202	lateral edges
36/ 1036	vertical main recesses of 34	210' / 230'	free faces of the cathode/of the anode

1101/ 1102	lateral edges of 1100	210"/ 230"	free faces of the cathode/of the anode located recessed
38/ 1038	horizontal channel of 34	D ₂₀	distance between the cutout D _n and the opposite face of the channel 18
2	Perforations present at the four ends of the anode and cathode sheets	D ₄₀	distance between the cutout D' _n and the opposite face of the channel 38
D ₁₀₂₀	distance between the cutout <u>D_n</u> and the opposite face of the channel 1018	D ₃₈	distance between the top of 36 and of 38

Description of the invention

The method according to the invention comprises first of all a step wherein a stack **I** of alternating sheets, these sheets being hereinafter called, according to the case, "anode sheets" and "cathode sheets". As will be seen in more detail by each anode sheet is intended to form the anode of a plurality of batteries, and each cathode sheet is intended to form the cathode of a plurality of batteries.

In the example illustrated in figure 1, five cathode sheets **1** are shown, as well as five anode sheets **3**. In practice, this stack is formed by a greater number of sheets, typically between ten and one thousand. In an advantageous embodiment, all these sheets have perforations **2** at the four ends thereof so that, when these perforations **2** are superimposed, all the cathodes and all the anodes of these sheets are arranged specifically, as will be explained in greater detail below (cf. figures 1 and 2). These perforations **2** at the four ends of the sheets may be produced by any suitable means, in particular on anode and

cathode sheets after fabrication or on anode and/or cathode sheets covered with a layer of electrolyte or covered with a separator so that this layer of electrolyte or this separator are interposed between two sheets of opposite polarity, i.e. between the anode sheet and the cathode sheet.

The physical and chemical structure of each anode or cathode sheet, which may be of a known type, does not form part of the invention and will be described only succinctly.

Each anode and respectively cathode sheet comprises an active anode layer and respectively an active cathode layer. Each of these active layers may be solid, i.e. with a dense or porous nature. Moreover, in order to avoid any electrical contact between two adjacent sheets, a layer of electrolyte or a separator impregnated with a liquid electrolyte is disposed on at least one of these two sheets, in contact with the opposite sheet. The layer of electrolyte or the separator impregnated with a liquid electrolyte, not shown in the figures describing the present invention, is interposed between two sheets of opposite polarity, i.e. between the anode sheet and the cathode sheet.

The mechanical structure of one of the cathode sheets **1** will now be described, on the understanding that the other cathode sheets have an identical structure. Moreover, as will be seen hereinafter, the anode sheets **3** have a structure very similar to that of the cathode sheets **1**.

As can be seen in figure 2, the cathode sheet **1** has a quadrilateral shape, substantially of the square type. It delimits a so-called perforated central area **10**, in which H-shaped slots are formed, which will be described below. With reference to the positioning of these H-shaped slots, a so-called vertical direction **YY** of the sheet is defined, which corresponds to the vertical

direction of these Hs, and a so-called horizontal direction **XX** of the sheet, perpendicular to the direction **YY**. The central area **10** is bordered by a peripheral frame **12** that is solid, namely with no slots. The function of this frame
5 is in particular to ensure easy manipulation of each sheet.

The H-shaped slots are distributed along lines **L₁** to **L_y**, disposed one underneath the other, as well as along rows **R₁** to **R_x** provided alongside each other. By way of non-limitative examples, in the context of the manufacture of
10 microbatteries of the surface mounted component type (hereinafter SMC), the anode and cathode sheets used may be plates 100 mm x 100 mm. Typically, the number of lines of these sheets is between 10 and 500, whereas the number of rows is between 10 and 500. According to the required
15 capacity of the battery, the dimensions thereof may vary and the number of lines and rows of anode and cathode sheets can be adapted accordingly. The dimensions of the anode and cathode sheets used may be modulated according to requirements. As shown in figure 2, two adjacent lines
20 are separated by bridges of material **20**, the height of which is denoted **H₂₀**, which is between 0.05 mm and 5 mm. Two adjacent rows are separated by strips of material, the width of which is denoted **L₂₂**, which is between 0.05 mm and 5 mm. These bridges and strips of material of the anode
25 and cathode sheets confer thereon sufficient mechanical rigidity for them to be able to be manipulated easily.

The slots **14** are through slots, namely they emerge on the respectively top and bottom faces of the sheet. The slots **14** can be produced in a manner known per se, directly
30 on the substrate, before any deposition of anode or cathode materials by chemical etching, by electroforming, by laser cutting, by microperforation or by stamping. These slots may also be produced on substrates covered with anode or cathode materials, on anode or cathode sheets covered with

a layer of electrolyte or with a separator, in a manner known per se, for example by laser cutting, by femtosecond laser cutting, by microperforation or by stamping. The slots **14**, produced in all the cathodes, are superimposed
5 as shown in particular in figure 3.

One of the H-shaped slots **14** will now be described, on the understanding that all the cutouts in the cathode sheet are identical. The slot **14** is formed by two vertical and parallel main recesses **16**, which are connected in their
10 top part thereof by a horizontal channel **18**, preferably perpendicular to the two vertical main recesses **16**. The following annotations are used:

- **H₁₄** the height of the slot assembly, which is typically between 0.25 mm and 10 mm;
- 15 • **L₁₄** the width thereof, which is typically between 0.25 mm and 10 mm;
- **L₁₆** the width of each main recess, which is typically between 0.02 mm and 5 mm;
- **H₁₈** the height of each channel, which is typically
20 between 0.01 mm and 0.5 mm;
- **D₁₈** the difference in heights between the top of the main recesses and the top of the channel, which is typically between 0.05 mm and 2 mm.

Each anode is also provided with various lines and
25 rows of slots **34**, provided in the same number as the slots **14**. As shown in particular by figure 4, the structure of each slot **34** is substantially similar to that of each slot **14**, namely that this slot **34** comprises two vertical main recesses **36**, connected by a channel **38**. The dimensions of
30 the vertical main recesses **36** are identical to those of the vertical main recesses **16** and, in a similar manner, the dimensions of the channels **38** are similar to those of the channels **18**.

In plan view, the vertical main recesses **36** are superimposed with those **16**. The only difference between the slots **14** and **34** lies in the fact that the channels **38** are provided in the lower part. As shown particularly in
5 figure 3, the channels **18** and **38** are mutually symmetrical in plan view, with respect to the median axis of the Hs, which is denoted **XH**.

It is supposed that the stack described above is subjected to steps aimed at ensuring the global mechanical
10 stability thereof. These steps, of a type known per se, include in particular the thermopressing of the various layers. As will be seen below, this stack allows the formation of individual batteries, the number of which is equal to the product between the number of lines Y and the
15 number of rows X.

For this purpose, with reference to figure 5, three lines **L_{n-1}** to **L_{n+1}** and three rows **R_{n-1}** to **R_{n+1}** have been illustrated. In accordance with the invention, two cutouts **D_n** and **D'_n** per line of slots are produced. Each cutout,
20 which is implemented so as to pass right through, namely it extends over the whole of the height of the stack, is produced in a manner known per se. By way of non-limitative examples, cutting by sawing will be mentioned, in particular cutting by swaging, cutting by guillotine or
25 cutting by laser.

As shown in particular by figure 6, which is a view to a larger scale of one of the slots in figure 5, each cutout is produced between a respective channel and the facing end of the H. It is supposed that the thickness of
30 said cutout is ignored. Under these conditions, with reference to this figure 6, by way of non-limitative examples, the following are noted:

- the distance **D₂₀** between the cutout **D_n** and the opposite face of the horizontal channel **18** is between 0.05

mm and 2 mm, on the understanding that this distance **D₂₀** is less than or equal to **D₁₈**;

- the distance **D₄₀** between the cutout **D'_n** and the opposite face of the horizontal channel **38**, between 0.05 mm and 2 mm, on the understanding that this distance **D₄₀** is less than or equal to **D₃₈**.

With reference once again to figure 5, each final battery is delimited, at the top and bottom, by the two cutouts and, to the right and to the left, by the internal faces of the vertical main recesses of the H. In this figure 5 the batteries **100** once cut by the cutting lines **D_n** and **D'_n** have been hatched, and the areas **40** of the sheets of the stack, which do not form the batteries, have been illustrated by dots, whereas the volume of the slots is left blank.

Figures 7 and 8 are views in cross section, taken along parallel cutting lines. The cross section **VII-VII** extends through the vertical main recesses of the H, whereas the cross section **VIII-VIII** passes through the material. In figure 7, the regions **40** have been referenced, illustrated also in figure 5, which correspond to off-cuts of material, in particular off-cuts of materials of anodes **43** and of materials of cathodes **41**. In figure 8 it is noted that the cutouts are made both through the anodes and the cathodes, namely at a distance **D₂₀** from the channels of the H-shaped slots so as to have, for each cathode **1**, and respectively each anode **3**, of the battery **100** a main body **111**, and respectively **131**, separated from a secondary body **112**, and respectively **132**, by a space free from any electrode material, electrolyte and/or current collector substrate **113**, and respectively **133**. It is a case there of a particularly advantageous feature of the invention since this makes it possible to improve the quality of the cutout compared

with the prior art and to avoid the presence of a short-circuit at the lateral edges of the battery.

The application WO 2016/001584 describes stacks of a plurality of elementary cells, consisting of anode and cathode sheets stacked in alternation and offset laterally (see figure 12), encapsulated in an encapsulation system in order to provide protection of the cell of the battery with respect to the atmosphere. The cutting of these encapsulated stacks making it possible to obtain unitary batteries, with anode and cathode connections bare, is implemented on a cutting plane passing through an alternating succession of electrode and encapsulation system. Through the difference in density existing between the electrode and the encapsulation system of the battery of the prior art, the cutting made along this cutting plane gives rise to a risk of tearing of the encapsulation system around the cutting plane, and thus the creation of short-circuits. In the prior art, during the encapsulation, the encapsulation layer fills the interstices of the stack of sheets carrying U-shaped cutouts. This encapsulation layer introduced at these interstices is thick and does not adhere very well to the stack, causing this risk of tearing of the encapsulation system during the subsequent cutting.

According to the present invention, this risk is eliminated with the use of sheets carrying H-shaped cutouts, since the H-shaped thermopressed mechanical structure is extremely rigid around the cutout, because of the alternating superimposition of cathode and anode sheets. The use of such a rigid structure, with the use of sheets carrying H-shaped cutouts, makes it possible to reduce the number of defects during cuts, to increase the cutting speed and thus to improve the efficiency of the production of the batteries.

According to the invention, the cutouts **D'_n** and **D_n** are made through the anodes and the cathodes with comparable density giving rise to a clean cutout of better quality. In addition, the presence of a space free from any electrode material, electrolyte and/or current-collector substrate prevents any risk of short-circuit.

With reference now to figures 9 to 11, there is an illustration of one **100** of the batteries according to the invention. The median axes, respectively longitudinal and lateral, of this battery are denoted **X100** and **Y100**. The lateral edges are denoted **101** and **102**, the longitudinal edges of this battery **103** and **104**. Moreover each cathode is denoted **110**, and each anode **130**. The number of these cathodes, which is identical to the number of these anodes, corresponds to the number of cathode sheets and anode sheets of the aforementioned stack.

As shown in figure 9, namely in plan view, the free spaces of the cathodes are superimposed. In addition, according to this same plan view, the free spaces of the anodes are superimposed. Finally, according to this same plan view, the free spaces of the cathodes and anodes are not coincident. This is in particular shown, by way of example, in figure 10.

The free space (113) connects the opposite longitudinal edges of the battery, which are shown as upper and lower in figure 9. This free space extends between the opposite longitudinal edges of the battery separating, for each anode and each cathode, a main body from a secondary body.

Each cathode **110** comprises a main body **111**, a secondary body **112** situated on a first lateral edge **101**, and a space free from any electrode material, electrolyte and/or current-collector substrate **113**. The latter, the

width of which corresponds to that of the channel **18** of the slot **14** described above, extends between the longitudinal edges **103** and **104**. In a similar manner, each anode **130** comprises a main body **131**, and a secondary body **132** located on the lateral edge **102**, opposite to the edge **101**. The main body **131** and the secondary body **132** are separated by a space **133** free from any electrode material, electrolyte and/or current-collector substrate, connecting the edges **103** and **104**, i.e. extending between the longitudinal edges **103** and **104**. The two free spaces **113** and **133** are mutually symmetrical, with respect to the median axis **Y100**.

The width **L₁₁₃** of each free space **113** corresponds to the width of the channel **18**, belonging to the slot described in the preceding figures. Moreover, the width **L₁₁₂** of each secondary body **112** corresponds to the distance **D₂₀**, as described with reference to figure 6 or to figure 8.

Figure 13 illustrates an additional variant of the invention. In this figure 13 the mechanical elements similar to those in figures 1 to 11 illustrating the first embodiment are therein allocated the same reference numbers increased by the number 1000.

This second variant embodiment differs from the first variant essentially in that the H-shaped slots **1014** are distributed along lines **L₁** to **L_y**, disposed one below the other, and along rows **R₁** to **R_x** provided alongside each other. In this way at least one of the vertical main recesses **1016** of the slot positioned in row **R_n** is coincident with at least one of the vertical main recesses **1016** of the adjacent slot positioned in row **R_{n-1}** and/or **R_{n+1}**. In this case, the two adjacent rows are not separated by strips of material. As shown in figure 13, two adjacent lines are separated by bridges of material **1020**, the height

of which is denoted **H₁₀₂₀**, which is between 0.05 mm and 5 mm. These bridges of material confer on the anode and cathode sheets sufficient mechanical rigidity for them to be able to be manipulated easily.

5 In this second variant of the invention, the H-shaped slots **1014** may preferably be the same as in the first variant. The slot **1014** is preferably formed by two vertical and parallel main recesses **1016**, which are connected in the top part thereof by a horizontal channel
10 **1018**, preferably perpendicular to the two vertical main recesses **1016**.

Each cathode is provided with various lines and rows of slots **1014**. Each anode is also provided with various lines and rows of slots **1034**, provided in the same number
15 as the slots **1014**.

The structure of each slot **1034** is substantially similar to that of each slot **1014**, namely that this slot **1034** comprises two vertical main recesses **1036**, connected by a channel **1038**. The dimensions of the vertical main
20 recesses **1036** are identical to those of the vertical main recesses **1016** and, in a similar manner, the dimensions of the channels **1038** are similar to those of the channels **1018**.

In plan view, the vertical main recesses **1036** are
25 superimposed with the vertical main recesses **1016**. The only difference between the slots **1014** and **1034** lies in the fact that the channels **1038** are provided at the bottom part. As shown in particular by figure 14, the channels **1018** and **1038** are mutually symmetrical in plan view, with
30 respect to the median axis of the Hs, which is denoted **XH'**.

It is supposed that the stack of the anode and cathode sheets described above is subjected to steps aimed at ensuring the global mechanical stability thereof. These steps, of a type known per se, include in particular

thermopressing of the various layers. As will be seen below, this stack allows the formation of individual batteries, the number of which is equal to the product between the number of lines Y and the number of rows X.

5 For this purpose, with reference to figure 14, three lines **L_{n-1}** to **L_{n+1}** and three rows **R_{n-1}** to **R_{n+1}** have been illustrated. According to the invention, two cutouts **D_n** and **D'_n** per line of slots are produced. Each cutout, which is done in a through manner, namely it extends over the
10 whole of the height of the stack, is produced in a manner known per se. By way of non-limitative examples, cutting by sawing, in particular cutting by swaging, cutting by guillotine or cutting by laser, will be mentioned.

Each cutout is produced between a respective channel
15 and the facing end of the H. It is supposed that the thickness of said cutout is ignored. The cutouts are produced both through the anodes and the cathodes, namely at a distance **D₁₀₂₀** from the channels of the H-shaped slots so as to have, for each cathode **1110** and respectively each
20 anode **1130** of the battery **1100**, a main body **1111** and respectively **1131**, separated from a secondary body **1112** and respectively **1132** by a space free from any electrode material, electrolyte and/or
current-collector substrate **1113**, respectively **1133**, as
25 illustrated in figure 15. This is a particularly advantageous feature of the invention since this makes it possible to improve the quality of the cutout compared with the prior art and to avoid the presence of short-circuit at the lateral edges of the battery. Each final
30 battery **1100** is delimited, at the top and bottom, by the two cutouts and, to the right and to the left, by the internal faces of the vertical main recesses of the H. In figure 13 the batteries **1100** once cut by the cutout lines **D_n** and **D'_n** have been hatched, the areas **1040** of the sheets

of the stack, which do not form the batteries, have been illustrated with dots, whereas the volume of the slots is left blank.

According to the invention, the cutouts **D'_n** and **D_n** are
5 produced through the anodes and cathodes with a comparable density giving rise to a clean cutout of great quality. In addition the presence of a space free from any electrode material, electrolyte and/or current-collector substrate prevents any risk of
10 short-circuit.

As shown in figure 15, each cathode **1110** comprises a main body **1111**, a secondary body **1112** located on a first lateral edge **1101**, and a space **1113** free from any electrode material, electrolyte and/or
15 current-collector substrate. The latter, the width of which corresponds to that of the channel **1018** of the slot **1014** described above, extends between the longitudinal edges. In a similar manner, each anode **1130** comprises a main body **1131** and a secondary body **1132** situated on the
20 lateral edge **1102**, opposite to the edge **1101**. The main body **1131** and the secondary body **1132** are separated by a space **1133** free from any electrode material, electrolyte and/or current-collector substrate, connecting the longitudinal edges, i.e. extending between the
25 longitudinal edges **1103** and **1104**. The two free spaces **1113** and **1133** are mutually symmetrical, with respect to the median axis **Y100**.

The width **L₁₁₁₃** of each free space **1113** corresponds to the width of the channel **1018**, belonging to the slot
30 described in the preceding figures. Moreover, the width **L₁₁₁₂** of each secondary body **1112** corresponds to the distance **D₁₀₂₀**, as described previously.

The battery **1100** obtained according to the second variant of the invention is in every respect identical to

that obtained according to the first variant of the invention even though the arrangement of the slots **1014** is different.

In a third variant of the invention that is not shown
5 in the figures, the H-shaped slots **14/1014** can be distributed along the lines **L₁** to **L_y**, disposed one underneath the other, and along the rows **R₁** to **R_x** provided alongside each other. In this way, on the same anode and/or cathode sheet, the H-shaped slots **14/1014** are disposed,
10 according to the first and second variant of the invention, on the anode and/or cathode sheets, so as to keep sufficient mechanical rigidity for these sheets to be able to be manipulated easily and so that the stack can advantageously define a maximum number of unitary
15 batteries.

The battery **1100** obtained according to the third variant of the invention is in every respect identical to that obtained according to the first and/or second variants of the invention even though the arrangement of the slots
20 **14/1014** on the anode and/or cathode sheets is different.

A comparison between figures 11 and 12 makes it possible to highlight advantages of the invention. This is because substantially the entire total volume of the battery is occupied by useful material, i.e. material that
25 contributes to the electrochemical functioning of the battery **100**. This is because only the two free spaces **133/1133**, which are very small, cannot be considered to be useful material. In this regard, with reference to figure 10, it is noted that the free faces **112'** of the secondary cathode bodies fit flush with the free spaces **131'** of the
30 main body of the anodes, whereas the free faces **132'** of the secondary anode bodies fit flush with the free faces **111'** of the main body of the cathodes. In other words, the opposite lateral edges of the battery according to the

invention, comprising electrode materials, are substantially continuous, in comparison with those of the prior art illustrated in figure 12, which are discontinuous because of the presence of the recesses.

5 The "free face of the secondary body" corresponds to the face belonging to the secondary body that is opposite to the main body.

 The "free face of the main body" corresponds to the face belonging to the main body that is opposite to the
10 secondary body.

 Furthermore, the presence of free spaces on each anode layer and respectively cathode layer of the battery makes it possible to dispense with the use of any encapsulation system, i.e. of any insulating material, such as parylene,
15 in the battery, these free spaces fulfilling the role of electrical insulator. The final steps of manufacture of batteries, such as encapsulation, are facilitated thereby. It is no longer necessary, as in the prior art and illustrated in figure 12, to insulate the recessed regions
20 **210", 230"** in the battery, i.e. to fill in the interstices of the structure of the prior art with an encapsulation system, to fill in the space present in the U-shaped cutouts positioned in opposite orientations and offset by an encapsulation system in order to avoid any short-circuit.
25 The use of a rigid structure according to the invention, with the use of sheets carrying H-shaped cutouts, facilitates the encapsulation and makes it possible to reduce the encapsulation thicknesses compared with the prior art. Encapsulation systems of the multilayer type
30 with thinner and more rigid layers than those of the prior art can be envisaged.

 Advantageously, after the step of stacking the anode and cathode sheets, the heat treatment thereof allowing assembly of the battery is implemented at a temperature of

between 50°C and 500°C, preferably at a temperature below 350°C, and/or the mechanical compression of the stack of anode and cathode sheets to be assembled is implemented at a pressure between 10 and 100 MPa, preferably between 20 and 50 MPa. In a particular embodiment, it is advantageous, after the step of stacking and heat treatment thereof, to encapsulate the stack by depositing an encapsulation system in order to provide protection of the cell of the battery with respect to the atmosphere. The encapsulation system must be chemically stable, withstand a high temperature and be impermeable to the atmosphere in order to fulfil its function of barrier layer. Advantageously, the stack of anode sheets and cathode sheets according to the invention can be covered with a sequence, preferably z sequences, of an encapsulation system comprising:

- a first covering layer, preferably selected from parylene, type F parylene, polyimide, epoxy resins, silicone, polyamide and/or a mixture thereof, deposited on the stack of anode and cathode sheets,
- a second covering layer composed of an electrically insulating material, deposited by depositing atomic layers on said first covering layer.

This sequence may be repeated z times with $z \geq 1$. This multilayer sequence has a barrier effect. The more the sequence of the encapsulation system is repeated, the greater will be this barrier effect. It will be all the greater, the greater the number of thin layers deposited.

Typically, the first covering layer is made from polymer, for example silicone (deposited for example by impregnation or by plasma enhanced chemical vapor deposition using hexamethyldisiloxane (HMDSO)) or from epoxy resin, or from polyimide, from polyamide, or from polyparaxylylene (better known by the term parylene). This first covering layer makes it possible to protect the

sensitive elements of the battery from the environment thereof. The thickness of said first covering layer is preferably between 0.5 μm and 3 μm .

Advantageously, the first covering layer may be made
5 from type C parylene, type D parylene, type N parylene (CAS 1633-22-3), type F parylene or a mixture of type C, D, N and/or F parylene. Parylene (also referred to as polyparaxylylene or poly(p-xylylene)) is a dielectric, transparent and semicrystalline material that has high
10 thermodynamic stability, excellent resistance to solvents and very low permeability. Parylene also has barrier properties making it possible to protect the battery from the external environment thereof. The protection of the battery is increased when this first covering layer is
15 produced from type F parylene. This first covering layer is advantageously obtained by condensing gaseous monomers deposited by chemical vapor deposition (CVD) on the surfaces, which makes it possible to have a conformal, thin and uniform covering of all the accessible surfaces
20 of the stack. This first covering layer is advantageously rigid; it cannot be considered to be a flexible surface.

The second covering layer is composed of an electrically insulating material, preferably inorganic. This second covering layer advantageously has a very low
25 WVTR coefficient, preferably less than 10^{-5} g/m².d. It is preferably deposited by depositing atomic layers (ALD), so as to obtain a conformal covering of all the accessible surfaces of the stack previously covered with the first covering layer. The layers deposited by ALD are very
30 fragile mechanically and require a rigid support surface for fulfilling their protective role. Depositing a fragile layer on a flexible surface would lead to the formation of cracks, causing a loss of integrity of this protective layer. Moreover, the growth of the layer deposited by ALD

is influenced by the nature of the substrate. A layer deposited by ALD on a substrate having areas of different chemical natures will have a non-homogeneous growth, which may cause a loss of integrity of this protective layer.

5 Techniques of deposition by ALD are particularly well adapted for covering surfaces having high roughness in a completely impervious and conforming manner. They make it possible to produce conformal layers, free from defects, such as holes (layers referred to as "pinhole free") and
10 represent very good barriers. The WVTR coefficient thereof is extremely low. The WVTR (water vapor transmission rate) coefficient makes it possible to evaluate the permeability to water vapor of the encapsulation system. The lower the WVTR coefficient, the more impervious is the encapsulation
15 system.

 The second covering layer can advantageously be deposited by plasma-enhanced chemical vapor deposition (PECVD) or by chemical vapor deposition of the HDPCVD (high density plasma chemical vapor deposition) type or of the
20 ICPCVD (inductively coupled plasma chemical vapor deposition) type.

 This second covering layer preferably has a thickness of between 10 nm and 10 μ m, preferentially a thickness of between 10 nm and 50 nm. The thickness of this second layer
25 is advantageously selected according to the level of impermeability to gases required, i.e. the WVTR coefficient required, and depends on the deposition technique used, in particular from ALD, PECVD, HDPCVD and ICPCVD.

30 The second covering layer may be made from a ceramic material, vitreous material or vitroceramic material, for example in the form of oxide, of the Al_2O_3 , Ta_2O_5 , silica, nitride, in particular silicon nitride, phosphates, oxynitride or siloxane type.

This second covering layer deposited by ALD, PECVD, HDPCVD or ICPCVD on the first covering layer makes it possible firstly to ensure the impermeability of the structure, i.e. to prevent migration of water inside the object, and secondly to protect the first covering layer, preferably of type F parylene, from the atmosphere, in particular from air and moisture, and from heat exposure in order to avoid degradation thereof. This second covering layer improves the service life of the encapsulated battery.

Alternatively, the encapsulation system, making it possible to provide protection of the battery cell, or of the stack of anode sheets and cathode sheets according to the invention, with respect to the atmosphere, may consist of a sequence, preferably of z' sequences, comprising a first alternative covering layer having a very low WVTR coefficient, preferably less than 10^{-5} g/m².d. This sequence may be repeated z' times with $z \geq 1$. It exhibits a barrier effect, which is all the greater, the higher the value of z' . The encapsulation of the stack of anode and cathode sheets in this sequence of the encapsulation system, preferably in z' sequences, makes it possible to reduce to the maximum extent the WVTR coefficient of the encapsulation, i.e. to increase the impermeability of the stack.

The thickness of said first alternative covering layer is preferably between 0.5 μ m and 50 μ m.

This alternative covering layer may be composed of a ceramic material and/or of a glass with a low melting point, preferably a glass the melting point of which is below 600°C, deposited at the external periphery of the stack of anode and cathode sheets. The ceramic and/or glass material used in this layer is advantageously selected from:

- a glass with a low melting point (typically < 600°C), preferably $\text{SiO}_2\text{-B}_2\text{O}_3$; $\text{Bi}_2\text{O}_3\text{-B}_2\text{O}_3$, $\text{ZnO-Bi}_2\text{O}_3\text{-B}_2\text{O}_3$, $\text{TeO}_2\text{-V}_2\text{O}_3$, PbO-SiO_2 ,
- oxides, nitrides, oxynitrides, Si_xN_y , SiO_2 , SiON ,
5 amorphous silicon or SiC .

These glasses can be deposited by moulding or by dip coating.

The ceramic materials are advantageously deposited by PECVD or preferentially by HDPCVD or by ICPCVD at low
10 temperature; these methods make it possible to deposit a layer having good impermeability properties.

Advantageously, the alternative encapsulation system may comprise z' alternative covering layers of different natures in order to reduce the WVTR coefficient of the
15 encapsulation, i.e. to increase the impermeability of the stack. By way of example, the encapsulation system may comprise a first layer composed of a ceramic material, a second layer composed of a glass with a low melting point disposed on the first layer, and vice versa.

20 The encapsulation in a glass film may be obtained by depositing an ink comprising oxides, phosphates, borates and/or precursors of a low melting point glass, followed by sintering.

In this way a rigid impermeable encapsulation is
25 obtained, which prevents in particular the passage of water vapor at the interface between the encapsulation system and the terminations.

The permeance to water vapor may be measured by means of a method that is the subject of US 7,624,621 and which
30 is also described in the publication "*Structural properties of ultraviolet cured polysilazane gas barrier layers on polymer substrates*" by A. Mortier et al, which appeared in the journal Thin Solid Films 6+550 (2014) 85-89.

The stack of anode and cathode sheets thus encapsulated in this sequence of the encapsulation system, preferably in z sequences, or in the alternative encapsulation system, can then be covered with a last
5 covering layer so as to mechanically protect the stack thus encapsulated and optionally to confer an aesthetic appearance thereon. This last covering layer protects and improves the service life of the battery. Advantageously, this last covering layer is also selected to withstand a
10 high temperature, and has sufficient mechanical strength to protect the battery during subsequent use thereof. Advantageously, the thickness of this last covering layer is between 1 μm and 50 μm . Ideally, the thickness of this last covering layer is approximately 10-15 μm , such a
15 thickness range makes it possible to protect the battery against mechanical damage.

This last covering layer is preferably based on epoxy resin, polyethylene naphthalate (PEN), polyimide, polyamide, polyurethane, silicone, sol-gel silica or
20 organic silica. Advantageously, this last covering layer is deposited by dipping.

The stack of anode and cathode layers thus coated is next cut by any suitable means along the cutting lines **D'**_n and **D**_n so as to bare the anode and cathode connections and
25 to obtain unitary batteries.

In the case of batteries impregnated with a liquid electrolyte, the impregnation of the battery by a liquid electrolyte is advantageously implemented, after the unitary batteries the anode and cathode connections of
30 which are bared are obtained, by a phase carrying lithium ions such as liquid electrolytes or an ionic liquid containing lithium salts; this phase carrying lithium ions penetrates the battery by capillarity.

Terminations (electrical contacts) are added at the point where the cathode and respectively anode connections are visible (not coated with insulating electrolyte). These contact areas are preferably disposed on opposite
5 sides of the stack of the battery in order to collect the current (lateral current collectors) or on adjacent sides. The connections are metalized by means of techniques known to a person skilled in the art, preferably by immersing in a conductive epoxy resin and/or a molten tin bath.
10 Preferably, the terminations are formed, in the vicinity of the cathode and anode connections, by a first stack of layers successively comprising a first layer of a material filled with graphite, preferably epoxy resin filled with graphite, and a second layer comprising a metallic copper
15 obtained from an ink filled with copper nanoparticles deposited on the first layer. This first stack of terminations is next sintered by infrared flash lamp so as to obtain a covering of the cathode and anode connections by a layer of metallic copper.

20 According to the final use of the battery, the terminations may additionally comprise a second stack of layers disposed on the first stack of terminations successively comprising a first layer of a tin-zinc alloy deposited, preferably by dipping in a molten tin-zinc bath,
25 so as to ensure impermeability of the battery at less cost, and a second layer based on pure tin deposited by electrodeposition or a second layer comprising an alloy based on silver, palladium and copper deposited on this first layer of the second stack.

30 The terminations make it possible to take up the alternately positive and negative electrical connections on each of the ends. These terminations make it possible to implement the electrical connections in parallel between the various battery elements. For this purpose,

only the cathode connections emerge on one end, and the anode connections are available on another end.

The battery according to the invention may be a lithium-ion microbattery, a lithium-ion minibattery, or a high-power lithium-ion battery. In particular, it may be designed and sized so as to have a capacity of less than or equal to approximately 1 mAh (normally referred to as a "microbattery"), so as to have a power greater than approximately 1 mAh up to approximately 1 Ah (normally referred to as a "minibattery"), or so as to have a capacity greater than approximately 1 Ah (normally referred to as a "power battery"). Typically, microbatteries are designed so as to be compatible with microelectronic manufacturing methods.

The batteries in each of these three power ranges may be produced:

- either with layers of the "completely solid" type, i.e. devoid of impregnated liquid or viscous phases (said liquid or viscous phases being able to be a medium conducting lithium ions, capable of acting as an electrolyte),

- or with layers of the mesoporous "completely solid" type, impregnated with a liquid or viscous phase, typically a medium conducting lithium ions, which spontaneously enter inside the layer and which no longer merge from this layer, so that this layer can be considered to be quasi-solid,

- or with impregnated porous layers (i.e. layers having a lattice of open pores that can be impregnated with a liquid or viscous phase, and which confers moist properties on these layers).

CLAIMS

1. A battery (100) comprising at least one anode (3) and at least one cathode (1), arranged on top of one another in an alternating manner, said battery (100) comprising lateral edges (101, 102) comprising an anode connection area and a cathode connection area, laterally opposite the
5 anode connection area, and longitudinal edges (103, 104), in which the anode (3) comprises
- a current collector substrate,
 - at least one anode layer, and
 - 10 - optionally a layer of an electrolyte material or of a separator impregnated with an electrolyte,
- and the cathode (1) comprises:
- a current collector substrate,
 - at least one cathode layer, and
 - 15 - optionally a layer of an electrolyte material or of a separator impregnated with an electrolyte,
- so that the battery comprises successively at least one anode layer, at least one layer of an electrolyte material or of a separator impregnated with an electrolyte, and at
20 least one cathode layer,
- characterized in that each anode and each cathode comprises a respective main body (111, 131), separated from a respective secondary body (112, 132) by a space (113, 133) free from any electrode material and current-collector
25 substrate, said free space connecting the opposite longitudinal edges (103, 104) of the battery.
2. The battery according to claim 1, characterized in that said free space is free of any material.

30

3. The battery according to claim 1 or claim 2, characterized in that said free space is empty.

4. The battery according to any one of claims 1 to 3,
5 characterized in that, in plan view, the free spaces of the cathodes are superimposed.

5. The battery according to any one of claims 1 to 4,
10 characterized in that, in plan view, the free spaces of the anodes are superimposed.

6. The battery according to any one of claims 1 to 5,
characterized in that, in plan view, the free spaces of the cathodes and of the anodes are not coincident.

15
7. The battery according to any one of claims 1 to 6, characterized in that free faces of the secondary bodies respectively of the cathodes (112') and of the anodes (132'), which are opposite to the free space, fit flush
20 with the free faces of the main body respectively of the anodes (131') and of the cathodes (111').

8. The battery according to any one of claims 1 to 7, characterized in that it comprises an encapsulation system
25 totally covering four of the six faces of said battery, the remaining two faces comprising an anode connection area and a cathode connection area.

9. The battery according to claim 8, characterized in that
30 the encapsulation system comprises:

- at least one first covering layer, preferably selected from parylene, type-F parylene, polyimide, epoxy resins,

silicone, polyamide, sol-gel silica, organic silica and/or a mixture thereof, deposited on the battery,

- at least one second covering layer composed of an electrically insulating material, deposited by deposition of atomic layers on said at least one first covering layer, on the understanding that this sequence of at least one first covering layer and of at least one second covering layer may be repeated z times with $z \geq 1$.

10 10. The battery according to any one of claims 1 to 9, characterized in that the anode connection area and the cathode connection area are covered by a termination system.

11. The battery according to claim 10, characterized in that the termination system comprises successively:

15 - a first layer of a material filled with graphite, preferably based on an epoxy resin filled with graphite,
- a second dense layer of metallic copper arranged on the first layer of the termination system, and
20 - optionally, a third layer based on a tin-zinc alloy of tin, arranged on the second layer,
- optionally a fourth layer based on tin or based on an alloy of silver, palladium and copper, arranged on the third layer of the termination system.

25

12. The battery according to any one of claims 1 to 11, characterized in that the width of the free space (L_{113}) is between 0.01 mm and 0.5 mm.

30 13. The battery according to any one of claims 1 to 12, characterized in that the width of the secondary bodies (L_{112}) is between 0.05 mm and 2 mm.

14. A method for manufacturing a battery, said battery comprising at least one anode (3) and at least one cathode (1), disposed one above the other in an alternating manner,
5 said battery (100) comprising longitudinal edges (103, 104) and lateral edges (101, 102), in which the anode (3) comprises:

- a current collector substrate,
- at least one anode layer, and

10 - optionally a layer of an electrolyte material or of a separator impregnated with an electrolyte,
and the cathode comprises:

- a current collector substrate,
- at least one cathode layer, and

15 - optionally a layer of an electrolyte material or of a separator impregnated with an electrolyte,
so that the battery comprises successively at least one anode layer, at least one layer of an electrolyte material or of a separator impregnated with an electrolyte, and at
20 least one cathode layer,

each anode (3) comprising an anode connection area, located in the vicinity of the first lateral edge of the battery, whereas each cathode (1) comprises a cathode connection area, situated on a second lateral edge of the battery,
25 opposite to said first edge,

said manufacturing method comprising:

a) the provision of a stack (1) of alternating sheets, this stack comprising first sheets or anode sheets, each of which is intended to form an anode layer of a plurality
30 of batteries, as well as second sheets or cathode sheets, each of which is intended to form a cathode layer of a plurality of batteries,

each anode sheet comprising at least one anode slot (34) and each cathode sheet comprising at least one cathode slot (14), said slot, respectively anode and cathode, comprising two longitudinal parts (16, 36) at least partly
5 superimposed, intended to delimit the longitudinal edges (103, 104) of the battery, as well as a lateral part (18, 38) connecting said two longitudinal parts, the lateral part of the anode slot (38) and the lateral part of the cathode slot (18) being mutually offset, it being
10 understood that each lateral part of the slots delimits a space free from any electrode material and current-collector substrate, said free space separating, for each anode and each cathode, a main body from a secondary body,
b) the implementation of a heat treatment and/or of a
15 mechanical compression of the stack of alternating sheets previously provided,
c) the production of two cutouts (D_n , D'_n) extending at least partially inside said slots, the first cutout extending between the lateral part of the anode slot and
20 the facing end of the longitudinal parts, whereas the second cutout extends between the lateral part of the cathode slot and the facing end of the longitudinal parts.

15. The method according to claim 14, characterized in
25 that, after the step c), the cut-out stack is encapsulated, by depositing:

- at least one first covering layer, preferably selected from parylene, type-F parylene, polyimide, epoxy resins, silicone, polyamide, sol-gel silica, organic silica and/or
30 a mixture thereof, on the battery,

- at least one second covering layer composed of an electrically insulating material, deposited by deposition of atomic layers on said at least one first covering layer, on the understanding that the sequence of at least one
5 first covering layer and of at least one second covering layer may be repeated z times with $z \geq 1$.

16. The method according to claim 15, characterized in that, after the step d) of encapsulating the cut-out stack,
10 the cut-out and encapsulated stack is impregnated, by a phase carrying lithium ions such as liquid electrolytes or an ionic liquid containing lithium salts.

17. The method according to claim 15 or claim 16,
15 characterized in that the terminations of the battery are produced by successively depositing:

- a first layer of a material filled with graphite, preferably based on an epoxy resin filled with graphite,
- a second dense layer of metallic copper arranged on the
20 first layer of the termination system, and
- optionally, a third layer based on a tin-zinc alloy of tin, arranged on the second layer of the termination system,
- optionally a fourth layer based on tin or based on an alloy of silver, palladium and copper, arranged on the
25 third layer of the termination system.

18. The method according to any one of claims 14 to 17, characterized in that the two cutouts (D_n , D'_n) are produced through at least a majority of the anodes and
30 cathodes, in particular through all the anodes and cathodes.

19. The method according to claim 18, characterized in that the distances between each cutout and the facing ends of the longitudinal parts are identical.

5 20. The method according to claim 19, characterized in that its distances are between 0.05 mm and 2 mm.

21. The method according to any one of claims 14 to 20, characterized in that each slot has a roughly H shape, the
10 longitudinal parts forming the vertical main recesses of the H, whereas the lateral part forms the channel of the H.

22. The method according to claim 21, characterized in
15 that the width of the lateral part is between 0.05 mm and 2 mm.

23. The method according to any one of claims 14 to 22, characterized in that each sheet belonging to said stack
20 comprises a plurality of slot lines disposed alongside each other, and in that the two cutouts are made through all the slots on the same line.

24. The method according to any one of claims 14 to 22,
25 characterized in that each sheet comprises a plurality of rows of slots disposed one below the other.

25. The method according to claim 24, characterized in that the distance separating adjacent cutouts, formed in
30 adjacent lines, is between 0.05 mm and 5 mm.

26. The method according to one of claims 24 or 25, characterized in that the number of lines is between 10 and 500 while the number of rows is between 10 and 500.

- 5 27. The method according to any one of claims 14 to 26, characterized in that each cutout is made by a sawing method, by a swaging cutting method, by guillotine, or by laser.