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Circuit board assembly and method for manufacturing the same

Abstract

A circuit board assembly includes an inner circuit substrate, a first outer circuit substrate, a second outer circuit substrate, a heat conducting block, an electronic component, and a reinforcing plate. The first outer circuit substrate and second outer circuit substrate are disposed on surfaces of the inner circuit substrate. The heat conducting block penetrates through the inner circuit substrate and connects to the first outer circuit substrate and the second outer circuit substrate. The heat conducting block made of aluminum nitride. An electronic component at least partially accommodated in the heat conducting block. The reinforcing plate is disposed on a surface of the second outer circuit substrate corresponding to the electronic component and faces away from the electronic component. The present disclosure further provides a method for manufacturing the circuit board assembly.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
4835598	12/1988	Higuchi	257/E23.101	H05K 1/021
7116557	12/2005	Raby	29/841	H05K 1/183
11122674	12/2020	Yu	N/A	H05K 1/0204
11160160	12/2020	Berkel	N/A	H01L 23/13
2005/0130349	12/2004	Sunohara	257/E21.503	H01L 21/563
2007/0164291	12/2006	Kim	257/79	H05K 1/021
2013/0228362	12/2012	Berkel	165/185	H01L 23/3677
2021/0144841	12/2020	Wang	N/A	H05K 3/0047
2022/0301975	12/2021	Ham	N/A	H01L 21/486
2022/0361324	12/2021	Ji	N/A	H01L 21/4857

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
107896423	12/2017	CN	N/A
110445957	12/2018	CN	N/A
201820559	12/2017	TW	N/A

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Background/Summary

FIELD

(1) The subject matter herein generally relates to circuit boards, and more particularly, to a circuit board assembly and a method for manufacturing the same.

BACKGROUND

(2) A circuit board is used as a support and a carrier for an electronic component. The electronic component is embedded in the circuit board to reduce the thickness of the electronic product, but it causes heat dissipation problems. Therefore, there is a room for improvement in the art.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) Implementations of the present technology will now be described, by way of example only, with reference to the attached figures.

(2) FIG. **1** is a cross-sectional view of an embodiment of an inner circuit substrate according to the present disclosure.

(3) FIG. **2** is a cross-sectional view showing a heat conducting block placed in a through hole of FIG. **1**.

(4) FIG. **3** is a cross-sectional view showing a first outer circuit substrate and a second outer circuit substrate formed on opposite surfaces of the inner circuit substrate of FIG. **1**.

(5) FIG. **4** is a cross-sectional view showing the first outer circuit substrate and the second outer circuit substrate corresponding to an insulating layer of FIG. **3** removed to expose the insulating layer.

(6) FIG. **5** is a cross-sectional view showing an accommodating groove passing through the first outer circuit substrate of FIG. **4** and recessed toward the heat conducting block.

(7) FIG. **6** is a cross-sectional view showing a thermally conductive filler and a first sub-component accommodated in the accommodating groove of FIG. **5**.

(8) FIG. **7** is a cross-sectional view showing a second sub-component connected to a surface of the first outer circuit substrate of FIG. **6**.

(9) FIG. **8** is a cross-sectional view showing a reinforcing plate formed on a surface of the second outer circuit substrate corresponding to the first sub-component of FIG. **4** to form a circuit board assembly.

(10) FIG. **9** is a cross-sectional view showing of another embodiment of a heat conducting block with a metal layer on its surface placed in a through hole of FIG. **1**.

(11) FIG. **10** is a cross-sectional view showing another embodiment of a circuit board assembly according to the present disclosure.

DETAILED DESCRIPTION

(12) It will be appreciated that for simplicity and clarity of illustration, where appropriate, reference numerals have been repeated among the different figures to indicate corresponding or analogous elements. In addition, numerous specific details are set forth in order to provide a thorough understanding of the embodiments described herein. However, it will be understood by those of ordinary skill in the art that the embodiments described herein can be practiced without these specific details. In other instances, methods, procedures, and components have not been described in detail so as not to obscure the related relevant feature being described. Also, the description is not to be considered as limiting the scope of the embodiments described herein. The drawings are not necessarily to scale, and the proportions of certain parts may be exaggerated to better illustrate details and features of the present disclosure.

(13) The term “comprising,” when utilized, means “including, but not necessarily limited to”; it specifically indicates open-ended inclusion or membership in the so-described combination, group, series, and the like.

(14) Some embodiments of the present disclosure will be described in detail with reference to the drawings. If no conflict, the following embodiments and features in the embodiments can be combined with each other.
(15) A method for manufacturing a circuit board assembly **100** is provided according to an embodiment of the present disclosure.
(16) In step **1**, referring to FIG. **1**, an inner circuit substrate **10** including a through hole **16** is provided.
(17) The inner circuit substrate **10** includes an inner dielectric layer **12** and two inner circuit layers **14**. The two inner circuit layers **14** are disposed on opposite surfaces of the inner dielectric layer **12**. In other embodiments, the number of the inner circuit layers **14** can be more, and the multilayer inner circuit layers **14** are electrically connected to each other.
(18) The two inner circuit layers **14** can be made of flexible materials such as polyimide, liquid crystal polymer, and modified polyimide. The two inner circuit layers **14** also can be made of hard materials such as polypropylene, and polytetrafluoroethylene. In the embodiment, the inner dielectric layer **12** is made of polypropylene.
(19) The through hole **16** penetrates through the inner dielectric layer **12** and the two inner circuit layers **14** along a direction in which the inner dielectric layer **12** and the inner circuit layers **14** are stacked.
(20) In some embodiments, the inner circuit substrate **10** can further include an insulating layer **18** disposed on two opposite surfaces of a portion of the inner circuit substrate **10**.
(21) In step **2**, referring to FIG. **2**, a heat conducting block **20** is placed in the through hole **16**.
(22) The heat conducting block **20** is made of aluminum nitride. A thermal conductivity of the aluminum nitride is 320 W/(m.Math.K), and an elasticity modulus of aluminum nitride is 320 Gpa. A thermal conductivity of stainless steel is 12.3 W/(m.Math.K), and an elasticity modulus of stainless steel is 190 Gpa. Compared with stainless steel, the aluminum nitride has the characteristics of high thermal conductivity and high rigidity.
(23) In some embodiments, the heat conducting block **20** is spaced apart from the sidewall forming the through hole **16**. That is, there is a gap between the heat conducting block **20** and the inner circuit substrate **10**.
(24) In step **3**, referring to FIG. **3**, a first outer circuit substrate **30** and a second outer circuit substrate **40** are formed on opposite surfaces of the inner circuit substrate **10**, and the first outer circuit substrate **30** and the second outer circuit substrate **40** cover the heat conducting block **20**.
(25) The first outer circuit substrate **30** includes a first outer dielectric layer **32** and a first outer circuit layer **34**. The second outer circuit substrate **40** includes a second outer dielectric layer **42** and a second outer circuit layer **44**. The number of each of the first outer dielectric layer **32**, the first outer circuit layer **34**, the second outer dielectric layer **42** and the second outer circuit layer **44** may be one or more. Both the first outer circuit substrate **30** and the second outer circuit substrate **40** are electrically connected to the inner circuit substrate **10**. The first outer dielectric layer **32** and the second outer dielectric layer **42** are connected to the heat conducting block **20**.
(26) In some embodiments, during forming the first outer circuit substrate **30** and the second outer circuit substrate **40**, the first outer dielectric layer **32** and the second outer dielectric layer **42** further fill the gap between the heat conducting block **20** and the inner circuit substrate **10**. The first outer dielectric layer **32** or the second outer dielectric layer **42** filled in the gap can fix and buffer the heat conducting block **20**.
(27) In some embodiments, during forming the second outer circuit substrate **40**, the method further includes forming a connecting block **46** connecting the heat conducting block **20** and the second outer circuit layer **44**. The connecting block **46** penetrates through the second outer dielectric layer **42**, so as to connect the second outer circuit layer **44** disposed on a surface of the second outer circuit substrate **40** away from the heat conducting block **20** to the heat conducting block **20**.

(28) In some embodiments, the first outer circuit substrate **30** and the second outer circuit substrate **40** further cover the insulating layer **18**.
(29) In some embodiments, a solder mask **50** is formed on surfaces of the first outer circuit substrate **30** and the second outer circuit substrate **40** facing away from the inner circuit substrate **10** to protect the first outer circuit layer **34** and the second outer circuit layer **44**.
(30) In step **4**, referring to FIG. **4**, the first outer circuit substrate **30** and the second outer circuit substrate **40** corresponding to the insulating layer **18** are removed to expose the insulating layer **18**, thereby forming a flexible region.
(31) In some implementations, the step **4** can be omitted.
(32) In step **5**, referring to FIG. **5**, an accommodating groove **60** is formed, which penetrates through the first outer circuit substrate **30** and is recessed toward the heat conducting block **20**.
(33) The accommodating groove **60** is formed along the direction in which the first outer circuit substrate **30**, the inner circuit substrate **10**, and the second outer circuit substrate **40** are stacked. During forming the accommodating groove **60**, the first outer circuit substrate **30** is penetrated, and then a portion of the heat conducting block **20** is removed to form the accommodating groove **60**. That is, the accommodating groove **60** penetrates the first outer circuit substrate **30** but does not penetrate the heat conducting block **20**, forming the heat conducting block **20** with a side wall **22** and a bottom wall **24**.
(34) In step **6**, referring to FIGS. **6** and **7**, an electronic component **70** is accommodated in the accommodating groove **60**, and the electronic component **70** is at least partially accommodated in the accommodating groove **60**.
(35) The electronic component **70** is electrically connected to the first outer circuit substrate **30**.
(36) The electronic component **70** can be an integral structure, or can include at least one first sub-component **72** and at least one second sub-component **74**.
(37) In the embodiment, taking the electronic component **70** including a first sub-component **72** and a second sub-component **74** as an example, the electronic component **70** is a lens module, the first sub-component **72** is a chip, and the second sub-component **74** is a lens. The chip and the lens cooperatively form a hollow cavity **76**. In other embodiments, the electronic component **70** is not limited to a lens module.
(38) Accommodating the electronic component **70** in the accommodating groove **60** may be carried out as follows.
(39) In step **601**: referring to FIG. **6**, a heat conducting filler **80***a* is filled in the accommodating groove **60**.
(40) The heat conducting filler **80***a* can be thermally conductive adhesive, which has both bonding effect and thermally conductive effect.
(41) The heat conducting filler **80***a* is filled in the heat conducting block **20**, and the heat conducting filler **80***a* is connected to the side wall **22** and the bottom wall **24**.
(42) In step **602**: referring to FIG. **6**, the first sub-component **72** is placed in the heat conducting filler **80***a*, the heat conducting filler **80***a* covers the periphery of the first sub-component **72**, so that the first sub-component **72** is spaced apart from the heat conducting block **20**. A portion of the first sub-component **72** used for electrical connection is exposed from the heat conducting filler **80***a*.
(43) The heat conducting filler **80***a* connects the first sub-component **72** and the heat conducting block **20**, so that the heat generated by the first sub-component **72** can be quickly transferred to the heat conducting block **20**. The heat conducting filler **80***a* further plays a buffering role, preventing the first sub-component **72** from being damaged due to rigid contact with the heat conducting block **20**.
(44) In some embodiments, a distance between the first sub-component **72** and the heat conducting block **20** can be from 0.1 mm to 0.7 mm. In an embodiment, the distance between the first sub-component **72** and the heat conducting block **20** is 0.3 mm.
(45) In step **603**: referring to FIG. **7**, a second sub-component **74** is connected to a surface of the

first outer circuit substrate **30**, and the second sub-component **74** is electrically connected to the first sub-component **72**.
(46) In step **7**, referring to FIG. **8**, a reinforcing plate **90** is formed on a surface of the second outer circuit substrate **40** corresponding to the electronic component **70** and facing away from the electronic component **70**, so as to form the circuit board assembly **100**.
(47) The reinforcing plate **90** can be made of stainless steel, red copper, aluminum nitride, graphene, and other materials with high thermal conductivity and high hardness.
(48) The reinforcing plate **90** may be connected to the second outer circuit substrate **40** through the heat conducting filler **80***b*. The heat conducting filler **80***b* can be a thermally conductive adhesive, which functions as both bonding and thermal conductivity.
(49) The step of forming the reinforcing plate **90** is any step after forming the second outer circuit substrate **40**. That is, the step of forming the reinforcing plate **90** may be before the step of forming the accommodating groove **60** or forming the electronic component **70**.
(50) In other embodiments, in block **2**, referring to FIG. **9**, a metal layer **26** is disposed on a surface of the heat conducting block **20**. The metal layer **26** can be made of copper, silver, or the like. The metal layer **26** is substantially parallel to an extending direction of the inner circuit substrate **10**. In step **3**, during forming the first outer circuit substrate **30** and the second outer circuit substrate **40**, the first outer circuit layer **34** and the second outer circuit layer **44** are contact with the metal layer **26**. Referring to FIG. **10**, the heat generated by the electronic component **70** penetrates through the heat conducting block **20** of the circuit board assembly **100**, and then quickly transfers to the first outer circuit layer **34** and the second outer circuit layer **44** through the metal layer **26**, thereby increasing the rate of heat transfer. In the embodiment, the connecting block **46** is omitted.
(51) Referring to FIG. **8** again, a circuit board assembly **100** is provided according to an embodiment of the present disclosure. The circuit board assembly **100** includes an inner circuit substrate **10**, a first outer circuit substrate **30**, a second outer circuit substrate **40**, an electronic component **70**, a heat conducting block **20**, and a reinforcing plate **90**.
(52) The inner circuit substrate **10**, the first outer circuit substrate **30**, and the second outer circuit substrate **40** may be flexible boards, rigid boards or rigid-flex boards.
(53) The inner circuit substrate **10** includes an inner dielectric layer **12** and two inner circuit layers **14** stacked with each other. The first outer circuit substrate **30** includes a first outer dielectric layer **32** and a first outer circuit layer **34** stacked with each other. The second outer circuit substrate **40** includes a second outer dielectric layer **42** and a second outer circuit layer **44** stacked with each other.
(54) The first outer circuit substrate **30** and the second outer circuit substrate **40** are respectively disposed on opposite surfaces of the inner circuit substrate **10**. The inner circuit substrate **10**, the first outer circuit substrate **30**, and the second outer circuit substrate **40** may be single-layer circuit substrates or multi-layer circuit substrates, respectively. The inner circuit substrate **10**, the first outer circuit substrate **30**, and the second outer circuit substrate **40** are electrically connected to each other.
(55) The heat conducting block **20** penetrates through the inner circuit substrate **10**. The first outer circuit substrate **30** and the second outer circuit substrate **40** cover the heat conducting block **20**. The heat conducting block **20** is connected to the inner circuit substrate **10** through the first outer dielectric layer **32** or the second outer dielectric layer **42**, which can prevent rigid contact between the heat conducting block **20** and the two inner circuit layers **14**.
(56) An accommodating groove **60** with an opening **62** towards the first outer circuit substrate **30** is defined on the heat conducting block **20**. The heat conduction block includes a side wall **22** and a bottom wall **24**, and the side wall **22** surrounds the bottom wall **24**. At least portion of the electronic component **70** is accommodated in the accommodation groove **60** formed by the side wall **22** and the bottom wall **24**.
(57) In some embodiments, the electronic component **70** includes a first sub-component **72** and a

second sub-component **74**. The first sub-component **72** is accommodated in the accommodating groove **60**, and the second sub-component **74** is disposed on a surface of the first outer circuit substrate **30** and is electrically connected to the first sub-component **72**. In the embodiment, the first sub-component **72** is a chip, and the second sub-component **74** is a lens. The chip and the lens cooperatively form a hollow cavity **76**.

(58) In some embodiments, a heat conducting filler **80***a* is further filled between the first sub-component **72** and the heat conducting block **20**. Multiple surfaces of the first sub-component **72** are contact with the heat conducting filler **80***a*, and the heat conducting filler **80***a* is contact with the heat conducting block **20** with a large contact area. The heat conducting filler **80***a* can quickly transfer the heat generated by the first sub-component **72** to the heat conducting block **20**. In addition, due to the high rigidity of the heat conducting block **20**, the heat conducting filler **80***a* can prevent the first sub-component **72** from being damaged due to rigid contact with the heat conducting filler **80***a*. The rigidity of the heat conducting block **20** is sufficient to support the first sub-component **72** and prevent the first sub-component **72** from being deformed and damaged.

(59) In some embodiments, the circuit board assembly **100** further includes a solder mask **50** disposed on surfaces of the first outer circuit substrate **30** and the second outer circuit substrate **40** away from the inner circuit substrate **10**.

(60) The reinforcing plate **90** is disposed on a surface of the second outer circuit substrate **40** corresponding to the electronic component **70** and facing away from the electronic component **70**. The reinforcing plate **90** can be connected to the second outer circuit substrate **40** through a heat conducting filler **80***b*.

(61) In some embodiments, the second outer circuit substrate **40** is also connected to the heat conducting block **20** through a connecting block **46**. The second outer circuit substrate **40** includes a second outer dielectric layer **42** and a second outer circuit layer **44** stacked with each other. The connecting block **46** penetrates through the second outer dielectric layer **42** and connects the second outer circuit layer **44** and the heat conducting block **20**.

(62) Further, the connecting block **46** is connected to the second outer circuit layer **44** disposed on the second outer circuit substrate **40** away from the heat conducting block **20**, so as to quickly transfer the heat generated by the electronic component **70** to the outside of the circuit board assembly **100**.

(63) Referring to FIG. **10** again, in some embodiments, a surface of the heat conducting block **20** facing the first outer circuit substrate **30** and a surface facing the second outer circuit substrate **40** are both provided with a metal layer **26**. The metal layer **26** is directly connected to the first outer circuit layer **34** and the second outer circuit layer **44** to conduct heat quickly.

(64) The circuit board assembly **100** provided by the present disclosure, a portion of the electronic component **70** is embedded in the first outer circuit substrate **30** and the inner circuit substrate **10**, which can effectively reduce the volume of the circuit board assembly **100**. By accommodating the electronic component **70** in the heat conducting block **20** which made of aluminum nitride, due to the high heat conduction efficiency and high rigidity of aluminum nitride, the electronic component **70** and the heat conducting block **20** have multiple contact surfaces (including the side wall **22** and the bottom wall **24**), which effectively improves the heat dissipation efficiency of the circuit board assembly **100**. In addition, the cooperation of the aluminum nitride heat conducting block **20** and the reinforcing plate **90** can reinforce the circuit board assembly **100**.

(65) It is to be understood, even though information and advantages of the present embodiments have been set forth in the foregoing description, together with details of the structures and functions of the present embodiments, the disclosure is illustrative only; changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the present embodiments to the full extent indicated by the plain meaning of the terms in which the appended claims are expressed.

Claims

1. A circuit board assembly, comprising: an inner circuit substrate; a first outer circuit substrate disposed on a surface of the inner circuit substrate; a second outer circuit substrate disposed on another surface of the inner circuit substrate away from the first outer circuit substrate; a heat conducting block penetrating through the inner circuit substrate and connecting to each of the first outer circuit substrate and the second outer circuit substrate, and an accommodating groove with an opening towards the first outer circuit substrate defined on the heat conducting block, the heat conducting block made of aluminum nitride; a lens module comprising a chip and a lens, the chip accommodated in the accommodating groove and electrically connected to the first outer circuit substrate, the lens disposed on a surface of the first outer circuit substrate and electrically connected to the chip, and the chip and the lens cooperatively forming a hollow cavity; and a reinforcing plate disposed on a surface of the second outer circuit substrate corresponding to the lens module and facing away from the lens module.
2. The circuit board assembly of claim 1, wherein the circuit board assembly further comprises a heat conducting filler, and the heat conducting filler is disposed between the chip and the heat conducting block.
3. The circuit board assembly of claim 1, wherein the first outer circuit substrate comprises a first outer circuit layer, the second outer circuit substrate comprises a second outer circuit layer, a metal layer is disposed on a surface of the heat conducting block facing the first outer circuit substrate and a surface facing the second outer circuit substrate, the metal layer is connected to the first outer circuit layer and the second outer circuit layer.
4. The circuit board assembly of claim 1, wherein the circuit board assembly further comprises a connecting block, the second outer circuit substrate comprises a second outer dielectric layer and a second outer circuit layer stacked with each other, and the connecting block connects the heat conducting block and the second outer circuit layer.
5. A method for manufacturing a circuit board assembly, the method comprising providing an inner circuit substrate with a through hole; placing a heat conducting block in the through hole, and the heat conducting block made of aluminum nitride; forming a first outer circuit substrate and a second outer circuit substrate on opposite surfaces of the inner circuit substrate, the first outer circuit substrate and the second outer circuit substrate covering the heat conducting block; forming an accommodating groove penetrating through the first outer circuit substrate and recessed toward the heat conducting block; at least partially accommodating a lens module in the accommodating groove comprising: accommodating a chip of the lens module in the accommodating groove such that an electrical connection portion of the chip is exposed, and electrically connecting the chip to the first outer circuit substrate; and connecting a lens of the lens module to a surface of the first outer circuit substrate, and electrically connecting the lens to the chip, the chip and the lens cooperatively forming a hollow cavity; and forming a reinforcing plate on a surface of the second outer layer circuit substrate corresponding to the lens module and facing away from the lens module.
6. The method of claim 5, wherein the first outer circuit substrate comprises a first outer dielectric layer the second outer circuit substrate comprises a second outer dielectric layer; both the first outer dielectric layer and the second outer dielectric layer are connected to the heat conducting block.
7. The method of claim 5, wherein before accommodating the chip in the accommodating groove, the method further comprises: filling a heat conducting filler in the accommodating groove, causing the chip to be spaced apart from the heat conducting block.
8. The method of claim 5, wherein the second outer circuit substrate comprises a second outer dielectric layer and a second outer circuit layer stacked with each other, forming the second outer circuit substrate further comprises forming a connecting block connecting the heat conducting

block and the second outer circuit layer.

9. The method of claim 5, wherein forming the reinforcing plate is after forming the second outer circuit substrate.

10. The method of claim 5, wherein a metal layer is disposed on a surface of the heat conducting block, the first outer circuit substrate comprises a first outer circuit layer, and the second outer circuit substrate comprises a second outer circuit layer, the first outer circuit layer and the second outer circuit layer are directly connected to the metal layer.