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POWER MODULE

Abstract

A power module includes an insulating board, a transformer and a first shielding layer. The insulating board includes a flat plate portion. The transformer includes a magnetic core and a first winding wound on the magnetic core, where the first winding includes a first part and a second part connected electrically, where the first part is located on one side of the insulating board away from the magnetic core, and the second part is set within the insulating board. The first shielding layer is set at least on one side of the insulating board facing towards the magnetic core. In a first reference plane parallel to the flat plate portion, a projection of the magnetic core is located in a projection range of the first shielding layer.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation-in-part application of U.S. application Ser. No. 18/818,606, filed on Aug. 29, 2024 entitled "POWER MODULE", which claims priority to Chinese Patent Application No. 202311115258.1, filed on Aug. 30, 2023. This application further claims priority to Chinese Patent Application No. 202520202924.3, filed on Feb. 8, 2025. The disclosures of the aforementioned applications are hereby incorporated by reference in their entireties.

TECHNICAL FIELD
[0002] The present application relates to the field of electrical equipment technologies and, in particular, to a power module.
BACKGROUND
[0003] A power module is a module that combines multiple electronic devices according to certain functions, is mainly used to control power output and electric energy conversion in circuits, and is widely used in various electronic devices.
[0004] In the solutions of related technologies, the power module includes a shell, and a transformer and a voltage power device set inside the shell, the shell is provided with an insulating board therein, the transformer includes a magnetic core, a first winding and a second winding. The first winding and the second winding are respectively connected to the corresponding voltage power devices. At least two of the magnetic core, the first winding, and the second winding are arranged on an insulating board, and insulation is achieved between the magnetic core, the first winding, and the second winding through the insulating board.
[0005] However, in technical solutions of the related art, air among the magnetic core and the first and second windings will generate a large electric field. When there are sharp burrs on the edge of the magnetic core, discharge may occur, thereby affecting the insulation life.
SUMMARY
[0006] In order to overcome the above defects under the relevant technologies, the purpose of the present application is to provide a power module that can improve an efficiency of a transformer in the power module. The present application is also beneficial for reducing the electric-field-strength in the air around the magnetic core, prolonging the insulation life, and improving the reliability of the product.
[0007] The present application provides a power module, including: [0008] a first side plate, a second side plate, and an insulating board; [0009] the insulating board including a flat plate portion, at least one protrusion portions, and at least one connecting bridges, the flat plate portion being parallel to a plane formed by a first direction and a second direction; at least one of the protrusion portion and the connecting bridge protruding along a third direction to form an insulation cavity; the insulating board, the first side plate, and the second side plate in combination forming a first accommodating space and a second accommodating space along the third direction; the first accommodating space being provided with a first power device, and the second accommodating space being provided with a second power device; and [0010] a transformer,

including a magnetic core and a winding wound on the magnetic core, the winding including a first winding and a second winding, at least part of the magnetic core being set within the insulation cavity or the connecting bridge; the first winding being electrically connected to the first power device, and the second winding being electrically connected to the second power device; [0011] where the first direction, the second direction, and the third direction are perpendicular to each other.

[0012] In the present application, since the at least part of the magnetic core is set within the insulation cavity or the connecting bridge, the flat plate portion will not penetrate through an air gap of the magnetic core, thus facilitating a control of a size of the air gap of the magnetic core and is beneficial for improving an efficiency of the transformer in the power module; in addition, the protrusion portion or connecting bridge set on the flat plate portion enables the insulating board to form a bending structure, which is beneficial for improving an overall strength of the insulating board.

[0013] The present application further provides a power module, including: [0014] an insulating board, comprising a flat plate portion; [0015] a transformer, comprising a magnetic core and a first winding wound on the magnetic core, wherein the first winding comprises a first part and a second part connected electrically, wherein the first part is located on one side of the insulating board away from the magnetic core, and the second part is set within the insulating board; [0016] a first shielding layer which is set at least on one side of the insulating board facing towards the magnetic core; [0017] where in a first reference plane parallel to the flat plate portion, a projection of the magnetic core is located in a projection range of the first shielding layer.

[0018] The present application sets the first shielding layer on the side of the insulating board facing towards the magnetic core, and the projection of the magnetic core is located within the projection range of the first shielding layer, so that the first shielding layer can be used to reduce the electric-field-strength in the air around the magnetic core, prolong the insulation life, and improve the reliability of the product.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0019] In order to explain the embodiments of the present application more clearly, the drawings needed to be used in the embodiments will be introduced briefly in the following. Obviously, the drawings in the following description are some embodiments of the present application. For those skilled in the art, other drawings can be obtained from these drawings without paying creative labor.

[0020] FIG. **1** is an external schematic diagram of a power module provided by an embodiment of the present application.

[0021] FIG. **2** is a structural diagram of a power module provided by an embodiment of the present application.

[0022] FIG. **3** is a structural diagram of an insulating board provided by an embodiment of the present application.

[0023] FIG. **4** is a structural diagram of an insulating board provided by another embodiment of the present application.

[0024] FIG. **5** is a structural diagram of a transformer provided by an embodiment of the present application.

[0025] FIG. **6** is a structural diagram of a transformer provided by another embodiment of the present application.

[0026] FIG. **7** is a schematic diagram of a connection structure of a transformer and an insulating board provided by an embodiment of the present application.

[0027] FIG. **8** is a schematic diagram of a connection structure of a transformer and an insulating board provided by another embodiment of the present application.
[0028] FIG. **9** is a schematic diagram of a connection structure of a transformer and an insulating board provided by still another embodiment of the present application.
[0029] FIG. **10** is a schematic diagram of a connection structure of a transformer and an insulating board provided by yet another embodiment of the present application.
[0030] FIG. **11** is a schematic diagram of a connection structure of a transformer and an insulating board provided by yet another embodiment of the present application.
[0031] FIG. **12** is a schematic diagram of a connection structure of a transformer and an insulating board provided by yet another embodiment of the present application.
[0032] FIG. **13** is a schematic diagram of a connection structure of a transformer and an insulating board provided by yet another embodiment of the present application.
[0033] FIG. **14** is a schematic diagram of a connection structure of a transformer and an insulating board provided by yet another embodiment of the present application.
[0034] FIG. **15** is a structural diagram of a power module provided by another embodiment of the present application.
[0035] FIG. **16** is a structural diagram of a power module provided by still another embodiment of the present application.
[0036] FIG. **17** is a structural diagram of a transformer provided by yet another embodiment of the present application.
[0037] FIG. **18** is a schematic diagram of a connection structure of a transformer and an insulating board provided by yet another embodiment of the present application.
[0038] FIG. **19** is a structural diagram of a magnetic core provided by yet another embodiment of the present application.
[0039] FIG. **20** is a structural diagram of a power module provided by an embodiment of the present application.
[0040] FIG. **21** is a side view of the FIG. **20**.
[0041] FIG. **22** is an A-A sectional view of the FIG. **21**.
[0042] FIG. **23** is a B-B sectional view of the FIG. **21**.
[0043] FIG. **24** is a structural diagram of a power module provided by another embodiment of the present application.
[0044] FIG. **25** is a side view of the FIG. **24**.
[0045] FIG. **26** is an A-A sectional view of the FIG. **25**.
[0046] FIG. **27** is a B-B sectional view of the FIG. **25**.
[0047] FIG. **28** is a structural diagram of a power module provided by a still another embodiment of the present application.
[0048] FIG. **29** is a side view of the FIG. **28**.
[0049] FIG. **30** is an A-A sectional view of the FIG. **29**.
[0050] FIG. **31** is a B-B sectional view of the FIG. **29**.
[0051] FIG. **32** is a structural diagram of a power module provided by a yet another embodiment of the present application.
[0052] FIG. **33** is a side view of the FIG. **32**.
[0053] FIG. **34** is an A-A sectional view of the FIG. **33**.
[0054] FIG. **35** is a B-B sectional view of the FIG. **33**.

REFERENCE SIGNS

[0055] **11**—First accommodating space; **12**—Second accommodating space; **13**—First power device; **14**—Second power device; **15**—Cover plate; **16**—Fan; [0056] **100**—Insulating board; **101**—First side plate; **102**—Second side plate; **110**—Flat plate section; **120**—Protrusion portion; **130**—Connecting bridge; **140**—Insulation cavity; **141**—First insulation cavity; **142**—Second insulation cavity; **150**—Partition board; [0057] **200**—Transformer; **201**—First endpoint; **202**—

Second endpoint; **203**—Third endpoint; **204**—Fourth endpoint; **205**—Fifth endpoint; **206**—Sixth endpoint; **207**—Seventh endpoint; **208**—Eighth endpoint; **210**—Magnetic core; **211**—First vertical pillar; **212**—Second vertical pillar; **213**—First transverse pillar; **214**—Second transverse pillar; **215**—First unit; **216**—Second unit; **217**—First longitudinal pillar; **218**—Second longitudinal pillar; **220**—First winding; **221**—First part; **222**—Second part; **230**—Second winding; **231**—First part; **232**—Second part; [0058] **500**—First shielding layer; **501**—First shielding end; **502**—Second shielding end; **503**—Third shielding end; **504**—Fourth shielding end; [0059] **600**—Third shielding layer; [0060] X—First direction; Y—Second direction; Z—Third direction.

DESCRIPTION OF EMBODIMENTS

[0061] As described in the BACKGROUND, in related art, the insulating board in the power module is penetrated between the primary side unit and the secondary side unit of the transformer, causing a width of an air gap of the magnetic core of the transformer to be greater than a thickness of the insulating board, resulting in a larger size of the air gap of the magnetic core and reducing the efficiency of the transformer.

[0062] In view of this, embodiments of the present application aim to provide a power module, by setting a protrusion portion and a connecting bridge on an insulating board, a protrusion is formed by at least one of the protrusion portion and the connecting bridge to enclose at least one insulation cavity with the insulating board, at least part of the magnetic core of the transformer is set within the insulation cavity or the connecting bridge, so that the flat plate portion of the insulating board does not penetrate through an air gap of the magnetic core, which facilitates a control of a size of the air gap of the magnetic core and is beneficial for improving an efficiency of the transformer in the power module.

[0063] To make the purposes, technical solutions and advantages of embodiments of the present application more clearly, the technical solutions in the embodiments of the present application are clearly and completely described in the following with reference to the accompanying drawings of the embodiments of the present application. Obviously, the described embodiments are part of embodiments of the present application, not all embodiments.

[0064] Based on the embodiments of the present application, all other embodiments obtained by those skilled in the art without paying creative efforts are all within the protection scope of the present application. In the absence of conflict, the following embodiments and the features in the embodiments may be combined with each other.

[0065] FIG. **1** is an external schematic diagram of a power module provided by an embodiment of the present application; FIG. **2** is a structural diagram of a power module provided by an embodiment of the present application; FIG. **3** is a structural diagram of an insulating board provided by an embodiment of the present application; FIG. **4** is a structural diagram of an insulating board provided by another embodiment of the present application; FIG. **5** is a structural diagram of a transformer provided by an embodiment of the present application; FIG. **6** is a structural diagram of a transformer provided by another embodiment of the present application; FIG. **7** is a schematic diagram of a connection structure of a transformer and an insulating board provided by an embodiment of the present application; FIG. **8** is a schematic diagram of a connection structure of a transformer and an insulating board provided by another embodiment of the present application; FIG. **9** is a schematic diagram of a connection structure of a transformer and an insulating board provided by still another embodiment of the present application; FIG. **10** is a schematic diagram of a connection structure of a transformer and an insulating board provided by yet another embodiment of the present application; FIG. **11** is a schematic diagram of a connection structure of a transformer and an insulating board provided by yet another embodiment of the present application; FIG. **12** is a schematic diagram of a connection structure of a transformer and an insulating board provided by yet another embodiment of the present application; FIG. **13** is a schematic diagram of a connection structure of a transformer and an insulating board provided by yet another embodiment of the present application; FIG. **14** is a schematic diagram of a connection structure of a transformer and an insulating board provided by yet another embodiment of the present application; FIG. **15** is a structural diagram of a power module provided by another embodiment of the present application; FIG. **16** is a structural diagram of a power module provided by still another embodiment of the present application; FIG. **17** is a structural diagram of a transformer provided by still another embodiment of the present application; FIG. **18** is a schematic diagram of a connection structure of a transformer and an insulating board provided by another embodiment of the present application; FIG. **19** is a structural diagram of a magnetic core provided by yet another embodiment of the present application.

[0066] It should be noted that in the embodiment, a first direction X, a second direction Y, and a third direction Z are three different directions perpendicular to each other in a three-dimensional space.

[0067] Please refer to FIG. **1**, FIG. **2**, FIG. **15**, and FIG. **16**, an embodiment provides a power module, which is provided with a first side plate **101**, a second side plate **102**, and an insulating board **100**. In a third direction Z, the insulating board **100**, the first side plate **101**, and the second side plate **102** in combination form a first accommodating space **11** and a second accommodating space **12**; the first accommodating space **11** is provided with a first power device **13** and at least part of a first winding **220**, and the second accommodating space **12** is provided with a second power device **14**, an insulation cavity **140** is connected to the second accommodating space **12** and has an equal potential, a second winding **230** is set within the insulation cavity **140**. The first power device **13** may be, for example, a low-voltage power device, the second power device **14** may be, for example, a high-voltage power device, the first winding **220** may be a low-voltage winding, and the second winding **230** may be a high-voltage winding. The first side plate **101** and the second side plate **102** may be a single-layer structure or a double-layer structure. For example, when the first power device **13** is a low-voltage power device and the second power device **14** is a high-voltage power device, sides of the first side plate **101** and the second side plate **102** located on one side of the first accommodating space may each have a single-layer structure, and sides of the first side plate **101** and the second side plate **102** located on one side of the second accommodating space may each have a double-layer structure. In terms of production manner, the first side plate **101**, the second side plate **102**, and the insulating board **100** may be integrally-formed, or may be separately produced and assembled. A volume will be smaller for the integrally-formed case, so a volume of the power module may be reduced and a power density may be increased.

[0068] In an embodiment, as shown in FIG. **2** and FIG. **15**, the power module also includes a cover plate **15**. In the third direction Z, the cover plate **15** covers the second accommodating space **12** to form a relatively sealed structure, thereby improving a safety during use. In an embodiment, the power module may also include another cover plate to cover the first accommodating space **11** in the third direction Z. In other possible implementations, the first power device **13** may be a high-voltage power device, the second power device **14** may be a low-voltage power device, the first winding **220** may be a high-voltage winding, and the second winding **230** may be a low-voltage winding. In the third direction Z, the cover plate covers the first accommodating space **11** so as to make the first accommodating space form a relatively sealed structure, thereby improving the safety during use.

[0069] Please refer to FIG. **2**, FIG. **3**, and FIG. **4**. In the embodiment, the insulating board **100** includes a flat plate portion **110**, a protrusion portion **120**, and a connecting bridge **130**. Depending on actual application requirements, the insulating board **100** may include multiple protrusion portions **120** and multiple connecting bridges **130**. The flat plate portion **110** is parallel to a plane formed by the first direction X and the second direction Y, and at least one of the protrusion portion **120** and the connecting bridge **130** protrude(s) along the third direction Z to jointly form an insulation cavity **140**. The number of insulation cavities **140** may also be increased according to actual requirements. At least one of the protrusion portion **120** and the connecting bridge **130** in the embodiment may protrude along the third direction Z in a positive or negative direction (where the positive direction may be a direction indicated by an arrow in the figure, and the negative direction is opposite to the positive direction) relative to the flat plate portion **110**. That is, as shown in FIG. **2** or FIG. **3**, only the protrusion portion **120** protrudes while the connecting bridge **130** does not protrude to form an insulation cavity **140**; or as shown in FIG. **4**, only the connecting bridge **130** protrudes while the protrusion portion **120** does not protrude to form an insulation cavity **140**; or both the protrusion portion **120** and the connecting bridge **130** protrude to form an insulation cavity **140**; in practical application processes, a manner of forming the insulation cavity **140** may be selected as required. It should be noted that the protrusion portion **120** may also be integrated into the flat plate portion **110** as a whole, and protrusion is not a necessary requirement for the protrusion portion **120**.

[0070] In the embodiment, along the second direction Y, both ends of the insulation cavity **140** are provided with openings to form a heat dissipation air duct, so air would be pulled through the heat dissipation air duct to cool the transformer **200**.

[0071] For convenience of explanation, referring to FIG. **2**, take the direction from the second accommodating space **12** to the first accommodating space **11** as the positive direction of the third direction Z, along the positive direction of the third direction Z, a position relationship between the protrusion portion **120** and the connecting bridge **130** may be the following two types: one is that the protrusion portion **120** is above the connecting bridge **130**, and another is that the connecting bridge **130** is above the protrusion portion **120**.

[0072] For example, in a possible implementation, as shown in FIG. **3**, along the third direction Z, a distance between the connecting bridge **130** and the flat plate portion **110** is zero, that is, a bottom surface of the connecting bridge is flush with a bottom surface of the flat plate portion, and the protrusion portion **120** is set to protrude, at one side thereof, towards the first accommodating space **11**. That is, in this implementation, the protrusion portion **120** may protrude towards the first accommodating space **11**, while the connecting bridge **130** does not protrude, and the connecting bridge **130** and the flat plate portion **110** are both parallel to a plane formed by the first direction X and the second direction Y.

[0073] In other possible implementations, along the third direction Z, the distance between the connecting bridge **130** and the flat plate portion **110** is zero, and the protrusion portion **120** may also be set to protrude, at one side thereof, towards the second accommodating space **12**. That is, in this implementation, the protrusion portion **120** may protrude towards the second accommodating space **12**, while the connecting bridge **130** does not protrude, and the connecting bridge **130** and the flat plate portion **110** are both parallel to a plane formed by the first direction X and the second direction Y.

[0074] For example, in another possible implementation, as shown in FIG. **4**, along the third direction Z, the distance between the protrusion portion **120** and the flat plate portion **110** is zero, and the connecting bridge **130** is set to protrude, at one side thereof, towards the second accommodating space **12**. That is, in this implementation, the connecting bridge **130** may protrude towards the second accommodating space **12**, while the protrusion portion **120** does not protrude, and the protrusion portion **120** and the flat plate portion **110** are both parallel to a plane formed by the first direction X and the second direction Y. At this time, the protrusion portion **120** and the flat plate portion **110** may be integrally-formed.

[0075] In other possible implementations, along the third direction Z, the distance between the protrusion portion **120** and the flat plate portion **110** is zero, and the connecting bridge **130** is set to protrude, at one side thereof, towards the first accommodating space **11**. That is, in this implementation, the connecting bridge **130** may protrude towards the first accommodating space **11**, while the protrusion portion **120** does not protrude, and the protrusion portion **120** and the flat plate portion **110** are both parallel to a plane formed by the first direction X and the second direction Y. At this time, the protrusion portion **120** and the flat plate portion **110** may be integrally-formed.

[0076] Please refer to FIG. **2**, FIG. **5**, and FIG. **6**. In this embodiment, the power module further includes a transformer **200**, which includes a magnetic core **210** and a winding wound on the magnetic core **210**. The winding may be directly wound on the magnetic core **210** or indirectly wound on the magnetic core **210**. The winding includes a first winding **220** and a second winding **230**. The first winding **220** is electrically connected to a first power device **13**, and the second winding **230** is electrically connected to a second power device **14**. The transformer **200** may achieve a voltage conversion on both sides of the first power device **13** and the second power device **14**.
[0077] In traditional power module structures, a size of an air gap of the magnetic core may generally only be adjusted in a thickness direction of an insulating board, that is, may be adjusted in the third direction Z, but due to limitations of the insulating board and an internal space, the air gap of the magnetic core cannot be flexibly adjusted, so that an overall design is limited. In this embodiment, at least part of the magnetic core **210** is set within the insulation cavity **140** or the connecting bridge **130**, so that the air gap of the magnetic core may be adjusted on three directions: the first direction X, the second direction Y, and the third direction Z. The size of the air gap of the magnetic core may be freely adjusted according to electrical parameter requirements of the transformer **200**, which greatly increases a flexibility in designing the magnetic core, and facilitates a control of a size and a tolerance of the air gap of the magnetic core, and an inductance value of the magnetic core, and beneficial for improving the efficiency of the transformer **200** in the power module. In addition, the setting of protrusion with respect to the protrusion portion **120** or the connecting bridge **130** on the flat plate portion **110** enables the insulating board **100** to form a bending structure, which is beneficial for improving an overall strength of the insulating board **100**, so that a thinner insulating board **100** may meet the requirements, which is beneficial for reducing an overall weight of the power module.
[0078] In a possible implementation, the magnetic core **210** of this embodiment may be penetrated into the insulation cavity **140**; that is, at least part of the magnetic core **210** is located within the insulation cavity **140**. Part of the winding is set within the connecting bridge **130**. The magnetic core **210** is provided with an opening along the first direction X, and the connecting bridge **130** is penetrated into the opening of the magnetic core **210**. Referring to FIG. **5**, FIG. **7**, FIG. **8**, FIG. **9**, and FIG. **10**, the magnetic core **210** includes a first vertical pillar **211** and a second vertical pillar **212** extending along the third direction Z, as well as a first transverse pillar **213** and a second transverse pillar **214** extending along the second direction Y. The first vertical pillar **211**, the second vertical pillar **212**, the first transverse pillar **213**, and the second transverse pillar **214** in combination form an opening towards the first direction X, and the connecting bridge **130** is located between the first transverse pillar **213** and the second transverse pillar **214**, the first transverse pillar **213** is located within the insulation cavity **140** formed by a combination of the connecting bridge **130** and the protrusion portion **120**.
[0079] One of the first winding **220** or the second winding **230** in this embodiment may be directly wound on the magnetic core **210**, and the other winding includes a first part and a second part interconnected. The first part is located on one side of the protrusion portion **120** away from the insulation cavity **140**, and the second part is located within the connecting bridge **130**. In an embodiment, the protrusion portion **120** may be of a hollow structure, and the first part of the other winding penetrates through a hollow portion of the protrusion portion **120**; the protrusion portion **120** may also be of a solid structure, and the first part of the other winding is set within the protrusion portion **120** and is integrally-formed with the protrusion portion **120**; or, an open groove is set on a surface of the side of the protrusion portion **120** away from the insulation cavity **140**, and the first part of the other winding is set within the groove, the first part of the other winding is integrally-formed or independently set with the protrusion portion **120**; or, the side of the protrusion portion **120** away from the insulation cavity **140** is set smoothly, without setting a groove, and the first part of the other winding is set on the surface of the side of the protrusion

portion **120** away from the insulation cavity **140**.

[0080] As shown in FIG. **7**, in one embodiment, the protrusion portion **120** protrudes, at one side thereof, towards the first accommodating space **11**, the connecting bridge **130** and the flat plate portion **110** are located within a same horizontal plane, the first transverse pillar **213** of the magnetic core **210** penetrates into the insulation cavity **140** enclosed by the protrusion portion **120** and the connecting bridge **130**, and the connecting bridge **130** penetrates between the first transverse pillar **213** and the second transverse pillar **214** of the magnetic core **210**. The second winding **230** is directly wound on the first transverse pillar **213**; the first winding **220** includes two electrically connected parts, the first part **221** of the first winding **220** is set on the outside of the protrusion portion **120**, and the second part **222** of the first winding **220** is set within the connecting bridge **130**. In this embodiment, reference may be made to the structure shown in FIG. **5** for a winding manner of the windings. The first winding **220** includes the first part **221** and the second part **222**, the first part **221** is located on the side of the protrusion portion **120** away from the insulation cavity **140**, and the second part **222** is located within the connecting bridge **130**. The second winding **230** is directly wound on the magnetic core **210**, and the insulation cavity **140** is connected to the second accommodating space **12** and they have an equal potential.

[0081] In an embodiment, the first part **221** and the second part **222** of the first winding **220** may be integrally-formed, at this time, a through-hole is set within the connecting bridge **130** (i.e., the through-hole penetrates through an inside of the connecting bridge **130**), the second part **222** is located within the through-hole.

[0082] Alternatively, the second part **222** may be integrally-formed with the connecting bridge **130**. For example, the second part **222** may be directly embedded within the connecting bridge **130** during production. An end of the second part **222** is located outside the connecting bridge **130**, and an end of the first part **221** is electrically connected to the end of the second part **222**. Specifically, the end of the first part **221** may be electrically connected to the end of the second part **222** through welding or in other manners.

[0083] As shown in FIG. **8**, in one embodiment, the protrusion portion **120** and the flat plate portion **110** are located within the same horizontal plane, and the connecting bridge **130** protrudes, at one side thereof, towards the second accommodating space **12**, the first transverse pillar **213** of the magnetic core **210** penetrates into the insulation cavity **140** enclosed by the protrusion portion **120** and the connecting bridge **130**. In this embodiment, the connecting bridge **130** is U-shaped, and part of the connecting bridge **130** penetrates between the first transverse pillar **213** and the second transverse pillar **214** of the magnetic core **210**. In this embodiment, the second winding **230** is directly wound on the magnetic core **210**, in an implementation, directly wound on the first transverse pillar **213**; the first winding **220** includes two electrically connected parts, the first part **221** of the first winding **220** is set on the outside of the protrusion portion **120**, the second part **222** of the first winding **220** is set within the connecting bridge **130**, and the insulation cavity **140** is connected to the second accommodating space **12**.

[0084] As shown in FIG. **9**, in one embodiment, the protrusion portion **120** protrudes, at one side thereof, towards the second accommodating space **12**, the connecting bridge **130** and the flat plate portion **110** are located within the same horizontal plane, the first transverse pillar **213** of the magnetic core **210** penetrates into the insulation cavity **140** enclosed by the protrusion portion **120** and the connecting bridge **130**, and the connecting bridge **130** penetrates between the first transverse pillar **213** and the second transverse pillar **214** of the magnetic core **210**. In this embodiment, the first winding **220** is directly wound on the magnetic core **210**, in an implementation, directly wound on the first transverse pillar **213**; the second winding **230** includes two electrically connected parts, the first part **231** of the second winding **230** is set on the outside of the protrusion portion **120**, and the second part **232** of the second winding **230** is set within the connecting bridge **130**, the insulation cavity **140** is connected to the first accommodating space **11**.

[0085] As shown in FIG. **10**, in one embodiment, the protrusion portion **120** and the flat plate portion **110** are located within the same horizontal plane, and the connecting bridge **130** protrudes, at one side thereof, towards the first accommodating space **11**, the first transverse pillar **213** of the magnetic core **210** penetrates into the insulation cavity **140** enclosed by the protrusion portion **120** and the connecting bridge **130**. In this embodiment, the connecting bridge **130** is U-shaped, and part of the connecting bridge **130** penetrates between the first transverse pillar **213** and the second transverse pillar **214** of the magnetic core **210**. In this embodiment, the first winding **220** is directly wound on the magnetic core **210**, in an implementation, directly wound on the first transverse pillar **213**; the second winding **230** includes two electrically connected parts, the first part **231** of the second winding **230** is set on the outside of the protrusion portion **120**, the second part **232** of the second winding **230** is set within the connecting bridge **130**, and the insulation cavity **140** is connected to the first accommodating space **11**.

[0086] In the embodiments shown in FIG. **7**, FIG. **8**, FIG. **9**, and FIG. **10**, the insulation cavity **140** is provided with an opening in the second direction Y. Referring to FIG. **1** and FIG. **3**, an airflow generated by a fan **16** may pass along the second direction Y, heat generated by the transformer arranged in the insulation cavity **140** may be directly carried away by the airflow, a heat dissipation efficiency is greatly improved, which is beneficial for reducing a volume of the power module and increasing a power density.

[0087] In another possible implementation, the connecting bridge **130** is provided with a through-hole in the first direction X, and the magnetic core **210** may be penetrated into the connecting bridge **130**; that is, at least part of the magnetic core **210** is located within the connecting bridge **130**. Referring to FIG. **6**, FIG. **11**, FIG. **12**, FIG. **13**, and FIG. **14**, the magnetic core **210** includes a first unit **215** and a second unit **216**. The first unit **215** is located on one side of the protrusion portion **120** away from the insulation cavity **140**, and the second unit **216** is fully or partially penetrated into the connecting bridge **130**, the second unit **216** may be integrally-formed with the connecting bridge **130**. In an embodiment, the protrusion portion **120** may be of a hollow structure, and the second unit **216** penetrates through a hollow portion of the protrusion portion **120**; the protrusion portion **120** may also be of a solid structure, the second unit **216** is set within the protrusion portion **120** and is integrally-formed with the protrusion portion **120**; an open groove is provided on a surface of the protrusion portion **120** away from the insulation cavity **140**, and the second unit **216** is set within the groove, the second unit **216** is independently set or integrally-formed with the protrusion portion **120**; or, the side of the protrusion portion **120** away from the insulation cavity **140** is set smoothly, without setting a groove, and the second unit **216** is set on the surface of the protrusion portion **120** away from the insulation cavity **140**. In an embodiment, the magnetic core **210** may only include the second unit **216** that penetrates into the connecting bridge, which is an I-type magnetic core, and there is no magnetic core **210** outside the protrusion portion **120**. In this implementation, based on the different structures of the protrusion portion **120** and the connecting bridge **130**, the following embodiments can be included.

[0088] As shown in FIG. **11**, in one embodiment, the protrusion portion **120** protrudes, at one side thereof, towards the first accommodating space **11**, and the connecting bridge **130** and the flat plate portion **110** are located within the same horizontal plane. The magnetic core **210** includes the first unit **215** and the second unit **216**, and the first unit **215** and the second unit **216** may be in direct contact or have a certain gap there between in the third direction Z. The first unit **215** is U-shaped and covers the outside of the protrusion portion **120**, while the second unit **216** is roughly strip-shaped in the first direction X and is set within the connecting bridge **130**. Another feasible manner not shown in FIG. **11** is that the first unit **215** of the magnetic core **210** is located on the outside of the protrusion portion **120**, and the second unit **216** is U-shaped and partially penetrated into the connecting bridge **130**. The second unit **216** may be integrally-formed with the connecting bridge **130**. The first winding **220** is wound on the first unit **215** of the magnetic core **210**, the first winding **220** may be wound on at least one of a transverse pillar and vertical pillars of the first unit **215**, or the first winding **220** may be wound on the second unit **216** of the magnetic core **210** set within the connecting bridge **130**. The second winding **230** is wound on the connecting bridge **130**, and the insulation cavity **140** is connected to the second accommodating space **12**.

[0089] As shown in FIG. **12**, in one embodiment, the protrusion portion **120** and the flat plate portion **110** are located within the same horizontal plane, and the connecting bridge **130** protrudes, at one side thereof, towards the second accommodating space **12**. The magnetic core **210** includes the first unit **215** and the second unit **216**, the first unit **215** and the second unit **216** may be in direct contact or have a certain gap there between in the third direction Z. The first unit **215** of the magnetic core **210** is located on the outside of the protrusion portion **120**, and the second unit **216** of the magnetic core **210** is U-shaped and penetrated into the connecting bridge **130**. Another feasible manner not shown in FIG. **12** is that the first unit **215** is also U-shaped, and a part of the first unit **215** is located on the outside of the protrusion portion **120** and another part is penetrated into the connecting bridge **130** along the third direction Z. At this time, the second unit **216** may be U-shaped or may be strip-shaped in the first direction X. The second unit **216** may be integrally-formed with the connecting bridge **130**. The first winding **220** located within the first accommodating space **11** is wound on the first unit **215** of the magnetic core **210** outside the protrusion portion **120**, the second winding **230** is wound on the connecting bridge **130**, and the second winding **230** is partially located in the second accommodating space **12** and partially located in the insulation cavity **140**, the insulation cavity **140** is connected to the second accommodating space **12**, which can be understood as the second winding **230** being fully located within the second accommodating space **12**. Specifically, the second winding **230** may be wound around at least one of a horizontal portion and vertical portions of the connecting bridge **130**.

[0090] As shown in FIG. **13**, in one embodiment, the protrusion portion **120** protrudes, at one side thereof, towards the second accommodating space **12**, and the connecting bridge **130** and the flat plate portion **110** are located within the same horizontal plane. The magnetic core **210** includes the first unit **215** and the second unit **216**, the first unit **215** and the second unit **216** may be in direct contact or have a certain gap there between in the third direction Z. The first unit **215** is U-shaped and covers the outside of the protrusion portion **120**, while the second unit **216** is roughly strip-shaped in the first direction X and is fully located within the connecting bridge **130**. Another feasible manner not shown in FIG. **13** is that the first unit **215** of the magnetic core **210** is located on the outside of the protrusion portion **120**, and the second unit **216** is U-shaped and partially penetrated into the connecting bridge **130**. The second unit **216** may be integrally-formed with the connecting bridge **130**. The first winding **220** is wound on the connecting bridge **130**, and the first winding **220** is partially located within the first accommodating space **11**, and partially in the insulation cavity **140**, the insulation cavity **140** is connected to the first accommodating space **11**, which may be understood as the first winding **220** being fully located within the first accommodating space **11**, and the second winding **230** located within the second accommodating space **12** being wound on the magnetic core **210** outside the protrusion portion **120**.

[0091] As shown in FIG. **14**, in one embodiment, the protrusion portion **120** and the flat plate portion **110** are located within the same horizontal plane, and the connecting bridge **130** protrudes, at one side thereof, towards the first accommodating space **11**. The magnetic core **210** includes the first unit **215** and the second unit **216**, the first unit **215** and the second unit **216** may be in direct contact or have a certain gap there between in the third direction Z. The first unit **215** of the magnetic core **210** is located on the outside of the protrusion portion **120**, and the second unit **216** of the magnetic core **210** is U-shaped and penetrated into the connecting bridge **130**. Another feasible manner not shown in FIG. **14** is that the first unit **215** is U-shaped, a part of the first unit **215** is located on the outside of the protrusion portion **120**, and another part is penetrated into the connecting bridge **130** along the third direction Z. At this time, the second unit **216** may be U-shaped or may be strip-shaped in the first direction X. The second unit **216** may be integrally-formed with the connecting bridge **130**. The first winding **220** is wound on the connecting bridge **130**, and the first winding **220** is partially located within the first accommodating space **11** and partially in the insulation cavity **140**, the insulation cavity **140** is connected to the first accommodating space **11**, which can be understood as the first winding **220** being fully located within the first accommodating space **11**, and the second winding **230** located within the second accommodating space **12** being wound on the magnetic core **210** outside the protrusion portion **120**.

[0092] In the embodiments shown in FIG. **11** to FIG. **14**, by setting the winding outside the insulation cavity **140**, the winding is not insulated, which is more conducive to a heat dissipation. Since a loss of the winding of the transformer is greater than a loss of the magnetic core, setting the winding outside the insulation cavity **140** may further improve the efficiency of the transformer **200**. In addition, in the embodiment, the winding does not need to penetrate through an interior of the connecting bridge **130**, and a connection of incoming and outgoing lines is simple; and at this time, a smooth air duct may be formed within the insulation cavity **140** in the second direction Y, which is more beneficial to the heat dissipation.

[0093] The surface of the insulating board **100** disclosed in the embodiment may be provided with a semi conductive layer, and materials of the semi conductive layer may include a graphene or a carbon black for shielding and other purposes. Common parameters for semi conductive coatings would include a thickness (10 um˜200 um), a conductivity range (10{circumflex over ( )}(−11) s/m˜10{circumflex over ( )}(3) s/m), but not limited thereto.

[0094] The insulation cavity **140** disclosed in the embodiment has openings at both ends along the second direction Y, that is, the interior of the insulation cavity **140** is conductive in the second direction Y, thus enabling the airflow generated by the fan **16** to directly act on the transformer **200**, to directly take away the heat generated by the transformer **200**, thereby greatly improving the efficiency of the heat dissipation, as well as reducing the volume of the power module, and increasing the power density.

[0095] In another embodiment, the power module may also have a structure as shown in FIG. **15**, that is, along the first direction X, the insulation cavity **140** is located at a middle of the insulating board **100**, and the corresponding transformer **200** is also located at the middle of the insulating board **100**.

[0096] By adopting the above structure, the first accommodating space **11** may be distributed on both sides of the insulation cavity **140**. Compared with the structure shown in FIG. **2**, where the insulation cavity **140** is set near an edge of the insulating board **100**, the structure shown in FIG. **15** is more advantageous for an arrangement of the first power device **13** in a limited space, which greatly improves space utilization, is beneficial for reducing the volume of the power module, and increment of the power density.

[0097] In another embodiment, the power module may also have a structure as shown in FIG. **16**, the insulating board **100** may be provided with multiple insulation cavities **140**. At this time, the power module includes multiple transformers **200**, and multiple transformers **200** correspond to multiple insulation cavities **140**, according to different circuit structures, at least one transformer **200** may also be placed in one insulation cavity. In this embodiment, multiple transformers **200** may be connected in series or parallel. As shown in FIG. **17**, in this embodiment, two transformers **200** connected in series are provided in one insulation cavity **140**, and transformers **200** in multiple insulation cavities **140** may be connected in parallel with each other.

[0098] By adopting the above structure, a size of a single transformer **200** may be reduced, and a height of the insulation cavity **140** may be reduced, so that the first power device **13** and the second power device **14** may be closer to the transformer **200**, which is beneficial for saving space, reducing the volume of the power module, and increasing the power density.

[0099] In another embodiment, the magnetic core **210** is provided with a through-hole along the third direction Z, and at this time, the insulating board **100** includes multiple protrusion portions **120** and multiple connecting bridges **130**, the multiple protrusion portions **120** and multiple connecting bridges **130** in combination form multiple insulation cavities **140**. As shown in FIG. **18**, the insulating board **100** includes at least two insulation cavities **140**, taking two insulation cavities **140** as an example, they are a first insulation cavity **141** and a second insulation cavity **142** respectively, both of them are provided with magnetic cores **210**. Referring to FIG. **19**, the magnetic core **210** includes a first longitudinal pillar **217** and a second longitudinal pillar **218** extending along the first direction X, as well as a first transverse pillar **213** and a second transverse pillar **214** extending along the second direction Y. The combination of the first longitudinal pillar **217**, the second longitudinal pillar **218**, the first transverse pillar **213**, and the second transverse pillar **214** forms an opening towards the third direction Z. The first winding **220** is set within the insulation cavity **140**, the second winding **230** is partially set within the connecting bridge **130**, and partially set within the second accommodating space **12**.

[0100] The protrusion portion **120** protrudes, at one side thereof, towards the second accommodating space **12**, and the connecting bridge **130** and the flat plate portion **110** are located within the same horizontal plane. The first transverse pillar **213** and the second transverse pillar **214** of the magnetic core **210** are respectively penetrated into the first insulation cavity **141** and the second insulation cavity **142**. In this embodiment, the number of windings is not limited, for example, there are two first windings **220** and two second windings **230**, the two first windings **220** are directly wound on the first transverse pillar **213** and the second transverse pillar **214** respectively; the two second windings **230** both include two electrically connected parts, the first parts **231** of the two second windings **230** are respectively set on the outsides of the protrusion portions **120** forming the first insulation cavity **141** and the second insulation cavity **142**, the second parts **232** of the two second windings **230** are respectively set within the connecting bridges **130** forming the first insulation cavity **141** and the second insulation cavity **142**. That is, the first transverse pillar **213** is wound by the first winding **220** and the second winding **230**, the second transverse pillar **214** is also wound by the first winding **220** and the second winding **230**. The first winding **220** wound on different transverse pillars may be electrically connected in series or parallel, and the second winding **230** wound on different transverse pillars may be electrically connected in series or parallel. By adopting this structure, a module output assembly is flexible.

[0101] Other feasible manners not shown in FIG. **18** include: the protrusion portion **120** and the flat plate portion **110** are located within the same horizontal plane, and the connecting bridge **130** protrudes, at one side thereof, towards the first accommodating space **11**; or, the connecting bridge **130** protrudes, at one side thereof, towards the second accommodating space **12**, the protrusion portion **120** and the flat plate portion **110** are located within the same horizontal plane; or, the connecting bridge **130** and the flat plate portion **110** are located within the same horizontal plane, and the protrusion portion **120** protrudes, at one side thereof, towards the first accommodating space **11**.

[0102] As described in the background, in the power module of the related art, air among the magnetic core and the first and second windings undertakes a large electric field. When there are sharp burrs on an edge of the magnetic core, discharge may occur, thereby affecting the insulation life.

[0103] In view of this, the embodiments of the present application aim to provide a power module, in which a first shielding layer is provided on one side of the insulating board facing towards the magnetic core, and a projection of the magnetic core is located within a projection range of the first shielding layer, so that the first shielding layer can be used to reduce the electric-field-strength in the air around the magnetic core, prolong insulation life, and improve reliability of the product.

[0104] The following will provide a detailed description of the embodiments of the present application in conjunction with the accompanying drawings, in order to enable the person skilled in the art to have a more detailed understanding of the content of the present application. In the description of the embodiments of the present application, a plane formed by the first direction X and the second direction Y is a first reference plane; a plane formed by the first direction X and the third direction Z is a second reference plane; and a plane formed by the second direction Y and the third direction Z is a third reference plane.

[0105] Please refer to FIG. **20** to FIG. **35**, the present embodiment provides a power module, including: [0106] an insulating board **100**, which can be formed using insulation materials; [0107] a transformer, which includes a magnetic core **210**, and at least one first winding **220** and at least one second winding **230** wound around the magnetic core **210**. The first winding **220** includes a first part **221** and a second part **222** that are electrically connected to each other. The first part **221** is located on one side of the insulating board **100** away from the magnetic core **210**, and the second part **222** is inserted into the insulating board **100**. One of the first winding **220** and the second winding **230** is a high-voltage winding, and the other is a low-voltage winding. One side of the insulating board **100** is set with a high-voltage power device, and the other side is set with a low-voltage power device. One of the first winding **220** and the second winding **230** is electrically connected to the high-voltage power device, and the other is electrically connected to the low-voltage power device; [0108] a first shielding layer **500**, which is provided on one side of the insulating board **100** facing towards the magnetic core **210**. For example, the first shielding layer **500** is a semi conductive layer, and a material of the first shielding layer **500** includes a graphene, a carbon black, a coating doped with conductive particles such as the graphene or the carbon black, or a thin film filled with the conductive particles. In the first reference plane, the projection of the magnetic core **210** is located within the projection range of the first shielding layer **500**; that is to say, the entire projection of the magnetic core **210** falls completely within the projection range of the first shielding layer **500**, so that the electromagnetic shielding effect against the magnetic core **210** can be achieved by using the first shielding layer **500**.

[0109] It can be understood that in this embodiment, the first shielding layer **500** is set on one side of the insulating board **100** facing towards the magnetic core **210**, and the projection of the magnetic core **210** is located within the projection range of the first shielding layer **500**, so that the first shielding layer **500** can be used to reduce the electric-field-strength in the air around the magnetic core **210**, prolong the insulation life, and improve the reliability of the product, and also reduce a size of the insulation layer.

[0110] In the present embodiment, the insulating board **100** includes a flat plate portion **110**, a protrusion portion **120**, and a connecting bridge **130**. The flat plate portion **110** is parallel to the first reference plane, and the protrusion portion **120** and/or the connecting bridge **130** protrude from the flat plate portion **110** along the third direction Z, thereby forming an insulation cavity. At least part of the magnetic core **210** is set within the insulation cavity. In the present embodiment, at least one of the protrusion portion **120** and the connecting bridge **130** may protrude relative to the flat plate portion **110**. For example, as shown in FIG. **20** and FIG. **28**, the connecting bridge **130** protrudes relative to the flat plate portion **110**, while the protrusion portion **120** does not protrude and is located in the same plane as the flat plate portion **110**. As shown in FIG. **24** and FIG. **32**, the protrusion portion **120** protrudes relative to the flat plate portion **110**, while the connecting bridge **130** does not protrude and is located in the same plane as the flat plate portion **110**. In other possible embodiments, the protrusion portion **120** and the connecting bridge **130** can both protrude relative to the flat plate portion **110**. It can be understood that in the present embodiment, the protrusion portion **120** and the connecting bridge **130** only refer to names of two different parts on the insulating board **100**, and the text does not represent their specific structure.

[0111] Furthermore, the first part **221** of the first winding **220** is located on a surface of the protrusion portion **120** or penetrates within the protrusion portion **120**. For example, the first part **221** is located on one side of the insulating board **100** away from the magnetic core **210**. At this time, the first part **221** can be located on the surface of the protrusion portion **120**, or part of the first part **221** can be buried inside the protrusion portion **120**, or the first part **221** can penetrate within the protrusion portion **120**. When the first part **221** penetrates within the protrusion portion **120**, the structure of the protrusion portion **120** can be the same as that of the connecting bridge **130**. The second part **222** is located within the connecting bridge **130**; that is to say, the second part

222 penetrates within the connecting bridge **130**. The second winding **230** is directly wound on the magnetic core **210**. For example, the second winding **230** can be located on the magnetic core **210** inside the insulation cavity, or on the magnetic core **210** outside the insulation cavity.

[0112] The magnetic core **210** of the present embodiment includes a first vertical pillar **211** and a second vertical pillar **212** arranged opposite to each other, as well as a first transverse pillar **213** and a second transverse pillar **214** arranged opposite to each other; the first vertical pillar **211**, the first transverse pillar **213**, the second vertical pillar **212**, and second transverse pillar **214** are connected head-to-tail in sequence.

[0113] It can be understood that the power module of the present embodiment can be set to different structures according to specific requirements.

[0114] In some possible implementations, as shown in FIG. **20** to FIG. **23**, along the third direction Z, a distance between the protrusion portion **120** and the flat plate portion **110** is zero, that is, the protrusion portion **120** and the flat plate portion **110** are located in the same plane, and the connecting bridge **130** protrudes from the flat plate portion **110**. Along the second direction Y, a height of the first transverse pillar **213** is greater than that of the insulation cavity. The first transverse pillar **213** penetrates through the insulation cavity, with a part of the first transverse pillar **213** located inside the insulation cavity and another part located outside the insulation cavity. The second transverse pillar **214** is located outside the insulation cavity, and the second winding **230** is wound around the first transverse pillar **213**.

[0115] In some possible implementations, as shown in FIG. **24** to FIG. **27**, along the third direction Z, a distance between the connecting bridge **130** and the flat plate portion **110** is zero, that is, the connecting bridge **130** and the flat plate portion **110** are located in the same plane, and the protrusion portion **120** protrudes from the flat plate portion **110**. Along the second direction Y, a height of the first transverse pillar **213** is greater than that of the insulation cavity. The first transverse pillar **213** penetrates through the insulation cavity, with a part of the first transverse pillar **213** located inside the insulation cavity and another part located outside the insulation cavity. The second transverse pillar **214** is located outside the insulation cavity, and the second winding **230** is wound around the first transverse pillar **213**.

[0116] In some possible implementations, as shown in FIG. **28** to FIG. **31**, along the third direction Z, a distance between the protrusion portion **120** and the flat plate portion **110** is zero, that is, the protrusion portion **120** and the flat plate portion **110** are located in the same plane, and the connecting bridge **130** protrudes from the flat plate portion **110**. The insulating board **100** also includes a partition board **150**, which is set inside the insulation cavity. The partition board **150** is connected with the protrusion portion **120** and the connecting bridge **130**, and divides the insulation cavity into a first insulation cavity and a second insulation cavity. Along the second direction Y, the height of the first transverse pillar **213** is greater than that of the first insulation cavity, and the height of the second transverse pillar **214** is greater than that of the second insulation cavity. The first transverse pillar **213** penetrates through the first insulation cavity, with a part of the first transverse pillar **213** located inside the first insulation cavity and another part located outside the first insulation cavity. The second transverse pillar **214** penetrates through the second insulation cavity, with a part of the second transverse pillar **214** located inside the second insulation cavity and another part located outside the second insulation cavity.

[0117] The transformer includes two first windings **220** and two second windings **230**. The two first windings **220** are respectively wound on outer sides of the two second windings **230**. The first parts **221** of the two first windings **220** are respectively provided on one side of the protrusion part **120** away from the insulation cavity. The second parts **222** of the two first windings **220** are respectively provided within the partition board **150** and the connecting bridge **130**. The two second windings **230** are respectively provided in the first and second insulation cavities and wound on the first transverse pillar **213** and the second transverse pillar **214**.

[0118] Compared with the implementations shown in FIG. **20** to FIG. **23**, the present implementation can fully utilize the structure of the magnetic core **210**, which is beneficial for improving power density of the power module and enabling the power module to meet the demand for higher power.

[0119] In one possible implementation, as shown in FIG. **32** to FIG. **35**, along the third direction Z, the distance between the connecting bridge **130** and the flat plate portion **110** is zero, that is, the connecting bridge **130** and the flat plate portion **110** are located in the same plane, and the protrusion portion **120** protrudes from the flat plate portion **110**. The insulating board **100** also includes a partition board **150**, which is set inside the insulation cavity. The partition board **150** is connected with the protrusion portion **120** and the connecting bridge **130**, and divides the insulation cavity into a first insulation cavity and a second insulation cavity. Along the second direction Y, the height of the first transverse pillar **213** is greater than that of the first insulation cavity, and the height of the second transverse pillar **214** is greater than that of the second insulation cavity. The first transverse pillar **213** penetrates through the first insulation cavity, with a part of the first transverse pillar **213** located inside the first insulation cavity and another part located outside the first insulation cavity. The second transverse pillar **214** penetrates through the second insulation cavity, with a part of the second transverse pillar **214** located inside the second insulation cavity and another part located outside the second insulation cavity.

[0120] The transformer includes two first windings **220** and two second windings **230**. The two first windings **220** are respectively wound on outer sides of the two second windings **230**. The first parts **221** of the two first windings **220** are respectively provided on one side of the protrusion part **120** away from the insulation cavity. The second parts **222** of the two first windings **220** are respectively provided within the partition board **150** and the connecting bridge **130**. The two second windings **230** are respectively provided in the first and second insulation cavities and wound on the first transverse pillar **213** and second transverse pillar **214**.

[0121] Compared with the implementations shown in FIG. **24** to FIG. **27**, the present implementation can fully utilize the structure of the magnetic core **210**, which is beneficial for improving power density of the power module and enabling the power module to meet the demand for higher power.

[0122] In traditional power module structures, a size of an air gap of the magnetic core may generally only be adjusted in a thickness direction of the insulating board, that is, in the third direction Z, but due to limitations of the insulating board and an internal space, the air gap of the magnetic core cannot be flexibly adjusted, so that an overall design is limited. In the present embodiment, at least part of the magnetic core **210** is set within the insulation cavity, so that the air gap of the magnetic core may be adjusted on three directions: the first direction X, the second direction Y, and the third direction Z. The size of the air gap of the magnetic core may be freely adjusted according to electrical parameter requirements of the transformer, which greatly increases a flexibility in designing the magnetic core, and facilitates a control of a size and a tolerance of the air gap of the magnetic core, and an inductance value of the magnetic core, and is beneficial for improving the efficiency of the transformer in the power module. In addition, the protrusion portion **120** or the connecting bridge **130** provided on the flat plate portion **110** enables the insulating board **100** to form a bending structure, which is beneficial for improving an overall strength of the insulating board **100**, so that a thinner insulating board **100** may meet the requirements, which is beneficial for reducing an overall weight of the power module.

[0123] Please continue to refer to FIG. **22**, FIG. **26**, FIG. **30**, and FIG. **34**. When within a plane parallel to the second reference plane, which penetrates through the magnetic core **210** and the insulating board **100**, in a cross-sectional view corresponding to the magnetic core **210** and the insulating board **100**, the magnetic core **210** includes a first endpoint **201**, a second endpoint **202**, a third endpoint **203**, and a fourth endpoint **204**. That is, the first endpoint **201**, the second endpoint **202**, the third endpoint **203**, and the fourth endpoint **204** are the four vertices of the magnetic core **210** in this plane, respectively.

[0124] Along the third direction Z, the first endpoint **201** and the second endpoint **202** are located at two ends of the magnetic core **210** near the protrusion portion **120**, respectively. The third endpoint **203** and the fourth endpoint **204** are located at two ends of the magnetic core **210** away from the protrusion portion **120**, respectively, that is, the third endpoint **203** is located on one side of the first endpoint **201** away from the protrusion portion **120**, and the fourth endpoint **204** is located on one side of the second endpoint **202** away from the protrusion portion **120**. It should be noted that in the implementation shown in FIG. **26**, since a part of the magnetic core **210** is located inside the insulation cavity in the plane formed by the first direction X and the third direction Z, the first endpoint **201** and the second endpoint **202** are two endpoints of the magnetic core **210** located inside the insulation cavity, while the third endpoint **203** and the fourth endpoint **204** are two endpoints of the magnetic core **210** located outside the insulation cavity. In the implementation shown in FIG. **34**, since the magnetic core **210** is located inside the insulation cavity in the plane formed by the first direction X and the third direction Z, the first endpoint **201** and the second endpoint **202** are two endpoints of the magnetic core **210** away from the flat plate portion **110**, while the third endpoint **203** and the fourth endpoint **204** are two endpoints of the magnetic core **210** near the flat plate portion **110**.
[0125] Along the first direction X, the first shielding layer **500** includes a first shielding end **501** and a second shielding end **502**. The first shielding end **501** is located near the first endpoint **201**, which can also be understood as the first shielding end **501** being located on one side of the first endpoint **201** away from the second endpoint **202**. The second shielding end **502** is located near the second endpoint **202**, which can also be understood as the second shielding end **502** being located on one side of the second endpoint **202** away from the first endpoint **201**. That is to say, a length of the first shielding layer **500** in the first direction X is greater than that of the magnetic core **210** in the first direction X. Therefore, the first shielding layer **500** can be used to eliminate the electric-field-strength in the air around the magnetic core **210** in the first direction X, prolong the insulation life, and improve the reliability of the product.
[0126] Please continue to refer to FIG. **23**, FIG. **27**, FIG. **31**, and FIG. **35**. When within a plane parallel to the third reference plane, which penetrates through the magnetic core **210** and the insulating board **100**, in a cross-sectional view corresponding to the magnetic core **210** and the insulating board **100**, the magnetic core **210** includes a fifth endpoint **205**, a sixth endpoint **206**, a seventh endpoint **207**, and an eighth endpoint **208**. That is, the fifth endpoint **205**, the sixth endpoint **206**, the seventh endpoint **207**, and the eighth endpoint **208** are the four vertices of the magnetic core **210** in this plane, respectively. Along the third direction Z, the fifth endpoint **205** and the sixth endpoint **206** are located at two ends of the magnetic core **210** near the protrusion portion **120**, respectively. The seventh endpoint **207** and the eighth endpoint **208** are located at two ends of the magnetic core **210** away from the protrusion portion **120**, that is, the seventh endpoint **207** is located on one side of the fifth endpoint **205** away from the protrusion portion **120**, and the eighth endpoint **208** is located on one side of the sixth endpoint **206** away from the protrusion portion **120**.
[0127] Along the second direction Y, the first shielding layer **500** includes a third shielding end **503** and a fourth shielding end **504**. The third shielding end **503** is located near the fifth endpoint **205**, which can also be understood as the third shielding end **503** being located on one side of the fifth endpoint **205** away from the sixth endpoint **206**. The fourth shielding end **504** is located near the sixth endpoint **206**, which can also be understood as the fourth shielding end **504** being located on one side of the sixth endpoint **206** away from the fifth endpoint **205**. That is to say, a length of the first shielding layer **500** in the second direction Y is greater than that of the magnetic core **210** in the second direction Y. Therefore, the first shielding layer **500** can be used to eliminate the electric-field-strength in the air around the magnetic core **210** in the second direction Y, prolong the insulation life, and improve the reliability of the product.
[0128] Please continue to refer to FIG. **23**, FIG. **27**, FIG. **31**, and FIG. **35**. In some possible implementations, along the second direction Y, a distance between the third shielding end **503** and

the fifth endpoint **205** is H**3**, and along the third direction Z, a distance between the seventh endpoint **207** and the protrusion portion **120** is D**3**; wherein H**3**/D**3** satisfies a condition of being greater than or equal to the third threshold and less than or equal to the fourth threshold. For example, in the present embodiment, the third threshold may be 1.5, and the fourth threshold may be 3, that is, 1.5≤H**3**/D**3**≤3. When H**3**/D**3** is less than the third threshold, the shielding effect of the first shielding layer **500** is poor. When H**3**/D**3** is greater than the fourth threshold, the shielding effect of the first shielding layer **500** does not significantly change. Therefore, when the first shielding layer **500** is set within the above parameter range, it can ensure that the first shielding layer **500** has a good shielding effect and will not have a significant impact on the power density of the power module.

[0129] Along the second direction Y, a distance between the fourth shielding end **504** and the six endpoint **206** is H**4**, and along the third direction Z, a distance between the eighth endpoint **208** and the protrusion portion **120** is D**4**, where H**4**/D**4** satisfies a condition of being greater than or equal to the third threshold and less than or equal to the fourth threshold. The third threshold may be 1.5, and the fourth threshold may be 3, that is, 1.5≤H**4**/D**4**≤3. When H**4**/D**4** is less than the third threshold, the shielding effect of the first shielding layer **500** is poor. When H**4**/D**4** is greater than the fourth threshold, the shielding effect of the first shielding layer **500** does not significantly change. Therefore, when the first shielding layer **500** is set within the above parameter range, it can ensure that the first shielding layer **500** has a good shielding effect and will not have a significant impact on the power density of the power module.

[0130] The present embodiment sets the endpoint of the first shielding layer **500** in the second direction Y and the corresponding endpoint of the magnetic core in the second direction Y within the above ratio range, which can meet the shielding requirements and reduce the size of the first shielding layer **500** in the second direction Y.

[0131] In some implementations, due to that the transformer is connected with the circuit board and an electronic device, and sizes of the circuit board and the electronic device in the first direction X are relatively large, the first shielding layer **500** needs to be adjusted according to the sizes of these devices. In the first direction X, the size of the first shielding layer **500** needs to be larger than that of the circuit board and the electrical device.

[0132] Similarly, in other implementations, please continue to refer to FIG. **22**, FIG. **26**, FIG. **30**, and FIG. **34**. along the first direction X, a distance between the first shielding end **501** and the first endpoint **201** is H**1**, and along the third direction Z, a distance between the third endpoint **203** and the protrusion portion **120** is D**1**; H**1**/D**1** satisfies a condition of being greater than or equal to the first threshold and less than or equal to the second threshold. The first threshold may be 1.5, and the second threshold may be 3, that is, 1.5≤H**1**/D**1**≤3. When H**1**/D**1** is less than the first threshold, the shielding effect of the first shielding layer **500** is poor. When H**1**/D**1** is greater than the second threshold, the shielding effect of the first shielding layer **500** does not significantly change. Therefore, when the first shielding layer **500** is set within the above parameter range, it can ensure that the first shielding layer **500** has a good shielding effect and will not have a significant impact on the power density of the power module.

[0133] Along the first direction X, a distance between the second shielding end **502** and the second endpoint **202** is H**2**, and along the third direction Z, a distance between the fourth endpoint **204** and the protrusion portion **120** is D**2**, where H**2**/D**2** satisfies a condition of being greater than or equal to the first threshold and less than or equal to the second threshold. The first threshold may be 1.5, and the second threshold may be 3, that is, 1.5≤H**2**/D**2**≤3. When H**4**/D**4** is less than the first threshold, the shielding effect of the first shielding layer **500** is poor. When H**2**/D**2** is greater than the second threshold, the shielding effect of the first shielding layer **500** does not significantly change. Therefore, when the first shielding layer **500** is set within the above parameter range, it can ensure that the first shielding layer **500** has a good shielding effect and will not have a significant impact on the power density of the power module.

[0134] The present embodiment sets the endpoints of the first shielding layer **500** in the first direction X and the corresponding endpoints of the magnetic core in the first direction X within the above ratio range, which can meet the shielding requirements and reduce the size of the first shielding layer **500** in the first direction X. If the transformer is connected with the circuit board and an electronic device in the second direction Y, and sizes of the circuit board and the electronic device are relatively large, then the first shielding layer **500** needs to be adjusted according to the sizes of these devices. In the second direction Y, the size of the first shielding layer **500** needs to be larger than that of the circuit board and the electrical device.
[0135] In some possible implementations, the endpoints of the first shielding layer **500** in the first direction X and the corresponding endpoints of the magnetic core **210** in the first direction X, as well as the endpoints of the first shielding layer **500** in the second direction Y and the corresponding endpoints of the magnetic core in the second direction Y, may all need to meet the above ratio range. At this time, there are no external devices around the transformer, or there is no need to shield external devices, or the sizes of external electronic devices are small. The first shielding layer **500** can meet the shielding requirements and reduce the size of the first shielding layer **500** within the above ratio range.
[0136] Please continue to refer to FIG. **20**, FIG. **24**, FIG. **28**, and FIG. **32**. In the first reference plane, the projection of the first shielding layer **500** is located within the projection range of the insulating board **100**, which means that the first shielding layer **500** does not exceed the range of the insulating board **100**.
[0137] Furthermore, in the present embodiment, the first shielding layer **500** is provided on one side of the flat plate portion **110** along the third direction Z, a surface of the connecting bridge **130**, and one side of the protrusion portion **120** facing towards the magnetic core **210**.
[0138] Specifically, as shown in FIG. **20** to FIG. **23**, the first shielding layer **500** is provided on one side of the flat plate portion **110** facing towards the magnetic core **210** along the third direction Z, one side of the protrusion portion **120** facing towards the magnetic core **210**, and the surface of the connecting bridge **130**. There is a through-hole inside the connecting bridge **130** (i.e., the through-hole penetrates through the interior of the connecting bridge **130**), the second part **222** of the first winding **220** is provided inside the through-hole of the connecting bridge **130**, and the first shielding layer **500** is provided on an inner surface of the through-hole and an outer surface of the connecting bridge **130**. The first shielding layer **500** provided on the connecting bridge **130** plays an electromagnetic shielding role for the second part **222** of the first winding **220**.
[0139] As shown in FIG. **24** to FIG. **27**, the first shielding layer **500** is provided on one side of the flat plate portion **110** away from the magnetic core **210** along the third direction Z, one side of the protrusion portion **120** facing towards the magnetic core **210**, and the surface of the connecting bridge **130**. The connecting bridge **130** includes the through-hole. The second part **222** of the first winding **220** is provided inside the through-hole of the connecting bridge **130**, and the first shielding layer **500** is provided on the inner surface of the through-hole and the inner and outer surfaces of the connecting bridge **130**. The first shielding layer **500** provided on the connecting bridge **130** plays an electromagnetic shielding role for the second part **222** of the first winding **220**. If the external electronic device is small or does not need to be shielded along the first direction X, then the first shielding layer **500** may not be provided on one side of the flat plate portion **110** facing away from the protrusion portion **120** along the third direction Z.
[0140] As shown in FIG. **28** to FIG. **31**, the first shielding layer **500** is provided on one side of the flat plate portion **110** facing towards the magnetic core **210** along the third direction Z, one side of the protrusion portion **120** facing towards the magnetic core **210**, the surface of the connecting bridge **130**, and a surface of the partition board **150**. The connecting bridge **130** and the partition board **150** include the through-hole. The second part **222** of the first winding **220** is provided inside the through-hole, and the first shielding layer **500** is provided on the inner surface of the through-hole, the outer surface of the connecting bridge **130** and the surface of the partition board **150**. The

first shielding layer **500** provided on the connecting bridge **130** and the partition board **150** plays an electromagnetic shielding role for the second part **222** of the first winding **220**.

[0141] As shown in FIG. **32** to FIG. **35**, the first shielding layer **500** is provided on one side of the flat plate portion **110** away from the magnetic core **210** along the third direction Z, one side of the protrusion portion **120** facing towards the magnetic core **210**, the surface of the connecting bridge **130**, and the surface of the partition board **150**. The connecting bridge **130** and the partition board **150** include the through-hole. The second part **222** of the first winding **220** is provided inside the through-hole, and the first shielding layer **500** is provided on the inner surface of the through-hole, the inner and outer surface of the connecting bridge **130** and the surface of the partition board **150**. The first shielding layer **500** provided on the connecting bridge **130** and the partition board **150** plays an electromagnetic shielding role for the second part **222** of the first winding **220**. If the external electronic device is small or does not need to be shielded along the first direction X, then the first shielding layer **500** may not be provided on one side of the flat plate portion **110** facing away from the protrusion portion **120** along the third direction Z. In some possible implementations, a side of the insulating board **100** facing towards the magnetic core **210** is further provided with a second shielding layer (not shown in the figure). The second shielding layer is connected with the first shielding layer **500** and surrounds an outer periphery of the first shielding layer **500**, resistivity of the second shielding layer is greater than that of the first shielding layer **500**.

[0142] For example, the second shielding layer is also a semiconducting layer, and the material of the second shielding layer includes a graphene or a carbon black. The first shielding layer **500** and the second shielding layer can be integrally formed. The conductivity of the first shielding layer **500** and the second shielding layer (resistivity and conductivity are reciprocal to each other) can be uniform or non-uniform. Moreover, minimum conductivity of the first shielding layer **500** is greater than maximum conductivity of the second shielding layer.

[0143] In an implementation, the first shielding layer **500** and the second shielding layer can be made of different materials, and the conductivity of the material used in the first shielding layer **500** is greater than that of the material used in the second shielding layer. Alternatively, the first shielding layer **500** and the second shielding layer can be made of the same material, but the concentration of conductive material in the first shielding layer **500** is greater than that in the second shielding layer. Alternatively, the material thickness of the first shielding layer **500** may be greater than that of the second shielding layer.

[0144] The present embodiment can reduce the electric field strength at the edge of the first shielding layer **500**, reduce the occurrence of discharge, and increase the product life by setting a second shielding layer on the outer peripheral side of the first shielding layer **500**.

[0145] Please continue to refer to FIG. **20** to FIG. **35**, one side of the insulating board **100** facing towards the first part **221** is further provided with a third shielding layer **600**. For example, the third shielding layer **600** is a semiconducting layer, and the material of the third shielding layer includes a graphene or a carbon black. In the first reference plane, the projection of the first part **221** is located in the projection range of the third shielding layer **600**.

[0146] Through the above structures, the present embodiment can adjust the electric-field-strength in the air around the first part **221** through the third shielding layer **600**, prolong the insulation life, and improve the reliability of the product.

[0147] Furthermore, one side of the insulating board **100** facing towards the first part **221** is further provided with a fourth shielding layer (not shown). The fourth shielding layer is connected with the third shielding layer **600** and surrounds an outer periphery of the third shielding layer **600**, resistivity of the fourth shielding layer is greater than that of the third shielding layer **600**.

[0148] For example, the fourth shielding layer is also a semiconducting layer, and the material of the fourth shielding layer includes a graphene or a carbon black. The third shielding layer **600** and the fourth shielding layer can be integrally formed. The conductivity of the third shielding layer

600 and the fourth shielding layer can be uniform or non-uniform. Moreover, minimum conductivity of the third shielding layer **600** is greater than maximum conductivity of the fourth shielding layer.

[0149] In an implementation, the third shielding layer **600** and the fourth shielding layer can be made of different materials, and the conductivity of the material used in the third shielding layer **600** is greater than that of the material used in the fourth shielding layer. Alternatively, the third shielding layer **600** and the fourth shielding layer can be made of the same material, but the concentration of conductive material in the third shielding layer **600** is greater than that in the fourth shielding layer. Alternatively, the material thickness of the third shielding layer **600** may be greater than that of the fourth shielding layer.

[0150] The present embodiment can reduce the electric field strength at the edge of the third shielding layer **600**, reduce the occurrence of discharge, and increase the product life by setting the fourth shielding layer on the outer peripheral side of the third shielding layer **600**.

[0151] In an implementation, the resistivity of the selected materials for the first shielding layer **500** and the third shielding layer **600** can be the same, or the resistivity of the selected materials can be different according to actual requirements.

[0152] In an implementation, the resistivity of the selected materials for the second and fourth shielding layers can be the same, or the resistivity of the selected materials can be different according to actual requirements.

[0153] In an implementation, the magnetic core **210** can be a U-shaped magnetic core, an E-shaped magnetic core, or other shaped magnetic cores. In the second reference plane, the magnetic core **210** includes vertices near the protrusion portion **120** and vertices away from the protrusion portion **120**. In the third reference plane, the magnetic core **210** includes vertices near the protrusion portion **120** and vertices away from the protrusion portion **120**.

[0154] In the description of the present application, it should be understood that the orientation or positional relationship indicated by the terms “center”, “longitudinal”, “transverse”, “length”, “width”, “thickness”, “up”, “down”, “front”, “back”, “left”, “right”, “vertical”, “horizontal”, “top”, “bottom”, “inside”, “outside”, “clockwise”, “counterclockwise”, “axial”, “radial”, “circumferential” and other terms is based on the orientation or positional relationship shown in the accompanying drawings, and is only for the convenience of describing the present application and simplifying the description, rather than indicating or implying that the apparatus or component referred to must have a specific orientation, or be constructed and operated in a specific orientation, therefore they cannot be understood as a limitation on the present application.

[0155] In the present application, unless otherwise specified and limited, the terms “installation”, “connection”, “link”, “fixation” and other terms should be broadly understood, for example, they may be fixed connections, detachable connections, or integrated; they may be directly connected or indirectly connected through an intermediate medium, they may be the internal connection of two components or the interaction relationship between two components. For those of ordinary skill in the art, the specific meanings of the above terms in the present application may be understood based on specific situations.

[0156] It should be noted that in the description of the present application, the terms “first” and “second” are only used for the convenience of describing different components, and cannot be understood as indicating or implying sequential relationships, relative importance, or implicitly indicating the quantity of technical features. Therefore, the features limited by “first” and “second” may explicitly or implicitly include at least one of these features.

[0157] In the present application, each embodiment or implementation is described in a progressive manner, and each embodiment focuses on the differences from other embodiments, the same and similar parts between each embodiment may be referred to each other.

[0158] In the description of the present application, the reference terms “one embodiment”, “some embodiments”, “illustrative embodiments”, “examples”, “specific examples”, or “some examples” and other descriptions refer to specific features, structures, materials, or characteristics described in combination with embodiments or examples included in at least one embodiment or example of the present application. In the present application, the illustrative expressions of the above terms may not necessarily refer to the same implementation or example. Moreover, the described specific features, structures, materials, or characteristics may be appropriately combined in any one or more embodiments or examples.

[0159] Finally, it should be noted that: the above embodiments are only used to illustrate the technical solutions of the present application, rather than limitation; although the present application has been illustrated in detail with reference to the foregoing embodiments, those of ordinary skill in the art should understand that: the technical solutions recorded in the foregoing embodiments may still be modified, or some or all of the technical features may be equivalently substituted; and these modifications or substitutions do not make the essence of the corresponding technical solutions deviate from the scope of the technical solutions of the embodiments of the present application.

Claims

1. A power module, comprising: an insulating board, comprising a flat plate portion; a transformer, comprising a magnetic core and a first winding wound on the magnetic core, wherein the first winding comprises a first part and a second part connected electrically, wherein the first part is located on one side of the insulating board away from the magnetic core, and the second part is set within the insulating board; a first shielding layer which is set at least on one side of the insulating board facing towards the magnetic core; wherein in a first reference plane parallel to the flat plate portion, a projection of the magnetic core is located in a projection range of the first shielding layer.

2. The power module according to claim 1, wherein the insulating board further comprises a protrusion portion and a connecting bridge; the flat plate portion is parallel to the first reference plane formed by a first direction and a second direction; the protrusion portion and/or the connecting bridge protrude from the flat plate portion along a third direction to form an insulation cavity; at least part of the magnetic core is set within the insulation cavity; the first part is located on one side of the protrusion portion away from the insulation cavity, and the second part is located within the connecting bridge, the transformer further comprises a second winding, the second winding is directly wound on the magnetic core; the magnetic core comprises a first vertical pillar and a second vertical pillar arranged opposite to each other, as well as a first transverse pillar and a second transverse pillar arranged opposite to each other; the first vertical pillar, the first transverse pillar, the second vertical pillar, and the second transverse pillar are connected head-to-tail in sequence; wherein every two of the first direction, the second direction, and the third direction are perpendicular to each other.

3. The power module according to claim 2, wherein within a plane parallel to a second reference plane formed by the first direction and the third direction, the magnetic core comprises a first endpoint, a second endpoint, a third endpoint, and a fourth endpoint; along the third direction, the first endpoint and the second endpoint are located at two ends of the magnetic core near the protrusion portion, respectively, and the third endpoint and the fourth endpoint are located at two ends of the magnetic core away from the protrusion portion, respectively; along the first direction, the first shielding layer comprises a first shielding end and a second shielding end, wherein the first shielding end is close to the first endpoint and the second shielding end is close to the second endpoint.

4. The power module according to claim 2, wherein within a plane parallel to a third reference plane formed by the second direction and the third direction, the magnetic core comprises a fifth endpoint, a sixth endpoint, a seventh endpoint, and an eighth endpoint; along the third direction, the fifth endpoint and the sixth endpoint are located at two ends of the magnetic core near the

protrusion portion, respectively, and the seventh endpoint and the eighth endpoint are located at two ends of the magnetic core away from the protrusion portion, respectively; along the second direction, the first shielding layer comprises a third shielding end and a fourth shielding end, wherein the third shielding end is close to the fifth endpoint and the fourth shielding end is close to the sixth endpoint.
5. The power module according to claim 3, wherein along the first direction, a distance between the first shielding end and the first endpoint is H**1**, and along the third direction, a distance between the third endpoint and the protrusion portion is D**1**; along the first direction, a distance between the second shielding end and the second endpoint is H**2**, and along the third direction, a distance between the fourth endpoint and the protrusion portion is D**2**, wherein H**1**/D**1** and H**2**/D**2** satisfies a condition of being greater than or equal to a first threshold and less than or equal to a second threshold.
6. The power module according to claim 5, wherein the first threshold is 1.5, and the second threshold is 3.
7. The power module according to claim 4, wherein along the second direction, a distance between the third shielding end and the fifth endpoint is H**3**, and along the third direction, a distance between the seventh endpoint and the protrusion portion is D**3**; along the second direction, a distance between the fourth shielding end and the six endpoint is H**4**, and along the third direction, a distance between the eighth endpoint and the protrusion portion is D**4**, wherein H**3**/D**3** and H**4**/D**4** satisfies a condition of being greater than or equal to a third threshold and less than or equal to a fourth threshold.
8. The power module according to claim 7, wherein the third threshold is 1.5, and the fourth threshold is 3.
9. The power module according to claim 2, wherein in the first reference plane, a projection of the first shielding layer is located in a projection range of the insulating board.
10. The power module according to claim 2, wherein the first shielding layer is provided on one side of the flat plate portion along the third direction, a surface of the connecting bridge, and one side of the protrusion portion facing towards the magnetic core.
11. The power module according to claim 1, further comprising a second shielding layer, which is provided on one side of the insulating board facing towards the magnetic core, wherein the second shielding layer is connected with the first shielding layer and surrounds an outer periphery of the first shielding layer, and resistivity of the second shielding layer is greater than that of the first shielding layer.
12. The power module according to claim 1, further comprising a third shielding layer, which is provided on one side of the insulating board facing towards the first part, wherein in the first reference plane, a projection of the first part is located in a projection range of the third shielding layer.
13. The power module according to claim 12, further comprising a fourth shielding layer, which is provided on one side of the insulating board facing towards the first part, wherein the fourth shielding layer is connected with the third shielding layer and surrounds an outer periphery of the third shielding layer, and resistivity of the fourth shielding layer is greater than that of the third shielding layer.
14. The power module according to claim 2, wherein along the third direction, a distance between the connecting bridge and the flat plate portion is zero, the protrusion portion protrudes from the flat plate portion, the first transverse pillar is located within the insulation cavity, the second transverse pillar is located outside the insulation cavity, the second winding is wound on the first transverse pillar.
15. The power module according to claim 2, wherein along the third direction, a distance between the protrusion portion and the flat plate portion is zero, the connecting bridge protrudes from the flat plate portion, the first transverse pillar is located within the insulation cavity, the second

transverse pillar is located outside the insulation cavity, the second winding is wound on the first transverse pillar.

16. The power module according to claim 2, wherein the insulating board further comprises a partition board, which is located within the insulation cavity, the protrusion portion is connected with the connecting bridge by the partition board, and the partition board divides the insulation cavity into a first insulation cavity and a second insulation cavity, the first transverse pillar is located within the first insulation cavity, and the second transverse pillar is located within the second insulation cavity.

17. The power module according to claim 16, wherein the transformer comprises two first windings and two second windings, the two first windings are respectively wound on outer sides of the two second windings, the first parts of the two first windings are respectively set on one side of the protrusion portion away from the insulation cavity, the second parts of the two first windings are respectively set within the partition board and the connecting bridge, the two second windings are respectively wound on the first transverse pillar and the second transverse pillar.

18. The power module according to claim 16, wherein along the third direction, a distance between the protrusion portion and the flat plate portion is zero, the connecting bridge protrudes from the flat plate portion.

19. The power module according to claim 16, wherein along the third direction, a distance between the connecting bridge and the flat plate portion is zero, the protrusion portion protrudes from the flat plate portion.