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SOLID STATE ELECTROLYTE BATTERY CELL IN ELONGATED CONTAINER

Abstract

A battery includes an elongated container including at least one elongated wall extending in a longitudinal direction between a first end wall and a second end wall; and a plurality of battery units stacked inside of the container along a stacking direction that intersects the at least one elongated wall. Each battery unit includes an anode, a cathode and a solid electrolyte between the anode and the cathode. Each battery unit has a length in the longitudinal direction, a thickness in the stacking direction and a width in a lateral direction. The longitudinal direction and the lateral direction are perpendicular to the stacking direction.

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Background/Summary

TECHNICAL FIELD

[0001] The present disclosure relates generally battery cells in container design, and more specifically to solid state electrolyte battery cells in container design.

BACKGROUND

[0002] Currently, the state of the art in battery cell packaging are cylindrical battery cell, pouch battery cell and prismatic battery cell. Since solid state electrolyte battery cells are stiff and brittle it is difficult to fit in the cylindrical shape. Therefore, these solids state electrolyte battery cells are available in pouch cell shape.

SUMMARY

[0003] A battery includes an elongated container including at least one elongated wall extending in a longitudinal direction between a first end wall and a second end wall; and a plurality of battery units stacked inside of the container along a stacking direction that intersects the at least one elongated wall. Each battery unit includes an anode, a cathode and a solid electrolyte between the anode and the cathode. Each battery unit has a length in the longitudinal direction, a thickness in the stacking direction and a width in a lateral direction. The longitudinal direction and the lateral direction are perpendicular to the stacking direction.

[0004] In examples, at least two of the battery units having different widths than each other.

[0005] In examples, in the stacking direction, the battery units include a first end battery unit, a second end battery unit and a plurality of interior battery units between the first end battery unit and the second end battery unit, the first end battery unit and the second end battery unit each having lesser widths than each of the interior battery units.

[0006] In examples, the interior battery units includes a middle battery unit midway between the first end battery unit and the second end battery unit, the interior battery units further including first intermediate battery units between the middle battery unit and the first end battery unit, the first intermediate battery units progressively increasing in width in the stacking direction toward the middle battery unit, the interior battery units further including second intermediate battery units between the middle battery unit and the second end battery unit, the second intermediate battery units progressively increasing in width in the stacking direction toward the middle battery unit.

[0007] In examples, the first end battery unit, the second end battery unit, the first intermediate battery units and the second intermediate battery units each have approximately a same thickness and length.

[0008] In examples, the at least one elongated wall is a single wall having a cylindrical shape as viewed in the longitudinal direction.

[0009] In examples, the at least one elongated wall is six walls having a hexagonal shape as viewed in the longitudinal direction.

[0010] In examples, the hexagonal shape forms a regular hexagon.

[0011] In examples, the hexagonal shape forms an irregular regular hexagon, the stacking direction intersecting two of the six walls, the two intersected walls each having a greater width than each of the other four walls.

[0012] In examples, the solid electrolytes are formed of a non-flammable ceramic or polymer material.

[0013] In examples, the each of the anodes, the cathodes and the solid electrolyte is shaped as a sheet, each battery unit is formed of the anode, cathode and the solid electrolyte laminated together.

[0014] A battery assembly is also provided including a plurality of the batteries arranged into a pattern of repeating rows and columns as viewed longitudinally, and the pattern is a hexagonal packing of circles or hexagons.

[0015] A method of constructing a battery is also provided, including forming a plurality of battery units, each battery unit being formed by laminating an anode, a cathode and a solid electrolyte together, each battery unit having a thickness, a length and a width; and stacking the battery units in

a stacking direction in an elongated container including at least one elongated wall extending in a longitudinal direction between a first end wall and a second end wall, the stacking direction being perpendicular to the longitudinal direction.

[0016] In examples, at least two of the battery units having different widths than each other.

[0017] In examples, each of the anodes, the cathodes and the solid electrolyte has a first lateral edge, a second lateral edge, a first longitudinal edge, a second longitudinal edge and two planar surfaces each extending from the first lateral edge to the second lateral edge and from the first longitudinal edge to the second longitudinal edge, the stacking including positioning the battery units within the container such that the first lateral edge, the second lateral edge and/or one of the two planar surfaces of the cathode and/or anode of each battery unit contacts the at least one elongated wall.

[0018] In examples, the at least one elongated wall is a single wall having a cylindrical shape as viewed in the longitudinal direction, the stacking including positioning the battery units within the container such that the first lateral edge, the second lateral edge and/or one of the two planar surfaces of the cathode and/or anode of each battery unit contacts the single wall.

[0019] In examples, the battery units include a first end battery unit, a second end battery unit and a plurality of interior battery units between the first end battery unit and the second end battery unit, the first end battery unit and the second end battery unit each having a lesser width than each of the interior battery units, the interior battery units includes a middle battery unit midway between the first end battery unit and the second end battery unit, the interior battery units further including first intermediate battery units between the middle battery unit and the first end battery unit, the first intermediate battery units progressively increasing in width in the stacking direction toward the middle battery unit, the interior battery units further including second intermediate battery units between the middle battery unit and the second end battery unit, the second intermediate battery units progressively increasing in width in the stacking direction toward the middle battery unit, the first end battery unit, the second end battery unit, the middle battery unit, the first intermediate battery units, and the second intermediate battery units each being positioned within the container such that the first lateral edge, the second lateral edge and/or one of the two planar surfaces of the cathode and/or anode of each of the first end battery unit, the second end battery unit, the middle battery unit, the first intermediate battery units, and the second intermediate battery units contacts the single wall.

[0020] In examples, the at least one elongated wall is six walls having a hexagonal shape as viewed in the longitudinal direction, the stacking including positioning the battery units within the container such that the first lateral edge, the second lateral edge and/or one of the two planar surfaces of the cathode and/or anode of each battery unit contacts at least one of the six walls.

[0021] In examples, the battery units include a first end battery unit, a second end battery unit and a plurality of interior battery units between the first end battery unit and the second end battery unit, the first end battery unit and the second end battery unit each having a lesser width than each of the interior battery units, the first end battery unit being positioned within the container such that one of the planar surfaces of the anode or cathode of the first end battery unit contacting a first wall of the container, the first end battery unit being positioned within the container such that one of the planar surfaces of the anode or cathode of the second end battery unit contacting a second wall of the container that is opposite of the first wall, the stacking direction intersecting the first wall and the second wall, the interior battery units each being positioned within the container such that the first lateral edge, the second lateral edge and/or one of the two planar surfaces of the cathode and/or anode of each interior battery unit contacts a third wall and/or a fourth wall of the container or contacts a fifth wall and/or a sixth wall of the container, the third wall and the fourth wall being directly connected to the first wall, the fifth wall and the sixth wall being directly connected to the second wall.

[0022] In examples, the interior battery units includes a middle battery unit midway between the

first end battery unit and the second end battery unit, the interior battery units further including first intermediate battery units between the middle battery unit and the first end battery unit, the first intermediate battery units progressively increasing in width in the stacking direction toward the middle battery unit, the interior battery units further including second intermediate battery units between the middle battery unit and the second end battery unit, the second intermediate battery units progressively increasing in width in the stacking direction toward the middle battery unit, the first intermediate battery units each being positioned within the container such that the first lateral edge, the second lateral edge and/or one of the two planar surfaces of the cathode and/or anode of each first intermediate battery unit contacts the third wall and/or the fourth wall of the container, the second intermediate battery units each being positioned within the container such that the first lateral edge, the second lateral edge and/or one of the two planar surfaces of the cathode and/or anode of each second intermediate battery unit contacts the fifth wall and/or the sixth wall of the container.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The present disclosure is described below by reference to the following drawings, in which:

[0024] FIG. **1***a* shows a cross-sectional view of a battery assembly including a plurality of batteries having a circalunar cross-section arranged into a pattern of repeating rows and columns as viewed longitudinally;

[0025] FIG. **1***b* shows a perspective view of an exemplary battery of FIG. **1***a*, viewing the container longitudinally with a top wall omitted to illustrate the battery units;

[0026] FIG. **1***c* shows a schematic side view of the battery shown in FIG. **1***b*;

[0027] FIG. **1***d* schematically shows the general shape of each of the anodes, the cathodes and the solid electrolyte of the battery shown in FIG. **1***b*;

[0028] FIG. **1***e* shows the tabs of the anodes and cathodes;

[0029] FIG. **2***a* shows a cross-sectional view of a battery assembly including a plurality of batteries having a regular hexagonal cross-section arranged into a pattern of repeating rows and columns as viewed longitudinally;

[0030] FIG. **2***b* shows a cross-sectional longitudinally facing view of an exemplary battery of FIG. **2***a*;

[0031] FIG. **3***a* shows a cross-sectional view of a battery assembly including a plurality of batteries having an irregular hexagonal cross-section arranged into a pattern of repeating rows and columns as viewed longitudinally;

[0032] FIG. **3***b* shows a cross-sectional longitudinally facing view of an exemplary battery of FIG. **3***a*; and

[0033] FIG. **4** shows a longitudinally facing cross-sectional view of another exemplary battery.

DETAILED DESCRIPTION

[0034] FIG. **1***a* shows a cross-sectional view of a battery assembly including a plurality of batteries **10** arranged into a pattern of repeating rows and columns as viewed longitudinally. Batteries **10** have a circular cross-section when view longitudinally, and thus the pattern is a hexagonal packing of circles when view longitudinally.

[0035] FIGS. **1***b* to **1***e* shows various views of an exemplary battery **10** and/or components thereof in accordance with the present disclosure. Battery **10** includes an elongated container **12**. As shown by viewing FIGS. **1***b* and **1***c* together, the elongated container **12** includes at least one elongated wall **14** extending in a longitudinal direction between a first end wall **16** and a second end wall **18**. A plurality of battery units **20***a* to **20***c* are stacked inside of the container **12** along a stacking direction that intersects the at least one elongated wall **14**. As shown in FIG. **1***c*, each battery unit

20 includes an anode **22**, a cathode **24** and a solid electrolyte **26**. Each battery unit **20** has a length L in a longitudinal direction D**1**, a thickness T in a stacking directing D**2** and a width W in a lateral direction D**3**. The lateral direction D**3** is perpendicular to the stacking direction D**2**. At least two of the battery units **20** have different widths than each other.

[0036] The anodes **22** each include anode material on an anode current collector and the cathodes **24** each include cathode material on a cathode current collector. The solid electrolytes **26** are formed of a non-flammable ceramic or polymer material.

[0037] In the stacking direction D**2**, the battery units **20** include a first end battery unit **20***a*, a second end battery unit **20***b* and a plurality of interior battery units **20***c* between the first end battery unit **20***a* and the second end battery unit **20***b*. The first end battery unit **20***a* and the second end battery unit **20***b* each have lesser widths than each of the interior battery units **20***c*.

[0038] The interior battery units **20***c* include a middle battery unit **34** midway between the first end battery unit **20***a* and the second end battery unit **20***b*. The interior battery units **20***c* further include first intermediate battery units **36** between the middle battery unit **34** and the first end battery unit **20***a*. The first intermediate battery units **36** are progressively increasing in width in the stacking direction toward the middle battery unit **34**. The first intermediate battery units **36**, considered together, have an average width that is less than the width of the middle battery unit **34** and greater than the width of the first end battery unit **20***a*.

[0039] The interior battery units **20***c* further include second intermediate battery units **38** between the middle battery unit **34** and the second end battery unit **20***b*. The second intermediate battery units **38** are progressively increasing in width in the stacking direction toward the middle battery unit **34**. The second intermediate battery units **38**, considered together, have an average width that is less than the width of the middle battery unit **34** and greater than the width of the second end battery unit **20***b*.

[0040] The first end battery unit **20***a* and first intermediate battery units **36** together form a first battery section (bottom half of the battery as view longitudinally in FIG. **1***b*), and the second end battery unit **20***b* and second intermediate battery units **38** together form a second battery section (top half of the battery as view longitudinally in FIG. **1***b*). The first battery section and the second battery section are symmetrical in terms of the width of the end battery units **20***a*, **20***b* and the intermediate battery units **36**, **38** with respect to each other when considered with respect to the middle battery unit **34**.

[0041] The first end battery unit **20***a*, the second end battery unit **20***b* and the intermediate battery units **36**, **38** each have each have approximately (+/−5%) a same thickness and length.

[0042] In the examples shown in FIGS. **1***a* to **1***c*, at least one elongated wall **14** is a single wall **44** having a cylindrical shape **40**.

[0043] FIG. **1***d* schematically shows that each of the anodes **22**, the cathodes **24** and the solid electrolyte **26** are shaped as a sheet. Each of anodes **22**, cathodes **24** and solid electrolyte **26** has a first lateral edge **52** and a second lateral edge **54** that delimit the width W, a first longitudinal edge **56** and a second longitudinal edge **58** that delimit the length L, and two planar surfaces—a planar surface **60** and a planar surface facing away from surface **60**—that delimit the thickness T. Each of the planar surfaces extends from the first lateral edge **52** to the second lateral edge **54** and from the first longitudinal edge **56** to the second longitudinal edge **58**.

[0044] Referring to FIGS. **1***b* and **1***d* together, the first end battery unit **20***a*, the second end battery unit **20***b*, the middle battery unit **34**, the first intermediate battery units **36**, and the second intermediate battery units **38** are each being positioned within the container **12** such that the first lateral edge **52**, the second lateral edge **54** and/or one of the two planar surfaces **60** of the cathode **24** and/or anode **22** of each of the first end battery unit **20***a*, the second end battery unit **20***b*, the middle battery unit **34**, the first intermediate battery units **36**, and the second intermediate battery units **38** contacts the single wall **14**. In the example shown in FIG. **1***b*, as cathodes **24** face away from the center of the battery **10**, cathodes **24** contact wall **14** at both lateral edges **52**, **54** and/or

cathodes **24** contact wall **14** at planar surface **60** adjacent to both edges **52**, **54**.
[0045] FIG. **1***e* schematically shows that each of the anodes **22** includes one or more tabs **22***a* formed by the anode current collector and protruding past the second longitudinal edge **58** past the anode material. Similarly, each of the cathode **24** includes one or more tabs **24***a* formed by the anode current collector and protruding past the first longitudinal edge **56** past the cathode material. In the example shown in FIGS. **1***a* to **1***e*, the battery cell is a monopolar cell, and thus each of the anodes and cathodes includes one or more tabs. In other examples, a bipolar battery cell can be used, and only the anode of one end battery unit and the cathode of another end battery unit can include the one or more tabs.
[0046] FIG. **2***a* shows a cross-sectional view of a battery assembly including a plurality of batteries **210** arranged into a pattern of repeating rows and columns as viewed longitudinally. Batteries **210** have a regular hexagonal cross-section when view longitudinally, and thus the pattern is a hexagonal packing of regular hexagons when view longitudinally.
[0047] FIG. **2***b* shows a longitudinally facing cross-sectional view of an exemplary battery **210**. Battery **210** is constructed in the same manner as battery **10**, except with a hexagonal cross-section. Instead of elongated container **212** having a single elongated wall **14**, elongated container **212** includes six walls **214***a* to **214***f*. In substantially the same manner as with battery **10**, battery **210** includes a plurality of battery units **20***a* to **20***c* stacked inside of the container **212**, with each battery unit **20** including an anode **22**, a cathode **24** and a solid electrolyte **26**. As with in battery **10**, each battery unit **20** has a length L in a longitudinal direction D**1**, a thickness T in a stacking directing D**2** and a width W in a lateral direction D**3**, and the first end battery unit **20***a* and the second end battery unit **20***b* each have lesser widths than each of the interior battery units **20***c*. The only difference between battery **10** and battery **210** is the shape of the container **12**, **212** and the widths of the units **20***a* to **20***c*, which are accommodated to the shape of the container **212**.
[0048] Battery **210** includes a first wall **214***a*, a second wall **214***b*, a third wall **214***c*, a fourth wall **214***d* and fifth wall **214***e* and a sixth wall **214***f*. The walls **214***a* to **214***f* together have a regular hexagonal cross-sectional when viewed longitudinally. The stacking direction intersects the first wall **214***a* and the second wall **214***b*. The third wall **214***c* and the fourth wall **214***d* are directly connected to opposite edges of the first wall **214***a* and the fifth wall **214***e* and the sixth wall **214***f* are directly connected to opposite edges of the second wall **214***b*. Further, the third wall **214***c* and the fifth wall **214***e* are directly connected to each other and the fourth wall **214***d* and the sixth wall **214***f* are directly connected to each other.
[0049] As with battery **10**, the first end battery unit **20***a* and first intermediate battery units **36** of battery **210** together form a first battery section (bottom half of the battery as view longitudinally in FIG. **2***b*), and the second end battery unit **20***b* and second intermediate battery units **38** of battery **210** together form a second battery section (top half of the battery as view longitudinally in FIG. **1***b*). The first battery section and the second battery section are symmetrical with respect to each other in terms of the width of the end battery units **20***a*, **20***b* and the intermediate battery units **36**, **38** with respect to each other when considered with respect to the middle battery unit **34**.
[0050] The first end battery unit **20***a* is positioned within the container **212** such that the planar surface **60** of the cathode **24** of the first end battery unit **20***a* contacts the first wall **214***a* of the container **214**, and the second end battery unit **20***b* is positioned within the container **212** such that the planar surface **60** of the cathode **24** of the second end battery unit **20***b* contacts the second wall **214***b* of the container **214**.
[0051] The battery units **20***a* to **20***c* are positioned within the container **12** such that the first lateral edge **52**, the second lateral edge **54** and/or one of the two planar surfaces **60** of the cathode **24** and/or anode **22** of each battery unit **20** contacts at least one of the six walls **214***a* to **214***f*. In the example shown in FIG. **2***b*, as cathodes **24** face away from the center of the battery **10**, cathodes **24** in the first battery section (bottom half of the battery as view longitudinally in FIG. **2***b*) contact walls **214***c* and **214***d* and cathodes **24** in the second battery section (top half of the battery as

viewed longitudinally in FIG. **2***b*) contact walls **214***e* and **214***f*.
[0052] FIG. **3***a* shows a cross-sectional view of a battery assembly including a plurality of batteries **310** arranged into a pattern of repeating rows and columns as viewed longitudinally. Batteries **310** have an irregular hexagonal cross-section when view longitudinally, and thus the pattern is a hexagonal packing of regular hexagons when view longitudinally.
[0053] FIG. **3***b* shows a longitudinally facing cross-sectional view of an exemplary battery **310**, which is formed in the exact same manner as battery **210**, except the hexagonal cross-section of the container **312** is an irregular hexagon, instead of the regular hexagon in battery **210**, and the width of the units **20***a* to **20***c* are accordingly adapted to the irregular hexagon shape. Thus, while walls **214***a* to **214***f* of container **212** are all of the same width, walls **314***a* and **314***b* of container **312** are wider than walls **314***c* to **314***f*.
[0054] FIG. **4** shows a longitudinally facing cross-sectional view of another exemplary battery **410**. Battery **410** is constructed in the same manner as battery **210**, except the battery units **420***a* to **420***c*, which have the same layers as battery units **20***a* to **20***c*, each have the same width and only end battery unit **420***a*, **420***b* contact the elongated walls **214***a*, **214***c*, **214***d* and elongated walls **214***b*, **214***e*, **214***f*, respectively, of container **212**. In other words, none of the interior battery units **420***c* contact any of elongated walls **214***a* to **214***f*.
LIST OF REFERENCE NUMERALS
[0055] **10** battery [0056] **12** container [0057] **14** at least one elongated wall [0058] **16** first end wall [0059] **18** second end wall [0060] **20***a* first end battery unit [0061] **20***b* second end battery unit [0062] **20***c* interior battery units [0063] **22** anode [0064] **22***a* one or more tabs [0065] **24** cathodes [0066] **24***a* one or more tabs [0067] **26** solid electrolyte [0068] **34** middle battery unit [0069] **35** central double anode [0070] **36** first intermediate battery units [0071] **38** second intermediate battery units [0072] **40** cylindrical shape [0073] **44** single wall [0074] **52** first lateral edge [0075] **54** second lateral edge [0076] **56** first longitudinal edge [0077] **58** second longitudinal edge [0078] **60** planar surface [0079] **210** battery [0080] **212** container [0081] **214** container [0082] **214***a* first wall [0083] **214***b* second wall [0084] **214***c third wall* [0085] **214***d* fourth wall [0086] **214***e* fifth wall [0087] **214***f* sixth wall [0088] **310** plurality of batteries [0089] **312** container [0090] **314***a* first wall [0091] **314***b* second wall [0092] **314***c* third wall [0093] **314***d* fourth wall [0094] **314***e* fifth wall [0095] **314***f* sixth wall [0096] **410** battery [0097] **420***a* first end battery unit [0098] **420***b* second end battery unit [0099] **420***c* interior battery units

Claims

1. A battery comprising: an elongated container including at least one elongated wall extending in a longitudinal direction between a first end wall and a second end wall; a plurality of battery units stacked inside of the container along a stacking direction that intersects the at least one elongated wall, each battery unit including an anode, a cathode and a solid electrolyte between the anode and the cathode, each battery unit having a length in the longitudinal direction, having a thickness in the stacking direction and a width in a lateral direction, the longitudinal direction and the lateral direction being perpendicular to the stacking direction.
2. The battery as recited in claim 1, wherein at least two of the battery units having different widths than each other.
3. The battery as recited in claim 2, wherein, in the stacking direction, the battery units include a first end battery unit, a second end battery unit and a plurality of interior battery units between the first end battery unit and the second end battery unit, the first end battery unit and the second end battery unit each having lesser widths than each of the interior battery units.
4. The battery as recited in claim 3, wherein the interior battery units includes a middle battery unit midway between the first end battery unit and the second end battery unit, the interior battery units further including first intermediate battery units between the middle battery unit and the first end

battery unit, the first intermediate battery units progressively increasing in width in the stacking direction toward the middle battery unit, the interior battery units further including second intermediate battery units between the middle battery unit and the second end battery unit, the second intermediate battery units progressively increasing in width in the stacking direction toward the middle battery unit.

5. The battery as recited in claim 4, wherein the first end battery unit, the second end battery unit, the first intermediate battery units and the second intermediate battery units each have approximately a same thickness and length.

6. The battery as recited in claim 1, wherein the at least one elongated wall is a single wall having a cylindrical shape as viewed in the longitudinal direction.

7. The battery as recited in claim 1, wherein the at least one elongated wall is six walls having a hexagonal shape as viewed in the longitudinal direction.

8. The battery as recited in claim 7, wherein the hexagonal shape forms a regular hexagon.

9. The battery as recited in claim 7, wherein the hexagonal shape forms an irregular regular hexagon, the stacking direction intersecting two of the six walls, the two intersected walls each having a greater width than each of the other four walls.

10. The battery as recited in claim 1, wherein the solid electrolytes are formed of a non-flammable ceramic or polymer material.

11. The battery as recited in claim 1, wherein the each of the anodes, the cathodes and the solid electrolyte is shaped as a sheet, each battery unit is formed of the anode, cathode and the solid electrolyte laminated together.

12. A battery assembly comprising: a plurality of the batteries as recited in claim 1 arranged into a pattern of repeating rows and columns as viewed longitudinally, the pattern being a hexagonal packing of circles or hexagons.

13. A method of constructing a battery comprising: forming a plurality of battery units, each battery unit being formed by laminating an anode, a cathode and a solid electrolyte together, each battery unit having a thickness, a length and a width; and stacking the battery units in a stacking direction in an elongated container including at least one elongated wall extending in a longitudinal direction between a first end wall and a second end wall, the stacking direction being perpendicular to the longitudinal direction.

14. The method as recited in claim 13 wherein at least two of the battery units having different widths than each other.

15. The method as recited in claim 14 wherein each of the anodes, the cathodes and the solid electrolyte has a first lateral edge, a second lateral edge, a first longitudinal edge, a second longitudinal edge and two planar surfaces each extending from the first lateral edge to the second lateral edge and from the first longitudinal edge to the second longitudinal edge, the stacking including positioning the battery units within the container such that the first lateral edge, the second lateral edge and/or one of the two planar surfaces of the cathode and/or anode of each battery unit contacts the at least one elongated wall.

16. The method as recited in claim 15, wherein the at least one elongated wall is a single wall having a cylindrical shape as viewed in the longitudinal direction, the stacking including positioning the battery units within the container such that the first lateral edge, the second lateral edge and/or one of the two planar surfaces of the cathode and/or anode of each battery unit contacts the single wall.

17. The method as recited in claim 16, wherein the battery units include a first end battery unit, a second end battery unit and a plurality of interior battery units between the first end battery unit and the second end battery unit, the first end battery unit and the second end battery unit each having a lesser width than each of the interior battery units, the interior battery units includes a middle battery unit midway between the first end battery unit and the second end battery unit, the interior battery units further including first intermediate battery units between the middle battery

unit and the first end battery unit, the first intermediate battery units progressively increasing in width in the stacking direction toward the middle battery unit, the interior battery units further including second intermediate battery units between the middle battery unit and the second end battery unit, the second intermediate battery units progressively increasing in width in the stacking direction toward the middle battery unit, the first end battery unit, the second end battery unit, the middle battery unit, the first intermediate battery units, and the second intermediate battery units each being positioned within the container such that the first lateral edge, the second lateral edge and/or one of the two planar surfaces of the cathode and/or anode of each of the first end battery unit, the second end battery unit, the middle battery unit, the first intermediate battery units, and the second intermediate battery units contacts the single wall.

18. The method as recited in claim 15, wherein the at least one elongated wall is six walls having a hexagonal shape as viewed in the longitudinal direction, the stacking including positioning the battery units within the container such that the first lateral edge, the second lateral edge and/or one of the two planar surfaces of the cathode and/or anode of each battery unit contacts at least one of the six walls.

19. The method as recited in claim 18, wherein the battery units include a first end battery unit, a second end battery unit and a plurality of interior battery units between the first end battery unit and the second end battery unit, the first end battery unit and the second end battery unit each having a lesser width than each of the interior battery units, the first end battery unit being positioned within the container such that one of the planar surfaces of the anode or cathode of the first end battery unit contacting a first wall of the container, the first end battery unit being positioned within the container such that one of the planar surfaces of the anode or cathode of the second end battery unit contacting a second wall of the container that is opposite of the first wall, the stacking direction intersecting the first wall and the second wall, the interior battery units each being positioned within the container such that the first lateral edge, the second lateral edge and/or one of the two planar surfaces of the cathode and/or anode of each interior battery unit contacts a third wall and/or a fourth wall of the container or contacts a fifth wall and/or a sixth wall of the container, the third wall and the fourth wall being directly connected to the first wall, the fifth wall and the sixth wall being directly connected to the second wall.

20. The method as recited in claim 19, wherein the interior battery units includes a middle battery unit midway between the first end battery unit and the second end battery unit, the interior battery units further including first intermediate battery units between the middle battery unit and the first end battery unit, the first intermediate battery units progressively increasing in width in the stacking direction toward the middle battery unit, the interior battery units further including second intermediate battery units between the middle battery unit and the second end battery unit, the second intermediate battery units progressively increasing in width in the stacking direction toward the middle battery unit, the first intermediate battery units each being positioned within the container such that the first lateral edge, the second lateral edge and/or one of the two planar surfaces of the cathode and/or anode of each first intermediate battery unit contacts the third wall and/or the fourth wall of the container, the second intermediate battery units each being positioned within the container such that the first lateral edge, the second lateral edge and/or one of the two planar surfaces of the cathode and/or anode of each second intermediate battery unit contacts the fifth wall and/or the sixth wall of the container.