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Through electrode substrate, manufacturing method thereof and mounting substrate

Abstract

A manufacturing method of a through electrode substrate includes: a step of preparing a substrate including a first surface and a second surface positioned oppositely to the first surface, and provided with a through hole; a step of providing a sealing layer blocking the through hole on the first surface of the substrate; an electrode forming step of forming a through electrode inside the through hole, the through electrode having a first part extending along a sidewall of the through hole, and a second part connected to the first part and spreading along the sealing layer; and a step of removing the sealing layer.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
3761782	12/1972	Youmans	257/E29.022	H01L 23/481
6313043	12/2000	Hattori	N/A	N/A
6485814	12/2001	Moriizumi	257/E23.068	H05K 3/4605
6512292	12/2002	Armbrust	257/E23.105	H01L 23/5222
7508072	12/2008	Morita	257/781	H01L 21/76898
7851880	12/2009	Suzuki	257/781	H01L 27/14683
8212331	12/2011	Kar-Roy	438/622	H01L 21/6835
8541820	12/2012	Hayasaki	438/57	H01L 23/481
9536783	12/2016	Radulescu	N/A	H01L 23/53247
RE46903	12/2017	Takachi	N/A	H01L 27/14627
11195768	12/2020	Kudo	N/A	H01L 23/15
2008/0191343	12/2007	Liu	257/E21.705	H01L 27/14618
2009/0189276	12/2008	Sano	257/E23.008	H01L 27/14618
2009/0284631	12/2008	Matsuo	257/E31.127	H01L 27/14625
2010/0079050	12/2009	Kamamori et al.	N/A	N/A
2010/0155940	12/2009	Kawashita et al.	N/A	N/A
2010/0190338	12/2009	Koike	257/E21.597	H01L 27/14689
2010/0264503	12/2009	Inoue	257/E31.127	H01L 21/743
2011/0067913	12/2010	Kaneko et al.	N/A	N/A
2011/0248405	12/2010	Li	257/E21.597	H01L 21/76898

2013/0256841	12/2012	Mieczkowski	257/E21.597	H01L 23/481
2014/0084474	12/2013	Suhr	257/751	H01L 21/76898
2015/0235955	12/2014	Kudo et al.	N/A	N/A
2016/0111380	12/2015	Sundaram et al.	N/A	N/A

FOREIGN PATENT DOCUMENTS

Patent No.	**Application Date**	**Country**	**CPC**
109-64231	12/1996	JP	N/A
2008-227433	12/2007	JP	N/A
2009-117564	12/2008	JP	N/A
2009-135452	12/2008	JP	N/A
2009-227433	12/2008	JP	N/A
2015-103586	12/2014	JP	N/A
2016-034030	12/2015	JP	N/A
2016-056046	12/2015	JP	N/A
2016-72433	12/2015	JP	N/A
2014/069662	12/2013	WO	N/A
2016/075863	12/2015	WO	N/A

OTHER PUBLICATIONS

May 26, 2023 Office Action issued in Japanese Patent Application No. 2022-096770. cited by applicant
Aug. 15, 2017 Search Report issued in International Patent Application No. PCT/JP2017/020702. cited by applicant
Dec. 4, 2018 International Preliminary Report on Patentability issued in International Patent Application No. PCT/JP2017/020702. cited by applicant
Jan. 9, 2018 Office Action issued in Japanese Patent Application No. 2017-564154. cited by applicant
Feb. 16, 2018 Office Action issued in Japanese Patent Application No. 2017-564154. cited by applicant
Dec. 12, 2019 Office Action issued in Taiwanese Patent Application No. 106118322. cited by applicant
Apr. 2, 2021 Office Action issued in Japanese Patent Application No. 2018-078673. cited by applicant
Sep. 14, 2021 Office Action issued in Taiwanese Patent Application No. 109119705. cited by applicant

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This is a Continuation of application Ser. No. 16/306,883 filed Dec. 3, 2018, which in turn is a National Phase Application of PCT/JP2017/020702 filed Jun. 2, 2017, which claims the benefit of Japanese Patent Application

No. 2016-112104 filed Jun. 3, 2016. The disclosure of the prior applications is hereby incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

(1) This embodiment of the disclosure relates to a through electrode substrate and a manufacturing method thereof. In addition, this embodiment of the disclosure relates to a mounting substrate including a through electrode substrate.

BACKGROUND ART

(2) A member so-called through electrode substrate, which includes a substrate having a first surface and a second surface, a plurality of through holes provided in the substrate, and an electrode provided inside each through hole is widely used. For example, a through electrode substrate is used as an interposer interposed between two LSI chips, when a plurality of LSI chips are stacked in order to increase a packaging density of an LSI. In addition, a through electrode substrate is sometimes interposed between an element such as an LSI chip and a mounting substrate such as a motherboard. In the following description, an electrode provided inside a through hole is sometimes referred to as “through electrode”.

(3) As an example of a through electrode, so-called filled via and conformal via are known. In the case of a filled via, a through electrode contains an electroconductive material such as copper filled inside a through hole.

(4) FIG. **37** shows an example of a through electrode substrate comprising a though electrode **22** formed as a filled via. In the case of a conformal via, as disclosed in Patent Document 1, for example, a through electrode includes a wall surface electroconductive layer spreading along a sidewall of a hole, a first surface electroconductive layer provided on a first surface of a substrate, and a second surface electroconductive layer provided on a second surface of the substrate. FIG. **38** shows an example of a through electrode substrate comprising a through electrode **22** formed as a conformal via. Patent Document 1: JP2015-103586A

DISCLOSURE OF THE INVENTION

(5) In order to efficiently use a surface area of a through electrode substrate, it is preferable that an element such as an LSI chip can be located on an area of a substrate, in which a through hole us provided. However, in the case of a conformal via, a through electrode is positioned on a wall surface of a through hole and a surface of a substrate, it is impossible to locate an element on an area of the substrate, in which a through hole is provided.

(6) This embodiment of the disclosure has been made in view of the above circumstances. The object thereof is to provide a through electrode substrate which enables that an element can be located on an area of the substrate, in which a through hole is provided, and a manufacturing method thereof.

(7) One embodiment of the disclosure is a manufacturing method of a through electrode substrate comprising: a step of preparing a substrate including a first surface and a second surface positioned oppositely to the first surface, and provided with a through hole; a step of providing a sealing layer blocking the through hole on the first surface of the substrate; an electrode forming step of providing a through electrode inside the through hole, the through electrode having a first part extending along a sidewall of the through hole, and a second part connected to the first part and spreading along the sealing layer; and a step of providing the sealing layer.

(8) The manufacturing method of a through electrode substrate according to the one embodiment of the disclosure may further comprise a step of providing a wiring layer on a side of the first surface of the substrate, the wiring layer having an electroconductive layer connected to the second part of the through electrode.

(9) In the manufacturing method of a through electrode substrate according to the one embodiment of the disclosure, in a surface direction of the first surface of the substrate, a size of a part of the electroconductive layer of the wiring layer, which is connected to the second part of the through

electrode, may be smaller than a size of the second part of the through electrode.
(10) In the manufacturing method of a through electrode substrate according to the one embodiment of the disclosure, the electroconductive layer may include an electrode having a profile overlapped with the second part of the through electrode and surrounded by the second part, when seen along a normal direction of the first surface of the substrate.
(11) In the manufacturing method of a through electrode substrate according to the one embodiment of the disclosure, the electroconductive layer may include a plurality of the electrode parts.
(12) In the manufacturing method of a through electrode substrate according to the one embodiment of the disclosure, the electroconductive layer may include a conductive wire part intersecting a profile of the second part of the through electrode, when seen along a normal direction of the first surface of the substrate.
(13) In the manufacturing method of a through electrode substrate according to the one embodiment of the disclosure, the electroconductive layer may include a plurality of the conductive wire parts.
(14) In the manufacturing method of a through electrode substrate according to the one embodiment of the disclosure, the substrate may contain glass.
(15) One embodiment of the disclosure is a through electrode substrate comprising: a substrate including a first surface and a second surface positioned oppositely to the first surface, and provided with a through hole; and a through electrode provided inside the through hole of the substrate; wherein: the through electrode has a first part spreading along a sidewall of the through hole, and a second part connected to the first part and spreading in a surface direction of the first surface to come into contact with the sidewall of the through hole on a side of the first surface of the substrate; and a hollow part exists inside the through hole between surfaces of the opposed first parts.
(16) In the through electrode substrate according to the embodiment of the disclosure, the second part of the through electrode may be positioned coplanarly with the first surface of the substrate.
(17) In the through electrode substrate according to the embodiment of the disclosure, a size of the through hole in the surface direction of the first surface of the substrate may increase from the first surface toward the second surface.
(18) In the through electrode substrate according to the embodiment of the disclosure, the substrate may contain glass.
(19) In the through electrode substrate according to the embodiment of the disclosure, a plurality of the through holes and a plurality of the through electrodes may be formed in the substrate, and the second parts of the through electrodes may be uniformly distributed in the first surface of the substrate.
(20) The through electrode substrate according to the embodiment of the disclosure may further comprise a wiring layer provided on the side of the first surface of the substrate, and having an electroconductive layer connected to the second part of the through electrode.
(21) In the through electrode substrate according to the embodiment of the disclosure, in the surface direction of the first surface of the substrate, a size of a part of the electroconductive layer of the wiring layer, which is connected to the second part of the through electrode, may be smaller than a size of the second part of the through electrode.
(22) In the through electrode substrate according to the embodiment of the disclosure, the electroconductive layer may include an electrode part having a profile overlapped with the second part of the through electrode and surrounded by the second part, when seen along a normal direction of the first surface of the substrate.
(23) In the through electrode substrate according to the embodiment of the disclosure, the electroconductive layer may include a plurality of the electrode parts.
(24) In the through electrode substrate according to the embodiment of the disclosure, the

electroconductive layer may include a conductive wire part intersecting a profile of the second part of the through electrode, when seen along a normal direction of the first surface of the substrate.
(25) In the through electrode substrate according to the embodiment of the disclosure, the electroconductive layer includes a plurality of the conductive wire parts.
(26) In the through electrode substrate according to the embodiment of the disclosure, the wiring layer may further have an insulation layer containing an organic material, and a stress relaxation layer containing an inorganic material.
(27) In the through electrode substrate according to the embodiment of the disclosure, the wiring layer may have a first wiring layer including the electroconductive layer positioned on the first surface of the substrate and the insulation layer, and a second wiring layer including the electroconductive layer positioned on the first wiring layer and the insulation layer, and the stress relaxation layer may be positioned at least between the first surface of the substrate and the insulation layer of the first wiring layer, or between the insulation layer of the first wiring layer and the insulation layer of the second wiring layer.
(28) One embodiment of the disclosure is a mounting substrate comprising: a through electrode substrate; and an element loaded on the through electrode substrate; wherein: the through electrode substrate comprises a substrate provided with a through hole passing therethrough from a first surface to a second surface positioned oppositely to the first surface, and a through electrode provided inside the through hole of the substrate; the through electrode has a first part spreading along a sidewall of the through hole, and a second part connected to the first part and spreading in a surface direction of the first surface to come into contact with the sidewall of the through hole on a side of the first surface of the substrate; a hollow part exists inside the through hole between surfaces of the opposed first parts; the through electrode further comprises an electrode part positioned on the second part of the through electrode; and the element has a terminal connected to the electrode part.
(29) Due to the through electrode substrate according to one embodiment of the disclosure, an element can be located on an area of the substrate, in which a through hole is provided.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a plan view showing a through electrode substrate according to an embodiment of a disclosure.
(2) FIG. **2** is a sectional view of the through electrode substrate of FIG. **1** seen from a II-II direction.
(3) FIG. **3** is a sectional view showing in enlargement a through electrode of the through electrode substrate of FIG. **2**.
(4) FIG. **4** is a sectional view showing an example in which the through electrode substrate of FIG. **1** further has a wiring layer.
(5) FIG. **5**A is a plan view of the through electrode substrate in the example shown in FIG. **4**.
(6) FIG. **5**B is a plan view showing another example of the through electrode substrate.
(7) FIG. **5**C is a plan view showing another example of the through electrode substrate.
(8) FIG. **6** is a view showing a step in which a resist layer is provided on a substrate.
(9) FIG. **7** is a view showing a step in which a through hole is formed in the substrate.
(10) FIG. **8** is a view showing a step in which a sealing layer is provided on a first surface side of the substrate.
(11) FIG. **9** is a view showing a step in which a first layer is provided on the substrate from a side of a second surface.
(12) FIG. **10** is a view showing a step in which a resist layer is provided on the first layer.

(13) FIG. **11** is a view showing a step in which a second layer is provided on the first layer.
(14) FIG. **12** is a view showing a step in which a thickness of the second layer on the sealing layer is increased.
(15) FIG. **13** is a view showing a step in which the resist layer is removed.
(16) FIG. **14** is a view showing a step in which a part of the first layer is removed.
(17) FIG. **15** is a view showing a step in which the sealing layer is removed.
(18) FIG. **16** is a view describing a manufacturing method of a through electrode substrate according to a comparative embodiment.
(19) FIG. **17** is a view describing the manufacturing method of a through electrode substrate according to the comparative embodiment.
(20) FIG. **18** is a view describing the manufacturing method of a through electrode substrate according to the comparative embodiment.
(21) FIG. **19** is a sectional view showing an example of a mounting substrate including the through electrode substrate according to this embodiment of the disclosure.
(22) FIG. **20** is a plan view showing the mounting substrate in the example shown in FIG. **19**.
(23) FIG. **21** is a sectional view showing another example of the mounting substrate.
(24) FIG. **22** is a sectional view showing the through electrode substrate according to a first modification example.
(25) FIG. **23** is a plan view showing the through electrode substrate according to the first modification example.
(26) FIG. **24** is a sectional view showing the through electrode substrate according to a second modification example.
(27) FIG. **25** is a plan view showing the through electrode substrate according to the second modification example.
(28) FIG. **26** is a sectional view showing the through electrode substrate according to a third modification example.
(29) FIG. **27** is a sectional view showing a mounting substrate including the through electrode substrate according to the third modification example.
(30) FIG. **28** is a view describing a manufacturing method of the through electrode substrate according to the third modification example.
(31) FIG. **29** is a view describing the manufacturing method of the through electrode substrate according to the third modification example.
(32) FIG. **30** is a view describing the manufacturing method of the through electrode substrate according to the third modification example.
(33) FIG. **31** is a view describing the manufacturing method of the through electrode substrate according to the third modification example.
(34) FIG. **32** is a view describing the manufacturing method of the through electrode substrate according to the third modification example.
(35) FIG. **33** is a sectional view showing the through electrode substrate according to a fourth modification example.
(36) FIG. **34** is a sectional view showing the through electrode substrate according to a fifth modification example.
(37) FIG. **35** is a sectional view showing the through electrode substrate according to a sixth modification example.
(38) FIG. **36** is a sectional view showing the through electrode substrate according to a seventh modification example.
(39) FIG. **37** is a view showing a conventional through electrode substrate having a filled via.
(40) FIG. **38** is a view showing a conventional through electrode substrate having a conformal via.
(41) FIG. **39** is a view showing examples of products on which the through electrode substrate according to this embodiment of the disclosure is loaded.

(42) FIG. **40** is a sectional view showing a through electrode substrate in an Example 1.
(43) FIG. **41** is a sectional view showing a through electrode substrate in a Comparative Example 1.

DETAILED DESCRIPTION OF THE INVENTION

(44) Herebelow, a structure of a through electrode substrate according to an embodiment of the disclosure and a manufacturing method thereof are described in more detail with reference to the drawings. The below embodiments are mere examples of this embodiments of the disclosure, and the disclosure should not be construed to be limited to these embodiments. In this specification, the terms "substrate", "base member", "sheet" and "film" are not differentiated from one another, based only on the difference of terms. For example, the "substrate" or the "base member" is a concept including a member that can be referred to as sheet or film. Further, terms specifying shapes, geometric conditions and their degrees, e.g., terms such as "parallel", "perpendicular", etc. and values of a length and a value, etc., are not limited to their strict definitions, but should be construed to include a range capable of exerting a similar function. In addition, in the drawings referred in embodiments, the same parts or parts having a similar function have the same reference number or similar reference number, and repeated description may be omitted. In addition, a scale size may be different from the actual one, for the convenience of easiness in illustration and understanding, and a part of a structure may be omitted from the drawings.
(45) This embodiment of the disclosure is described herebelow with reference to FIGS. **1** to **15**.
(46) Through Electrode Substrate
(47) A through electrode substrate **10** according to this embodiment is firstly described with reference to FIGS. **1** and **2**. FIG. **1** is a plan view showing the through electrode substrate **10**. FIG. **2** is a sectional view of the through electrode substrate **10** of FIG. **1**, which is cut along one-dot chain lines, seen from a II-II direction.
(48) The through electrode substrate **10** comprises a substrate **12**, a plurality of through holes **20** provided in the substrate **12**, and a through electrode **22** provided inside each through hole **20**. Herebelow, the respective constituent elements of the through electrode substrate **10** are described.
(49) (Substrate)
(50) The substrate **12** includes a first surface **13** and a second surface **14** positioned oppositely to the first surface **13**. The substrate **12** is made of a material having a certain insulation property. For example, the substrate **12** may be a glass substrate, a quartz substrate, a sapphire substrate, a resin substrate, a silicon substrate, a silicon carbide substrate, an alumina (Al_2O_3) substrate, a aluminum nitride (AlN) substrate, a zirconium oxide (ZrO_2) substrate and so on, or a substrate made by stacking these substrates. The substrate **12** may include a substrate made of a material having an electroconductive property, such as an aluminum substrate, a stainless substrate and so on.
(51) A thickness of the substrate **12** is not particularly limited, but the use of the substrate **12** having a thickness of not less than 100 μm and not more than 800 μm is preferred. More preferably, the substrate **12** has a thickness of not less than 200 μm and not more than 600 μm. When the substrate **12** has a thickness of not less than 100 μm, warpage of the substrate **12** can be prevented from increasing. Thus, it can be prevented that handling of the substrate **12** during a manufacturing step becomes difficult, and that the substrate **12** is warped because of an internal stress of a membrane formed on the substrate **12**. In addition, when the substrate **12** has a thickness of not more than 800 μm, it can be prevented that a period of time required for a step of forming the through holes **20** in the substrate **12** is elongated to increase a manufacturing cost of the through electrode substrate **10**.
(52) (Through Hole)
(53) Each of the through holes **20** is provided in the substrate **12** so as to extend from the first surface **13** of the substrate **12** to reach the second surface **14** thereof. A size S**1** of the though hole **20** in a surface direction D**1** of the first surface **13** is within a range of, for example, not less than 20 μm and not more than 150 μm, in each position in a thickness direction of the substrate **12**. In

addition, an interval P between the adjacent two through holes **20** in the surface direction D**1**, i.e., an arrangement pitch of the through holes **20** is, for example, within a range between not less than 40 μm and not more than 300 μm. The dimension S**1** of the through hole in the surface direction D**1** of the first surface **13** is a maximum value of an opening width of the through hole **20**, when the through hole **20** is cut along a given plane parallel to the first surface **13**. In addition, the surface direction D**1** is a direction parallel to the first surface **13**. In FIGS. **1** and **2**, a reference numeral S**11** depicts a size of the through hole **20** on the first surface **13** of the substrate **12**. In addition, in FIG. **2**, the reference numeral S**11** depicts a size of the through hole **20** on the second surface **14** of the substrate **12**.

(54) (Through Electrode)

(55) The through electrode **22** is a member having an electroconductive property, which is provided inside the through hole **20**. As shown in FIG. **2**, the through electrode **22** has at least a first part **23** and a second part **24**. The first part **23** is a part that spreads from the side of the first surface **13** to the side of the second surface **14** along a sidewall **21** of the through hole **20**. The second part **24** is a part that is connected to the first part **23** at an end portion of the first part **23** on the side of the first surface **13**, and spreads in the surface direction D**1** of the first surface **13** to come into contact with the sidewall **21** of the through hole **20** on the side of the first surface **13**.

(56) As shown in FIG. **2**, the through electrode **22** may further have a third part **25**. The third part **25** is a part that is connected to the first part **23** on an end portion of the first part **23** on the side of the second surface **14**, and is provided on the second surface **14**.

(57) FIG. **3** is a sectional view showing in enlargement the through electrode **22** of the through electrode substrate **10** of FIG. **2**. Preferably, the second part **24** of the through electrode **22** is positioned coplanarly with the first surface **13** of the substrate **12**. The term "coplanar" means that, in a normal direction of the first surface **13** of the substrate **12**, a difference ΔH between the position of the first surface **13** and the position of an outer surface **24***a* of the second part **24** is not more than 1 μm. The difference ΔH can be measured by means of a reflection-type confocal laser microscope or a finger-type step gauge. Although FIG. **3** shows an example in which the outer surface **24***a* of the second part **24** projects outward from the first surface **13**, the present invention is not limited thereto. Although not shown, the outer surface **24***a* of the second part **24** may be recessed inward from the first surface **13**, as long as the difference ΔH is not more than 1 μm.

(58) As long as the through electrode **22** has an electroconductive property, a method of forming the through electrode **22** is not particularly limited. For example, the through electrode **22** may be formed by a physical film deposition method such as a vapor deposition method or a sputtering method, or may be formed by a chemical film deposition method or a plating method. In addition, the through electrode **22** may be composed of a single layer having an electroconductive property, or may include a plurality of layers having an electroconductive property. Herein, as shown in FIG. **3**, an example in which the through electrode **22** includes a first layer **22***a* and a second layer **22***b* both having an electroconductive property is described.

(59) The first layer **22***a* is a so-called seed layer which is a layer having an electroconductive property, and serves as a base on which metal ions in a plating liquid deposit to grow the second layer **22***b*, during an electrolytic plating step of forming the second layer **22***b* by a plating process. Preferably, an electroconductive material having a high adhesion property to the material of the substrate **12** is used as a material of the first layer **22***a*. For example, as the material of the first layer **22***a*, titanium, molybdenum, tungsten, tantalum, nickel, chrome, aluminum, a compound of them, an alloy of them, or lamination of them may be used. In addition, as the material of the first layer **22***a*, a material that prevents the second layer **22***b* from diffusing inside the substrate **12** may be used. For example, when the second layer **22***b* contains copper, the first layer **22***a* may also contain copper. When the first layer **22***a* contains copper, a layer of a metal material, which has a high adhesion property to the substrate **12**, such as titanium or titanium nitride, may be provided between the substrate **12** and the first layer **22***a*, in order to increase an adhesion property between

the substrate **12** and the first layer **22***a*. When the first layer **22***a* has a sufficient thickness and an electroconductive property, the first layer **22***a* may constitute the through electrode **22**, without providing the second layer **22***b*.
(60) When the second layer **22***b* is provided on the first layer **22***a*, a thickness of the first layer **22***a* is, for example, not more than 0.2 μm. When the second layer **22***b* is not provided, the thickness of the first layer **22***a* is, for example, not less than 1 μm and not more than 10 μm.
(61) The second layer **22***b* is a layer having an electroconductive property, which is provided on the first layer **22***a* in order to increase an electroconductive property of the through electrode **22**. As a material of the second layer **22***b*, an electroconductive material having a high adhesion property to the first layer **22***a* and a high electroconductive property is preferably used. For example, a metal such as copper, gold, silver, platinum, rhodium, tin, aluminum, nickel and chrome, alloy of them, or lamination of them may be used as the material of the second layer **22***b*. A thickness of the second layer **22***b* is within a range between not less than 1 μm and not more than 10 μm, for example.
(62) The thickness of the second layer **22***b* is determined in accordance with the electroconductive property required for the through electrode **22**.
(63) For example, when the through electrode **22** is a member for conduction of a power supply line or a ground line, the second layer **22***b* having a sufficient thickness is used. On the other hand, when the through electrode **22** is a member for conduction of a weak electric signal, the second layer **22***b* having a small thickness may be used. Alternatively, only the second layer **22***a* may be provided on the through hole **20** to constitute the through electrode **22**, without providing the second layer **22***b*.
(64) The through electrode **22** is configured to form a hollow part inside the through hole **20**. The hollow part is an area inside the though hole **20** where any sold bodies such as the first layer **22***a* and the second layer **22***b* do not exist. In other words, as shown in FIG. **3**, the hollow part is the area inside the through hole **20**, which is between surfaces of the first parts **23** opposed inside the through hole **20**. The surface is a surface of the first part **23**, which is positioned oppositely to a surface on the side of the sidewall of the through hole **20**. A size of the hollow part in the surface direction D**1** of the first surface **13** is, for example, not less than 20% and not more than 90% of the size S**1** when it is measured on the same position in the thickness direction of the substrate **12**.
(65) Since the through electrode **22** is formed such that the hollow part is formed inside the through hole **20**, the time required for forming the through electrode **22** can be reduced, as compared with a case in which the inside of the through hole **20** is completely filled with the through electrode **22**.
(66) Although not shown, a material having an insulation property, such as resin, may be provided in the hollow part. Owing to this, it is possible to prevent that a process liquid such as a developing liquid or a washing liquid enters the hollow part during a manufacturing step of the through electrode substrate **10**.
(67) As shown in FIG. **2**, preferably, the size S**1** of the through hole **20** in the surface direction D**1** of the first surface **13** of the substrate **12** increases from the first surface **13** toward the second surface **14**. In other words, the through hole **20** has a tapered shape that narrows toward the first surface **13**. Thus, when a below-described sealing layer **17** is peeled from the second part **24** of the through electrode **22**, the second part **24** is prevented from being pulled to move toward the side of the first surface **13**. It is not necessary that the through hole **20** has the tapered shape as a whole. As long as the through electrode **22** is prevented from being pulled to move by the sealing layer **17**, various shapes can be employed as the shape of the through hole **20**.
(68) The size S**11** of the through hole **20** on the first surface **13** of the substrate **12** is, for example, not less than 10 μm and not more than 100 μm. In addition, the size S**12** of the through hole **20** on the second surface **14** of the substrate **12** is, for example, not les than 20 μm and not more than 200 μm.
(69) As shown in FIG. **1**, preferably, the second parts **24** of the through electrodes **22** are uniformly distributed on the first surface **13** of the substrate **12**. For example, when the substrate **12** is

virtually divided equally into sections the number of which is N in the surface direction D**1**, the number of through holes **20** formed in the N sections is within a range of an average value ±20%. Herein, N is a suitable integer of e.g., 16.
(70) (Wiring Layer)
(71) As shown in FIG. **4**, the through electrode substrate **10** may further comprise a wiring layer **30** provided on the side of the first surface **13** of the substrate **12**. The wiring layer **30** has at least an electroconductive layer **31** connected to the second part **24** of the through electrode **22**. In the example shown in FIG. **4**, the electroconductive layer **31** includes an electrode part **33** provided on the second part **24** of the through electrode **22**. For example, the electrode part **33** is a bump that is connected to a terminal **52** of an element **51** described below. A material having an electroconductive property, such as a metal, is used as a material of the electroconductive layer **31**.
(72) FIG. **5**A is a plan view of the through electrode substrate **10** of the example shown in FIG. **4**. As shown in FIG. **5**A, both the second part **24** of the through electrode **22** and the electrode part **33** have a circular shape in a plan view. In addition, the electrode part **33** is overlapped with the second part **24** of the through electrode **22**, when seen along the normal direction of the substrate **12**. In addition, the electrode part **33** has a profile that is surrounded by the second part **24** of the through electrode **22**, when seen along the normal direction of the substrate **12**. For example, in the surface direction D**1** of the first surface **13**, a size S**3** of the electrode part **33** is smaller than a size S**2** of the second part **24**.
(73) FIGS. **5**B and **5**C are plan views respectively showing other examples of the through electrode substrate **10**. The shape of the electrode part **33** in a plan view is optional. For example, as shown in FIG. **5**B, the electrode part **33** may have an elliptical shape in a plan view. In this case, the size of S**3** of the elliptical electrode part **33** in a major-axis direction may be smaller than the size S**2** of the second part **24**.
(74) Alternatively, as shown in FIG. **5**C, the electrode part **33** may have a quadrangular shape in a plan view. In this case, the size S**3** of one side of the quadrangular electrode part **33** may be smaller than the size S**2** of the second part **24**.
(75) The shape of the second part **24** of the through electrode **22** in a plan view is also optional.
(76) Manufacturing Method of Through Electrode Substrate
(77) Herebelow, an example of a manufacturing method of through electrode substrate **10** is described with reference to FIGS. **6** to **15**.
(78) (First Resist Layer Forming Step)
(79) Firstly, the substrate **12** is prepared. Then, as shown in FIG. **6**, a first resist layer **16** is provided on the second surface **14** of the substrate **12**. The first resist layer **16** is provided such that it covers an area of the second surface **14** of the substrate **12**, in which the through hole **20** is not formed. An opening **16***a* of the first resist layer **16** is positioned on an area of the second surface **14** of the substrate **12**, in which the through hole **20** is formed.
(80) (Through Hole Forming Step)
(81) Thereafter, the substrate **12** is processed in the opening **16***a* of the first resist layer **16** from the side of the second surface **14**, so that a plurality of the through holes **20** are formed in the substrate **12**, as shown in FIG. **7**. As a method of processing the substrate **12**, a dry etching method, such as a reactive ion etching method or a deep reactive ion etching method, a wet etching method and the like may be used. Following thereto, the first resist layer **16** is removed. In this manner, the substrate **12** provided with the through holes **20** can be prepared.
(82) Preferably, as shown in FIG. **7**, the substrate **12** is processed such that each through hole **20** has a tapered shape that narrows from the side of the second surface **14** toward the side of the first surface **13**. For example, the through hole **20** has the size S**12** of about 50 μm on the side of the second surface **14**, and has the size S**11** of about 30 μm on the side of the first surface **13**.
(83) When the substrate **12** contains glass, hydrogen fluoride (HF), a mixture liquid of ammonium fluoride (NH.sub.4F) and hydrogen fluoride, that is, so-called buffered fluoride may be used as an

etching liquid for wet etching the substrate **12**. Alternatively, when the substrate **12** contains silicon, potassium hydroxide (KH), tetramethylammonia hydroxide (TMAH), ethylene diamine pyrocatechol (EDP), hydration hydrazine (N.sub.2H.sub.4.Math.H.sub.2O), etc. may be used as an etching liquid for wet etching the substrate **12**.
(84) As the dry etching method, a dry etching RIE (Reactive Ion Etching) method using plasma, a DRIE (Deep Reactive Ion Etching RIE) method using a Bosch process, a sand blasting method, and so on may be used.
(85) The through holes **20** may be formed in the substrate **12** by irradiating the substrate **12** with a laser. In this case, the first resist layer **16** may not be provided. As a laser for the laser machining, an excimer laser, an Nd:YAG laser, a femtosecond laser and so on may be used. When an Nd:YAG laser is used, a fundamental wave having a wavelength of 1064 nm, a second radiofrequency having a wavelength of 532 nm, and a third radiofrequency having a wavelength of 355 nm and so on may be used.
(86) In addition, laser radiation and wet etching may suitably be combined. To be specific, an altered layer is formed by laser radiation on an area of the substrate **12**, in which the through holes **20** should be formed. Then, the substrate **12** is immersed in hydrogen fluoride to etch the altered layer. Thus, the through holes **20** can be formed in the substrate **12**.
(87) In FIGS. **6** and **7**, although an example in which the substrate **12** is processed from the side of the second surface **14** so as to form the through holes **20** in the substrate **12**, the present invention is not limited thereto. For example, the substrate **12** may be processed from the side of the first surface **13** so as to form the through holes **20** in the substrate **12**. In addition, the substrate **12** may be processed from both the sides of the first surface **13** and the second surface **14** so as to form the through holes **20** in the substrate **12**.
(88) (Sealing Layer Forming Step)
(89) Then, as shown in FIG. **8**, a sealing layer **17** blocking the through holes **20** is provided on the first surface **13** of the substrate **12**. The sealing layer **17** is a layer serving as a base when the second part **24** of the aforementioned through electrode **22** is deposited inside the through hole **20**. The sealing layer **17** includes, for example, a base member layer containing a resin such as polyethylene terephthalate, and an adhesive layer laminated on the base member layer to be adhered to the first surface **13** of the substrate **12**. The sealing layer **17** is a dicing tape, for example.
(90) Preferably, the adhesive layer of the sealing layer **17** contains a photo-curing resin that is cured when irradiated with light such as ultraviolet light. In this case, after the second part **24** of the through electrode **22** has been formed on the sealing layer **17**, the sealing layer **17** is irradiated with light such as ultraviolet light so that the adhesive layer of the sealing layer **17** is cured. Thus, the sealing layer **17** can be easily peeled from the first surface **13** of the substrate **12**.
(91) (Electrode Forming Step)
(92) Then, an electrode forming step in which the through electrode **22** is formed inside the through hole **20** is carried out. In the electrode forming step, as shown in FIG. **9**, the first layer **22***a* is firstly formed from the side of the second surface **14** of the substrate **12** on the second surface **14** of the substrate **12**, the sidewall **21** of the through hole **20** and the sealing layer **17**, at a part where the through hole **20** is blocked. As a method of forming the first layer **22***a*, a physical film deposition method such as a vapor deposition method or a sputtering method, or a chemical film deposition method may be used, for example.
(93) Following thereto, as shown in FIG. **10**, a second resist layer **18** is partially formed on the first layer **22***a* above the second surface **14** of the substrate **12**. To be specific, the second resist layer **18** is formed such that an area of the second surface **14**, on which the third part **25** of the through electrode **22** is not provided, is covered with the second resist layer **18**.
(94) Following thereto, as shown in FIG. **11**, the second layer **22***b* is formed on the first layer **22***a* by electrolytic plating. To be specific, a plating liquid is supplied from the side of the first surface

14 of the substrate **12**, and current is applied to the first layer **22***a*. Thus, it is possible to form the first layer **22***a* and the second layer **22***b* which spread over the sidewall **21**, over the sealing layer **17** and over the second surface **14**, along the sealing layer **17**. A part of the first layer **22***a* and the second layer **22***b*, which extends along the sidewall **21**, becomes the first part **23** of the through electrode **22**. A part of the first layer **22***a* and the second layer **22***b*, which spreads along the sealing layer **17**, becomes the second part **24** of the through electrode **22**. A part of the first layer **22***a* and the second layer **22***b*, which spreads along the second surface **14**, becomes the third part **25** of the through electrode **22**. Preferably, the electrolytic plating is continued until a thickness T**2** of the first layer **22***a* and the second layer **22***b* formed on the sealing layer **17** becomes larger than a thickness T**1** of the first layer **22***a* and the second layer **22***b* formed on the sidewall **21** of the through hole **20**, as shown in FIG. **12**. For example, the thickness T**2** is larger than the thickness T**1** at least by 1 μm.

(95) Following thereto, as shown in FIG. **13**, the second resist layer **18** is removed. Then, as shown in FIG. **14**, the first layer **22***a* which has been covered with the second resist layer **18** is removed. Thereafter, as shown in FIG. **15**, the sealing layer **17** is removed. For example, the sealing layer **17** is firstly irradiated with ultraviolet light so that an adhesive force of the adhesive layer of the sealing layer **17** is decreased. Then, the sealing layer **17** is peeled from the substrate **12**. In this manner, the through electrode **22** including the first layer **22***a* and the second layer **22***b* can be formed. The through electrode **22** has the first part **23** that extends along the sidewall **21** of the through hole **20**, the second part **24** that is connected to the first part **23** and spreads in the surface direction D**1** of the first surface **13** to come into contact with the sidewall **21** of the through hole **20** on the side of the first surface **13** of the substrate **12**, and the third part **25** that is connected to the first part **23** and provided on the second surface **14**.

(96) In the above description, an example in which the first part **23**, the second part **24** and the third part **25** of the through electrode **22** are simultaneously formed is shown, but the present invention is not limited thereto. For example, although not shown, the second part **24**, the first part **23** and the third part **25** may be sequentially formed. Alternatively, after the second part **24** has been formed, the first part **23** and the third part **25** may be simultaneously formed. In this case, a step of removing the sealing layer **17** may be carried out between the step of forming the second part **24** and the step of forming the first part **23**. Alternatively, after the second part **24** and the first part **23** have simultaneously been formed, the third part **25** may be formed.

(97) Advantages of the aforementioned manufacturing method of the through electrode substrate **10** according to this embodiment are described herebelow.

(98) According to this embodiment, the through electrode **22** is formed inside the through hole **20**, with the through hole **20** being blocked by the sealing layer **17**. Thus, even when a so-called conformal via, in which there exists a hollow part inside the through hole **20**, is employed, the second part **24** of the through electrode **22**, which is positioned coplanarly with the first surface **13** of the substrate **12**, can be provided on an area overlapped with the through hole **20**. Thus, the through electrode **22** and the electroconductive layer **31** of the wiring layer **30** can be connected in the area overlapped with the through hole **20**. Therefore, since it is not necessary to ensure an area on the first surface **13** of the substrate **12** to be connected to the electroconductive layer **31** of the wiring layer **30**, an interval P between the adjacent two through holes **20** can be made smaller. As a result, a distribution density of the through holes **20** of the through electrode substrate **10** can be increased. In addition, the employment of the conformal via reduces a time required for the step of forming the through electrode **22**, as compared with the case of the filled via.

(99) Manufacturing Method of Through Electrode Substrate in Comparative Embodiment

(100) As a method of forming the through electrode **22** having the first part **23** and the second part **24**, a below method according to a comparative embodiment is conceivable in addition to the aforementioned method according to this embodiment. Herebelow, the manufacturing method of the through electrode substrate **10** according to the comparative embodiment is described with

reference to FIGS. **16** to **18**.

(101) As shown in FIG. **16**, an electroconductive layer **71** is firstly provided on a first surface **13** of a substrate **12**. To be specific, the electroconductive layer **71** is provided so as to cover a through hole **20** that is succeedingly formed in the substrate **12**. Then, as shown in FIG. **17**, the through hole **20** is formed in the substrate **12** from the side of a second surface **14**. For example, the through hole **20** is formed in the substrate **12** by dry etching, wet etching, laser irradiation, etc. Thereafter, as shown in FIG. **18**, a through electrode **22** to be connected to the electroconductive layer **71** is formed inside the through hole **20**.

(102) In the comparative embodiment, as described above, after the electroconductive layer **71** has been provided on the side of the first surface **13** of the substrate **12**, the through hole **20** is formed from the side of the second surface **14** of the substrate **12**. In this case, when the process of the substrate **12** reaches the electroconductive layer **71** across the first surface **13** of the substrate **12**, as shown in FIG. **17**, a recess **71***a* is formed in the electroconductive layer **71**. Thus, in the comparative embodiment, the electroconductive layer **71** needs to have a sufficiently large thickness in order to prevent that the recess **71***a* passes through the electroconductive layer **71**. As a result, the thickness of the through electrode substrate **10** as a whole increases. In addition, when the thickness of the electroconductive layer **71** is large, the through electrode substrate **10** is likely to be warped because of a residual stress inside the electroconductive layer **71**. In addition, in a case where the through hole **20** is formed by dry etching or wet etching, when an etching gas and/or an etching liquid remains in the recess **71***a* of the electroconductive layer **71**, the electroconductive layer **71** is likely to become corroded. As a result, connection reliability between the electroconductive layer **71** and the through electrode **22** is impaired.

(103) In addition, in the step of forming the through hole **20** in the substrate **12** by processing the substrate **12** from the side of the second surface **14**, there is a possibility that a position and/or a size of the through hole **20** deviates from a design because of a manufacturing tolerance. In order that the through hole **20** is covered with the electroconductive layer **71** even when the position and/or the size of the through hole **20** deviates from the design, it is necessary that the size of the electroconductive layer **71** in the surface direction of the first surface **13** of the substrate **12** is made larger than the size of the through hole **20** and the second part **24** of the through electrode **22** by at least the manufacturing tolerance. Thus, the electroconductive layer **71** spreads up to a part that is not overlapped with the through hole **20**. In this case, an interval between the adjacent two through holes **20** is set in consideration of a part that spreads up to the part of the electroconductive layer **71**, which is not overlapped with the through hole **20**. Therefore, in the comparative embodiment, it is not easy to increase a distribution density of the through holes **20** of the through electrode substrate **10**.

(104) On the other hand, in this embodiment, after the second part **24** of the through electrode **22** has been formed, the electroconductive layer **31** of the wiring layer **30** is formed on the second part **24**. In addition, since the second part **24** is formed on the surface of the sealing layer **17**, the outer surface **24***a* of the second part **24** has a flatness equivalent to the surface of the sealing layer **17**. Thus, even when the thickness of the electroconductive layer **31** is small, the connection reliability between the electroconductive layer **31** and the second part **24** of the through electrode **22** can be ensured. Thus, the thickness of the through electrode substrate **10** as a whole can be made smaller. In addition, it can be prevented that the through electrode substrate **10** is warped because of a residual stress inside the electroconductive layer **31**.

(105) In addition, according to this embodiment, since the electroconductive layer **31** of the wiring layer **30** is formed on the outer surface **24***a* of the second part **24**, the size S**3** of the electroconductive layer **31** in the surface direction of the first surface **13** of the substrate **12** can be made smaller than the size of the second part **24**. As a result, the interval P between the adjacent two through holes **20** can be made smaller. Owing thereto, the distribution density of the through holes **20** of the through electrode substrate **10** can be increased.

(106) Mounting Substrate
(107) Herebelow, an example of the use of the through electrode substrate **10** according to this embodiment is described. Herein, an example in which a mounting substrate **50** is formed by loading an element **51** on the through electrode substrate **10** is described.
(108) FIG. **19** is a sectional view showing the mounting substrate **50**. FIG. **20** is a plan view of the mounting substrate **50** shown in FIG. **19**. The mounting substrate **50** includes the through electrode substrate **10**, and an element **51** loaded on the through electrode substrate **10** on the side of the first surface **13** of the substrate **12**. The element **51** is an LSI chip such as a logic IC or a memory IC. The element **51** may be a MEMS (Micro Electro Mechanical Systems) chip. A MEMS chip is an electronic device in which a mechanical component, a sensor, an actuator, an electronic circuit and so on are integrated on one substrate. As shown in FIG. **19**, the element **51** has a terminal **52** connected to the electrode part **33** of the wiring layer **30** of the through electrode substrate **10**.
(109) As shown in FIG. **21**, the mounting substrate **50** may further comprise a circuit board **55** connected to the through electrode substrate **10** on the side of the second surface **14** of the substrate **12**. In this case, the through electrode substrate **10** of the mounting substrate **50** further has an electrode part **38** provided on the third part **25** of the through electrode **22**. In addition, the circuit board **55** has a base member **56**, and an electrode part **57** provided on the base member **56** to be connected to the electrode part **38** of the through electrode substrate **10**.
(110) The base member **56** of the circuit board **55** contains an organic material such as polyimide, epoxy, acryl or the like. In this case, when the base member **56** is subjected to a certain heat treatment, there is a possibility that an internal stress is generated in the base member **56** because of thermal expansion. Here, according to this embodiment, since the substrate **12** of the through electrode substrate **10** contains a highly rigid material such as glass or silicon, it can be prevented that the internal stress of the base member **56** gives an impact on the element **51** loaded on the side of the first surface **13** of the through electrode substrate **10** and the wiring layer **30**. Thus, the connection reliability between the through electrode substrate **10** and the element **51** can be ensured.
(111) The aforementioned embodiment can be variously modified. Herebelow, modification examples are described with reference to the drawings according to need. In the below description and the drawings for the description, the same part as that of the above embodiment is shown by the same reference number, and detailed description thereof is omitted. In addition, when the effect obtained in the above embodiment is apparently obtained also in the modification examples, description thereof may be omitted.
First Modification Example
(112) FIG. **22** is a sectional view of the through electrode substrate according to a first modification example. FIG. **23** is a plan view of the through electrode substrate **10** according to the first modification example, when seen from the side of the first surface **13** of the substrate **12**. As shown in FIGS. **22** and **23**, the electroconductive layer **31** of the wiring layer **30** may include a plurality of the electrode parts **33** provided on the second part **24** of the through electrode **22**. Since the electroconductive layer **31** of the wring layer **30** is formed after the second part **24** of the through electrode **22** of the through electrode substrate **10** has been formed, the electrode part **33** of the electroconductive layer **31** on the second part **24** can be divided into plural ones.
Second Modification Example
(113) FIG. **24** is a sectional view showing the through electrode substrate **10** according to a second modification example. FIG. **25** is a plan view of the through electrode substrate **10** according to the second modification example, when seen from the side of the first surface **13** of the substrate **12**. As shown in FIGS. **24** and **25**, the electroconductive layer **31** of the wiring layer **30** includes a conductive wire part **34** that intersects the profile of the second part **24** of the through electrode **22**, when seen along the normal direction of the first surface **13** of the substrate **12**. As shown in FIG. **25**, in the surface direction D**1** of the first surface **13**, a size S**4** of the conductive wire part **34**

positioned on the second part **24** is smaller than the size S**2** of the second part **24**. The size S**4** of the conductive wire part **34** is measured in a direction perpendicular to a second direction D**2** along which the conductive wire part **34** positioned on the second part **24** extends.
(114) As described above, the second part **24** of the through electrode **22** of the through electrode substrate **10** is positioned coplanarly with the first surface **13** of the substrate **12**. In other words, there is little step between the outer surface **24***a* of the second part **24** and the first surface **13** of the substrate **12**. Thus, even when the conductive wire part **34** extends across the second part **24** and the first surface **13** as in this modification example, it is possible to prevent that a stress is concentrated on a part of the conductive wire part **23** caused by the step, whereby the disconnection of the conductive wire part **34** can be prevented. Thus, reliability of the conductive wire part **34** can be ensured. In addition, since the thickness of the conductive wire part **34** can be made smaller, the thickness of the through electrode substrate **10** as a whole can be made smaller.
Third Modification Example
(115) FIG. **26** is a sectional view of the through electrode substrate according to a third modification example. As shown in FIG. **26**, the wiring layer **30** provided on the side of the first surface **13** of the substrate **12** may further have an insulation layer **36** in addition to the electroconductive layer **31**. The insulation layer **36** contains an organic material having an insulation property. For example, it contains polyimide. In this case, the electroconductive layer **31** includes, for example, the electrode part **33** serving as a through electrode passing through the insulation layer **36**, and the conductive wire part **34** covered with the insulation layer **36**.
(116) As shown in FIG. **26**, the wiring layer **30** may have a plurality of layers each including the electroconductive layer **31** and the insulation layer **36**. For example, the wiring layer **30** has a first wiring layer **41** including the electroconductive layer **31** provided on the first surface **13** of the substrate **12** and the insulation layer **36**, and a second wiring layer **42** including the electroconductive layer **31** provided on the first wiring layer **41** and the insulation layer **36**.
(117) As shown in FIG. **26**, a layer of the wiring layer **30**, which is positioned nearest to the surface, herein, the second wiring layer **42** may further include a coating layer **35** provided on the electrode part **33**. The coating layer **35** contains an electroconductive material having corrosion resistance. For example, it contains gold. In addition, the coating layer **35** may include a plurality of layers. For example, the coating layer **35** may include a gold layer positioned nearest to the surface, and a nickel layer located between the gold layer and the electrode part **33**.
(118) As shown in FIG. **27**, the mounting substrate **50** may be formed by loading the element **51** on the wiring layer **30** shown in FIG. **26**. The aforementioned coating layer **35** functions as a pad connected to the terminal **52** of the element **51**. Although not shown, the coating layer **35** may not be provided. Also in this case, the mounting substrate **50** can be formed by connecting the terminal **52** of the element **51** to the electrode part **33** of the second wiring layer **42** of the wiring layer **30**.
(119) Herebelow, an example of the manufacturing method of the wiring layer **30** according to this modification example is described with reference to FIGS. **28** to **32**.
(120) Firstly, the through electrode substrate **10** according to the above embodiment is prepared. Then, as shown in FIG. **28**, the electrode part **33** is formed on the second part **24** of the through electrode **22** of the through electrode substrate **10**. In addition, the conductive wire part **34** is formed on the first surface **13** of the substrate **12** of the through electrode substrate **10**.
(121) As a method of forming the electrode part **33** and the conductive wire part **34**, for example, the same method as the method of forming the through electrode **22** of the through electrode substrate **10** can be employed. For example, formation of the first layer functioning as a seed layer, formation of the resist layer, formation of the second layer by an electrolytic plating process, removal of the resist layer, and the removal of the first layer are carried out in this order. In this case, the electrode part **33** and the conductive wire part **34** respectively have the first layer having an electroconductive property and functioning as a seed layer, and the second layer having an electroconductive property and formed on the first layer by an electrolytic plating process. A layer

of metal material such as titanium or titanium nitride, which has high adhesiveness to the through electrode **22** or the substrate **12**, may be provided between the first layer functioning as a seed layer and the through electrode **22** or the substrate **12**.
(122) In the through electrode substrate **10** according to the above embodiment, there is little step between the outer surface **24***a* of the second part **24** and the first surface **13** of the substrate **12**. Thus, even when the thickness of the electroconductive layer **31** provided on the outer surface **24***a* of the second part **24** and the first surface **13** of the substrate **12**, such as the aforementioned first layer of the electrode part **33** and the conductive wire part **34**, is small, disconnection of the electroconductive layer **31** caused by the step can be prevented.
(123) Then, a layer of an organic material having a photosensitive property and an insulation property is provided on the first surface **13** of the substrate **12** so as to cover the electrode part **33** and the conductive wire part **34**. Thereafter, the layer of an organic material is exposed to be developed, such that a part of the layer of an organic material, which is on the electrode part **33**, is removed. Thus, as shown in FIG. **29**, it is possible to form the insulation layer **36** which has an opening **36***a* from which the electrode part **33** on the through electrode **22** is exposed, and covers the conductive wire part **34**.
(124) Then, as shown in FIG. **30**, the electrode part **33** is further formed on the electrode part **33**, and the conductive wire part **34** is formed on the insulation layer **36**. For example, similarly to the case when the electrode part **33** and the conductive wire part **34** are formed on the substrate **12**, formation of the first layer functioning as a seed layer, formation of the resist layer, formation of the second layer by an electrolytic plating process, removal of the resist layer, and removal of the first layer are carried out in this order.
(125) Then, as shown in FIG. **31**, the electrode part **33** on the through electrode **22** is exposed, and the insulation layer **36** covering the conductive wire part **34** is formed. Following thereto, as shown in FIG. **32**, the electrode part **33** is further formed on the already provided electrode part **33**, such that the electrode part **33** projects from the surface of the insulation layer **36**. In this manner, it is possible to form the wiring layer **30** including the electrode parts **33** passing through the insulation layers **36**, and the conductive wire parts **34** covered with the insulation layers **36**.
Fourth Modification Example
(126) FIG. **33** is a sectional view showing the through electrode substrate **10** according to a fourth modification example. As shown in FIG. **33**, a plurality of the electrode parts **33** passing through the insulation layer **36** of the wiring layer **30** may be connected to the second part **24** of the one through electrode **22**. Since the electroconductive layer **31** of the wring layer **30** is formed after the second part **24** of the through electrode **22** of the through electrode substrate **10** has been formed, the electrode part **33** of the electroconductive layer **31** on the second part **24** can be divided into plural ones.
Fifth Modification Example
(127) FIG. **34** is a sectional view of the through electrode substrate **10** according to a fifth modification example. As shown in FIG. **34**, the wiring layer **30** provided on the side of the first surface **13** of the substrate **12** may further has a stress relaxation layer **37** located between the substrate **12** and the insulation layer **36**. The stress relaxation layer **37** is a layer for relaxing an internal stress of the insulation layer **36**. The stress relaxation layer **37** contains an inorganic material having an insulation property.
(128) Herebelow, advantages of provision of the stress relaxation layer **37** are described. The insulation layer **36** of the wiring layer **30** contains an organic material. When such an insulation layer **36** is provided on the substrate **12** containing glass, an internal stress that pulls the substrate **12** is likely to be generated in the insulation layer **36**. Herebelow, such an internal stress is referred to as tensile stress. When the tensile stress increases, there is a possibility that the substrate **12** is warped.
(129) On the other hand, an internal stress that compresses the substrate **12** is likely to be generated

in the stress relaxation layer **37** containing an inorganic material. Herebelow, such an internal stress is referred to as compressive stress. According to this modification example, since the stress relaxation layer **37** is provided between the substrate **12** and the insulation layer **36**, the tensile stress of the insulation layer **36** can be relaxed. Thus, it can be prevented that the substrate **12** is warped.
(130) FIG. **34** shows an example in which the stress relaxation layer **37** is provided between the substrate **12** and the insulation layer **36** of the first wiring layer **41**. However, the concrete position of the stress relaxation layer **37** is not particularly limited.
(131) For example, the stress relaxation layer **37** may be positioned between the insulation layer **36** of the first wiring layer **41** and the insulation layer **36** of the second wiring layer **42**. In this case, another stress relaxation layer **37** may also be present between the substrate **12** and the insulation layer **36** of the first wiring layer **41**. Alternatively, the stress relaxation layer **37** may not be present between the substrate **12** and the insulation layer **36** of the first wiring layer **41**.
(132) The thickness of the insulation layer **36** and the thickness of the stress relaxation layer **37** are set such that their stresses can be suitably negated each other. For example, when the insulation layer **36** contains an organic material having an insulation property such as polyimide, epoxy, acryl, etc., and has a thickness of not less than 5 μm and not more than 20 μm, the stress relaxation layer **37** contains an insulation material such as a silicon compound and has a thickness of not less than 1 μm and not more than 5 μm. Examples of a silicon compound may be SiO.sub.2, SiN, SiOC, SiC, SiOF, SiON, SiCN, etc.
Sixth Modification Example
(133) In the above embodiment, an example in which the sidewall **21** of the through hole **20** has a linear shape in the sectional view is shown. However, as long as the through electrode **22** including the first part **23** and the second part **24** can be provided, the shape of the through hole **20** is not particularly limited. For example, as shown in FIG. **35**, the sidewall **21** of the through hole **20** may have a curved shape in a sectional view.
Seventh Modification Example
(134) In the above embodiment, an example in which the through electrode **22** has the third part **25** that is provided on the second surface **14**, in addition to the first part **23** that spreads along the sidewall **21** of the through hole **20**, the second part **24** that spreads in the surface direction D**1** of the first surface **13** to come into contact with the sidewall **21** of the through hole **20** on the side of the first surface **13**, is shown. However, as shown in FIG. **36**, it is sufficient that the through electrode **22** has at least the first part **23** and the second part **24**.
(135) [Examples of Product on which Through Electrode Substrate is Loaded]
(136) FIG. **39** is a view showing examples on which the through electrode substrate **10** according to this embodiment of the disclosure can be loaded. The through electrode substrate **10** according to this embodiment of the disclosure can be used in various products. For example, the through electrode substrate **10** can be loaded on a note-type personal computer **110**, a tablet terminal **120**, a mobile phone **130**, a smart phone **140**, a digital video camera **150**, a digital camera **160**, a digital watch **170**, a server **180** and so on.
EXAMPLES
(137) Next, the disclosure is described in more detail by way of examples. However, the disclosure should not be limited to the below description of the examples, a long as the disclosure departs from its scope.
Example 1
(138) Firstly, a through electrode substrate **10** shown in FIG. **40** was manufactured based on the manufacturing method of the through electrode substrate **10** according to the above embodiment of the disclosure. The through electrode substrate **10** included a substrate provided with a through hole **20**, a through electrode **22** provided inside the through hole **20** and having a first part **23**, a second part **24** and a third part **25**, and a wiring layer **30** provided on the side of a first surface **13** of

the substrate **12** and having an electrode part **33** connected to the second part **24** of the through electrode **22**. The wiring layer **30** included an insulation layer **36** provided on the side of the first surface **13** of the substrate **12** and having an opening corresponding to the electrode part **33**, and a conductive wire part **34** provided on the insulation layer **36** and connecting the electrode parts **33** on the second parts **24** of the through hole electrodes **22** of the adjacent two through holes **20** through the openings of the insulation layer **36**.

(139) A temperature cycle test was carried out 1000 times, with applying current between the through electrodes **22** of the adjacent two through holes **20**. Each cycle included a step in which an ambient temperature of the through electrode substrate **10** was increased from −45° C. to 125° C., a step in which the ambient temperature was maintained at 125° C., a step in which the ambient temperature is decreased from 125° C. to −45° C., and a step in which the ambient temperature was maintained at −45° C.

(140) A time required for one cycle was 40 minutes.

(141) After the temperature cycle test was carried out 1000 times, whether failure in current application occurred or not was inspected. It was confirmed that, in all the inspection points, no failure in current application occurred.

Comparative Example 1

(142) Firstly, a through electrode substrate **70** shown in FIG. **41** was manufactured based on the manufacturing method of the through electrode substrate **70** according to the above comparative embodiment. The through electrode substrate **70** included a substrate **12** provided with a through hole **20**, a through electrode **22** provided inside the through hole **20** and having a first part **23**, a second part **24** and a third part **25**, and a wiring layer **80** provided on the side of a first surface **13** of the substrate **12** and having an electroconductive layer **71** connected to the second part **24** of the through electrode **22**. The wing layer **80** included an insulation layer **36** provided on the side of the first surface **13** of the substrate **12** and having an opening corresponding to the electroconductive layer **71**, and a conductive wire part **34** provided on the insulation layer **36** and connecting the electroconductive layers **71** on the second parts **24** of the through hole electrodes **22** of the adjacent two through holes **20** through the openings of the insulation layer **36**.

(143) Similarly to the case of the above Example 1, the temperature cycle test was carried out 1000 times.

(144) In 80% of the inspection points, failure in current application occurred. In the Comparative Example 1, the failure in current application was considered to occur because the recess **71***a* was generated in the electroconductive layer **71** so that electric connection between the electroconductive layer **71** and the second part **24** of the through electrode **22** became unstable by corrosion of the recess **71***a*.

DESCRIPTION OF REFERENCE NUMERALS

(145) **10** Through electrode substrate **12** Substrate **13** First surface **14** Second surface **16** First resist layer **16***a* Opening **17** Sealing layer **18** Second resist layer **20** Through hole **21** Sidewall **22** Through electrode **22***a* First layer **22***b* Second layer **23** First part **24** Second part **25** Third part **30** Wiring layer **31** Electroconductive layer **33** Electrode part **34** Conductive wire part **35** Coating layer **36** Insulation layer **36***a* Opening **37** Stress relaxation layer **38** Electrode part **41** First wiring layer **42** Second wiring layer **50** Mounting substrate **51** Element **52** Terminal **55** Circuit board **56** Base member **57** Electrode part **70** Through electrode substrate **71** Electroconductive layer

Claims

1. A mounting substrate comprising: a through electrode substrate; and a circuit board connected to the through electrode substrate, wherein the through electrode substrate comprises: a substrate including a first surface, a second surface positioned oppositely to the first surface, and a through hole; a through electrode inside the through hole of the substrate; and a wiring layer provided on

the first surface of the substrate, wherein the substrate of the through electrode substrate contains glass, wherein the through electrode comprises: a first part spreading along a sidewall of the through hole; a second part connected to the first part and spreading in a surface direction of the first surface; and a third part connected to an end portion of the first part on a side of the second surface, wherein the second part includes an outer surface positioned coplanarly with the first surface of the substrate, wherein the wiring layer includes an electroconductive layer connected to the outer surface of the second part, and wherein the circuit board includes a base member, and an electrode part provided on the base member and electrically connected to the third part of the through electrode substrate.

2. The mounting substrate according to claim 1, wherein the third part is positioned on the second surface.

3. The mounting substrate according to claim 1, wherein the through electrode substrate includes an electrode part positioned on the third part, and wherein the electrode part of the through electrode substrate is connected to the electrode part of the circuit board.

4. The mounting substrate according to claim 1, wherein the base member of the circuit board contains an organic material.

5. The mounting substrate according to claim 1, wherein a size of the through hole in the surface direction of the first surface of the substrate increases from the first surface toward the second surface.

6. The mounting substrate according to claim 1, wherein the through hole is one of a plurality of through holes formed in the substrate and the through electrode is one of a plurality of through electrodes formed in the substrate, and when the substrate is virtually divided equally into sixteen sections in the surface direction of the first surface, each of the number of the through holes formed in the sixteen sections is within a range of an average value ±20%, and a virtually divided substrate is an imaginary division of the substrate.

7. The mounting substrate according to claim 1, wherein in the surface direction of the first surface of the substrate, a size of a part of the electroconductive layer of the wiring layer, which is connected to the second part of the through electrode, is smaller than a size of the second part of the through electrode.

8. The mounting substrate according to claim 1, wherein the electroconductive layer includes an electrode part having a profile overlapped with the second part of the through electrode and surrounded by the second part, when seen along a normal direction of the first surface of the substrate.

9. The mounting substrate according to claim 8, wherein the electrode part is one of a plurality of electrode parts and the electroconductive layer includes the plurality of the electrode parts.

10. The mounting substrate according to claim 1, wherein the electroconductive layer includes a conductive wire part intersecting a profile of the second part of the through electrode, when seen along a normal direction of the first surface of the substrate.

11. The mounting substrate according to claim 10, wherein the conductive wire part is one of a plurality of conductive wire parts and the electroconductive layer includes the plurality of the conductive wire parts.

12. The mounting substrate according to claim 1, wherein the wiring layer further has an insulation layer containing an organic material, and a stress relaxation layer containing an inorganic material.

13. The mounting substrate according to claim 12, wherein the wiring layer has a first wiring layer including the electroconductive layer positioned on the first surface of the substrate and the insulation layer, and a second wiring layer including the electroconductive layer positioned on the first wiring layer and the insulation layer, and the stress relaxation layer is positioned at least between the first surface of the substrate and the insulation layer of the first wiring layer, or between the insulation layer of the first wiring layer and the insulation layer of the second wiring layer.

14. The mounting substrate according to claim 1, comprising: an element loaded on the through electrode substrate.