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JP 2006236605 A **JP 2005302501 A**
JP 2005122927 A **US 20120196170 A1**

(58) Field of Search:
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Other: **EPODOC, WPI, TXTE**

(54) Title of the Invention: **Battery**
Abstract Title: **Battery cell stack housing made of flexible pouch seals**

(57) A battery consists of a stack of pouch cells, each cell comprising a cell stack contained within a flexible housing, wherein the housing has a pair of opposing planar surfaces joined to form one or more seal regions (22a-d, fig 1). The seal regions are shaped to provide reinforcement flaps, 24a-d that engage a corresponding reinforcement flaps of an adjacent pouch cell in the stack. The reinforcement flaps may be bent in the same direction and be engaged using an adhesive or heat sealing. The engaged reinforcement flaps may form wall portions that hold the pouch cells together in a self-standing integral structure. The flexible housing may be formed of a laminate material such as a metal sheet (e.g. aluminium) and a polymeric layer on either side of the metal sheet. The battery may be a lithium sulphur battery and may include connection tabs that protrude from the flexible housing.

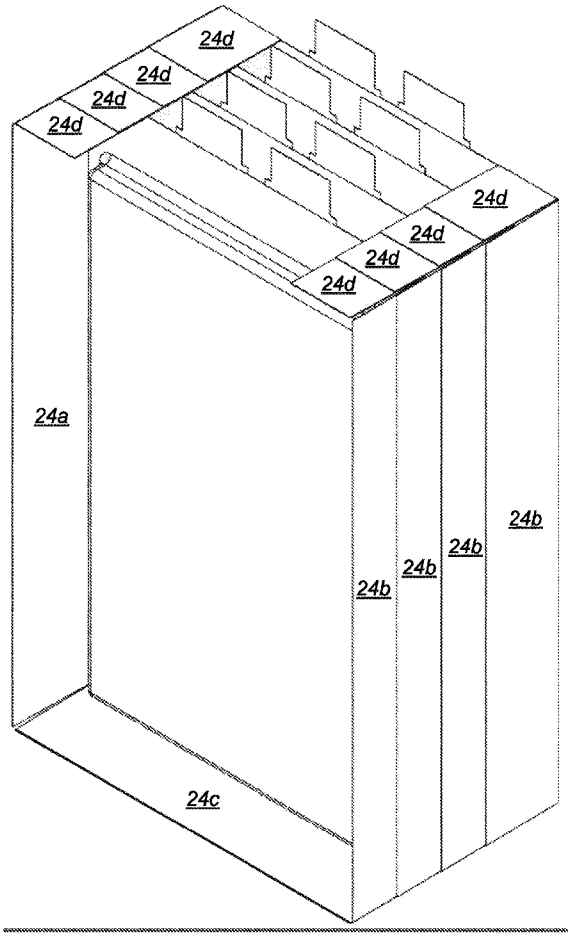

FIG. 2

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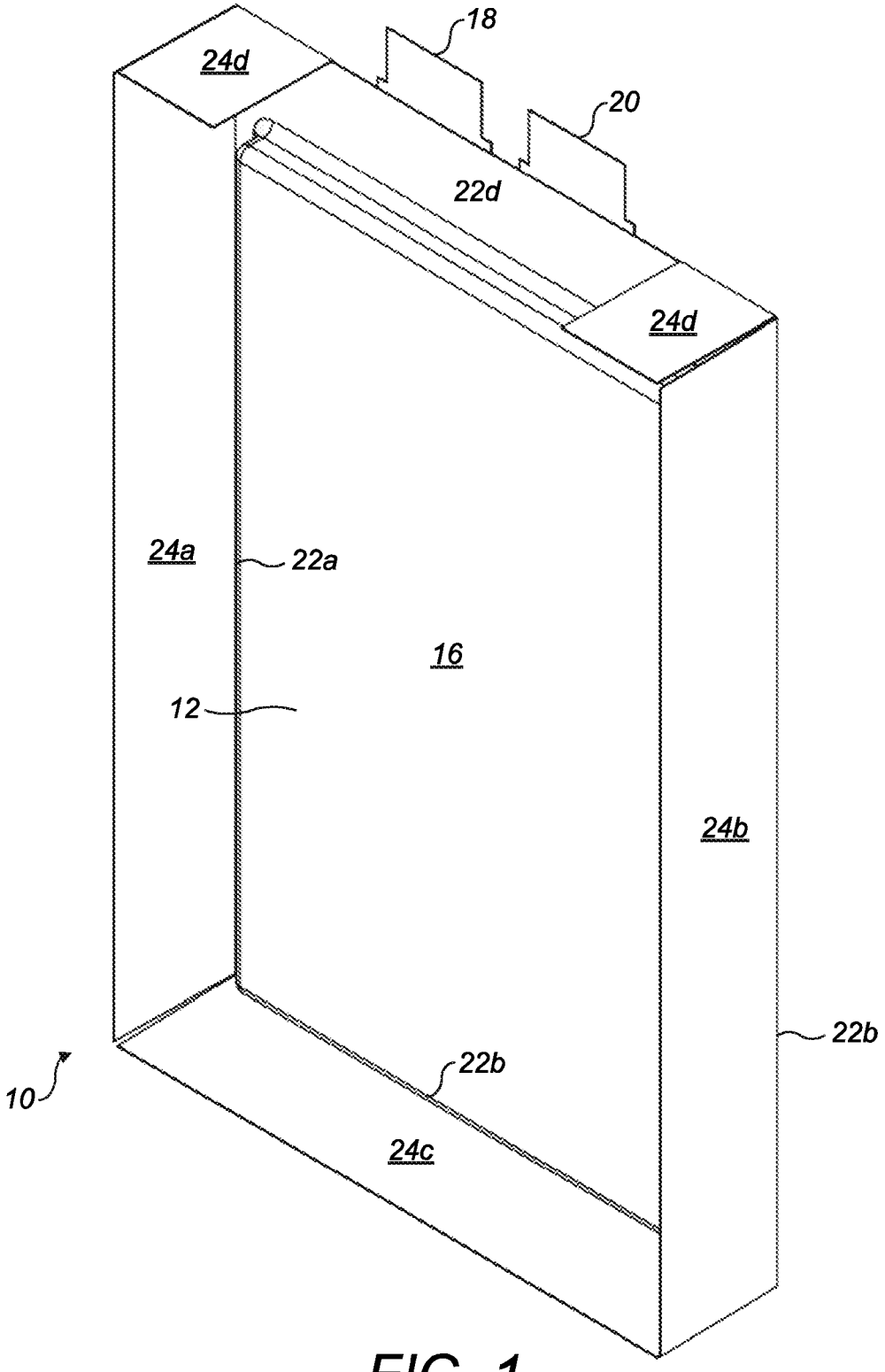

FIG. 1

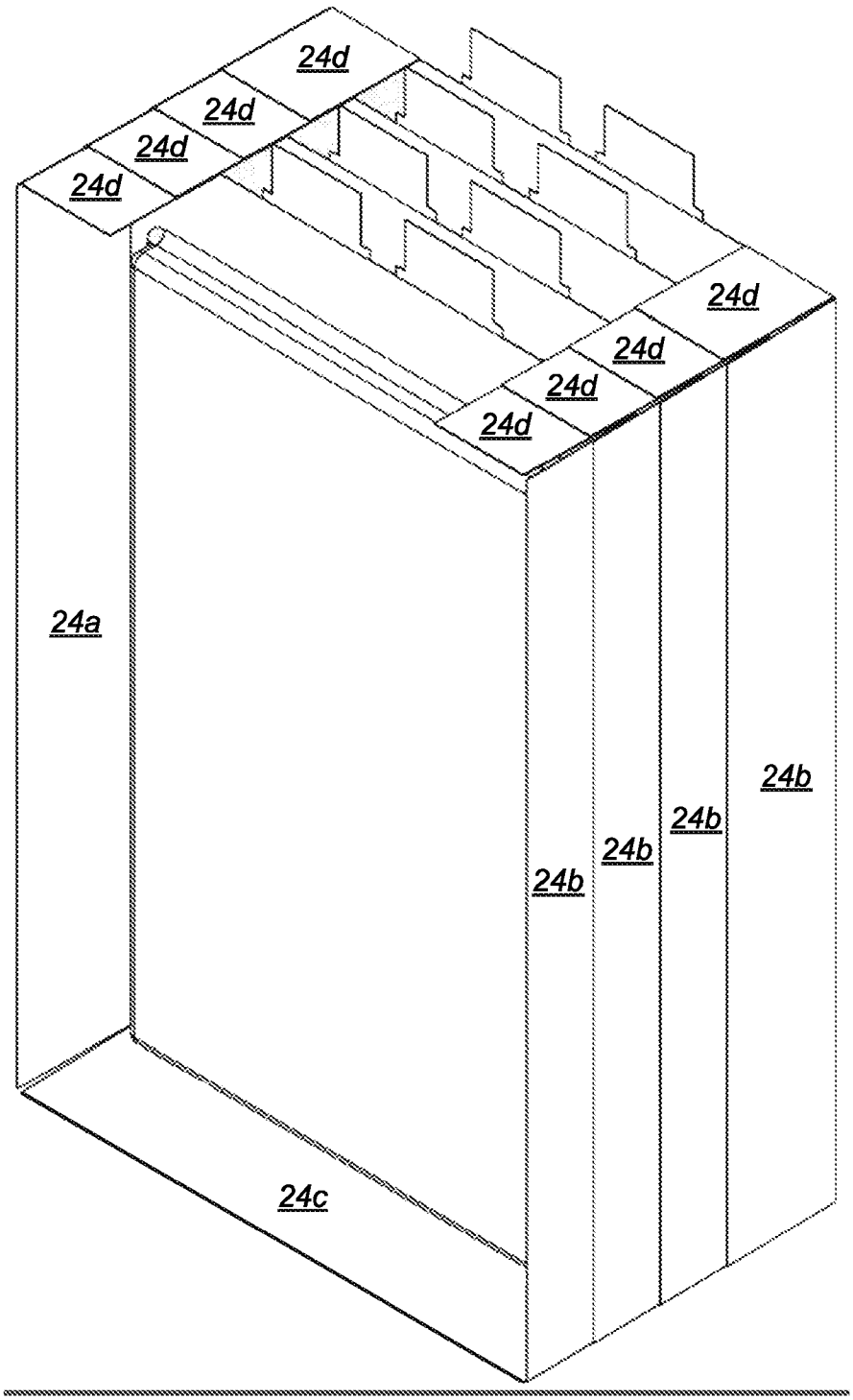

FIG. 2

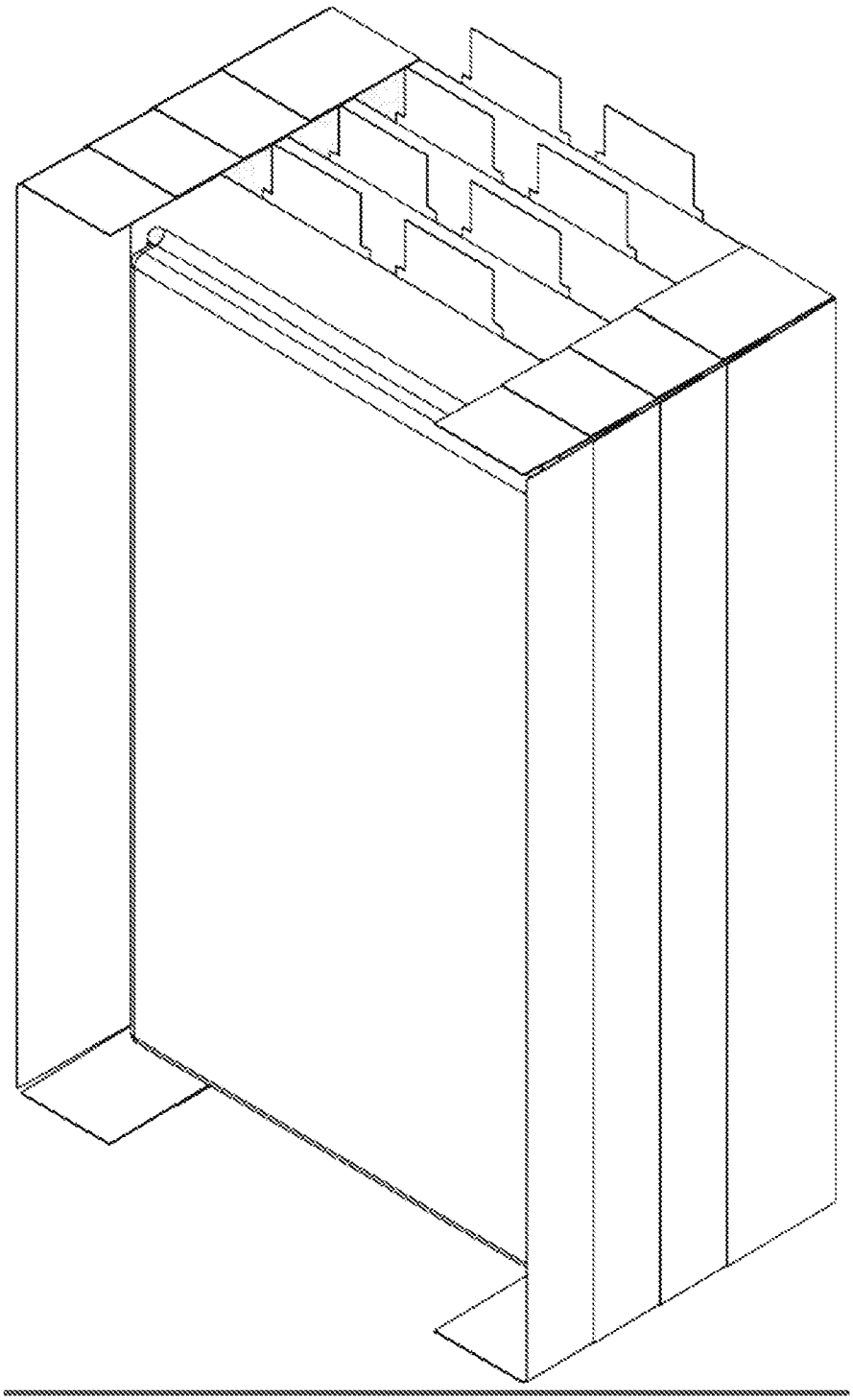

FIG. 3

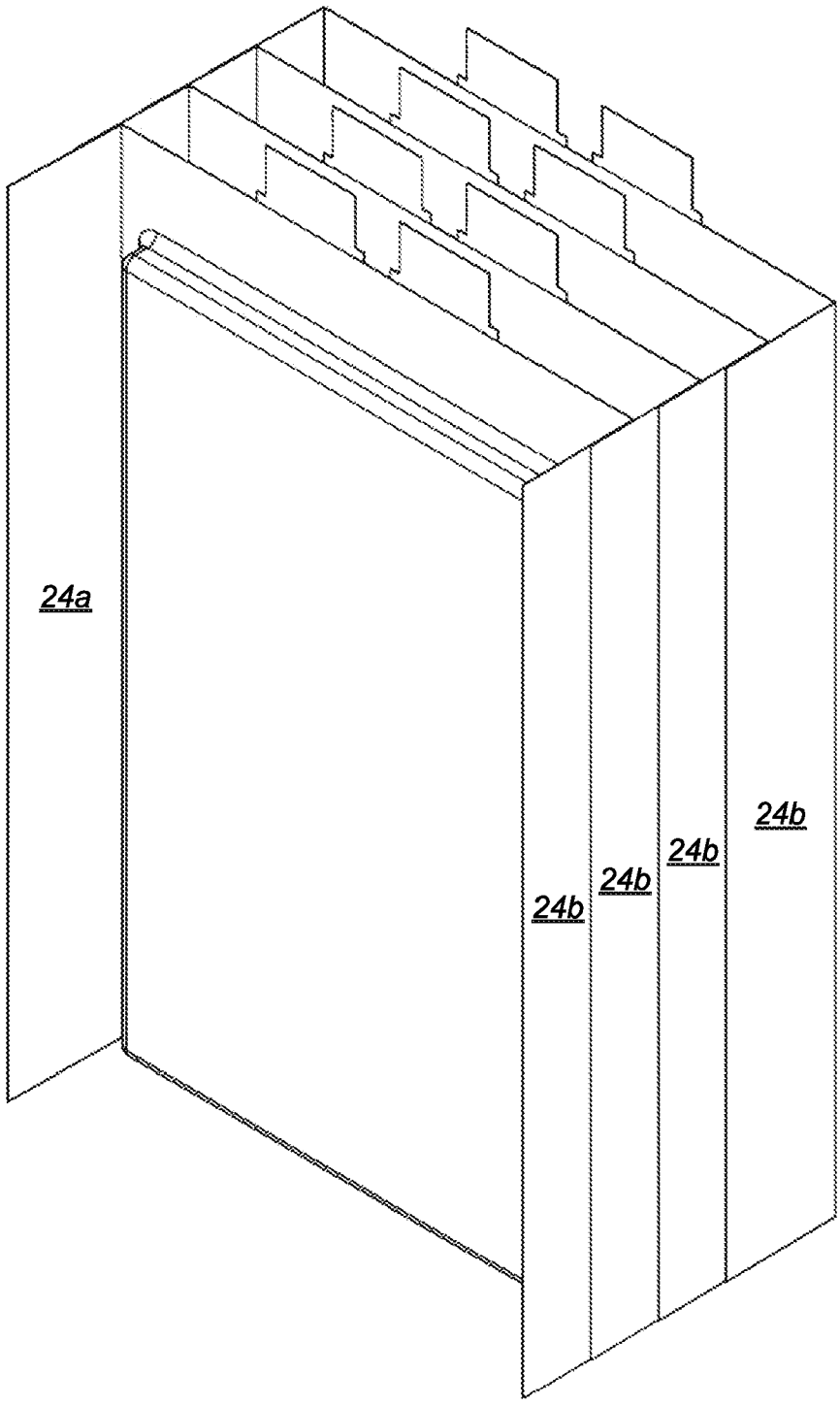

FIG. 4

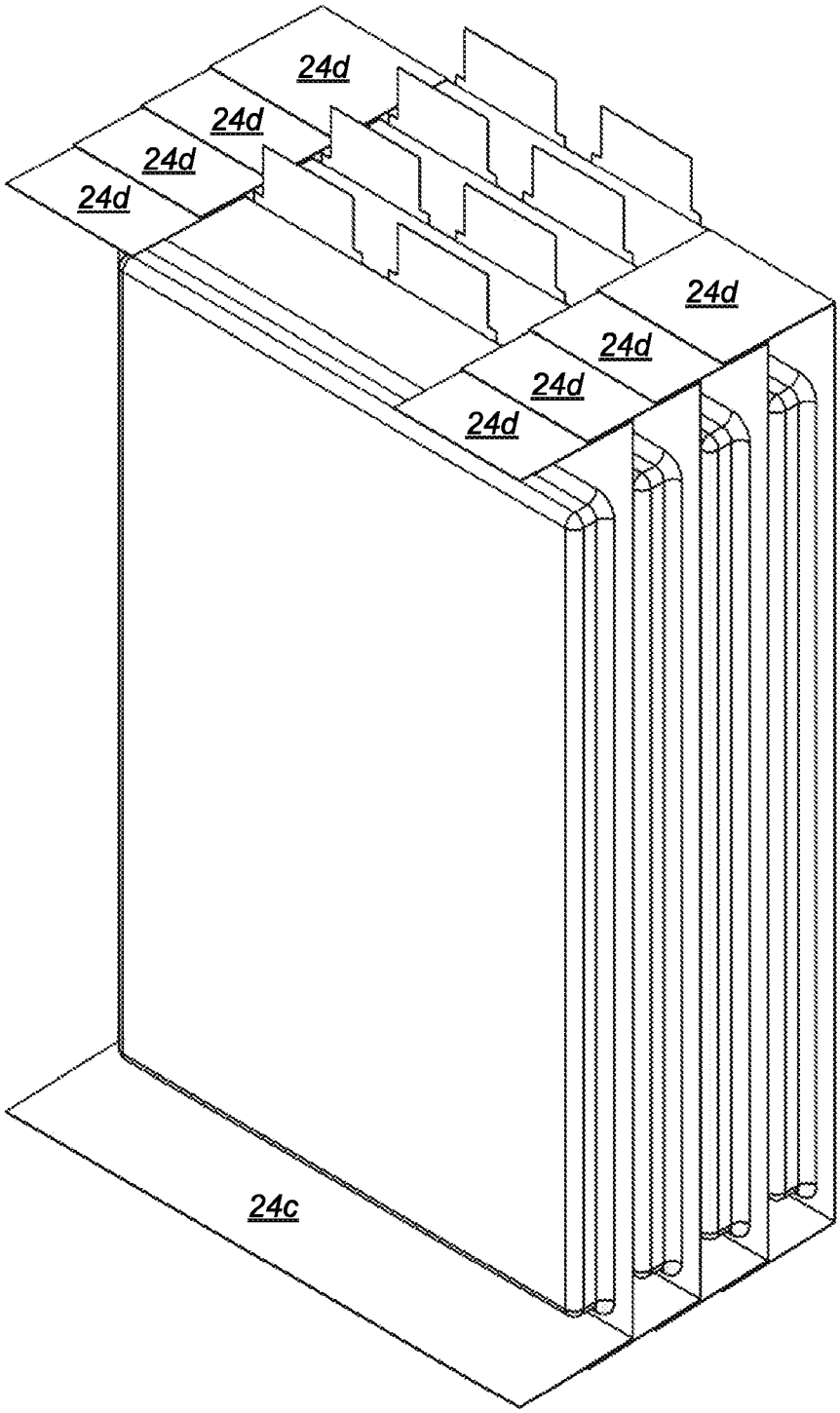

FIG. 5

Battery

BACKGROUND

[0001] This disclosure relates to a battery.

[0002] A typical electrochemical cell stack comprises a cell unit comprising an anode, a cathode and an electrolyte disposed between the anode and cathode. The cell stack may include a plurality of such cell units, so that the cell stack comprises a plurality of anodes, a plurality of cathodes and electrolyte disposed between each anode and cathode.

[0003] The cell stack may be contained within a flexible housing to form a pouch cell. The flexible housing may be formed of opposing planar surfaces of a flexible material. The flexible material may seal the cell stack from its surroundings. This may be important, for example, in the case of cells that comprise lithium anode(s) because lithium's sensitivity to air and moisture.

[0004] Contact tabs may be coupled to the anode(s) and cathode(s) of the cell stack. These contact tabs may protrude from the flexible housing to provide electrical connection with the anode(s) and cathode(s) in the cell stack.

[0005] A battery may comprise a plurality of pouch cells. The pouch cells may be arranged in a frame, which supports or retains the pouch cells in a desired position. For example, the pouch cells may be retained so that one planar surface of a pouch cell faces a planar surface of an adjacent pouch cell. The frame provides rigidity to the resulting battery. In some examples, the frame may be formed of a plastics material.

BRIEF DESCRIPTION OF FIGURES

[0006] Aspects of the present disclosure are shown schematically, by way of example only, in the accompanying drawings, in which:

[0007] Figure 1 provides isometric views of a pouch cell;

[0008] Figure 2 is an isometric view of a battery comprising a stack of pouch cells of Figure 1;

[0009] Figure 3 is an isometric view of an alternative battery to the battery shown in Figure 2;

[0010] Figure 4 is an isometric view of another alternative battery to the battery shown in Figure 2; and

[0011] Figure 5 is an isometric view of yet another alternative battery to the battery shown in Figure 2.

[0012] DESCRIPTION

[0013] Before particular examples of the present invention are described, it is to be understood that the present disclosure is not limited to the particular battery or method disclosed herein. It is also to be understood that the terminology used herein is used for describing particular examples only and is not intended to be limiting, as the scope

[0014] In describing and claiming the battery and method of the present invention, the following terminology will be used: the singular forms "a", "an", and "the" include plural forms unless the context clearly dictates otherwise. Thus, for example, reference to "an anode" includes reference to one or more of such elements.

[0015] According to the present disclosure, there is provided a battery comprising a stack of pouch cells, each pouch cell comprising a cell stack contained within a flexible housing, wherein the flexible housing comprises a pair of opposing planar surfaces that are joined together to form at least one seal region, wherein the seal region is shaped to provide a reinforcement flap that engages a corresponding reinforcement flap of at least one adjacent pouch cell in the stack of pouch cells.

[0016] In the present disclosure, the seal region is shaped to provide a reinforcement flap. The reinforcement flap may be an extension of the seal region. For example, at least part of the seal region may extend outwards from the cell stack contained within the flexible housing as a reinforcement flap. In one example, a part or parts of the seal region may extend further than other parts of the seal region to form reinforcement flap(s). Alternatively, the seal region along at least one side of the flexible housing may be larger than the seal region along another part of the flexible housing. This larger seal region may provide the reinforcement flap.

[0017] The reinforcement flap may be bent relative to the planar face of the flexible housing. For example, the reinforcement flap may be bent substantially at right angles to the planar face of the flexible housing. When a corresponding flexible housing is positioned adjacent to this flexible housing, the reinforcement flaps of the two flexible housings may overlap and engage one another. The reinforcement flaps of engaged pouch cells may be bent in substantially the same direction. The reinforcement flap(s) of a pouch cell located at an intermediate position in a stack of pouch cells may engage corresponding reinforcement flap(s) of the neighbouring pouch cells on either side.

[0018] The engaged reinforcement flaps can help to hold the adjacent pouches of the stack in the desired position relative to one another. Because the engaged reinforcement flaps overlap one another, this can also help to provide a thickened region that can provide at least part of the structure with improved rigidity. This improved rigidity can improve the structural integrity of the stack of pouch cells.

[0019] Advantageously, in some examples of the present disclosure, frames typically used to retain the individual pouch cells in position within the battery can be omitted. In other words, the battery may be a frameless battery. A frameless battery comprising a given number of cells will be lighter than a comparable battery formed from the same number of pouch cells contained within a frame. Thus, all other things being equal, the specific energy of the frameless battery will be improved relative to that of the comparable battery formed with a frame. Also, frameless batteries may take up less space, making them attractive for applications where space is limited.

[0020] When the reinforcement flaps of adjacent pouches engage, reinforcing wall portions can be formed. These wall portions can keep the pouch cells in position within the stack of pouch cells. The wall portions can also help to provide structural integrity and/or rigidity to the resulting structure, as the engaged reinforcement flaps can overlap with one another to provide a thicker combined flap. The wall portions can help to ensure that the battery is self-standing. In some examples, the wall portions keep the pouch cells in the stack of pouch cells in spaced relation to one another. This gap between the cells allows for expansion during charge and discharge of the electrochemical cells. The flaps themselves may also be configured to allow for expansion, for instance, they may have a zigzag configuration.

[0021] The wall portions may be formed at any point around the stack of pouch cells. In some examples, the wall portions may extend along one side or along part of a side of the stack of pouch cells. Alternatively, the wall portions may be present at one or more of the corners of the stack of pouch cells. Preferably, the wall portions extend along a first side or along part of a first side of stack of pouch cells and along a second side or part of a second side of pouch cells. The first and second sides may face each other. Alternatively, the first and second sides may form an angle to one another.

[0022] In one example, the flexible housing comprises a pair of opposing planar surfaces that are joined together to form at least two seal regions, for example, a seal region on one side of the flexible housing and a seal region on the opposite side of the flexible housing. These seal regions may be shaped to provide reinforcement flaps that engage corresponding reinforcement flaps of at least one adjacent pouch in the stack. As described above, at least part of the seal regions of each pouch cell may extend outwards from the cell

stack contained within the flexible housing to provide the reinforcement flaps. The reinforcement flaps may extend along the length of the flexible housing or along part of the flexible housing. In this example, when the reinforcement flaps of adjacent pouches engage, wall portions can be formed on opposing sides of the stack of pouch cells. These wall portions can act as retaining walls on opposing sides of the stack of pouch cells.

[0023] In one example, the flexible housing comprises reinforcement flaps on 3 sides of the flexible housing. Thus, as well as providing reinforcement flaps on opposing sides of the flexible housing, a reinforcement flap is provided on a side connecting the opposing sides of the flexible housing to add additional rigidity to the structure. These reinforcement flaps may form reinforcement wall portions on three sides of the stack of pouch cells. To save weight, part of the walls may be removed or cut out.

[0024] The battery may comprise a stack of at least two pouch cells. The stack comprises pouch cells arranged such that a planar surface of one cell faces a planar surface of the other cell. The battery may comprise a stack of at least three pouch cells, wherein the reinforcement flap(s) of an intermediate pouch located at an intermediate location within the stack engages corresponding reinforcement flap(s) of a pouch on either side of the intermediate pouch.

[0025] The reinforcement flaps may be engaged using any suitable means. Examples include a heat seal or adhesive. Alternatively, mechanical fasteners or an adhesive tape may be used. Examples of mechanical fasteners include rivets, eyelets and snap fasteners.

[0026] In some examples, the reinforcement flaps are reinforced with a reinforcement member that is coupled to the seal region. The reinforcement member may be a rod or strip. The rod or strip may be formed of metal, plastic or cardboard. The reinforcement member may be applied to the reinforcement flap, for example, using an adhesive. Alternatively, the reinforcement member may be sealed into the material used to form the reinforcement flap. For example, where the reinforcement member is formed of a laminate, the reinforcement member may be sealed or positioned within the layers of the laminate.

[0027] Any suitable material may be used to form the flexible housing. Preferably, the flexible housing is formed of a laminate material. The laminate comprises a metal sheet and at least one polymeric layer on either side of the metal sheet. In one example, the metal sheet is formed of aluminium. Other examples of metals include copper and stainless steel. Suitable polymer layers include nylon, polyethylene terephthalate and polypropylene (e.g. polypropylene copolymer). In one example, the laminate comprises polyethylene terephthalate on one side and polypropylene on the other. The polymer(s) may be coupled to the metal sheet using an adhesive. An example of a laminate are laminates comprising

aluminium laminated with nylon and polypropylene, respectively. Examples include C4-150 ad C4-300 by Showa Denko. The laminate may be 50 to 500 microns thick, for example, 100 to 150 microns thick.

[0028] The flexible housing may be formed by placing opposing planar surfaces on either face of the cell stack. The opposing planar surfaces may be folded or wrapped around one side of the cell stack are joined together around the other sides of the cell stack to form seal regions. This joining may be carried out using an adhesive or a heat seal. In an alternative example, one sheet of laminate may be placed on one face of the cell stack and a separate sheet of laminate may be placed on the opposite face of the cell stack. Sealed regions may be formed around the cell stack by sealing all around the cell stack e.g. using an adhesive or a heat seal. Preferably, contact tabs are allowed to protrude beyond the flexible housing to allow electrical connection to the electrodes within the cell stack.

[0029] The flexible housing can protect the cell stack from exposure to the surroundings. This may be important, for example, if any of the cell components are formed of air or moisture-sensitive materials (e.g. lithium).

[0030] The sealed regions may be shaped to provide the reinforcement flaps. For example, rather than cutting the sealed regions throughout along the seal, at least part of the flexible material is left to extend outwards from the cell stack to provide the reinforcement regions as discussed above.

[0031] The reinforcement flaps may be of any suitable length. In one example, the reinforcement flap may as long as the depth of at least 2 pouch cells, for instance, 4 pouch cells. In one example, the flaps may be 20 mm to 50 mm.

[0032] The pouch cell may be take any form. Preferably, the pouch cell is substantially planar. The pouch may be substantially rectangular. The shape of the pouch cell may be determined by the shape of the cell stack. In one example, the pouch cell has a length of 100 to 200 mm, a width of 50 to 110 mm and a depth of 2 to 15 mm.

[0033] The battery may be any suitable battery.

[0034] The battery may contain any suitable pouch cells. In some examples of the disclosure, the cells are lithium cells. Suitable lithium cells include lithium-ion, lithium-air, lithium-polymer and lithium-sulphur cells.

[0035] In a preferred embodiment, the battery is a lithium sulphur battery.

[0036] Where the battery comprises a lithium battery (e.g. a lithium sulphur cell), the battery may comprise a plurality of lithium pouch cells. Each pouch cell may comprise a cell

stack comprising one or more electrochemical cell units, each comprising the anode, cathode and electrolyte.

[0037] The anode may comprise a conductive substrate that is in the form of a sheet of lithium metal or lithium metal alloy. This sheet may be coupled to a contact tab formed, for example, of nickel. The contact tab may be coupled to the sheet of lithium metal or lithium metal alloy by welding, for instance, ultrasonic welding.

[0038] The cathode may comprise a current collector on to which an electroactive material is deposited. The current collector may be formed of a metal foil, for example, aluminium foil. The electroactive material may comprise an electroactive sulphur material, which may be mixed with an electrically conductive material. The resulting mixture may be coated onto the current collector as an electroactive matrix. A contact tab formed, for example, by aluminium may be coupled to the current collector. This coupling may be carried out by welding, for example, ultrasonic welding.

[0039] The electroactive sulphur material deposited on the current collector may comprise elemental sulphur, sulphur-based organic compounds, sulphur-based inorganic compounds and sulphur-containing polymers. Preferably, elemental sulphur is used.

[0040] The electrically conductive material may be any suitable solid electrically conductive material. Preferably, this solid electroconductive material may be formed of carbon. Examples include carbon black, carbon fibre, graphene and carbon nanotubes. Other suitable materials include metal (e.g. flakes, filings and powders) and conductive polymers. Preferably, carbon black is employed.

[0041] The electroactive sulphur material may be present in the matrix deposited on the current collector in an amount of 60 to 90 weight %, preferably 65 to 85 weight %, more preferably 70 to 80 weight %.

[0042] The electrically conductive material may be present in the matrix deposited on the current collector in an amount of 10 to 45 weight %, preferably 15 to 35 weight %, more preferably 20 to 25 weight %.

[0043] The weight ratio of electroactive sulphur material to electrically conductive material may be 0.01 - 10 : 10 - 50, preferably 0.1 - 5 : 15 - 45, more preferably 1 - 5 : 20 - 35.

[0044] The pouch cell may further comprise an electrolyte in contact with the anode and the cathode. Any suitable electrolyte may be used. The electrolyte may comprise an organic solvent and a lithium salt. Suitable organic solvents include ethers, esters, amide, amine, sulfoxides, sulfamides, organophosphates and sulfones. Examples include tetrahydrofuran, 2-methyltetrahydrofuran, methylpropylpropionate, ethylpropylpropionate,

methyl acetate, 1,2-dimethoxyethane, 1,3-dioxolane, diglyme (2-methoxyethyl ether), triglyme, tetraglyme, butyrolactone, 1,4-dioxane, 1,3-dioxane, hexamethyl phosphoamide, pyridine, dimethyl sulfoxide, tributyl phosphate, trimethyl phosphate, N, N, N, N-tetraethyl sulfamide, and sulfones and their mixtures.

[0045] Suitable electrolyte salts include lithium salts. Suitable lithium salts include lithium hexafluorophosphate, lithium hexafluoroarsenate, lithium nitrate, lithium perchlorate, lithium trifluoromethanesulfonimide, lithium bis(oxalate) borate and lithium trifluoromethanesulphonate. Preferably the lithium salt is lithium trifluoromethanesulphonate (also known as lithium triflate). Combinations of salts may be employed. For example, lithium triflate may be used in combination with lithium nitrate. The lithium salt may be present in the electrolyte at a concentration of 0.1 to 5M, preferably, 0.5 to 3M.

[0046] A separator may be placed between the anode and cathode. Where a separator is present, the separator may comprise any suitable porous substrate that allows ions to move between the electrodes of the cell. The separator should be positioned between the electrodes to prevent direct contact between the electrodes. The porosity of the substrate should be at least 30%, preferably at least 50%, for example, above 60%. Suitable separators include a mesh formed of a polymeric material. Suitable polymers include polypropylene, nylon and polyethylene. Non-woven polypropylene is particularly preferred. It is possible for a multi-layered separator to be employed.

[0047] Aspects of the present invention will now be described with reference to the drawings.

[0048] Figure 1 is an isometric view of a pouch cell according to one example of the present disclosure. The pouch cell 10 is substantially planar and comprises substantially planar opposing surfaces 12 (only one shown). The pouch cell 10 contains a cell stack (not shown). The cell stack is encased in a flexible housing 16 formed of a flexible material. The flexible material extends over the planar opposing surfaces 12 and is joined or sealed around the cell stack e.g. by heat sealing. Contact tabs 18, 20 protrude from the flexible housing 16 to allow electrical connection with the electrodes in the cell stack.

[0049] The flexible material is sealed across seal regions 22 a, b, c and d. The seal regions extend to form reinforcement flaps on opposing sides of the pouch cell. Seal regions 22a and 22b provide extended reinforcement flaps 24a, 24b along the length of the pouch cell, while only part of the seal regions 22c and 22d are extended to provide reinforcement flaps at 24c and 24d. The reinforcement flaps may be folded in a direction substantially perpendicular to the pouch cell as shown in Figure 1.

[0050] Figure 2 shows a battery formed from a stack of pouch cells 10 shown in Figure 1. As can be seen from the figure, reinforcement flaps 24a, b, c and d of adjacent pouch cells 10 engage one another providing the resulting stack of pouch cells with reinforcement wall portions. These wall portions provide the battery with rigidity and structural integrity, reducing or eliminating the need for a supporting frame. Thus, the wall portions ensure that the battery is a self-standing structure.

[0051] Figure 3 shows an alternative embodiment to the battery shown in Figure 2. In this embodiment, the reinforcement wall portions have been cut back so that the reinforcement wall portions only remain in the vicinity of the corners of the pouch cell. This can help to reduce the weight of the battery.

[0052] Figure 4 shows another alternative embodiment to the battery shown in Figure 2. Here, the reinforcement flaps 24a, b are provided on opposing sides of the stack of pouch cells. The seal regions at the other opposing sides of the pouch cells are cut back so the reinforcement flaps 24 and d present in the embodiment of Figure 2 are not present.

[0053] Figure 5 shows yet another embodiment the battery shown in Figure 2. Here the reinforcement flaps 24a, b along the length of the pouch cells have been removed. However, the reinforcement flap along one width 24c has been retained to provide structural integrity to the structure. The reinforcement flaps 24d on the opposing width have also be retained.

Claims

1. A battery comprising a stack of pouch cells, each pouch cell comprising a cell stack contained within a flexible housing, wherein the flexible housing comprises a pair of opposing planar surfaces that are joined together to form at least one seal region, wherein the seal region is shaped to provide a reinforcement flap that engages a corresponding reinforcement flap of at least one adjacent pouch cell in the stack.

2. A battery as claimed in claim 1, wherein the flexible housing comprises a pair of opposing planar surfaces that are joined together to form a seal region on one side of the flexible housing and a seal region on the opposite side of the flexible housing, said seal regions being shaped to provide reinforcement flaps that engage corresponding reinforcement flaps of at least one adjacent pouch in the stack.

3. A battery as claimed in any one of the preceding claims, which comprises a stack of at least three pouch cells, wherein the reinforcement flap(s) of an intermediate pouch located at an intermediate location within the stack engages corresponding reinforcement flap(s) of a pouch on either side of the intermediate pouch.

4. A battery as claimed in any one of the preceding claims, wherein the engaged reinforcement flaps of the pouches are bent in substantially the same direction.

5. A battery as claimed in any one of the preceding claims, wherein the engaged reinforcement flaps are engaged using and adhesive or heat sealing.

6. A battery as claimed in any one of the preceding claims, wherein the engaged reinforcement flaps form reinforcing wall portion(s).

7. A battery as claimed in claim 6, wherein the reinforcing wall portion(s) hold the pouch cells in place within the stack.

8. A battery as claimed in claim 7, wherein the reinforcing wall portion(s) hold the pouch cells in spaced relation to one another within the stack.

9. A battery as claimed in any one of claims 6 to 8, wherein the reinforcing wall portion(s) hold the pouch cells together to form a self-standing integral structure.

10. A battery as claimed in any one of claims 6 to 9, wherein wall portion(s) extend across at least part of at least two sides of the battery.

11. A battery as claimed in claim 9, wherein wall portion(s) extend across the length of at least two opposing sides of the battery.

12. A battery as claimed in any one of the preceding claims, wherein the reinforcement flaps are reinforced with a reinforcement member that is coupled to the seal region.

13. A battery as claimed in any one of the preceding claims, wherein the opposing planar surfaces comprise a laminate material comprising a metal foil coated on each side with a polymer material.

14. A battery as claimed in any one of the preceding claims, which is a lithium sulphur battery.

15. A battery as claimed in any one of the preceding claims, which comprises connection tabs that protrude from the flexible housing, said connection tabs being in electrical communication with the electrodes in the cell stacks contained within the flexible housing.

Intellectual Property Office

Application No:	GB1621878.6	**Examiner:**	Dr Maria Lada
Claims searched:	1-15	**Date of search:**	5 June 2017

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-15	JP 2006236605 A (NEC) [see abstract, description and figs 1-2]
X	1-15	US 2012/196170 A1 (IJAZ) [see abstract, description and figs 1&6]
X	1-15	JP 2005122927 A (JAPANSTORAGE) [see abstract, description and figs 1-2]
X	1-15	JP2005302501 A (UCHIYAMA) [see abstract, description and figs 1-4]

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[X] :

Worldwide search of patent documents classified in the following areas of the IPC

H01M

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI, TXTE

International Classification:

Subclass	Subgroup	Valid From
H01M	0002/02	01/01/2006
H01M	0002/10	01/01/2006