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Semiconductor structure and manufacturing method thereof

Abstract

A semiconductor structure including a device wafer, a carrier structure, and a redistribution layer (RDL) structure is provided. The device wafer includes a first substrate, a first dielectric layer, first bonding pads, and a power via structure. The carrier structure includes the following components. A second substrate has a third surface and a fourth surface opposite to each other. A second dielectric layer is located on the third surface. Second bonding pads are located in the second dielectric layer. The second bonding pads are bonded to the first bonding pad, and the second dielectric layer is bonded to the first dielectric layer. A heat dissipation plate is located on the fourth surface. Through-substrates via (TSVs) pass through the second substrate. The TSV is electrically connected to the heat dissipation plate and the second bonding pad. The RDL structure is electrically connected to the power via structure.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

(1) This application claims the priority benefit of Taiwanese application no. 112112555, filed on Mar. 31, 2023. The entirety of the above-mentioned patent application is hereby incorporated by

reference herein and made a part of this specification.

BACKGROUND

Technical Field

(2) The invention relates to a semiconductor structure and a manufacturing method thereof, and particularly relates to a semiconductor structure capable of improving heat dissipation performance and a manufacturing method thereof.

Description of Related Art

(3) Currently, the backside power delivery network has been developed. Therefore, the power circuit and the signal circuit in the semiconductor structure can be separated, thereby reducing the complexity of the circuit design and improving the performance of the semiconductor structure. However, the semiconductor structure with the backside power delivery network has poor heat dissipation performance. Therefore, how to improve the heat dissipation performance of the semiconductor structure with the backside power delivery network is the goal of continuous efforts.

SUMMARY

(4) The invention provides a semiconductor structure and a manufacturing method thereof, which can effectively improve the heat dissipation performance of the semiconductor structure.

(5) The invention provides a semiconductor structure, which includes a device wafer, a carrier structure, and a redistribution layer (RDL) structure. The device wafer includes a first substrate, a first dielectric layer, first bonding pads, and a power via structure. The first substrate has a first surface and a second surface opposite to each other. The first dielectric layer is located on the first surface. The first bonding pads are located in the first dielectric layer. The power via structure passes through the first substrate. The carrier structure includes a second substrate, a second dielectric layer, second bonding pads, a heat dissipation plate, and through-substrate vias (TSVs). The second substrate has a third surface and a fourth surface opposite to each other. The second dielectric layer is located on the third surface. The second bonding pads are located in the second dielectric layer. The second bonding pads are bonded to the first bonding pads, and the second dielectric layer is bonded to the first dielectric layer. The heat dissipation plate is located on the fourth surface. The TSVs pass through the second substrate. Each of the TSVs is electrically connected to the heat dissipation plate and the corresponding second bonding pad. The RDL structure is located on the second surface. The RDL structure is electrically connected to the power via structure.

(6) According to an embodiment of the invention, in the semiconductor structure, the carrier structure may further include an integrated passive device (IPD). The integrated passive device is located in the second dielectric layer. The integrated passive device may be electrically connected to one of the second bonding pads.

(7) According to an embodiment of the invention, in the semiconductor structure, the carrier structure may further include a third dielectric layer. The third dielectric layer is located on the fourth surface. The heat dissipation plate is located in the third dielectric layer.

(8) According to an embodiment of the invention, in the semiconductor structure, the third dielectric layer may completely cover the heat dissipation plate.

(9) According to an embodiment of the invention, in the semiconductor structure, the third dielectric layer may expose the heat dissipation plate.

(10) According to an embodiment of the invention, in the semiconductor structure, the power via structure may be a multilayer structure.

(11) According to an embodiment of the invention, in the semiconductor structure, the power via structure may be a single-layer structure.

(12) According to an embodiment of the invention, in the semiconductor structure, the TSVs may be directly connected to the heat dissipation plate.

(13) According to an embodiment of the invention, in the semiconductor structure, the TSVs may be directly connected to the second bonding pads.

(14) According to an embodiment of the invention, in the semiconductor structure, the device wafer may further include an interconnect structure. The interconnect structure is located in the first dielectric layer. The interconnect structure may be electrically connected to the power via structure. The interconnect structure may be electrically connected to the first bonding pads.

(15) According to an embodiment of the invention, in the semiconductor structure, the RDL structure may include a third dielectric layer, an RDL, a pad, and an integrated passive device. The third dielectric layer is located on the second surface. The RDL is located in the third dielectric layer. The RDL may be electrically connected to the power via structure. The pad is located in the third dielectric layer. The pad may be electrically connected to the RDL. The integrated passive device is located in the third dielectric layer. The integrated passive device may be electrically connected to the RDL.

(16) According to an embodiment of the invention, the semiconductor structure may further include a connection terminal. The connection terminal is located on the RDL structure. The connection terminal may be electrically connected to the pad.

(17) According to an embodiment of the invention, the semiconductor structure may further include an under-bump metallurgy (UBM). The UBM is located between the connection terminal and the pad.

(18) The invention provides a manufacturing method of a semiconductor structure, which includes the following steps. A device wafer is formed. The device wafer includes a first substrate, a first dielectric layer, first bonding pads, and a power via structure. The first substrate has a first surface and a second surface opposite to each other. The first dielectric layer is located on the first surface. The first bonding pads are located in the first dielectric layer. The power via structure passes through the first substrate. A carrier structure is formed above the first surface. The carrier structure includes a second substrate, a second dielectric layer, second bonding pads, a heat dissipation plate, and TSVs. The second substrate has a third surface and a fourth surface opposite to each other. The second dielectric layer is located on the third surface. The second bonding pads are located in the second dielectric layer. The second bonding pads are bonded to the first bonding pads, and the second dielectric layer is bonded to the first dielectric layer. The heat dissipation plate is located on the fourth surface. The TSVs pass through the second substrate. Each of the TSVs is electrically connected to the heat dissipation plate and the corresponding second bonding pad. An RDL structure is formed above the second surface. The RDL structure is electrically connected to the power via structure.

(19) According to an embodiment of the invention, in the manufacturing method of the semiconductor structure, the carrier structure may further include an integrated passive device. The integrated passive device is located in the second dielectric layer. The integrated passive device may be electrically connected to one of the second bonding pads.

(20) According to an embodiment of the invention, in the manufacturing method of the semiconductor structure, the method of bonding the second bonding pads to the first bonding pads and bonding the second dielectric layer to the first dielectric layer is, for example, a hybrid bonding method.

(21) According to an embodiment of the invention, in the manufacturing method of the semiconductor structure, the heat dissipation plate may be formed first, and then the RDL structure may be formed.

(22) According to an embodiment of the invention, in the manufacturing method of the semiconductor structure, the RDL structure may be formed first, and then the heat dissipation plate may be formed.

(23) According to an embodiment of the invention, in the manufacturing method of the semiconductor structure, the RDL structure may include a third dielectric layer, an RDL, a pad, and an integrated passive device. The third dielectric layer is located on the second surface. The RDL is located in the third dielectric layer. The RDL may be electrically connected to the power via

structure. The pad is located in the third dielectric layer. The pad may be electrically connected to the RDL. The integrated passive device is located in the third dielectric layer. The integrated passive device may be electrically connected to the RDL.

(24) According to an embodiment of the invention, the manufacturing method of the semiconductor structure may further include the following step. A connection terminal is formed on the RDL structure. The connection terminal may be electrically connected to the pad.

(25) Based on the above description, in the semiconductor structure and the manufacturing method thereof according to the invention, the second bonding pads are bonded to the first bonding pads, the TSVs pass through the second substrate, and each of the TSVs is electrically connected to the heat dissipation plate and the corresponding second bonding pad. Therefore, the heat dissipation performance of the semiconductor structure can be effectively improved by the heat dissipation plate. In some embodiments, the heat dissipation plate can be used as a power line, thereby improving the circuit design flexibility and the circuit performance.

(26) In order to make the aforementioned and other objects, features and advantages of the invention comprehensible, several exemplary embodiments accompanied with drawings are described in detail below.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

(2) FIG. 1A to FIG. 1G are cross-sectional views of a manufacturing process of a semiconductor structure according to some embodiments of the invention.

(3) FIG. 2A to FIG. 2F are cross-sectional views of a manufacturing process of a semiconductor structure according to other embodiments of the invention.

(4) FIG. 3 to FIG. 5 are cross-sectional views of a semiconductor structure according to other embodiments of the invention.

DESCRIPTION OF THE EMBODIMENTS

(5) The embodiments are described in detail below with reference to the accompanying drawings, but the embodiments are not intended to limit the scope of the invention. For the sake of easy understanding, the same components in the following description will be denoted by the same reference symbols. In addition, the drawings are for illustrative purposes only and are not drawn to the original dimensions. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

(6) FIG. 1A to FIG. 1G are cross-sectional views of a manufacturing process of a semiconductor structure according to some embodiments of the invention. FIG. 2A to FIG. 2F are cross-sectional views of a manufacturing process of a semiconductor structure according to other embodiments of the invention. FIG. 2A to FIG. 2F are cross-sectional views of the manufacturing process following the step of FIG. 1C. FIG. 3 to FIG. 5 are cross-sectional views of a semiconductor structure according to other embodiments of the invention.

(7) Referring to FIG. 1A, a device wafer **100** may be provided. The device wafer **100** may include a substrate **102**, a dielectric layer **104**, bonding pads **106**, and a via **108**. The substrate **102** has a first surface **S1** and a second surface **S2** opposite to each other. In some embodiments, the first surface **S1** may be the front side of the substrate **102**, and the second surface **S2** may be the back side of the substrate **102**. The substrate **102** may be a semiconductor substrate such as a silicon substrate. In addition, although not shown in the figure, the substrate **102** may have required

semiconductor devices (e.g., active device and/or passive device) thereon, and the description thereof is omitted here.

(8) The dielectric layer **104** is located on the first surface **S1**. In some embodiments, dielectric layer **104** may be a multilayer structure. The material of the dielectric layer **104** may include silicon oxide, silicon nitride, or a combination thereof. The bonding pads **106** are located in the dielectric layer **104**. The material of the bonding pad **106** may include copper, tantalum, tantalum nitride, or a combination thereof. The via **108** is located in the substrate **102** and the dielectric layer **104**. The material of the via **108** may include tungsten, copper, tantalum, tantalum nitride, or a combination thereof.

(9) In some embodiments, the device wafer **100** may further include an interconnect structure **110**. The interconnect structure **110** is located in the dielectric layer **104**. The interconnect structure **110** may be electrically connected to the via **108**. The interconnect structure **110** may be electrically connected to the bonding pads **106**. In some embodiments, the interconnect structure **110** may include a front end of line (FEOL) interconnect structure and a back end of line (BEOL) interconnect structure. The interconnect structure **110** may include a contact, a via, a conductive line, or a combination thereof. The material of the interconnect structure **110** may include copper, aluminum, tungsten, tantalum, tantalum nitride, titanium, titanium nitride, or a combination thereof. In addition, the quantity, shape, and arrangement of the interconnect structure **110** may be adjusted according to the requirement.

(10) Referring to FIG. **1B**, a carrier structure **112** may be provided. The carrier structure **112** includes a substrate **114**, a dielectric layer **116**, bonding pads **118**, and TSVs **120**. The substrate **114** has a third surface **S3** and a fourth surface **S4** opposite to each other. The substrate **114** may be a semiconductor substrate such as a silicon substrate. The dielectric layer **116** is located on the third surface **S3**. In some embodiments, the dielectric layer **104** may be a multilayer structure. The material of the dielectric layer **116** may include silicon oxide, silicon nitride, or a combination thereof.

(11) The bonding pads **118** are located in the dielectric layer **116**. The material of the bonding pad **106** may include copper, tantalum, tantalum nitride, or a combination thereof. The TSVs **120** are located in the substrate **114**. In some embodiments, the TSVs **120** may be further located in the dielectric layer **116**. Each of the TSVs **120** is electrically connected to the corresponding bonding pad **118**. The material of the TSV **120** may include copper, tantalum, tantalum nitride, or a combination thereof.

(12) In some embodiments, the carrier structure **112** may further include an integrated passive device **122**. The integrated passive device **122** is located in the dielectric layer **116**. In other embodiments, although not shown in the figure, the integrated passive device **122** may be further located in the substrate **114**. The integrated passive device **122** may be electrically connected to one of the bonding pads **118**. In some embodiments, the integrated passive device **122** may be a trench type passive device or a 3D cylinder type passive device. In some embodiments, the integrated passive device **122** may be a passive device such as a capacitor.

(13) In some embodiments, the carrier structure **112** may further include an interconnect structure **124**. The interconnect structure **124** is located in the dielectric layer **116**. In addition, the interconnect structure **124** may be electrically connected to the TSV **120**. Furthermore, the interconnect structure **124** may be electrically connected to the bonding pad **118**. In the present embodiment, each of the TSVs **120** may be electrically connected to the corresponding bonding pad **118** by the interconnect structure **124**. On the other hand, the interconnect structure **124** may be electrically connected to the integrated passive device **122**. That is, each of the integrated passive devices **122** may be electrically connected to the corresponding bonding pad **118** by the interconnect structure **124**. The interconnect structure **124** may include a contact, a via, a conductive line, or a combination thereof. The material of the interconnect structure **124** may include copper, aluminum, tungsten, tantalum, tantalum nitride, titanium, titanium nitride, or a

combination thereof. Moreover, the quantity, shape, and arrangement of the interconnect structure **124** may be adjusted according to the requirement.

(14) Referring to FIG. **1C**, the bonding pads **118** may be bonded to the bonding pads **106**, and the dielectric layer **116** may be bonded to the dielectric layer **104**. In some embodiments, the method of bonding the bonding pads **118** to the bonding pad **106** and bonding the dielectric layer **116** to the dielectric layer **104** is, for example, a hybrid bonding method.

(15) Referring to FIG. **1D**, a portion of the substrate **114** may be removed from the fourth surface **S4** to expose the TSV **120**. Therefore, the TSV **120** may pass through the substrate **114**. In some embodiments, the portion of the substrate **114** may be removed by a chemical mechanical polishing (CMP) process and an etch-back process.

(16) A dielectric layer **126** and a heat dissipation plate **128** may be formed. The dielectric layer **126** and the heat dissipation plate **128** are located on the fourth surface **S4**. In some embodiments, the dielectric layer **126** may be a multilayer structure. The material of the dielectric layer **126** may include silicon oxide, silicon nitride, or a combination thereof. The heat dissipation plate **128** is located in the dielectric layer **126**. The heat dissipation plate **128** may be electrically connected to the TSV **120**. In addition, each of the TSVs **120** is electrically connected to the heat dissipation plate **128** and the corresponding bonding pad **118**. The material of the heat dissipation plate **128** may include copper, tantalum, tantalum nitride, or a combination thereof. Furthermore, the dielectric layer **126** and the heat dissipation plate **128** may be fabricated by the conventional method, and the description thereof is omitted here.

(17) By the above method, the carrier structure **112A** may be formed on the first surface **S1**. The carrier structure **112A** includes the substrate **114**, the dielectric layer **116**, the bonding pads **118**, the heat dissipation plate **128** and the TSVs **120**. In some embodiments, the carrier structure **112A** may further include the integrated passive device **122** and the interconnect structure **124**.

(18) Referring to FIG. **1E**, a thinning process may be formed on the substrate **102** from the second surface **S2** to reduce the thickness of the substrate **102**. In some embodiments, the thinning process may be a grinding process, a CMP process, or a combination thereof.

(19) A dielectric layer **130** may be formed on the second surface **S2**. The material of the dielectric layer **130** may include silicon oxide. The method of forming the dielectric layer **130** is, for example, a chemical vapor deposition (CVD) method.

(20) A via **132** may be formed in the dielectric layer **130** and the substrate **102**. Therefore, the power via structure **134** may be formed. The power via structure **134** passes through the substrate **102**. In the present embodiment, the power via structure **134** may include the via **108** and the via **132**. That is, the power via structure **134** may be a multilayer structure, but the invention is not limited thereto. The via **132** may be electrically connected to the via **108**. The material of the via **132** may include tungsten, copper, tantalum, tantalum nitride, or a combinations thereof. In some embodiments, the via **132** may be formed by a damascene process.

(21) By the above method, the device wafer **100A** may be formed. The device wafer **100A** includes the substrate **102**, the dielectric layer **104**, the bonding pads **106**, and the power via structure **134**. In some embodiments, the device wafer **100A** may further include the interconnect structure **110** and the dielectric layer **130**.

(22) Referring to FIG. **1F**, an RDL structure **136** is formed above the second surface **S2**. The RDL structure **136** is electrically connected to the power via structure **134**. In some embodiments, the RDL structure **136** may be used as a backside power delivery network.

(23) In some embodiments, the RDL structure **136** may include a dielectric layer **138**, an RDL **140**, a pad **142**, and an integrated passive device **143**. The dielectric layer **138** is located on the second surface **S2**. In some embodiments, the dielectric layer **138** may be located on the dielectric layer **130**. The RDL **140** is located in the dielectric layer **138**. The RDL **140** may be electrically connected to the power via structure **134**. The material of the RDL **140** may include copper, tantalum, tantalum nitride, or a combination thereof. The pad **142** is located in the dielectric layer

138. The pad **142** may be electrically connected to the RDL **140**. The material of the pad **142** may include a conductive material such as aluminum. The integrated passive device **143** is located in the dielectric layer **138**. In other embodiments, although not shown in the figure, the integrated passive device **143** may be further located in the dielectric layer **130** and the substrate **102**. The integrated passive device **143** may be electrically connected to the RDL **140**. In some embodiments, the integrated passive device **143** may be a trench type passive device or a 3D cylinder type passive device. In some embodiments, the integrated passive device **143** may be a passive device such as a capacitor. The RDL structure **136** may be fabricated by the conventional method, and the description thereof is omitted here.

(24) Referring to FIG. **1G**, an opening **OP1** may be formed in the dielectric layer **138**. The opening **OP1** may expose the pad **142**. A UBM **144** may be formed in the opening **OP1**. The UBM **144** may be electrically connected to the pad **142**. A connection terminal **146** may be formed on the RDL structure **136**. In some embodiments, the connection terminal **146** may be formed on the UBM **144**. The connection terminal **146** may be electrically connected to the pad **142**. The connection terminal **146** may be a bump (e.g., solder ball), but the invention is not limited thereto.

(25) In the present embodiment, the heat dissipation plate **128** may be formed first, and then the RDL structure **136** may be formed, but the invention is not limited thereto. In other embodiments, as shown in FIG. **2A** to FIG. **2F**, the RDL structure **136** may be formed first, and then the heat dissipation plate **128** may be formed. First, as shown in FIG. **2A**, after forming the structure as shown in FIG. **1C**, the steps as shown in FIG. **1E** may be performed to form the dielectric layer **130** and the power via structure **134**. Therefore, the device wafer **100A** may be formed. As shown in FIG. **2B**, the steps as shown in FIG. **1F** may be performed to form the RDL structure **136** above the second surface **S2**. As shown in FIG. **2C**, a carrier structure **200** may be bonded to the RDL structure **136**, wherein the carrier structure **200** may include a substrate **202** and a dielectric layer **204**. In some embodiments, the dielectric layer **204** of the carrier structure **200** may be bonded to the dielectric layer **138** of the RDL structure **136**. As shown in FIG. **2D**, the steps as shown in FIG. **1D** may be performed to form the dielectric layer **126** and the heat dissipation plate **128**. Therefore, the carrier structure **112A** may be formed on the first surface **S1**. As shown in FIG. **2E**, the carrier structure **200** may be removed. As shown in FIG. **2F**, the steps as shown in FIG. **1G** may be performed to form the UBM **144** and the connection terminal **146**. In addition, in FIG. **1A** to FIG. **1G** and FIG. **2A** to FIG. **2F**, the same or similar components are denoted by the same reference symbols, and the description thereof is omitted here.

(26) Hereinafter, the semiconductor structure **10** of the above embodiments will be described with reference to FIG. **1G**. In addition, although the method for forming the semiconductor structure **10** is described by taking the above method as an example, the invention is not limited thereto.

(27) Referring to FIG. **1G**, the semiconductor structure **10** includes a device wafer **100A**, a carrier structure **112A** and an RDL structure **136**. The device wafer **100A** includes a substrate **102**, a dielectric layer **104**, bonding pads **106**, and a power via structure **134**. The substrate **102** has a first surface **S1** and a second surface **S2** opposite to each other. The dielectric layer **104** is located on the first surface **S1**. The bonding pads **106** are located in the dielectric layer **104**. The power via structure **134** passes through the substrate **102**. The device wafer **100A** may further include an interconnect structure **110** and a dielectric layer **130**. The interconnect structure **110** is located in the dielectric layer **104**. In addition, the interconnect structure **110** may be electrically connected to the power via structure **134**. Furthermore, the interconnect structure **110** may be electrically connected to the bonding pads **106**. The dielectric layer **130** may be located on the second surface **S2**.

(28) The carrier structure **112A** includes a substrate **114**, a dielectric layer **116**, bonding pads **118**, a heat dissipation plate **128**, and TSVs **120**. The substrate **114** has a third surface **S3** and a fourth surface **S4** opposite to each other. The dielectric layer **116** is located on the third surface **S3**. The bonding pads **118** are located in the dielectric layer **116**. The bonding pads **118** are bonded to the

bonding pads **106**, and the dielectric layer **116** is bonded to the dielectric layer **104**. The heat dissipation plate **128** is located on the fourth surface **S4**. Therefore, the heat dissipation performance of the semiconductor structure **10** can be effectively improved by the heat dissipation plate **128**. In some embodiments, the heat dissipation plate **128** can be used as a power line, thereby improving the circuit design flexibility and the circuit performance. The TSVs **120** pass through the substrate **114**. Each of the TSVs **120** is electrically connected to the heat dissipation plate **128** and the corresponding bonding pad **118**. In some embodiments, the TSVs **120** may be directly connected to the heat dissipation plate **128**.

(29) In some embodiments, the carrier structure **112A** may further include an integrated passive device **122**, thereby improving the performance of the power circuit. The integrated passive device **122** is located in the dielectric layer **116**. In other embodiments, although not shown in the figure, the integrated passive device **122** may be further located in the substrate **114**. The integrated passive device **122** may be electrically connected to one of the bonding pads **118**. In some embodiments, the carrier structure **112** may further include an interconnect structure **124**. The interconnect structure **124** is located in the dielectric layer **116**. In addition, the interconnect structure **124** may be electrically connected to the TSV **120**. Furthermore, the interconnect structure **124** may be electrically connected to the bonding pad **118**. On the other hand, the interconnect structure **124** may be electrically connected to the integrated passive device **122**. In some embodiments, the carrier structure **112A** may further include a dielectric layer **126**. The dielectric layer **126** is located on the fourth surface **S4**. The heat dissipation plate **128** may be located in the dielectric layer **126**.

(30) The RDL structure **136** is located on the second surface **S2**. In some embodiments, RDL structure **136** may be located on dielectric layer **130**. The RDL structure **136** is electrically connected to the power via structure **134**. The RDL structure **136** may include a dielectric layer **138**, an RDL **140**, a pad **142**, and an integrated passive device **143**. The dielectric layer **138** is located on the second surface **S2**. In some embodiments, the dielectric layer **138** may be located on the dielectric layer **130**. The RDL **140** is located in the dielectric layer **138**. The RDL **140** may be electrically connected to the power via structure **134**. The pad **142** is located in the dielectric layer **138**. The pad **142** may be electrically connected to the RDL **140**. The integrated passive device **143** is located in the dielectric layer **138**. In other embodiments, although not shown in the figure, the integrated passive device **143** may be further located in the dielectric layer **130** and the substrate **102**. The integrated passive device **143** may be electrically connected to the RDL **140**.

(31) In some embodiments, the semiconductor structure **10** may further include a connection terminal **146**. The connection terminal **146** is located on the RDL structure **136**. The connection terminal **146** may be electrically connected to the pad **142**. In some embodiments, the semiconductor structure **10** may further include a UBM **144**. The UBM **144** is located between the connection terminal **146** and the pad **142**.

(32) In the present embodiment, as shown in FIG. 1G, the dielectric layer **126** may completely cover the heat dissipation plate **128**, but the invention is not limited thereto. In other embodiments, as shown in FIG. 3, the dielectric layer **126** may expose the heat dissipation plate **128**, thereby further improving the heat dissipation performance of the semiconductor structure **10**.

(33) In the present embodiment, as shown in FIG. 1G, the power via structure **134** may be a multilayer structure, but the invention is not limited thereto. In other embodiments, as shown in FIG. 4, the power via structure **134** may be a single-layer structure.

(34) In the present embodiment, as shown in FIG. 1G, each of the TSVs **120** may be electrically connected to the corresponding bonding pad **118** by the interconnect structure **124**, but the invention is not limited thereto. In other embodiments, as shown in FIG. 5, the TSVs **120** may be directly connected to the bonding pads **118**. Furthermore, as shown in FIG. 5, the interconnect structure **124** may be omitted.

(35) In the present embodiment, as shown in FIG. 1G, the carrier structure **112** may include the

integrated passive device **122**, but the invention is not limited thereto. In other embodiments, as shown in FIG. 5, the integrated passive device **122** may be omitted.

(36) In addition, the remaining components in the semiconductor structure **10** may refer to the descriptions of the above-mentioned embodiments. Furthermore, the details of the components in the semiconductor structure **10** (e.g., materials and forming methods) have been described in detail in the above-mentioned embodiments, and the description thereof is omitted here. On the other hand, in FIG. 1G and FIG. 3 to FIG. 5, the same or similar components are denoted by the same reference symbols, and the description thereof is omitted here.

(37) Based on the above embodiments, in the semiconductor structure **10** and the manufacturing method thereof, the bonding pads **118** are bonded to the bonding pads **106**, the TSVs **120** pass through the substrate **114**, and each of the TSVs **120** is electrically connected to the heat dissipation plate **128** and the corresponding bonding pad **118**. Therefore, the heat dissipation performance of the semiconductor structure **10** can be effectively improved by the heat dissipation plate **128**. In some embodiments, the heat dissipation plate **128** can be used as a power line, thereby improving the circuit design flexibility and the circuit performance.

(38) In summary, in the semiconductor structure and the manufacturing method thereof of the aforementioned embodiments, since the carrier structure includes bonding pads, a heat dissipation plate, and TSVs, the heat dissipation performance, circuit design flexibility, and circuit performance of the semiconductor structure can be effectively improved.

(39) Although the invention has been described with reference to the above embodiments, it will be apparent to one of ordinary skill in the art that modifications to the described embodiments may be made without departing from the spirit of the invention. Accordingly, the scope of the invention is defined by the attached claims not by the above detailed descriptions.

Claims

1. A semiconductor structure, comprising: a device wafer comprising: a first substrate having a first surface and a second surface opposite to each other; a first dielectric layer located on the first surface; first bonding pads located in the first dielectric layer; and a power via structure passing through the first substrate; a carrier structure comprising: a second substrate having a third surface and a fourth surface opposite to each other; a second dielectric layer located on the third surface; second bonding pads located in the second dielectric layer, wherein the second bonding pads are bonded to the first bonding pads, and the second dielectric layer is bonded to the first dielectric layer; a heat dissipation plate located on the fourth surface; and through-substrate vias (TSVs) passing through the second substrate, wherein each of the TSVs is electrically connected to the heat dissipation plate and the corresponding second bonding pad; and a redistribution layer (RDL) structure located on the second surface, wherein the RDL structure is electrically connected to the power via structure.
2. The semiconductor structure according to claim 1, wherein the carrier structure further comprises: an integrated passive device located in the second dielectric layer and electrically connected to one of the second bonding pads.
3. The semiconductor structure according to claim 1, wherein the carrier structure further comprises: a third dielectric layer located on the fourth surface, wherein the heat dissipation plate is located in the third dielectric layer.
4. The semiconductor structure according to claim 3, wherein the third dielectric layer completely covers the heat dissipation plate.
5. The semiconductor structure according to claim 3, wherein the third dielectric layer exposes the heat dissipation plate.
6. The semiconductor structure according to claim 1, wherein the power via structure comprises a multilayer structure.

7. The semiconductor structure according to claim 1, wherein the power via structure comprises a single-layer structure.
 8. The semiconductor structure according to claim 1, wherein the TSVs are directly connected to the heat dissipation plate.
 9. The semiconductor structure according to claim 1, wherein the TSVs are directly connected to the second bonding pads.
 10. The semiconductor structure according to claim 1, wherein the device wafer further comprises: an interconnect structure located in the first dielectric layer, wherein the interconnect structure is electrically connected to the power via structure, and the interconnect structure is electrically connected to the first bonding pads.
 11. The semiconductor structure according to claim 1, wherein the RDL structure comprises: a third dielectric layer located on the second surface; an RDL located in the third dielectric layer and electrically connected to the power via structure; a pad located in the third dielectric layer and electrically connected to the RDL; and an integrated passive device located in the third dielectric layer and electrically connected to the RDL.
 12. The semiconductor structure according to claim 11, further comprising: a connection terminal located on the RDL structure and electrically connected to the pad.
 13. The semiconductor structure according to claim 12, further comprising: an under-bump metallurgy located between the connection terminal and the pad.
 14. A manufacturing method of a semiconductor structure, comprising: forming a device wafer, wherein the device wafer comprises: a first substrate having a first surface and a second surface opposite to each other; a first dielectric layer located on the first surface; first bonding pads located in the first dielectric layer; and a power via structure passing through the first substrate; forming a carrier structure above the first surface, wherein the carrier structure comprises: a second substrate having a third surface and a fourth surface opposite to each other; a second dielectric layer located on the third surface; second bonding pads located in the second dielectric layer, wherein the second bonding pads are bonded to the first bonding pads, and the second dielectric layer is bonded to the first dielectric layer; a heat dissipation plate located on the fourth surface; and TSVs passing through the second substrate, wherein each of the TSVs is electrically connected to the heat dissipation plate and the corresponding second bonding pad; and forming an RDL structure above the second surface, wherein the RDL structure is electrically connected to the power via structure.
 15. The manufacturing method of the semiconductor structure according to claim 14, wherein the carrier structure further comprises: an integrated passive device located in the second dielectric layer and electrically connected to one of the second bonding pads.
 16. The manufacturing method of the semiconductor structure according to claim 14, wherein a method of bonding the second bonding pads to the first bonding pads and bonding the second dielectric layer to the first dielectric layer comprises a hybrid bonding method.
 17. The manufacturing method of the semiconductor structure according to claim 14, wherein the heat dissipation plate is formed first, and then the RDL structure is formed.
 18. The manufacturing method of the semiconductor structure according to claim 14, wherein the RDL structure is formed first, and then the heat dissipation plate is formed.
 19. The manufacturing method of the semiconductor structure according to claim 14, wherein the RDL structure comprises: a third dielectric layer located on the second surface; an RDL located in the third dielectric layer and electrically connected to the power via structure; a pad located in the third dielectric layer and electrically connected to the RDL; and an integrated passive device located in the third dielectric layer and electrically connected to the RDL.
 20. The manufacturing method of the semiconductor structure according to claim 19, further comprising: forming a connection terminal on the RDL structure, wherein the connection terminal is electrically connected to the pad.
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