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(54) **BATTERY COMPONENT FABRICATION METHOD AND SYSTEM**

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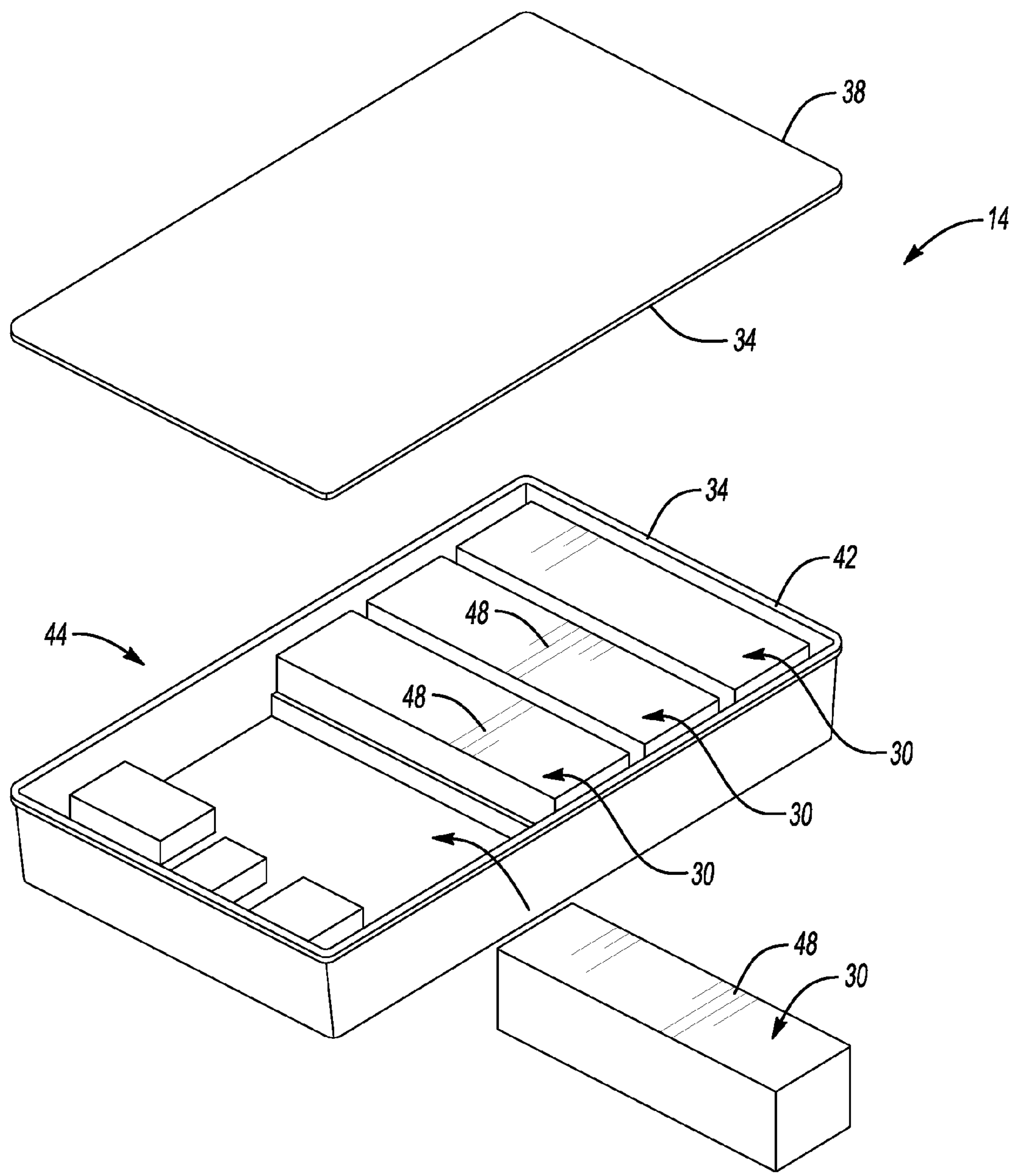
(57) **ABSTRACT**

A battery component fabrication method includes compressing a powder mixture to provide a composite film layer, surface treating the composite film layer, and compressing the composite film layer together with a foil layer to provide an electrode. The electrode provided by the method can be considered a dry electrode for a lithium-ion battery.



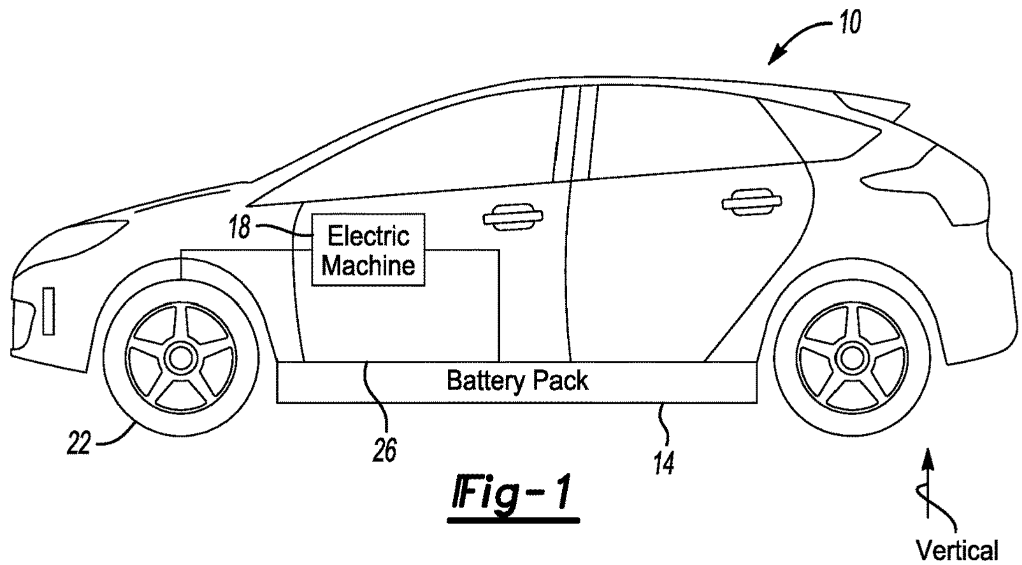

10
18
Electric
Machine
Battery Pack
22
26
14
Vertical

Fig-1

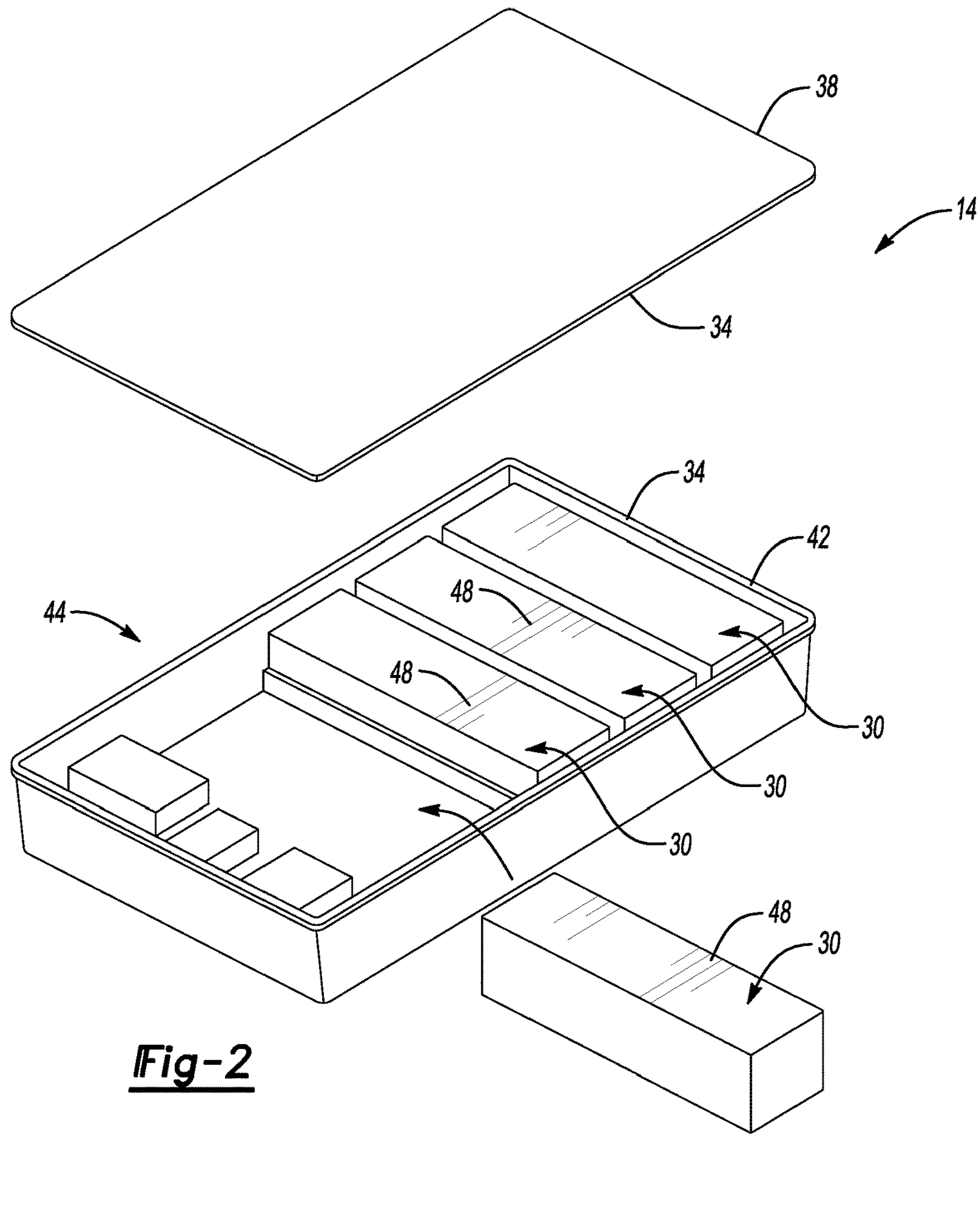

38
14
34
34
42
44
48
48
30
30
30
48
30

Fig-2

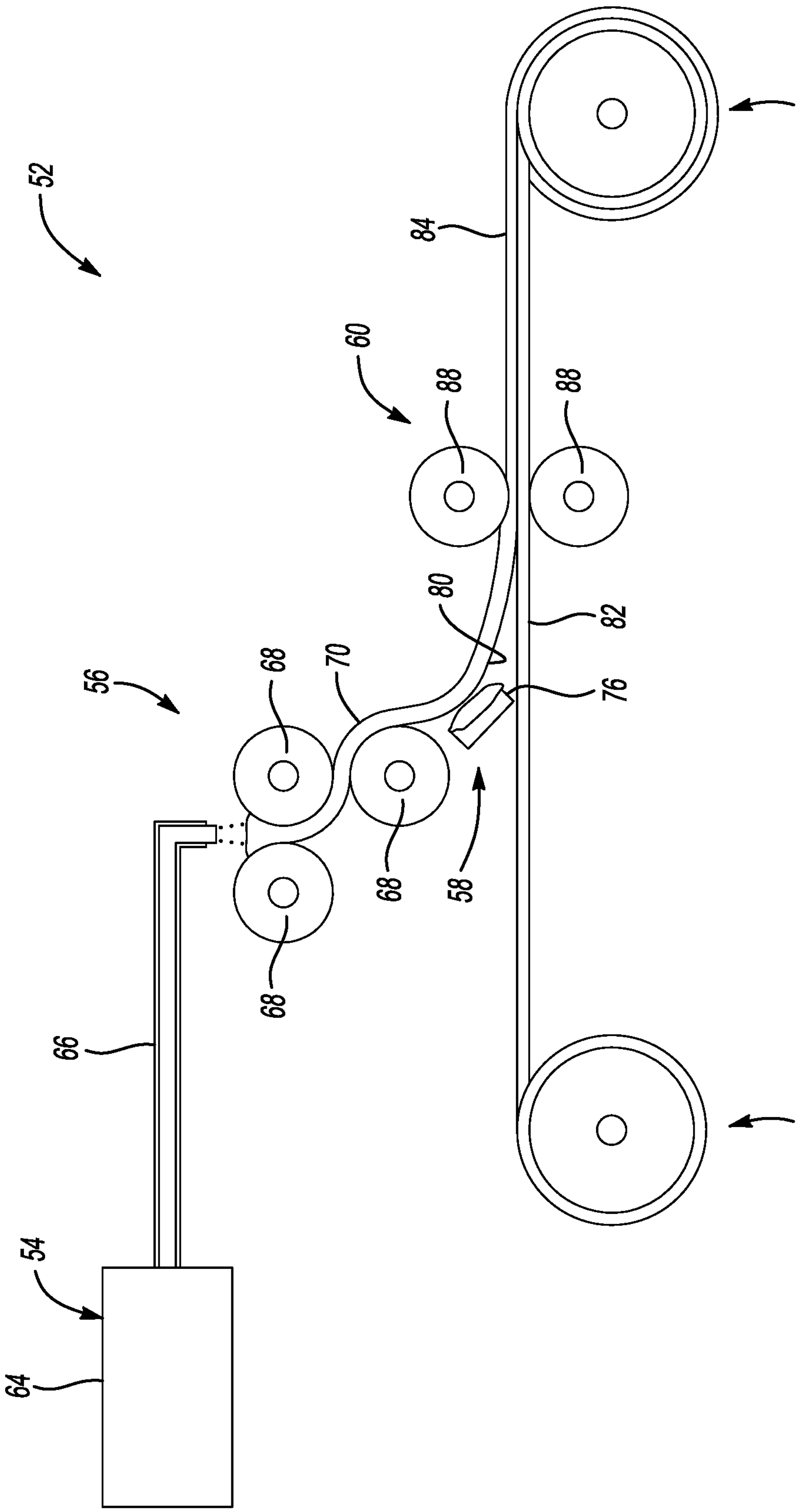


Fig-3

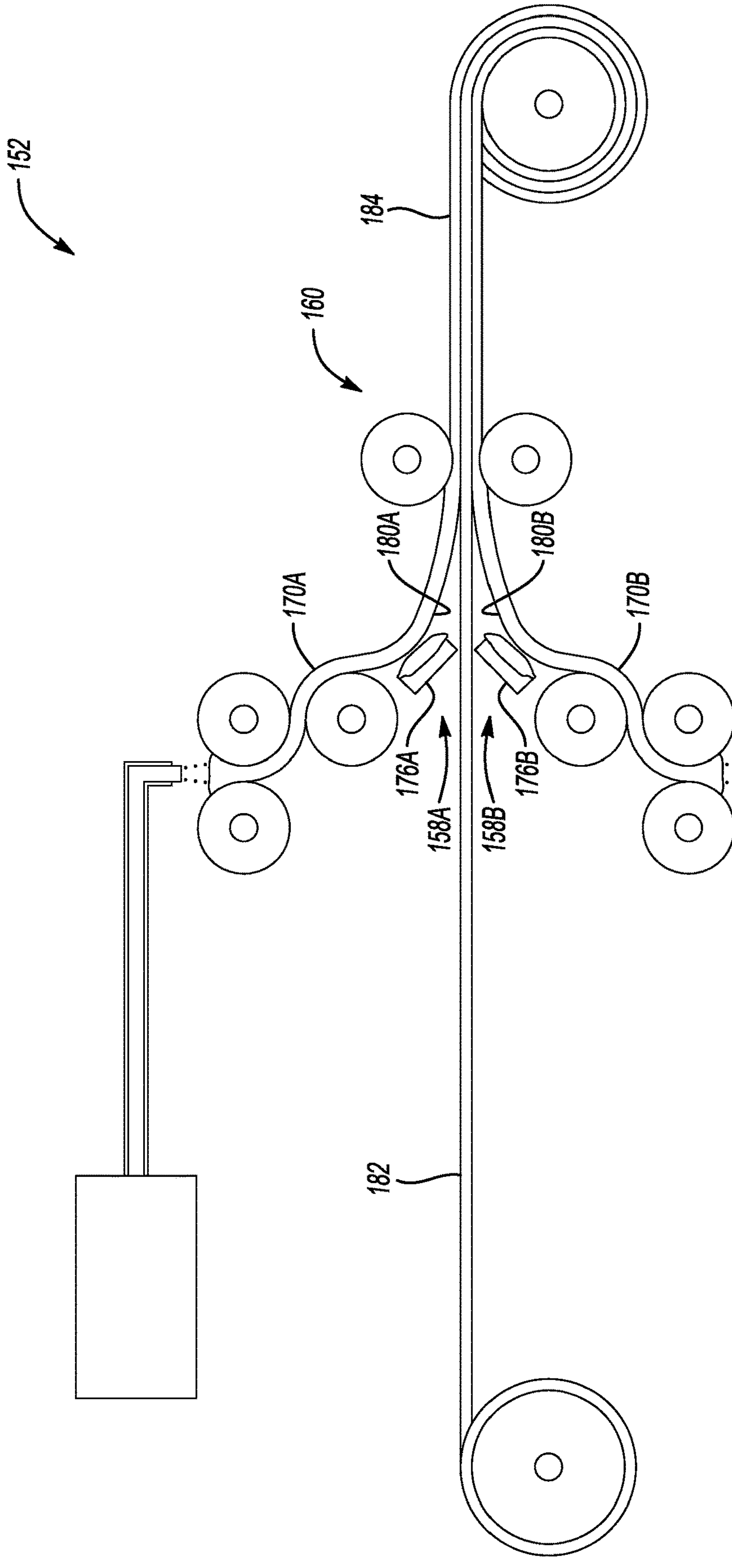


Fig-4

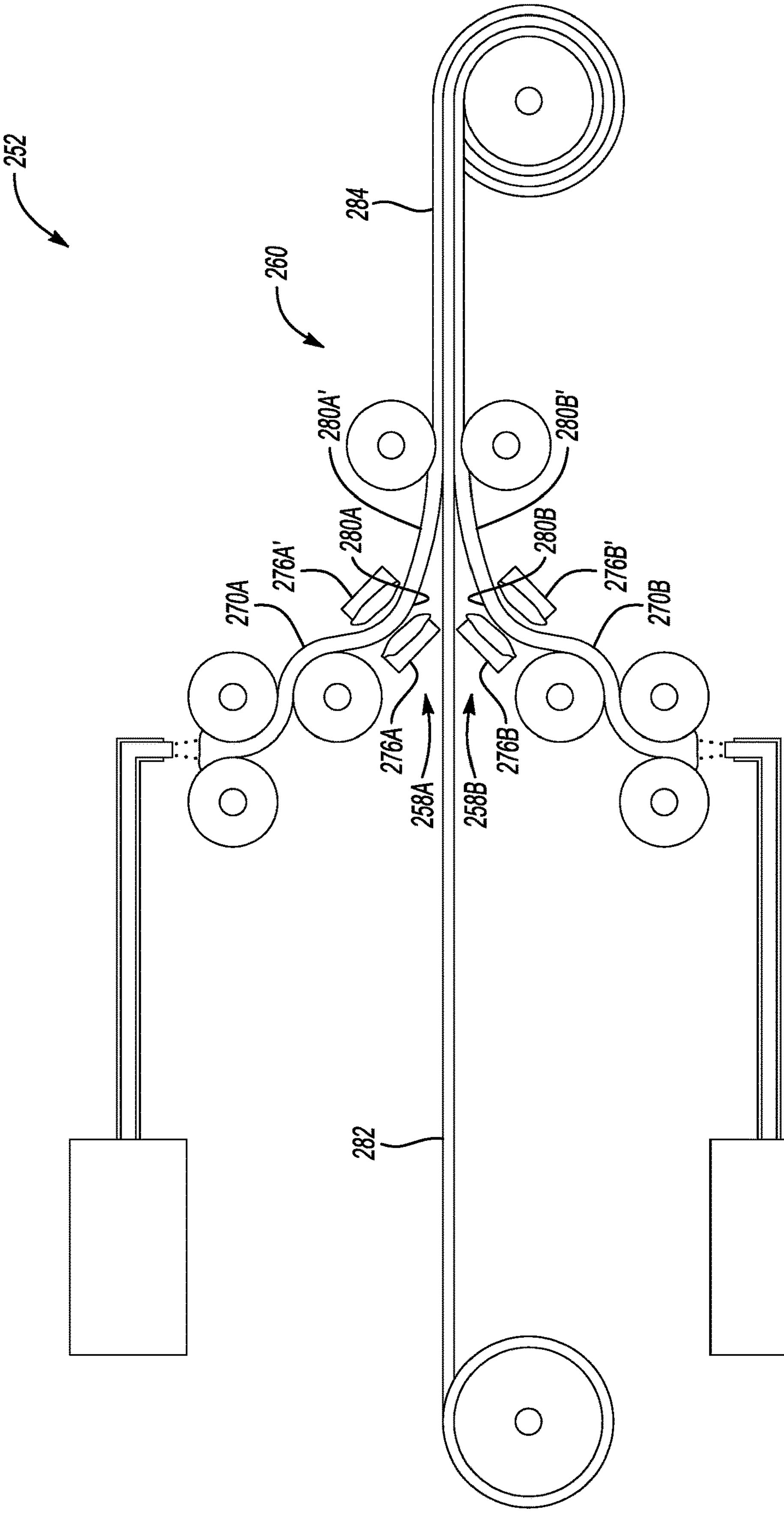

252
260
284
280A'
280B'
280A
280B
276A'
276B'
270A
270B
276A
276B
258A
258B
282

Fig-5

BATTERY COMPONENT FABRICATION METHOD AND SYSTEM

TECHNICAL FIELD

[0001] This disclosure relates generally to fabricating battery components and, more particularly, to dry electrodes of lithium-ion batteries used in electrified vehicles.

BACKGROUND

[0002] Electrified vehicles differ from conventional motor vehicles because electrified vehicles include a drivetrain having one or more electric machines. A battery pack can power the electric machines. The battery pack can include arrays of battery cells.

SUMMARY

[0003] In some aspects, the techniques described herein relate to a battery component fabrication method, including: compressing a powder mixture to provide a composite film layer; surface treating the composite film layer; and compressing the composite film layer together with a foil layer to provide an electrode.

[0004] In some aspects, the techniques described herein relate to a battery component fabrication method, wherein the electrode is a lithium-ion battery electrode.

[0005] In some aspects, the techniques described herein relate to a battery component fabrication method, wherein the surface treating includes plasma surface modification.

[0006] In some aspects, the techniques described herein relate to a battery component fabrication method, wherein the surface treating includes corona treatment that uses a corona discharge plasma.

[0007] In some aspects, the techniques described herein relate to a battery component fabrication method, wherein the surface treating includes a laser treatment.

[0008] In some aspects, the techniques described herein relate to a battery component fabrication method, wherein the surface treating includes a light treatment.

[0009] In some aspects, the techniques described herein relate to a battery component fabrication method, wherein the composite film layer is a first composite film layer compressed against a first side of the foil layer and, further including compressing another powder mixture to provide a second composite film layer, surface treating the second composite film layer, and compressing the second composite film layer against an opposite second side of the foil layer.

[0010] In some aspects, the techniques described herein relate to a battery component fabrication method, wherein the powder mixture includes a binder material.

[0011] In some aspects, the techniques described herein relate to a battery component fabrication method, wherein the powder mixture is a dry powder mixture.

[0012] In some aspects, the techniques described herein relate to a battery component fabrication method, wherein the composite film layer is a dry electrode.

[0013] In some aspects, the techniques described herein relate to a battery component fabrication method, further including heating during the compressing.

[0014] In some aspects, the techniques described herein relate to a battery component fabrication method, further including compressing the powder mixture by calendering the powder mixture.

[0015] In some aspects, the techniques described herein relate to a battery component fabrication method, further including compressing the powder mixture using at least one roller of a calender.

[0016] In some aspects, the techniques described herein relate to a battery component fabrication method, wherein the at least one roller is a heated roller that heats powder mixture during the compressing.

[0017] In some aspects, the techniques described herein relate to a battery component fabrication method, further including heating the composite film layer and the foil layer when compressing the composite film layer together with the foil layer.

[0018] In some aspects, the techniques described herein relate to a battery component fabrication method, wherein further including winding the composite film layer and the foil layer after compressing the composite film layer together with the foil layer.

[0019] In some aspects, the techniques described herein relate to a battery component fabrication system, including: a powder compression station that compresses a dry power into a composite film layer; a surface treatment station that surface treats a side of the composite film layer; and an electrode compression station that compresses the side of the composite film layer against a foil layer to provide an electrode.

[0020] In some aspects, the techniques described herein relate to a battery component fabrication system, wherein the electrode is a lithium-ion battery electrode.

[0021] In some aspects, the techniques described herein relate to a battery component fabrication system, wherein the surface treatment station is a plasma surface modification.

[0022] In some aspects, the techniques described herein relate to a battery component fabrication system, wherein the side is a first side, and the surface additionally treats an opposite, second side of the composite film layer.

[0023] The embodiments, examples and alternatives of the preceding paragraphs, the claims, or the following description and drawings, including any of their various aspects or respective individual features, may be taken independently or in any combination. Features described in connection with one embodiment are applicable to all embodiments, unless such features are incompatible.

BRIEF DESCRIPTION OF THE FIGURES

[0024] The various features and advantages of the disclosed examples will become apparent to those skilled in the art from the detailed description. The figures that accompany the detailed description can be briefly described as follows:

[0025] FIG. **1** illustrates a side view of an electrified vehicle having a traction battery pack.

[0026] FIG. **2** illustrates an expanded, perspective view of the traction battery pack from the electrified vehicle of FIG. **1**.

[0027] FIG. **3** illustrates selected portions of a battery component fabrication system according to an exemplary aspect of the present disclosure.

[0028] FIG. **4** illustrates selected portions of a battery component fabrication system according to another exemplary aspect of the present disclosure.

[0029] FIG. **5** illustrates selected portions of a battery component fabrication system according to another exemplary aspect of the present disclosure.

DETAILED DESCRIPTION

[0030] This disclosure details processes for fabricating battery components and, in particular, fabricating electrodes of batteries using a dry process. In the past, wet processes have been used to fabricate such electrodes. The dry process does not typically involve solvents and drying times commonly associated with wet processes.

[0031] With reference to FIG. **1**, an electrified vehicle **10** includes a battery pack **14**, an electric machine **18**, and wheels **22**. The battery pack **14** powers an electric machine **18**, which can convert electrical power to mechanical power to drive the wheels **22**. The battery pack **14** can be a relatively high-voltage battery.

[0032] The battery pack **14** is, in the exemplary embodiment, secured to an underbody **26** of the electrified vehicle **10**. The battery pack **14** could be located elsewhere on the electrified vehicle **10** in other examples.

[0033] The electrified vehicle **10** is an all-electric vehicle. In other examples, the electrified vehicle **10** is a hybrid electric vehicle, which selectively drives wheels using torque provided by an internal combustion engine instead of, or in addition to, an electric machine. Generally, the electrified vehicle **10** could be any type of vehicle having a traction battery pack.

[0034] With reference now to FIG. **2**, the battery pack **14** includes a plurality of battery arrays **30** held within an enclosure assembly **34**. In the exemplary embodiment, the enclosure assembly **34** includes an enclosure cover **38** and an enclosure tray **42**. The enclosure cover **38** is secured to the enclosure tray **42** to provide an interior area **44** that houses the plurality of battery arrays **30**.

[0035] The battery arrays **30** each includes a plurality of battery cells **48** (or simply, "cells") stacked side-by side relative to each other. Although a specific number of cells **48** and arrays **30** are illustrated in the various figures of this disclosure, the battery pack **14** could include any number of arrays **30** having any number of cells **48**. In other words, this disclosure is not limited to the specific configuration of cells **48** and arrays **30** shown in FIG. **2**.

[0036] The battery cells **48** supply electrical power to various components of the electrified vehicle **10**. The battery cells **48** each include a respective electrode that is fabricated using a dry electrode fabricating process. Such electrodes can be provided by compressing a powder mixture into a film, which is then bonded to a foil without utilizing wet solvents or a wet slurry. The battery cells **48** are lithium-ion battery cells in this example. In other examples, the battery cells **48** can be solidum-ion, lithium-sulfur, or all solid electrolyte batteries with dry electrodes.

[0037] Referring to FIG. **3** with continuing reference to FIG. **2**, an example battery component fabrication system **52** includes, among other things, a powder supply **54**, a powder compression station **56**, a surface treatment station **58**, and an layer compression station **60**. A method of fabricating electrodes for the battery cells **48** the battery pack **14** includes, generally, compressing powder from the powder supply **54** to provide a layer, surface treating that layer, and then joining that layer to a foil.

[0038] In this example, the powder supply **54** contains a dry powder mixture **64** including, among other things, active materials, binders, and conductive agents. The binders can be fluoropolymers, such as polytetrafluoroethylene and polyvinylidene fluoride, polyolefins, polyurethane, acrylics, sericin, protein-based, etc. The binders can be of a single use or a mixture with two or more polymers. Additives that include a limited amount of solvent can be added to facilitate processing or electrode performance.

[0039] The system **52** include a conduit **66** that conveys the dry powder mixture **64** from the powder supply **54** to the powder compression station **56**.

[0040] The example powder compression station **56** is a multi-roll calender system. At the powder compression station **56**, the dry powder mixture **64** is compressed—here by three calender rollers **68**—into a composite film layer **70**. In other examples more than three calender rollers **68** can be used. The rollers **68** can be heated to heat the dry powder mixture **64** as the dry powder mixture **64** is compressed.

[0041] From the powder compression station **56**, the composite film layer **70** passes through the surface treatment station **72**, which uses at least one surface treatment device **76** to treat a surface **80** of the composite film layer **70**. The surface treating can be, for example, a plasma surface modification, a corona treatment that uses a corona discharge plasma, a laser treatment, a light treatment or some combination of these. A distance between the surface **80** of the composite film layer **70** and the surface treatment device **76** can be from 0 to 1.25 meters.

[0042] From the surface treatment station **58**, the composite film layer **70** passes to the layer compression station **60**, which compresses the composite film layer **70** together with a foil layer **82** to provide an electrode sheet **84**. The foil layer **82** is unrolled from a foil roll **86** and routed to the layer compression station **60**. The foil layer **82** can be aluminum, copper, or some other material. The selection of the material for the foil layer **82** can depend on whether an anode electrode sheet or cathode electrode is desired.

[0043] In this example, the layer compression station **60** is a calender system that compresses the composite film layer **70** together with the foil layer **82** using at least one calender roller **88**, which can be a heated roller.

[0044] The electrode sheet **84** from the layer compression station **60** can be wound into an electrode roll **90**. When assembling the battery cells **48**, the electrode sheet **84** can be unwound from the electrode roll **90** and cut to a desired size for use as an electrode in one of the battery cells **48**. Again, in this example the electrode is an electrode for a lithium-ion batteries, and the electrode is a dry electrode.

[0045] The surface treatment of the surface **80** of composite film layer **70** prior to compressing the composite film layer **70** against the foil layer **82** can, among other things, help to activate binders within composite film layer **70**. Activating the binders helps to bond the composite film layer **70** to the foil layer **82** at the layer compression station **60**.

[0046] The embodiment of FIG. **3** can be considered a fabrication system that has a single side foil coating and a single side treatment. That is, the layer compression station **60** is used to compress a single foil layer together with a single composite film layer, and the single composite film layer is treated on only the surface **80** prior to being compressed together with the composite film layer.

[0047] With reference to FIG. **4**, a battery component fabrication system **152** can apply a first composite film layer **170**A to a first side of a foil layer **182**, and an second composite film layer **170**B to an opposite second side of the foil layer **182**. The electrode sheet **184** provided by the battery component fabrication system **152** thus includes a foil layer **182** sandwiched between the first composite film layer **170**A and the second composite film layer **170**B.

[0048] The system **152** includes a first surface treatment station **158**A having at least one surface treatment device **176**A that treats a surface **180**A of the first composite film layer **170**A prior to compressing the first composite film layer **170**A together with the foil layer **182** at a layer compression station **160**. The surface **180**A interfaces directly with the foil layer **182** in the electrode sheet **184**

[0049] The system **152** includes a second surface treatment station **158**B having at least one surface treatment device **176**B that treats a surface **180**B of the second composite film layer **170**B prior to compressing the second composite film layer **170**B together with the foil layer **182** at a layer compression station **160**.

[0050] With reference to FIG. **5**, a battery component fabrication system **252** can apply a first composite film layer **270**A to a first side of a foil layer **282**, and an second composite film layer **270**B to an opposite second side of the foil layer **282**. The electrode sheet **284** provided by the battery component fabrication system **252** thus includes a foil layer **282** sandwiched between the first composite film layer **270**A and the second composite film layer **270**B.

[0051] The system **252** includes a first surface treatment station **258**A having at least one surface treatment device **276**A that treats a surface **280**A of the first composite film layer **270**A prior to compressing the first composite film layer **270**A together with the foil layer **282** at a layer compression station **260**. The surface **280**A interfaces directly with the foil layer **282** in the electrode sheet **284**. The first surface treatment station **258**A further includes a second surface treatment device **276**A' that treats a surface **280**A' of the first composite film layer **270**A that is opposite the surface **280**A.

[0052] The system **252** includes a second surface treatment station **258**B having at least one surface treatment device **276**B that treats a surface **280**B of the second composite film layer **270**B prior to compressing the second composite film layer **270**B together with the foil layer **182** at a layer compression station **260**. The surface **280**B interfaces directly with the foil layer **282** in the electrode sheet **284**. The second surface treatment station **258**B further includes a second surface treatment device **276**B' that treats a surface **280**B' of the second composite film layer **270**B that is opposite the surface **280**B.

[0053] Treating the surfaces **280**A' and the surfaces **280**B' may be desired to inhibit the surfaces **280**A' and the surfaces **280**B' from adhering to the rollers at the layer compression station **260**.

[0054] Features of some of the disclosed examples include facilitating adhesion between layers of a dry electrode by surface treating a composite file coating layer. This can help to reduce delamination. The surface treatment can be an in-line continuous process.

[0055] The preceding description is exemplary rather than limiting in nature. Variations and modifications to the disclosed examples may become apparent to those skilled in the art that do not necessarily depart from the essence of this disclosure. Thus, the scope of protection given to this disclosure can only be determined by studying the following claims.

What is claimed is:

1. A battery component fabrication method, comprising:

compressing a powder mixture to provide a composite film layer;

surface treating the composite film layer; and

compressing the composite film layer together with a foil layer to provide an electrode.

2. The battery component fabrication method of claim **1**, wherein the electrode is a lithium-ion battery electrode.

3. The battery component fabrication method of claim **1**, wherein the surface treating comprises plasma surface modification.

4. The battery component fabrication method of claim **1**, wherein the surface treating comprises corona treatment that uses a corona discharge plasma.

5. The battery component fabrication method of claim **1**, wherein the surface treating comprises a laser treatment.

6. The battery component fabrication method of claim **1**, wherein the surface treating comprises a light treatment.

7. The battery component fabrication method of claim **1**, wherein the composite film layer is a first composite film layer compressed against a first side of the foil layer and, further comprising compressing another powder mixture to provide a second composite film layer, surface treating the second composite film layer, and compressing the second composite film layer against an opposite second side of the foil layer.

8. The battery component fabrication method of claim **1**, wherein the powder mixture includes a binder material.

9. The battery component fabrication method of claim **1**, wherein the powder mixture is a dry powder mixture.

10. The battery component fabrication method of claim **1**, wherein the composite film layer is a dry electrode.

11. The battery component fabrication method of claim **1**, further comprising heating during the compressing.

12. The battery component fabrication method of claim **1**, further comprising compressing the powder mixture by calendering the powder mixture.

13. The battery component fabrication method of claim **1**, further comprising compressing the powder mixture using at least one roller of a calender.

14. The battery component fabrication method of claim **13**, wherein the at least one roller is a heated roller that heats powder mixture during the compressing.

15. The battery component fabrication method of claim **1**, further comprising heating the composite film layer and the foil layer when compressing the composite film layer together with the foil layer.

16. The battery component fabrication method of claim **1**, wherein further comprising winding the composite film layer and the foil layer after compressing the composite film layer together with the foil layer.

17. A battery component fabrication system, comprising:

a powder compression station that compresses a dry power into a composite film layer;

a surface treatment station that surface treats a side of the composite film layer; and

an electrode compression station that compresses the side of the composite film layer against a foil layer to provide an electrode.

18. The battery component fabrication system of claim **17**, wherein the electrode is a lithium-ion battery electrode.

19. The battery component fabrication system of claim **17**, wherein the surface treatment station is a plasma surface modification.

20. The battery component fabrication system of claim **17**, wherein the side is a first side, and the surface additionally treats an opposite, second side of the composite film layer.

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