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Inventor(s)	ABE; Kosyo et al.

BATTERY MODULE

Abstract

A first supporting portion and a second supporting portion sandwich one battery cell of a plurality of battery cells in a first direction. The first supporting portion includes a plurality of first protrusions. Each of the plurality of first protrusions protrudes with respect to a first main surface portion in the first direction and extends in the form of a strip along a second direction orthogonal to the first direction. The second supporting portion includes a plurality of second protrusions. Each of the plurality of second protrusions protrudes with respect to a second main surface portion in the first direction. When viewed in the first direction, each of the plurality of second protrusions extends in the form of a strip so as not to overlap with the plurality of first protrusions, or extends in the form of a strip along a third direction different from the second direction.

Inventors: **ABE; Kosyo (Himeji-shi, JP), TAKEDA; Takahide (Himeji-shi, JP)**

Applicant: **Prime Planet Energy & Solutions, Inc.** (Tokyo, JP)

Family ID: **1000008434986**

Assignee: **Prime Planet Energy & Solutions, Inc. (Tokyo, JP)**

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This nonprovisional application is based on Japanese Patent Application No. 2024-019338 filed on Feb. 13, 2024 with the Japan Patent Office, the entire contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present technology relates to a battery module.

Description of the Background Art

[0003] Japanese Patent Laying-Open No. 2023-074271 is a prior art document that discloses a configuration of a battery module. The battery module described in Japanese Patent Laying-Open No. 2023-074271 includes battery cells and a supporting member. The supporting member includes a side wall portion and a partition wall portion. Each of the battery cells is sandwiched between the side wall portion and the partition wall portion in a stacking direction of the battery cells. The side wall portion is provided with protuberance portions. The partition wall portion is provided with ribs. A part of the protuberance portions of the side wall portion and the ribs of the partition wall portion extend in the same direction in a direction orthogonal to the stacking direction of the battery cells. The part of the protuberance portions of the side wall portion and a part of the ribs of the partition wall portion are disposed to overlap with each other in the stacking direction of the battery cells.

SUMMARY OF THE INVENTION

[0004] In the battery module described in Japanese Patent Laying-Open No. 2023-074271, a region to which pressing forces of the supporting portion are applied from both sides beside a battery cell is present in one cross section of the battery cell along the stacking direction of the battery cells. When the battery cell is compressed by the pressing forces, a flow path for electrolyte solution in the battery cell becomes narrow, with the result that the electrolyte solution may be less likely to flow. Therefore, reliability of the battery module is required to be improved by facilitating the electrolyte solution to flow in the battery cell.

[0005] The present technology has been made to solve the above-described problem, and has an object to provide a battery module having high reliability so as to facilitate an electrolyte solution to flow in a battery cell.

[0006] The present technology provides the following battery module.

[1]

[0007] A battery module comprising: [0008] a plurality of battery cells arranged side by side in a first direction and each having a prismatic shape; and [0009] a first supporting portion and a second supporting portion that sandwich one battery cell of the plurality of battery cells in the first direction, wherein [0010] the battery cell includes a first side surface portion and a second side surface portion facing each other in the first direction, [0011] the first supporting portion includes [0012] a first main surface portion located on the first side surface portion side of the battery cell in the first direction, and [0013] a plurality of first protrusions each protruding with respect to the first main surface portion in the first direction and each extending in a form of a strip along a second direction orthogonal to the first direction, [0014] the second supporting portion includes [0015] a second main surface portion located on the second side surface portion side of the battery cell in the first direction, and [0016] a plurality of second protrusions each protruding with respect to the

second main surface portion in the first direction, and [0017] when viewed in the first direction, each of the plurality of second protrusions extends in a form of a strip so as not to overlap with the plurality of first protrusions or extends in a form of a strip along a third direction different from the second direction.
[2]
[0018] The battery module according to [1], wherein the second direction and the third direction are orthogonal to each other.
[3]
[0019] The battery module according to [1] or [2], further comprising a plurality of cases, each of the plurality of cases accommodating at least two battery cells of the plurality of battery cells, each of the plurality of cases supporting the at least two battery cells in at least the first direction, each of the plurality of cases forming a unit including the at least two battery cells, wherein [0020] each of the plurality of cases includes the first supporting portion and the second supporting portion.
[4]
[0021] The battery module according to [3], wherein [0022] each of the cases has a first wall portion located at a position other than an end portion of the case in the first direction, a second wall portion located at the end portion of the case in the first direction, and a third wall portion that connects the first wall portion and the second wall portion in the first direction, [0023] the first supporting portion is provided at the first wall portion and the second supporting portion is provided at the second wall portion, and [0024] a cooling medium path along the second direction is formed between the plurality of first protrusions, and [0025] a through hole is provided to extend through the third wall portion and communicate with the cooling medium path.
[5]
[0026] The battery module according to [4], wherein [0027] each of the plurality of first protrusions protrudes toward the first side surface portion with respect to the first main surface portion, and [0028] each of the plurality of second protrusions protrudes, toward a side opposite to the second side surface portion, with respect to the second main surface portion.
[6]
[0029] The battery module according to [4] or [5], wherein a cross sectional area of the cooling medium path when viewed in the second direction is larger than a cross sectional area of a space between the plurality of second protrusions when viewed in the third direction.
[0030] The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0031] FIG. **1** is a perspective view showing a configuration of a battery module according to a first embodiment of the present technology.
[0032] FIG. **2** is a perspective view showing an internal configuration of the battery module according to the first embodiment of the present technology.
[0033] FIG. **3** is a perspective view showing a configuration of a unit included in the battery module according to the first embodiment of the present technology.
[0034] FIG. **4** is a perspective view of the unit of FIG. **3** when viewed in a direction of an arrow IV.
[0035] FIG. **5** is a perspective view showing a configuration of each battery cell according to the first embodiment of the present technology.
[0036] FIG. **6** is a cross sectional view of the unit of FIG. **3** when viewed in a direction of arrows of a line VI-VI.

[0037] FIG. **7** is a cross sectional view of the unit of FIG. **3** when viewed in a direction of arrows of a line VII-VII.
[0038] FIG. **8** is a schematic diagram showing a positional relation between a plurality of first protrusions and a plurality of second protrusions according to the first embodiment of the present technology.
[0039] FIG. **9** is a schematic diagram showing a positional relation between a plurality of first protrusions and a plurality of second protrusions according to a comparative example.
[0040] FIG. **10** is a schematic diagram showing a positional relation among the plurality of first protrusions, the plurality of second protrusions, and an electrode assembly according to the first embodiment of the present technology.
[0041] FIG. **11** is a schematic diagram showing a positional relation between a plurality of first protrusions and a plurality of second protrusions according to a second embodiment of the present technology.
[0042] FIG. **12** is a schematic diagram showing a positional relation between a plurality of first protrusions and a plurality of second protrusions according to a third embodiment of the present technology.
[0043] FIG. **13** is a schematic diagram showing a positional relation between a plurality of first protrusions and a plurality of second protrusions according to a fourth embodiment of the present technology.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0044] Hereinafter, embodiments of the present technology will be described. It should be noted that the same or corresponding portions are denoted by the same reference characters, and may not be described repeatedly.
[0045] It should be noted that in the embodiments described below, when reference is made to number, amount, and the like, the scope of the present technology is not necessarily limited to the number, amount, and the like unless otherwise stated particularly. Further, in the embodiments described below, each component is not necessarily essential to the present technology unless otherwise stated particularly. Further, the present technology is not limited to one that necessarily exhibits all the functions and effects stated in the present embodiment.
[0046] It should be noted that in the present specification, the terms “comprise”, “include”, and “have” are open-end terms. That is, when a certain configuration is included, a configuration other than the foregoing configuration may or may not be included.
[0047] Also, in the present specification, when geometric terms and terms representing positional/directional relations are used, for example, when terms such as “parallel”, “orthogonal”, “obliquely at 45°”, “coaxial”, and “along” are used, these terms permit manufacturing errors or slight fluctuations. In the present specification, when terms representing relative positional relations such as “upper side” and “lower side” are used, each of these terms is used to indicate a relative positional relation in one state, and the relative positional relation may be reversed or turned at any angle in accordance with an installation direction of each mechanism (for example, the entire mechanism is reversed upside down).
[0048] In the present specification, the term “battery” is not limited to a lithium ion battery, and may include other batteries such as a nickel-metal hydride battery and a sodium ion battery. In the present specification, the term “electrode” may collectively represent a positive electrode and a negative electrode.
[0049] Further, the “battery module” can be mounted on vehicles such as a hybrid electric vehicle (HEV), a plug-in hybrid electric vehicle (PHEV), and a battery electric vehicle (BEV). It should be noted that the use of the “battery module” is not limited to the use in a vehicle.
[0050] It should be noted that in each of the figures, an X direction is defined as a direction in which a positive electrode terminal and a negative electrode terminal of a battery cell are arranged side by side, a Y direction is defined as a direction in which a plurality of battery cells are stacked,

and a Z direction is defined as a direction in which an upper surface portion and a lower surface portion of a housing of each battery cell face each other. In order to facilitate understanding of the present technology, the size of each configuration in the figures may be illustrated to be changed from its actual size.

First Embodiment

[0051] FIG. **1** is a perspective view showing a configuration of a battery module according to a first embodiment of the present technology. FIG. **2** is a perspective view showing an internal configuration of the battery module according to the first embodiment of the present technology.

[0052] First, an overall structure of a battery module **1** will be described. As shown in FIGS. **1** and **2**, battery module **1** according to the first embodiment of the present technology includes a plurality of units **10**, end plates **400**, restraint members **500**, a duct **600**, a wiring member **700**, and connection terminal portions **800**.

[0053] The plurality of units **10** are arranged side by side in the first direction (Y direction). Six units **10** are arranged side by side in the first direction (Y direction) as the plurality of units **10** according to the present embodiment. It should be noted that the number of the plurality of units **10** is not particularly limited as long as two or more units **10** are included. The number of the plurality of units may be 18, for example.

[0054] The plurality of units **10** are sandwiched between two end plates **400** in the first direction (Y direction). The plurality of units **10** according to the present embodiment are pressed by one end plate **400**A and other end plate **400**B, and are restrained between two end plates **400**A, **400**B.

[0055] End plates **400** are provided at the both ends beside the plurality of units **10** in the first direction (Y direction). Each of end plates **400** is fixed to a base such as a pack case that accommodates battery module **1**. End plate **400** is composed of, for example, aluminum, aluminum alloy, iron, or iron alloy.

[0056] Restraint members **500** are provided on both ends beside the plurality of units **10** and end plates **400** in the X direction. When restraint members **500** are engaged with end plates **400** with compressive force in the first direction (Y direction) being applied to the plurality of units **10** arranged side by side and to end plates **400** and then the compressive force is released, tensile force acts on restraint members **500** that connect two end plates **400**. As a reaction thereto, restraint members **500** press two end plates **400** in directions of bringing them closer to each other. As a result, restraint members **500** restrain the plurality of units **10** in the first direction (the Y direction).

[0057] Each of restraint members **500** includes a plate-shaped portion **510**, a first flange portion **520**, and second flange portions **530**. Restraint member **500** is composed of iron or iron alloy, for example.

[0058] Plate-shaped portion **510** is a member extending in the first direction (Y direction). Plate-shaped portion **510** is provided with a plurality of openings **511**. The plurality of openings **511** are provided at intervals in the first direction (Y direction). Each of openings **511** is constituted of a through hole extending through plate-shaped portion **510** in the X direction.

[0059] First flange portion **520** extends from beside the side surfaces of the plurality of units **10** in the X direction so as to be located over the upper surfaces of the plurality of units **10**. By providing first flange portion **520**, rigidity of restraint member **500** formed to be relatively thin can be secured.

[0060] Second flange portions **530** are connected to both ends of plate-shaped portion **510** in the first direction (Y direction). Second flange portions **530** are fixed to end plates **400**. Second flange portions **530** are fixed to end plates **400** by a known fixing method such as fastening of bolt, for example. Thus, restraint members **500** connect two end plates **400** to each other.

[0061] Duct **600** is configured to permit gas to flow therein. As shown in FIG. **1**, duct **600** extends in the first direction (Y direction). Duct **600** extends at a position overlapping with wiring member **700** when viewed in the Z direction. Duct **600** is disposed between each of the plurality of units **10** and wiring member **700** in the Z direction.

[0062] Wiring member **700** is provided mainly to detect voltage of a battery cell **100** described later. Wiring member **700** is provided at a position facing the plurality of units **10** in the Z direction. Wiring member **700** extends in the Y direction to pass through the central portion of each of the plurality of units **10** in the X direction. Wiring member **700** is electrically connected to the plurality of units **10**. Wiring member **700** is, for example, a flexible printed circuit board.
[0063] Connection terminal portions **800** are arranged on both sides beside the plurality of units **10** arranged side by side in the first direction (Y direction). Connection terminal portions **800** are fixed to end plates **400**. Connection terminal portion **800** has a negative side connection terminal portion **800**A and a positive side connection terminal portion **800**B. Each of connection terminal portions **800** forms a path for electric connection between battery module **1** and a driving source or the like disposed outside battery module **1**.
[0064] Next, a structure of unit **10** will be described. FIG. **3** is a perspective view showing a configuration of the unit included in the battery module according to the first embodiment of the present technology. FIG. **4** is a perspective view of the unit of FIG. **3** when viewed in a direction of an arrow IV. FIG. **5** is a perspective view showing a configuration of each battery cell according to the first embodiment of the present technology.
[0065] As shown in FIGS. **3** to **5**, each of the plurality of units **10** includes a plurality of battery cells **100**, a case **200**, and bus bars **300**.
[0066] Unit **10** includes two or more battery cells **100**. Unit **10** according to the present embodiment includes two battery cells **100** as an even number of battery cells **100**. It should be noted that the number of battery cells **100** included in each of the plurality of units **10** is not particularly limited as long as two or more battery cells **100** are included. Moreover, an odd number of battery cells **100** may be included in each of the plurality of units **10**. The total number of battery cells **100** in battery module **1** is, for example, 12 or 36.
[0067] The plurality of battery cells **100** are arranged side by side in the first direction (Y direction). As shown in FIGS. **1** and **3**, the arrangement direction of the plurality of units **10** is the same as the arrangement direction of the plurality of battery cells **100** in each of the plurality of units **10**.
[0068] As shown in FIG. **5**, battery cell **100** is, for example, a lithium ion battery. Battery cell **100** has a prismatic shape.
[0069] Battery cell **100** according to the present embodiment has electrode terminals **110**, a housing **120**, and a gas-discharge valve **130**.
[0070] Electrode terminals **110** are formed on housing **120**. Electrode terminals **110** have a positive electrode terminal **111** and a negative electrode terminal **112** as two electrode terminals **110** arranged side by side along the X direction.
[0071] Positive electrode terminal **111** and negative electrode terminal **112** are provided to be separated from each other in the X direction. Positive electrode terminal **111** and negative electrode terminal **112** are provided on both sides beside duct **600** and wiring member **700** in the X direction.
[0072] Housing **120** has a rectangular parallelepiped shape, and forms an external appearance of battery cell **100**. An electrode assembly **140** described below and an electrolyte solution described below are accommodated in housing **120**.
[0073] Housing **120** has an upper surface portion **121**, a lower surface portion **122**, a first side surface portion **123**, a second side surface portion **124**, and third side surface portions **125**.
[0074] Upper surface portion **121** is a flat surface orthogonal to the Z direction. Electrode terminals **110** are disposed on upper surface portion **121**. Upper surface portion **121** is covered with a below-described upper wall portion **260** of case **200**. Lower surface portion **122** faces upper surface portion **121** along the Z direction.
[0075] Each of first side surface portion **123** and second side surface portion **124** is constituted of a flat surface orthogonal to the Y direction. First side surface portion **123** and second side surface portion **124** face each other in the first direction (Y direction). Each of first side surface portion **123**

and second side surface portion **124** has the largest area among the areas of the plurality of side surfaces of housing **120**. Each of first side surface portion **123** and second side surface portion **124** has a rectangular shape when viewed in the Y direction. Each of first side surface **123** and second side surface **124** has a rectangular shape in which the X direction corresponds to the long-side direction and the Z direction corresponds to the short-side direction when viewed in the Y direction.

[0076] The pair of third side surface portions **125** are provided in battery cell **100**. The pair of third side surface portions **125** are arranged side by side in the X direction. Each of the pair of third side surface portions **125** connects the end portions of first side surface portion **123** and second side surface portion **124**. The pair of third side surface portions **125** are disposed to face below-described third wall portions **230**, **240** of case **200** in the X direction.

[0077] The plurality of battery cells **100** are stacked such that first side surface portions **123** of battery cells **100**, **100** adjacent to each other in the Y direction face each other and second side surface portions **124** of battery cells **100**, **100** adjacent to each other in the Y direction face each other. Thus, positive electrode terminals **111** and negative electrode terminals **112** are alternately arranged in the Y direction in which the plurality of battery cells **100** are stacked.

[0078] Gas-discharge valve **130** is provided in upper surface portion **121**. When internal pressure of housing **120** becomes more than or equal to a predetermined value due to gas generated inside housing **120**, gas-discharge valve **130** discharges the gas to the outside of housing **120**. The gas from gas-discharge valve **130** flows through duct **600** in FIG. **1** and is discharged to the outside of battery module **1**.

[0079] As shown in FIGS. **3** and **4**, case **200** has an external appearance with a rectangular parallelepiped shape. Case **200** accommodates at least two battery cells **100** of the plurality of battery cells **100**. In the present embodiment, case **200** accommodates two battery cells **100**.

[0080] Case **200** is composed of, for example, a resin such as polypropylene. Case **200** is formed by, for example, injection molding. As shown in FIGS. **1** to **2**, case **200** is compressed in the first direction (Y direction) by restraint members **500** when assembled to battery module **1**.

[0081] Each of the plurality of bus bars **300** is composed of an electric conductor. The plurality of bus bars **300** electrically connect the plurality of battery cells **100** together.

[0082] The plurality of bus bars **300** include a first bus bar **310**, a second bus bar **320**, and a third bus bar **330**. First bus bar **310** electrically connects electrode terminals **110** of battery cells **100** accommodated in one unit **10**. Each of second bus bar **320** and third bus bar **330** electrically connects electrode terminals **110** of battery cell **100** of one unit **10** and battery cell **100** of another unit **10** adjacent thereto.

[0083] Next, a detailed structure of case **200** will be described. FIG. **6** is a cross sectional view of the unit of FIG. **3** when viewed in a direction of arrows of a line VI-VI. FIG. **7** is a cross sectional view of the unit of FIG. **3** when viewed in a direction of arrows of a line VII-VII.

[0084] As shown in FIGS. **3**, **4**, **6** and **7**, case **200** is constituted of a single member. Case **200** has a first wall portion **210**, a second wall portion **220**, a pair of third wall portions **230**, **240**, a fourth wall portion **250**, and an upper wall portion **260**.

[0085] First wall portion **210** is located at a position other than an end portion of case **200** in the first direction (Y direction). First wall portion **210** is located substantially at the center of case **200** in the first direction (Y direction). First wall portion **210** is located between two battery cells **101**, **102** to insulate two battery cells **101**, **102** from each other. First wall portion **210** is connected to the pair of third wall portions **230**, **240** and upper wall portion **260**.

[0086] Second wall portion **220** is located at an end portion of case **200** on one side in the first direction (Y direction).

[0087] The pair of third wall portions **230**, **240** are arranged side by side in the X direction. Each of the pair of third wall portions **230**, **240** connects second wall portion **220** and fourth wall portion **250**.

[0088] One third wall portion **230** is adjacent to one restraint member **500**. One third wall portion **230** connects first wall portion **210** and second wall portion **220** in the first direction (Y direction).
[0089] As shown in FIGS. **3** and **7**, one third wall portion **230** is provided with a first through hole **231**. First through hole **231** extends through one third wall portion **230** and communicates with a cooling medium path **201** described later. First through hole **231** is provided at a portion protruding to the one restraint member **500** side with respect to one third wall portion **230**. The portion provided with first through hole **231** is inserted in opening **511** of restraint member **500**.
[0090] Other third wall portion **240** faces one third wall portion **230** with the plurality of battery cells **100** being interposed therebetween in the X direction. Other third wall portion **240** connects first wall portion **210** and second wall portion **220** in the first direction (Y direction).
[0091] As shown in FIGS. **4** and **7**, other third wall portion **240** is provided with a second through hole **241**. Second through hole **241** extends through other third wall portion **240** and communicates with cooling medium path **201** described later. Second through hole **241** is provided at a portion protruding to the other restraint member **500** side with respect to other third wall portion **240**. The portion provided with second through hole **241** is inserted in opening **511** of restraint member **500**.
[0092] Fourth wall portion **250** is arranged side by side with and face second wall portion **220** in the first direction (Y direction) with first wall portion **210** being interposed therebetween. Fourth wall portion **250** is located at an end portion of case **200** on the other side in the first direction (Y direction).
[0093] As shown in FIGS. **3** and **4**, upper wall portion **260** includes first partition walls **261**, second partition walls **262**, and a plurality of holes **263**. Two first partition walls **261** are formed in parallel at the central portion in the X direction so as to extend in the Y direction. Second partition walls **262** are provided on both sides with respect to first partition walls **261** in the X direction, and partitions installation locations for bus bars **300**. The plurality of holes **263** are provided to expose electrode terminals **110** and gas-discharge valves **130** from upper wall portion **260**. The plurality of holes **263** communicate with gas-discharge valves **130**.
[0094] As shown in FIG. **6**, case **200** is not provided with a bottom wall portion facing lower surface portions **122** of battery cells **100**. Therefore, battery cells **100** can be accommodated with battery cells **100** being covered with case **200** from above. Unit **10** can stand by itself in a state in which case **200** is placed with upper wall portion **260** facing upward.
[0095] Next, a structure to support battery cells **100** by case **200** will be described. FIG. **8** is a schematic diagram showing a positional relation between a plurality of first protrusions and a plurality of second protrusions according to the first embodiment of the present technology.
[0096] As shown in FIGS. **6** to **8**, case **200** supports two battery cells **100** in at least the first direction (Y direction). Case **200** supports two battery cells **100** in the Y direction and the X direction.
[0097] Case **200** can sandwich two battery cells **100** in the first direction (Y direction) in a state in which no load is applied from another constituent member in the first direction (Y direction). Case **200** sandwiches battery cells **100** in the first direction (Y direction) using first wall portion **210**, second wall portion **220**, and fourth wall portion **250**.
[0098] One battery cell **101** is sandwiched between first wall portion **210** and second wall portion **220**. On the other hand, other battery cell **102** is sandwiched between first wall portion **210** and fourth wall portion **250**. In the Y direction, each of a clearance between first wall portion **210** and second wall portion **220** and a clearance between first wall portion **210** and fourth wall portion **250** is the same as or narrower than the width of battery cell **100**.
[0099] Each of the plurality of cases **200** includes a first supporting portion **211** and a second supporting portion **221**. First supporting portion **211** is provided at first wall portion **210**. Second supporting portion **221** is provided at second wall portion **220**. First supporting portion **211** and second supporting portion **221** are portions overlapping at least with battery cell **100** in the first direction (Y direction). First supporting portion **211** and second supporting portion **221** sandwich

one battery cell **101** in the first direction (Y direction).
[0100] It should be noted that the first supporting portion may constitute a part of the first wall portion, or the first supporting portion may constitute a whole of the first wall portion. Further, the second supporting portion may constitute a part of the second wall portion, or the second supporting portion may constitute a whole of the second wall portion.
[0101] First supporting portion **211** includes thin portions **212**, a first main surface portion **213**, and a plurality of first protrusions **270**.
[0102] Each of thin portions **212** is a portion of first wall portion **210** that has a thickness thinner than each of those of the other portions of first wall portion **210** in the Y direction. Thin portion **212** is provided to form a large cross sectional area of cooling medium path **201** described later.
[0103] First main surface portion **213** is located on the first side surface portion **123** side of one battery cell **101** in the first direction (Y direction). First main surface portion **213** mainly constitutes an outer surface of thin portion **212** of first supporting portion **211**.
[0104] Each of the plurality of first protrusions **270** protrudes with respect to first main surface portion **213** in the first direction (Y direction). Each of the plurality of first protrusions **270** protrudes toward first side surface portion **123** with respect to first main surface portion **213**.
[0105] The plurality of first protrusions **270** are arranged at intervals in the Z direction. In the present embodiment, the plurality of first protrusions **270** are constituted of three first protrusions **271**, **272**, **273**. It should be noted that the number of the plurality of first protrusions **270** is not limited to three.
[0106] Each of the plurality of first protrusions **270** extends in the form of a strip along a second direction orthogonal to the first direction (Y direction). Each of the plurality of first protrusions **270** in the present embodiment extends in the form of a strip along the X direction serving as the second direction.
[0107] Second supporting portion **221** has a second main surface portion **222** and a plurality of second protrusions **280**.
[0108] Second main surface portion **222** is located on the second side surface portion **124** side of one battery cell **101** in the first direction (Y direction).
[0109] Each of the plurality of second protrusions **280** protrudes with respect to second main surface portion **222** in the first direction (Y direction). Each of the plurality of second protrusions **280** protrudes, toward a side opposite to second side surface portion **124**, with respect to second main surface portion **222**. In the present embodiment, the plurality of second protrusions **280** are constituted of three second protrusions **281**, **282**, **283**. It should be noted that the number of the plurality of second protrusions **280** is not limited to three.
[0110] Each of the plurality of second protrusions **280** extends in the form of a strip along a third direction different from the second direction (X direction) when viewed in the first direction (Y direction). Each of the plurality of second protrusions **280** in the present embodiment extends in the form of a strip along the Z direction serving as the third direction.
[0111] The second direction and the third direction are orthogonal to each other. In the present embodiment, since the second direction is the X direction and the third direction is the Z direction, the second direction and the third direction are orthogonal to each other.
[0112] Cooling medium paths **201** along the second direction (X direction) are formed between the plurality of first protrusions **270**. Thus, battery cells **100** accommodated in case **200** can be cooled by introducing cooling air from first through hole **231** or second through hole **241** so as to allow the cooling air to flow in cooling medium paths **201**.
[0113] As shown in FIGS. **6** and **7**, a cross sectional area S**1** of each cooling medium path **201** when viewed in the second direction (X direction) is larger than a cross sectional area S**2** of each space between the plurality of second protrusions **280** when viewed in the third direction (Z direction). Thus, a large amount of cooling medium can be introduced into cooling medium path **201** as compared with the space between the plurality of second protrusions **280**.

[0114] A width W**1** of each of the plurality of first protrusions **270** in the third direction (Z direction) when viewed in the second direction (X direction) is narrower than a width W**2** of each of the plurality of second protrusions **280** in the second direction (X direction) when viewed in the third direction (Z direction). Thus, cross sectional area S**1** of cooling medium path **201** can be secured to be larger than cross sectional area S**2** of the space between the plurality of second protrusions **280**.
[0115] As described above, the plurality of first protrusions **270** have: a function as a load path to transmit a pressing force to battery cell **100** when supporting battery cell **100** by case **200**; and a function of forming cooling medium path **201** to cool battery cell **100**. The plurality of second protrusions **280** have a function as a load path to transmit a pressing force to battery cell **100** when supporting battery cell **100** by case **200**.
[0116] As with first wall portion **210** and second wall portion **220** that sandwich one battery cell **101**, first wall portion **210** and fourth wall portion **250** that sandwich other battery cell **102** are also each provided with a plurality of protrusions.
[0117] Here, a battery module according to a comparative example will be described. Since the battery module according to the comparative example is different from battery module **1** according to the first embodiment of the present technology in terms of the configurations of the plurality of first protrusions in the first supporting portion and the plurality of second protrusions in the second supporting portion, the same configurations as those of battery module **1** according to the first embodiment of the present technology will not be described repeatedly.
[0118] FIG. **9** is a schematic diagram showing a positional relation between the plurality of first protrusions and the plurality of second protrusions according to the comparative example. As shown in FIG. **9**, battery module **9** according to the comparative example includes battery cells **900** and a case. The case includes a first supporting portion and a second supporting portion. Each of a plurality of first protrusions **970** protrudes with respect to a first main surface portion of the first supporting portion. Each of a plurality of second protrusions **980** protrudes with respect to a second main surface portion of the second supporting portion.
[0119] Each of the plurality of first protrusions **970** extends in the form of a strip along the second direction (X direction). As with each of the plurality of first protrusions **970**, each of the plurality of second protrusions **980** extends in the form of a strip along the second direction (X direction).
[0120] The plurality of first protrusions **970** and the plurality of second protrusions **980** are disposed to overlap when viewed in the first direction (Y direction). Battery cell **900** is pressed from both sides beside positions at which the plurality of first protrusions **970** and the plurality of second protrusions **980** overlap in the first direction (Y direction). When battery cell **900** is compressed by applying pressing forces of the first supporting portion and the second supporting portion from the both sides beside battery cell **900** in one cross section (XY plane) along the first direction (Y direction), a flow path for electrolyte solution in battery cell **900** becomes narrow.
[0121] The electrolyte solution accommodated in battery cell **900** according to the comparative example is moved in a direction (DR91 direction) along the X direction at a region at which the plurality of first protrusions **970** and the plurality of second protrusions **980** do not overlap in the first direction (Y direction). However, since the plurality of first protrusions **970** and the plurality of second protrusions **980** overlap in the first direction (Y direction) to narrow the flow path for electrolyte solution in a direction (DR92 direction) along the Z direction, the electrolyte solution is less likely to be moved.
[0122] On the other hand, as shown in FIG. **8**, in battery cell **100** according to the first embodiment, a region at which the plurality of first protrusions **270** and the plurality of second protrusions **280** overlap in the first direction (Y direction) is reduced as compared with battery cell **900** according to the comparative example. Therefore, in one cross section (XY plane) along the first direction (Y direction), a region to which the pressing forces of first supporting portion **211** and second supporting portion **221** are applied from both sides beside battery cell **100** is reduced.

Thus, the pressing forces to battery cell **100** are distributed, thereby reducing a region at which the flow path for electrolyte solution is narrow in battery cell **100** when battery cell **100** is compressed. As a result, a region at which the electrolyte solution is less likely to be moved in battery cell **100** can be reduced.

[0123] Since the flow path for electrolyte solution is secured, the electrolyte solution accommodated in battery cell **100** according to the first embodiment is likely to be moved in a direction (DR11 direction) along the X direction and a direction (DR12 direction) along the Z direction at the region at which the plurality of first protrusions **270** and the plurality of second protrusions **280** do not overlap in the first direction (Y direction).

[0124] FIG. **10** is a schematic diagram showing a positional relation among the plurality of first protrusions, the plurality of second protrusions, and the electrode assembly according to the first embodiment of the present technology.

[0125] As shown in FIG. **10**, electrode assembly **140** is disposed inside battery cell **100**. Electrode assembly **140** is a wound type electrode assembly. Electrode assembly **140** is wound with respect to the X direction serving as an axial center. Curved portions **141** are formed at end portions at each of which electrode assembly **140** is curved. Curved portion **141** has a curved shape with an imaginary center C serving as a base point.

[0126] The plurality of first protrusions **270** and the plurality of second protrusions **280** are provided at positions not overlapping with curved portions **141** of electrode assembly **140** in the first direction (Y direction). The plurality of first protrusions **270** and the plurality of second protrusions **280** are provided within a range of a length L**1** that connects respective imaginary centers C of curved portions **141** located at both ends in Z direction. Thus, a pressing force resulting from the supporting by case **200** is suppressed from being applied to each of curved portions **141** of electrode assembly **140**. Since the pressing force of case **200** can be applied to a flat portion of electrode assembly **140**, electrode assembly **140** can be securely restrained and the electrolyte solution can be facilitated to flow.

[0127] In battery module **1** according to the first embodiment of the present technology, the plurality of first protrusions **270** each in the form of a strip and each extending in the second direction (X direction) orthogonal to the stacking direction of battery cells **100** are provided at first supporting portion **211** that supports one surface (first side surface portion **123**) of battery cell **100**. Further, the plurality of second protrusions **280** each in the form of a strip and each extending in the third direction (Z direction) different from the second direction are provided at second supporting portion **221** that supports the other surface (second side surface portion **124**) of battery cell **100**. Thus, as compared with a case where the first protrusions and the second protrusions extend in the same direction and overlap in the stacking direction of the battery cells, it is possible to reduce a region at which the plurality of first protrusions **270** and the plurality of second protrusions **280** overlap to sandwich battery cell **100** when viewed in the stacking direction of battery cells **100**. Since the pressing forces with which battery cell **100** is sandwiched are distributed, a flow path for electrolyte solution in battery cell **100** can be secured. As a result, the electrolyte solution can be facilitated to flow in battery cell **100**, thereby providing battery module **1** having high reliability.

[0128] In battery module **1** according to the first embodiment of the present technology, since the second direction (X direction) and the third direction (Z direction) are orthogonal to each other, the electrolyte solution can be facilitated to be moved to the upper, lower, left, and right corners of battery cell **100** while uniformly supporting battery cell **100** by first supporting portion **211** and second supporting portion **221**.

[0129] In battery module **1** according to the first embodiment of the present technology, since each of the plurality of cases **200** that each form unit **10** including battery cells **100** has first supporting portion **211** and second supporting portion **221**, first supporting portion **211** and second supporting portion **221** can be formed in one piece, thereby reducing the number of components of battery module **1**.

[0130] In battery module **1** according to the first embodiment of the present technology, cooling medium path **201** along the second direction (X direction) is formed between the plurality of first protrusions **270**, and the through holes (first through hole **231** and second through hole **241**) communicating with cooling medium path **201** are provided, thereby efficiently cooling battery cell **100**.

[0131] In battery module **1** according to the first embodiment of the present technology, since each of the plurality of first protrusions **270** protrudes toward first side surface portion **123** with respect to first main surface portion **213** and each of the plurality of second protrusions **280** protrudes, toward the side opposite to second side surface portion **124**, with respect to second main surface portion **222**, the plurality of second protrusions **280** can be disposed at the outer surface of case **200**. When case **200** is formed in one piece by resin molding, each configuration of case **200** is a resin-molded portion. In the case where case **200** is formed in one piece by resin molding, a mold for resin molding to form the plurality of second protrusions **280** is readily disposed at the time of manufacturing, with the result that the plurality of second protrusions **280** constituting parts of the resin-molded portions can be readily formed.

[0132] In battery module **1** according to the first embodiment of the present technology, since cross sectional area S**1** of cooling medium path **201** when viewed in the second direction (X direction) is larger than cross sectional area S**2** of the space between the plurality of second protrusions **280** when viewed in the third direction (Z direction), a high capacity of cooling air can flow in cooling medium path **201**, thereby efficiently cooling battery cell **100** while battery cell **100** is supported by first supporting portion **211** and second supporting portion **221**.

[0133] Hereinafter, each of battery modules according to second to fourth embodiments of the present technology will be described. In each of the battery modules according to the second to fourth embodiments of the present technology, since the configurations of the plurality of first protrusions in the first supporting portion and the plurality of second protrusions in the second supporting portion are different from those of battery module **1** according to the first embodiment of the present technology, the same configurations as those of battery module **1** according to the first embodiment of the present technology will not be described repeatedly.

Second Embodiment

[0134] FIG. **11** is a schematic diagram showing a positional relation between the plurality of first protrusions and the plurality of second protrusions according to the second embodiment of the present technology.

[0135] As shown in FIG. **11**, a battery module **1**A according to the present embodiment includes battery cells **100**, a first supporting portion, and a second supporting portion. Each of a plurality of first protrusions **270**A protrudes with respect to a first main surface portion of the first supporting portion. Each of a plurality of second protrusions **280**A protrudes with respect to a second main surface portion of the second supporting portion.

[0136] Each of the plurality of first protrusions **270**A extends in the form of a strip along the second direction (X direction). Each of the plurality of second protrusions **280**A extends in the form of a strip so as not to overlap with the plurality of first protrusions **270**A when viewed in the first direction (Y direction). Each of the plurality of second protrusions **280**A extends in the form of a strip in the second direction (X direction) so as not to overlap with the plurality of first protrusions **270**A when viewed in the first direction (Y direction).

[0137] In battery cell **100** according to the present embodiment, in one cross section (XY plane) along the first direction (Y direction), there is no region to which the pressing forces of the first supporting portion and the second supporting portion are applied from both sides beside battery cell **100**. Thus, a flow path for electrolyte solution in battery cell **100** can be secured. The electrolyte solution is likely to be moved in a direction (DR21 direction) along the X direction and a direction (DR22 direction) along the Z direction at the region at which the plurality of first protrusions **270** and the plurality of second protrusions **280** do not overlap in the first direction (Y

direction).
[0138] In battery module **1**A according to the second embodiment of the present technology, the plurality of first protrusions **270**A each in the form of a strip and each extending in the second direction orthogonal to the stacking direction of battery cells **100** are provided at the first supporting portion that supports one surface (first side surface portion) of battery cell **100**, and the plurality of second protrusions **280**A each in the form of a strip and each not overlapping with the plurality of first protrusions **270**A when viewed in the first direction are provided at the second supporting portion that supports the other surface (second side surface portion) of battery cell **100**. Thus, since the pressing forces with which battery cell **100** is sandwiched are distributed, a flow path for electrolyte solution in battery cell **100** can be secured. As a result, the electrolyte solution can be facilitated to flow in battery cell **100**, thereby providing battery module **1**A having high reliability.
[0139] In battery module **1**A according to the second embodiment of the present technology, since battery cell **100** is alternately pressed oppositely in the Y direction when viewed along the Z direction, battery cell **100** can be securely positioned with respect to the case in the Z direction when battery cell **100** is accommodated in and supported by the case.
Third Embodiment
[0140] FIG. **12** is a schematic diagram showing a positional relation between the plurality of first protrusions and the plurality of second protrusions according to the third embodiment of the present technology.
[0141] As shown in FIG. **12**, a battery module **1**B according to the present embodiment includes battery cells **100**, a first supporting portion, and a second supporting portion. Each of a plurality of first protrusions **270**B protrudes with respect to a first main surface portion of the first supporting portion. Each of a plurality of second protrusions **280**B protrudes with respect to a second main surface portion of the second supporting portion. Each of the plurality of second protrusions **280**B extends to be inclined with respect to the X direction, rather than extending to be orthogonal to the X direction.
[0142] The electrolyte solution is likely to be moved in a direction (DR31 direction) along the X direction and a direction (DR32 direction) inclined with respect to the X direction at a region at which the plurality of first protrusions **270**B and the plurality of second protrusions **280**B do not overlap in the first direction (Y direction).
[0143] In battery module **1**B according to the third embodiment of the present technology, since each of the plurality of second protrusions **280**B is disposed in any direction oblique to the X direction, the electrolyte solution can be facilitated to be moved to a desired position.
Fourth Embodiment
[0144] FIG. **13** is a schematic diagram showing a positional relation between the plurality of first protrusions and the plurality of second protrusions according to the fourth embodiment of the present technology.
[0145] As shown in FIG. **13**, a battery module **1**C according to the present embodiment includes battery cells **100**, a first supporting portion, and a second supporting portion. Each of a plurality of first protrusions **270**C protrudes with respect to a first main surface portion of the first supporting portion. Each of a plurality of second protrusions **280**C protrudes with respect to a second main surface portion of the second supporting portion. The plurality of second protrusions **280**C are not orthogonal to the X direction, and three of the plurality of second protrusions **280**C on the left side extend to be inclined in a direction different from a direction in which three of the plurality of second protrusions **280**C on the right side extend to be inclined. The plurality of second protrusions **280**C are disposed with a clearance being provided at the central portion of battery cell **100** in the X direction.
[0146] The electrolyte solution is likely to be moved in a direction (DR41 direction) along the X direction and a direction (DR42 direction) inclined with respect to the X direction at a region at

which the plurality of first protrusions **270**C and the plurality of second protrusions **280**C do not overlap in the first direction (Y direction).
[0147] In battery module **1**C according to the fourth embodiment of the present technology, since a pressing force can be avoided from being excessively applied to battery cell **100** at its central portion at which electrode assembly **140** is likely to be expanded, the electrolyte solution can be facilitated to be moved in battery cell **100**.
[0148] It should be noted that each of the first protrusions may not necessarily extend in the X direction and may extend in any direction in the XZ plane. Further, the electrode assembly disposed in the battery cell is not limited to the wound type electrode assembly, and may be a stacked type electrode assembly.
[0149] It should be noted that when at least either of the number of the first protrusions and the number of the second protrusions is one, a pressing force applied from the case to the battery cell is likely to be concentrated. Further, even when one protrusion extends on the XZ plane with the direction of the one protrusion being changed, a region at which the first protrusion(s) and the second protrusion(s) overlap is increased. Therefore, since the plurality of the first protrusions and the plurality of second protrusions are provided in the present embodiment, the region at which the first protrusions and the second protrusions overlap can be reduced as compared with the case where at least either of the number of the first protrusions and the number of the second protrusions is one. As a result, the electrolyte solution in battery cell **100** is facilitated to be moved.
[0150] Further, the plurality of second protrusions each extending in the form of a strip so as not to overlap with the plurality of first protrusions when viewed in the first direction and the plurality of second protrusions each extending in the form of a strip along the third direction different from the second direction provide a function of distributing the pressing force on the battery cell so as to facilitate movement of the electrolyte solution in the battery cell.
[0151] Although the embodiments of the present invention have been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation. The scope of the present invention is defined by the terms of the claims, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

Claims

1. A battery module comprising: a plurality of battery cells arranged side by side in a first direction and each having a prismatic shape; and a first supporting portion and a second supporting portion that sandwich one battery cell of the plurality of battery cells in the first direction, wherein the battery cell includes a first side surface portion and a second side surface portion facing each other in the first direction, the first supporting portion includes a first main surface portion located on the first side surface portion side of the battery cell in the first direction, and a plurality of first protrusions each protruding with respect to the first main surface portion in the first direction and each extending in a form of a strip along a second direction orthogonal to the first direction, the second supporting portion includes a second main surface portion located on the second side surface portion side of the battery cell in the first direction, and a plurality of second protrusions each protruding with respect to the second main surface portion in the first direction, and when viewed in the first direction, each of the plurality of second protrusions extends in a form of a strip so as not to overlap with the plurality of first protrusions or extends in a form of a strip along a third direction different from the second direction.
2. The battery module according to claim 1, wherein the second direction and the third direction are orthogonal to each other.
3. The battery module according to claim 1, further comprising a plurality of cases, each of the plurality of cases accommodating at least two battery cells of the plurality of battery cells, each of

the plurality of cases supporting the at least two battery cells in at least the first direction, each of the plurality of cases forming a unit including the at least two battery cells, wherein each of the plurality of cases includes the first supporting portion and the second supporting portion.

4. The battery module according to claim 2, further comprising a plurality of cases, each of the plurality of cases accommodating at least two battery cells of the plurality of battery cells, each of the plurality of cases supporting the at least two battery cells in at least the first direction, each of the plurality of cases forming a unit including the at least two battery cells, wherein each of the plurality of cases includes the first supporting portion and the second supporting portion.

5. The battery module according to claim 3, wherein each of the cases has a first wall portion located at a position other than an end portion of the case in the first direction, a second wall portion located at the end portion of the case in the first direction, and a third wall portion that connects the first wall portion and the second wall portion in the first direction, the first supporting portion is provided at the first wall portion and the second supporting portion is provided at the second wall portion, and a cooling medium path along the second direction is formed between the plurality of first protrusions, and a through hole is provided to extend through the third wall portion and communicate with the cooling medium path.

6. The battery module according to claim 4, wherein each of the cases has a first wall portion located at a position other than an end portion of the case in the first direction, a second wall portion located at the end portion of the case in the first direction, and a third wall portion that connects the first wall portion and the second wall portion in the first direction, the first supporting portion is provided at the first wall portion and the second supporting portion is provided at the second wall portion, and a cooling medium path along the second direction is formed between the plurality of first protrusions, and a through hole is provided to extend through the third wall portion and communicate with the cooling medium path.

7. The battery module according to claim 5, wherein each of the plurality of first protrusions protrudes toward the first side surface portion with respect to the first main surface portion, and each of the plurality of second protrusions protrudes, toward a side opposite to the second side surface portion, with respect to the second main surface portion.

8. The battery module according to claim 6, wherein each of the plurality of first protrusions protrudes toward the first side surface portion with respect to the first main surface portion, and each of the plurality of second protrusions protrudes, toward a side opposite to the second side surface portion, with respect to the second main surface portion.

9. The battery module according to claim 5, wherein a cross sectional area of the cooling medium path when viewed in the second direction is larger than a cross sectional area of a space between the plurality of second protrusions when viewed in the third direction.

10. The battery module according to claim 6, wherein a cross sectional area of the cooling medium path when viewed in the second direction is larger than a cross sectional area of a space between the plurality of second protrusions when viewed in the third direction.