United States Patent Application Publication	20250258218
Kind Code	A1
Publication Date	August 14, 2025
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ELECTRICAL CONNECTION APPARATUS

Abstract

An electrical connection apparatus includes a probe, a wiring board including a first electrode electrically connected to the probe, internal wiring, and a second electrode electrically connected to the first electrode via the internal wiring, and a wiring sheet with flexibility including a first connection portion arranged on a first sheet surface, a second connection portion arranged on a second sheet surface, and an internal circuit electrically connected to at least any one of the first connection portion and the second connection portion. A claw portion with conductivity projecting obliquely relative to a surface perpendicular to a thickness direction of the wiring sheet is arranged on at least any one of the first connection portion and the second connection portion. The internal wiring of the wiring board and the internal circuit of the wiring sheet are electrically connected via the claw portion.

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Family ID: **96660793**

Appl. No.: **19/052235**

Filed: **February 12, 2025**

Foreign Application Priority Data

JP	2024-020424	Feb. 14, 2024

Publication Classification

Int. Cl.: **G01R31/28** (20060101)

U.S. Cl.:

CPC **G01R31/2889** (20130101);

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is based on, and claims priority from Japanese Patent Application No. 2024-020424, filed on Feb. 14, 2024, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to an electrical connection apparatus used for inspecting electrical characteristics of an object to be inspected.

BACKGROUND ART

[0003] To measure electrical characteristics of an object to be inspected such as an integrated circuit, an electrical connection apparatus having a terminal for inspection in contact with the object to be inspected is used. In the measurement using the electrical connection apparatus, the object to be inspected is electrically connected to an inspection device such as a tester via the terminal for inspection. In order to measure various characteristics of the object to be inspected, the electrical connection apparatus is configured by superimposing a plurality of circuit boards such as a printed board and a space transformer.

CITATION LIST

Patent Literature

[0004] [Patent Literature 1] JP 2019-178901 A

SUMMARY

[0005] If a plurality of circuit boards constituting an electrical connection apparatus have different degrees of flatness, a gap is formed between the circuit boards, and the stability of electrical connection between the circuit boards deteriorates. An object of the present disclosure is to provide an electrical connection apparatus in which electrical connection between circuit boards is stabilized.

[0006] An electrical connection apparatus according to one aspect of the present disclosure includes: a terminal for inspection; a wiring board including a first electrode electrically connected to the terminal for inspection, internal wiring, and a second electrode; and a wiring sheet with flexibility including a first connection portion arranged on a first sheet surface, a second connection portion arranged on a second sheet surface, and an internal circuit electrically connected to at least any one of the first connection portion and the second connection portion. A claw portion with conductivity projecting obliquely relative to a surface perpendicular to a thickness direction of the wiring sheet is arranged on at least any one of the first connection portion and the second connection portion. The internal wiring of the wiring board and the internal circuit of the wiring sheet are electrically connected via the claw portion.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a schematic view showing a configuration of an electrical connection apparatus according to a first embodiment.

[0008] FIG. **2**A is a schematic plan view showing the configuration of the electrical connection apparatus according to the first embodiment.

[0009] FIG. **2**B is a schematic cross-sectional view showing the configuration of the electrical

connection apparatus according to the first embodiment.
[0010] FIG. **3** is a schematic cross-sectional view showing a configuration example of a wiring sheet in the electrical connection apparatus according to the first embodiment.
[0011] FIG. **4** is a schematic view showing configuration examples of claw portions of the wiring sheet in the electrical connection apparatus according to the first embodiment.
[0012] FIG. **5** is a schematic view showing arrangement examples of the claw portions of the wiring sheet in the electrical connection apparatus according to the first embodiment.
[0013] FIG. **6** is a schematic view showing examples of projecting directions of the claw portions of the wiring sheet in the electrical connection apparatus according to the first embodiment.
[0014] FIG. **7** is a schematic view showing another example of configurations of claw portions of the wiring sheet in the electrical connection apparatus according to the first embodiment.
[0015] FIG. **8** is a schematic view showing still another example of configurations of claw portions of the wiring sheet in the electrical connection apparatus according to the first embodiment.
[0016] FIG. **9** is a schematic view showing an example of an internal circuit of the wiring sheet in the electrical connection apparatus according to the embodiment.
[0017] FIG. **10** is a schematic view showing another example of the internal circuit of the wiring sheet in the electrical connection apparatus according to the embodiment.
[0018] FIG. **11** is a schematic view showing another example of the internal circuit of the wiring sheet in the electrical connection apparatus according to the embodiment.
[0019] FIG. **12** is a schematic view showing an example of a loopback circuit using the wiring sheet shown in FIG. **11**.
[0020] FIG. **13** is a schematic view showing another example of the internal circuit of the wiring sheet in the electrical connection apparatus according to the embodiment.
[0021] FIG. **14** is a schematic view showing another example of the internal circuit of the wiring sheet in the electrical connection apparatus according to the embodiment.
[0022] FIG. **15** is a schematic view showing a configuration of an electrical connection apparatus according to a second embodiment.
[0023] FIG. **16** is a schematic view showing a configuration of an electrical connection apparatus according to a third embodiment.

DETAILED DESCRIPTION

[0024] Embodiments will be described with reference to the drawings. In the description of the drawings below, the same or similar parts are denoted with the same or similar reference numerals. However, it should be noted that the drawings are schematically shown and the ratios of the thickness of each portion and the like are different from those in reality. Further, it is needless to say that the drawings include portions where the relationships and ratios of dimensions are different between drawings. The following embodiments exemplify an apparatus and a method for embodying the technical concept of the present invention, and the embodiments do not specify the material, shape, structure, arrangement, and the like of components to the following.

First Embodiment

[0025] An electrical connection apparatus **1** according to a first embodiment shown in FIG. **1** is used for inspecting an object **2** to be inspected. The electrical connection apparatus **1** includes a plurality of probes **10** that come into contact with the object **2** to be inspected when the object is inspected, a wiring board **20** connected to the probes **10**, a wiring sheet **30** laminated on the wiring board **20**, and a printed board **40** laminated on the wiring sheet **30**. The electrical connection apparatus **1** further includes a stiffener **50** laminated on the printed board **40**. In the following description, a direction in which the electrical connection apparatus **1** is located when viewed from the object **2** to be inspected is defined as an upward direction, and a direction in which the object **2** to be inspected is located when viewed from the electrical connection apparatus **1** is defined as a downward direction. As shown in FIG. **1**, a direction from the downward direction to the upward direction is defined as a Z direction, and a plane perpendicular to the Z direction is defined as an

XY plane. In FIG. **1**, a left-right direction of the drawing is defined as an X direction, and a front-back direction is defined as a Y direction. Further, a surface facing the upward direction of each component of the electrical connection apparatus **1** will be referred to as an upper surface, and a surface facing the downward direction will be referred to as a lower surface.

[0026] The probes **10** function as terminals for inspection for electrically connecting the object **2** to be inspected and an inspection device. The probes **10** have tips disposed so as to be in contact with the object **2** to be inspected and proximal ends connected to the tips. As shown in FIG. **1**, the probes **10** may be supported by a probe head **60** through which the probes **10** pass. The probes **10** are held while passing through through-holes formed in the probe head **60**, for example. The probe head **60** is fixed to the wiring board **20**, for example. The proximal ends of the probes **10** are connected to the wiring board **20**.

[0027] The object **2** to be inspected is mounted on a stage **3**. The electrical connection apparatus **1** and the stage **3** are movable relative to one another in an up-down direction. When the object **2** to be inspected is inspected, a distance between the electrical connection apparatus **1** and the stage **3** is made small, and the tips of the probes **10** contact signal terminals (not shown) of the object **2** to be inspected. FIG. **1** shows a state in which the probes **10** and the object **2** to be inspected are separated.

[0028] The wiring board **20** includes first electrodes **21** electrically connected to the probes **10**, internal wiring **200**, and second electrodes **22**. Each first electrode **21** is connected to a proximal end of any one of the plurality of probes **10** of the electrical connection apparatus **1**. The second electrodes **22** are electrically connected to the first electrodes **21** via the internal wiring **200**. A multilayer wiring board such as a Multi-Layer Organic (MLO) board or a Multi-Layer Ceramic (MLC) board may be used for the wiring board **20**, for example.

[0029] The wiring sheet **30** includes a first sheet surface **311** which faces the wiring board **20**, and a second sheet surface **312** which faces in an opposite direction of the first sheet surface **311** and faces the printed board **40**. First connection portions **31** are arranged on the first sheet surface **311**, and second connection portions **32** are arranged on the second sheet surface **312**. Further, the wiring sheet **30** has an internal circuit (not shown in FIG. **1**) electrically connected to at least any one of the first connection portions **31** and the second connection portions **32**. The wiring sheet **30** has flexibility and elastically deforms in a thickness direction.

[0030] Each claw portion **300** with conductivity projecting obliquely relative to the first sheet surface **311** and the second sheet surface **312** perpendicular to the thickness direction of the wiring sheet **30** is arranged on at least any one of the first connection portion **31** and the second connection portion **32** of the wiring sheet **30**.

[0031] The printed board **40** is arranged to face the wiring board **20** with the wiring sheet **30** therebetween. The printed board **40** includes first ends **41** arranged on a lower surface thereof facing the wiring sheet **30**, second ends **42** arranged on an upper surface facing in an opposite direction of a first main surface, and wiring patterns **400** for electrically connecting the first ends **41** and the second ends **42**. Each second end **42** of the wiring pattern **400** is electrically connected to an inspection device (not shown).

[0032] The first sheet surface **311** is a lower surface of the wiring sheet **30** facing the wiring board **20**. The second sheet surface **312** is an upper surface of the wiring sheet **30** facing the printed board **40**. In the wiring sheet **30** interposed between the wiring board **20** and the printed board **40**, claw portions **300** are disposed on both the first connection portions **31** and the second connection portions **32**. The first connection portions **31** of the wiring sheet **30** are connected to the second electrodes **22** of the wiring board **20** via the claw portions **300**, and the second connection portions **32** are connected to the first ends **41** of the wiring patterns **400** of the printed board **40** via the claw portions **300**. This electrically connects the internal wiring **200** of the wiring board **20** and the internal circuit of the wiring sheet **30**, and electrically connects the wiring patterns **400** of the printed board **40** and the internal circuit of the wiring sheet **30**.

[0033] As described above, the first connection portions **31** of the wiring sheet **30** are electrically connected to the second electrodes **22** of the wiring board **20**, and the second connection portions **32** are electrically connected to the wiring patterns **400** of the printed board **40**. In other words, the wiring sheet **30** has functions of an interposer between the wiring board **20** and the printed board **40**.

[0034] The wiring board **20** may be a space transformer that transforms a distance between the proximal ends of the probes **10** to a distance between the first ends **41** of the printed board **40** when viewed from a direction normal to a main surface of the wiring board **20**, for example. Due to the wiring board **20** being a space transformer, it is possible to electrically connect the proximal ends of the probes **10** arranged at a distance corresponding to a distance between signal terminals arranged on the object **2** to be inspected, to the wiring patterns **400** in the printed board **40** arranged at a distance larger than a distance between the proximal ends. Due to an increase in distance between the second ends **42** of the wiring patterns **400**, the electrical connection between the wiring patterns **400** in the printed board **40** and the inspection device is facilitated.

[0035] As shown in FIG. **1**, the stiffener **50** may be laminated on the printed board **40**. The stiffener **50** has higher stiffness than the printed board **40**, and ensures the mechanical strength of the electrical connection apparatus **1** by preventing the printed board **40** from being bent. In addition, the stiffener **50** may be used as a support for fixing each component of the electrical connection apparatus **1**. The stiffener **50** may be fixed to the printed board **40** using screws, for example.

[0036] FIG. **2**A is a plan view (hereinafter also referred to as “in plan view”) of a structure in which the wiring board **20**, the wiring sheet **30**, the printed board **40**, and the stiffener **50** are laminated, as viewed from the Z direction. FIG. **2**B is a cross-sectional view of a side surface as viewed from the Y direction of an XY plane perpendicular to the Z direction. FIG. **2**B does not show the first electrodes **21** and the second electrodes **22** of the wiring board **20**, the first connection portions **31** and the second connection portions **32** of the wiring sheet **30**, and the wiring patterns **400** of the printed board **40**.

[0037] The stiffener **50** is arranged on an upper surface of the printed board **40** that is circular in plan view. As shown in FIG. **2**A, the stiffener **50** has a shape in which an outer circular ring and an inner rectangular ring are connected using spokes, for example. The wiring board **20** and the wiring sheet **30** are arranged in the vicinity of the center of a lower surface of the printed board **40**. The wiring board **20**, the wiring sheet **30**, the printed board **40**, and the stiffener **50** are fixed with screws, for example. FIG. **2**B shows an example in which the wiring board **20**, the wiring sheet **30**, and the printed board **40** are joined using screws **70**.

[0038] The wiring sheet **30** may have a structure in which a conductive film and an insulating film are laminated. An internal circuit may be constituted from a conductive pattern formed on a conductive film, for example. FIG. **3** shows an example of a configuration of the wiring sheet **30**. FIG. **3** does not show the first connection portions **31** and the second connection portions **32**.

[0039] The wiring sheet **30** shown in FIG. **3** has a structure in which a laminated body constituted by conductive films **302** and insulating films **303** is interposed between a pair of cover films **301** of insulating materials. The number of laminated bodies constituted by the conductive films **302** and the insulating films **303** can be set to any number. The conductive films **302** may be metal materials such as copper foils, for example. The insulating films **303** may be insulating materials such as polyimide sheets, for example. The cover films **301** may be insulating materials such as solder resists, for example. An adhesive may be used for joining the conductive films **302**, the insulating films **303**, and the cover films **301** to each other, for example. The wiring sheet **30** may have a structure in which a film (also referred to as a “base film”) of an insulating material is further interposed between laminated bodies including the conductive films **302** and the insulating films **303**.

[0040] The wiring sheet **30** is flexible, and therefore irregularities on an upper surface of the wiring board **20** and irregularities on a lower surface of the printed board **40** are mitigated by the wiring

sheet **30**. Further, even if the outer shape of the wiring board **20** or the printed board **40** is distorted, the distortion is mitigated by the wiring sheet **30** and a structure of the electrical connection apparatus **1** is stabilized. This can suppress deterioration in the accuracy of the inspection of the object **2** to be inspected performed using the electrical connection apparatus **1**.

[0041] Further, each claw portion **300** of the wiring sheet **30** is formed on a surface of each cover film **301** such that each claw portion **300** can be elastically deformed. That is, each claw portion **300** receives an external force generated by contact between the wiring sheet **30**, and the wiring board **20** and the printed board **40**, and approaches a surface of the wiring sheet **30**. After removal of the external force, a state of each claw portion **300** returns to an original state. In this way, each claw portion **300** can be elastically deformed in the thickness direction of the wiring sheet **30**.

[0042] When the wiring sheet **30** is interposed between the wiring board **20** and the printed board **40**, the claw portions **300** is elastically deformed. This ensures the connection between the first connection portions **31** of the wiring sheet **30** and the second electrodes **22** of the wiring board **20**. Even if the degrees of flatness of the first sheet surface **311** of the wiring sheet **30** and an upper surface of the wiring board **20** are different, the stability of the electrical connection between the internal circuit of the wiring sheet **30** and the internal wiring **200** of the wiring board **20** is maintained, for example. At the same time, the connection between the second connection portions **32** of the wiring sheet **30** and the first ends **41** of the wiring patterns **400** of the printed board **40** is ensured. Even if the degrees of flatness of the second sheet surface **312** of the wiring sheet **30** and a lower surface of the printed board **40** are different, the stability of the electrical connection between the internal circuit of the wiring sheet **30** and the wiring patterns **400** of the printed board **40** is maintained, for example.

[0043] Each claw portion **300** with conductivity which can be elastically deformed in the thickness direction of the wiring sheet **30** may be formed as follows, for example. First, a part of an insulating film on a surface of the wiring sheet **30** is lifted to form a projecting portion which projects obliquely from the surface. Thereafter, the projecting portion and a periphery thereof are plated with a conductive material. As a result, the projecting portion becomes each claw portion **300** with conductivity. As shown in FIG. **4**, the periphery of each claw portion **300** becomes each support portion **310** for supporting each claw portion **300**. Each claw portion **300** has a cantilever structure having a fixed end connected to each support portion **310**, and a free end separated from the wiring sheet **30**. Each support portion **310** with conductivity is electrically connected to the internal circuit of the wiring sheet **30**. The internal circuit shown in FIG. **4** is short-circuit wiring **331** for electrically connecting the first connection portions **31** and the second connection portions **32**. Each claw portion **300** and each support portion **310** may be formed by means of copper plating, for example.

[0044] As shown in FIG. **5**, the plurality of claw portions **300** may be arranged in a matrix in plan view viewed from a direction normal to the thickness direction (Z direction). Projecting directions of the claw portions **300** can be arbitrarily set. In the array of the claw portions **300** shown in FIG. **5**, projecting directions of claw portions **300** arranged in the X direction are the same, for example. Meanwhile, projecting directions of adjacent claw portions **300** of claw portions **300** arranged in the Y direction are mutually opposite. FIG. **4** is a cross-sectional view of the claw portions in the X direction, for example. Alternatively, as shown in FIG. **6**, projecting directions of adjacent claw portions **300** of a plurality of claw portions **300** arrayed in the same direction may be mutually opposite.

[0045] As shown in FIG. **6**, by making the projecting directions of the claw portions **300** mutually opposite, a direction of a force applied to the wiring sheet **30** from the wiring board **20** and the printed board **40** is distributed, for example. This can suppress misalignment of the wiring board **20** or the printed board **40** relative to the wiring sheet **30** in the XY plane.

[0046] Although a case where one claw portion **300** is connected to one support portion **310** has been described as an example, the plurality of claw portions **300** may be connected to one support

portion **310**. As shown in FIG. **7**, two claw portions **300** having different projecting directions may be connected to one support portion **310**, for example. Alternatively, as shown in FIG. **8**, two claw portions **300** having the same projecting direction may be connected to one support portion **310**.
[0047] According to the configuration shown in FIG. **7**, claw portions **300** contact the wiring board **20** and the printed board **40** from different directions. This can strengthen the electrical connection between the wiring sheet **30**, and the wiring board **20** and the printed board **40**. According to the configuration shown in FIG. **8**, it is possible to decrease the length of the claw portions **300**. When the claw portions **300** are short, high-frequency characteristics of the object **2** to be inspected can be measured favorably. However, the length of the claw portions **300** is set such that pressing forces by the claw portions **300** do not decrease by decreasing the length of the claw portions **300**.
[0048] As described above, in the electrical connection apparatus **1** according to the first embodiment, the claw portions **300** with conductivity projecting obliquely are disposed on the first connection portions **31** and the second connection portions **32** of the wiring sheet **30**. Therefore, according to the electrical connection apparatus **1** shown in FIG. **1**, the electrical connection between the internal wiring **200** of the wiring board **20** and the wiring patterns **400** of the printed board **40** can be stabilized even if there is a difference in the degrees of flatness between the wiring board **20** and the printed board **40**.
[0049] The wiring sheet **30** may be selected from among a plurality of wiring sheet candidates. Each of the wiring sheet candidates has first connection portions **31** arranged on the first sheet surface **311**, second connection portions **32** arranged on the second sheet surface **312**, and an internal circuit. Each of the wiring sheet candidates may include an internal circuit having a configuration different from that of another wiring sheet candidate. One wiring sheet **30** selected from among the plurality of wiring sheet candidates is laminated on the wiring board **20** such that the first connection portions **31** thereof are connected to the second electrodes **22** of the wiring board **20**. The wiring sheet **30** may be configured in an attachable/detachable manner between the wiring board **20** and the printed board **40** in the electrical connection apparatus **1**. In order to replace the wiring sheet **30** laminated on the wiring board **20** with another wiring sheet candidate, the wiring sheet **30** is attached and detached between the wiring board **20** and the printed board **40**, for example.
[0050] An example of the configuration of wiring sheet candidates included in a wiring sheet group will be described below. In the following, when each of the wiring sheet candidates is not limited, the wiring sheet candidates will be collectively referred to as a wiring sheet **30**.
[0051] An internal circuit of a wiring sheet **30** as any one of the group of wiring sheets may include a circuit for electrically connecting the first connection portions **31** and the second connection portions **32** (hereinafter also referred to as “interposer circuit”). When the interposer circuit is formed on the wiring sheet **30** of the structure shown in FIG. **3**, wiring is formed, which passes through the cover films **301**, the conductive films **302**, and the insulating films **303**, from the first sheet surface **311** to the second sheet surface **312** of the wiring sheet **30**, for example.
[0052] If the internal circuit of the wiring sheet **30** includes the interposer circuit, the internal circuit of the wiring sheet **30** shown in FIG. **9** may include a circuit for short-circuiting the first connection portions **31** and the second connection portions **32**. In the internal circuit of the wiring sheet **30** shown in FIG. **9**, the first connection portions **31** and the second connection portions **32** are electrically short-circuited by the short-circuit wiring **331**.
[0053] By attaching the wiring sheet **30** shown in FIG. **9** to the electrical connection apparatus **1**, the probes **10** and the wiring patterns **400** in the printed board **40** are short-circuited via the internal circuit of the wiring sheet **30**. This electrically connects the object **2** to be inspected and the inspection device. As a result, an electrical signal propagates between an inspection device such as an IC tester and the object **2** to be inspected, and characteristics of the object **2** to be inspected are measured. One first connection portion **31** and one second connection portion **32** are connected in a one-to-one relationship by means of the internal circuit of the wiring sheet **30**, for example.

Alternatively, one first connection portion **31** may be connected to a plurality of second connection portions **32**, or a plurality of first connection portions **31** may be connected to one second connection portion **32** by means of the internal circuit.

[0054] When the internal circuit of the wiring sheet **30** includes the interposer circuit, the internal circuit may include a matching circuit **332** having a first terminal connected to each first connection portion **31** and a second terminal connected to each second connection portion **32**, as shown in FIG. **10**. The matching circuit **332** may perform impedance matching between each first connection portion **31** and each second connection portion **32**. The matching circuit **332** may include a x-type filter, for example.

[0055] The internal circuit of the wiring sheet **30** may include a circuit for electrically connecting any one of the first connection portions **31** and another one of the first connection portions **31**. In other words, the internal circuit of the wiring sheet **30** may include a circuit for electrically connecting an output terminal and an input terminal of the object **2** to be inspected (hereinafter also referred to as a "loopback circuit"). Two signal terminals of the object **2** to be inspected are electrically connected by the loopback circuit.

[0056] The internal circuit of the wiring sheet **30** may include a circuit for short-circuiting any one of the first connection portions **31** and another one of the first connection portions **31** as shown in FIG. **11**, for example. In the internal circuit of the wiring sheet **30** shown in FIG. **11**, the one first connection portion **31** and the other first connection portion **31** are electrically short-circuited by loopback wiring **333**. By attaching the wiring sheet **30** shown in FIG. **11** to the electrical connection apparatus **1**, one of the probes **10** and another one of the probes **10** are short-circuited via the internal circuit of the wiring sheet **30**. This electrically connects one signal terminal and the other signal terminal of the object **2** to be inspected.

[0057] FIG. **12** shows a configuration in which a first signal terminal **2**A of the object **2** to be inspected in contact with one of the probes **10**, and a second signal terminal **2**B of the object **2** to be inspected in contact with another one of the probes **10**, are electrically connected via the loopback wiring **333** of the wiring sheet **30**. Suppose that the object **2** to be inspected is a receiving circuit, the first signal terminal **2**A is an output terminal of the object **2** to be inspected, and the second signal terminal **2**B is an input terminal of the object **2** to be inspected, for example. In the above case, a transmission test can be performed by returning an output from the object **2** to be inspected to an input. In other words, it is possible to test whether an output portion and an input portion of the object **2** to be inspected are functioning normally, even if there is no destination equipment for transmission. As an inspection in accordance with a jitter tolerance test performed for the receiving circuit, an output signal output from the first signal terminal **2**A (output terminal) may be input to the second signal terminal **2**B (input terminal) as an input signal to inspect whether a specified error rate is ensured, for example.

[0058] When the internal circuit of the wiring sheet **30** includes the loopback circuit, the internal circuit may include a circuit having a capacitor **34** connected in series between any one of the first connection portions **31** and another one of the first connection portions **31** as shown in FIG. **13**. One terminal of the capacitor **34** is connected to the one first connection portion **31**, and the other terminal of the capacitor **34** is connected to the other first connection portion **31**. The capacitor **34** may be a capacitor formed using a semiconductor manufacturing process (hereinafter also referred to as a "process capacitor").

[0059] Further, the internal circuit of the wiring sheet **30** may include a relay circuit that switches to electrically connect one of the first connection portions **31** to either one of the second connection portions **32** or another one of the first connection portions **31**. The internal circuit shown in FIG. **14** includes a relay circuit **334** that constitutes either the interposer circuit for connecting a first connection portion **31** and a second connection portion **32**, or the loopback circuit for connecting first connection portions **31** each other, for example.

[0060] When the relay circuit **334** shown in FIG. **14** constitutes the interposer circuit, a first contact

terminal **334***a* and a second contact terminal **334***b* are connected, and a third contact terminal **334***c* and a fourth contact terminal **334***d* are connected. This electrically connects the first connection portion **31** and the second connection portion **32**. When the relay circuit **334** constitutes the loopback circuit, the first contact terminal **334***a* and a common contact terminal **334***e* of the relay circuit **334** are connected, and the third contact terminal **334***c* and the common contact terminal **334***e* are connected. This electrically connects one of the first connection portions **31** and another one of the first connection portions **31**.

[0061] Although examples of the internal circuit of the wiring sheet **30** have been described with reference to FIGS. **9** to **14**, it is needless to say that the configuration of the internal circuit is not limited to the above. The internal circuit may include an inductor instead of the capacitor **34** shown in FIG. **13**, or the internal circuit may include both a capacitor and an inductor, for example. In other words, the internal circuit of the wiring sheet **30** may include a passive circuit including any element. Further, the internal circuit may include a switching circuit using a diode or the like instead of the relay circuit **334** shown in FIG. **14**.

[0062] An element included in the internal circuit of the wiring sheet **30** may be formed using a Micro Electro Mechanical Systems (MEMS) process, for example. By using the MEMS process, an element which is reduced in size can be formed integrally with the wiring sheet **30**.

[0063] As described above, various circuit configurations as shown in FIGS. **9** to **14** can be implemented in the electrical connection apparatus **1** shown in FIG. **1** by merely replacing the wiring sheet **30** in the electrical connection apparatus **1**, for example. Therefore, a plurality of types of measurements can be performed on the object **2** to be inspected using the electrical connection apparatus **1**. A DC test may be performed on the object **2** to be inspected by mounting, in the electrical connection apparatus **1**, the wiring sheet **30** including the internal circuit for short-circuiting the first connection portions **31** and the second connection portions **32**, for example. Further, a high-frequency test may be performed on the object **2** to be inspected by mounting, in the electrical connection apparatus **1**, the wiring sheet **30** including the internal circuit having the matching circuit or the loopback circuit.

[0064] Further, by arranging the relay circuit **334** in the wiring sheet **30** shown in FIG. **14** of the electrical connection apparatus **1**, the wiring length of the interposer circuit and the loopback circuit can be reduced, compared to that when a relay element is arranged on the printed board **40**. As a result, according to the electrical connection apparatus **1**, it is possible to shorten a propagation path of an electrical signal and suppress the loss of an electrical signal and noise.

[0065] Further, by arranging the matching circuit **332** in the wiring sheet **30** shown in FIG. **10** of the electrical connection apparatus **1**, wiring connected to the matching circuit **332** can be shortened. The matching circuit **332** can be arranged in the immediate vicinity of wiring for which impedance matching is to be performed, and therefore impedance matching can be performed effectively, for example.

[0066] In the measurement of the object **2** to be inspected, the stage **3** serves as a heat generation source. Therefore, an ambient temperature of a lower surface of the wiring board **20** facing the stage **3** is higher than that of another region. Therefore, by arranging the wiring sheet **30** on an upper surface of the wiring board **20**, an increase in an ambient temperature of an electronic component constituting the internal circuit of the wiring sheet **30** can be suppressed compared to that of an electronic component arranged on the lower surface of the wiring board **20**. As a result, the electronic component functions at an ambient temperature that is equal to or less than an allowable temperature, and the measurement of the object **2** to be inspected can be accurately performed.

[0067] As described above, the electrical connection apparatus **1** has the wiring sheet **30** including the internal circuit capable of constituting any circuit, which is interposed between the wiring board **20** and the printed board **40** in an attachable/detachable manner, and therefore it is possible to configure an arbitrary measurement system. As a result, characteristics of the object **2** to be

inspected can be measured with high accuracy with the electrical connection apparatus **1**.

Second Embodiment

[0068] As shown in FIG. **15**, an electrical connection apparatus **1**A according to a second embodiment includes a first wiring sheet **30**A interposed between the wiring board **20** and the printed board **40**, and a second wiring sheet **30**B interposed between the probe head **60** and the wiring board **20**. In the following, when each of the first wiring sheet **30**A and the second wiring sheet **30**B is not limited, the wiring sheets will be collectively referred to as a wiring sheet **30**. The electrical connection apparatus **1**A shown in FIG. **15** differs from the electrical connection apparatus **1** according to the first embodiment in that the electrical connection apparatus **1**A has the wiring sheet **30** interposed between the probe head **60** and the wiring board **20**. Other configurations of the electrical connection apparatus **1**A according to the second embodiment are the same as those of the electrical connection apparatus **1** of the first embodiment shown in FIG. **1**.

[0069] The first connection portions **31** arranged on the first sheet surface **311** of the second wiring sheet **30**B are in contact with proximal ends of the probes **10** exposed from the probe head **60**, without interposing claw portions **300** therebetween. Meanwhile, the second connection portions **32** arranged on the second sheet surface **312** of the second wiring sheet **30**B are connected to the first electrodes **21** of the wiring board **20** via the claw portions **300**. That is, the claw portions **300** are arranged only on the second connection portions **32** of the second wiring sheet **30**B, and the claw portions **300** are not arranged on the first connection portions **31**. Other configurations of the second wiring sheet **30**B are the same as those of the wiring sheet **30** described in the first embodiment.

[0070] Similar to the wiring sheet **30** of the electrical connection apparatus **1** shown in FIG. **1**, both the first connection portions **31** and the second connection portions **32** of the first wiring sheet **30**A have the claw portions **300**. The first connection portions **31** of the first wiring sheet **30**A are connected to the second electrodes **22** of the wiring board **20** via the claw portions **300**. The second connection portions **32** are connected to the wiring patterns **400** in the printed board **40** via the claw portions **300**.

[0071] The electrical connection apparatus **1**A is configured such that the wiring sheet **30** with flexibility is interposed between the proximal ends of the probes **10** and the wiring board **20**. According to the electrical connection apparatus **1**A, the contact between the probes **10** and the object **2** to be inspected is stabilized by means of a preload function which is obtained by the wiring sheet **30**, and which is for generating a pressing force between the wiring sheet **30** and the probes **10**. As a result, the accuracy of the measurement of the object **2** to be inspected can be enhanced.

[0072] Electronic components can be mounted on both the first wiring sheet **30**A and the second wiring sheet **30**B in the electrical connection apparatus **1**A. This can increase the number of electronic components mounted in the electrical connection apparatus **1**A. Further, it is possible to arrange an electronic component near the object **2** to be inspected by mounting the electronic component on the second wiring sheet **30**B in the electrical connection apparatus **1**A. This can reduce the wiring length between the object **2** to be inspected and the electronic component. As a result, it is possible to enhance the accuracy of measurement performed on the object **2** to be inspected.

[0073] Further, the second wiring sheet **30**B with flexibility which is interposed between the probe head **60** and the wiring board **20** in the electrical connection apparatus **1**A can mitigate warpages and irregularities of surfaces of the probe head **60** and the wiring board **20**. This can suppress rattling and contact failure of the electrical connection apparatus **1**A caused by a gap between the probe head **60** and the wiring board **20**.

[0074] Other configurations of the electrical connection apparatus **1**A according to the second embodiment are substantially the same as those of the electrical connection apparatus of the first embodiment, and duplicated description thereof will be omitted. The wiring sheet **30** including the

internal circuit capable of constituting any circuit described with reference to FIGS. **9** to **14** can be interposed between the probe head **60** and the wiring board **20** in an attachable/detachable manner, for example.

Third Embodiment

[0075] As shown in FIG. **16**, in an electrical connection apparatus **1**B according to a third embodiment, the wiring sheet **30** is interposed between the probe head **60** and the wiring board **20** instead of the wiring sheet **30** being interposed between the wiring board **20** and the printed board **40**. Other configurations of the electrical connection apparatus **1**B according to the third embodiment are the same as those of the electrical connection apparatus of the second embodiment shown in FIG. **15**.

[0076] The first connection portions **31** arranged on the first sheet surface **311** of the wiring sheet **30** in the electrical connection apparatus **1**B shown in FIG. **16** are in contact with proximal ends of the probes **10** without interposing claw portions **300** therebetween. Meanwhile, the second connection portions **32** arranged on the second sheet surface **312** of the wiring sheet **30** are connected to the first electrodes **21** of the wiring board **20** via the claw portion **300**. That is, as shown in FIG. **16**, the claw portions **300** are arranged only on the second connection portions **32** of the wiring sheet **30**, and the claw portions **300** are not arranged on the first connection portions **31**.

[0077] According to the electrical connection apparatus **1**B having the wiring sheet **30** with flexibility which is interposed between the proximal ends of the probes **10** and the wiring board **20**, the contact between the probes **10** and the object **2** to be inspected is stabilized by means of a preload function which is obtained by the wiring sheet **30**. As a result, the accuracy of the measurement of the object **2** to be inspected can be enhanced.

[0078] Further, the wiring sheet **30** with flexibility which is interposed between the probe head **60** and the wiring board **20** in the electrical connection apparatus **1**B can mitigate warpages and irregularities of surfaces of the probe head **60** and the wiring board **20**. This can suppress the rattling and contact failure of the electrical connection apparatus **1**B caused by a gap between the probe head **60** and the wiring board **20**.

[0079] Other configurations of the electrical connection apparatus **1**B according to the third embodiment are substantially the same as those of the electrical connection apparatuses of the first and second embodiments, and duplicated descriptions thereof will be omitted. The wiring sheet **30** including the internal circuit capable of constituting any circuit described with reference to FIGS. **9** to **14** can be interposed between the probe head **60** and the wiring board **20** in an attachable/detachable manner, for example.

Other Embodiments

[0080] Although embodiments of the present invention have been described above, the discussion and drawings forming part of this disclosure should not be construed as limiting the invention. Various alternative embodiments, examples, and operational techniques will be apparent to those skilled in the art from this disclosure.

[0081] The wiring sheet **30** may include an internal circuit in which a plurality of types of circuit configurations are mixed, for example. The wiring sheet **30** may include an internal circuit in which the short-circuit wiring **331** and the matching circuit **332** are mixed, for example. Alternatively, the wiring sheet **30** may include an internal circuit in which an interposer circuit and a loopback circuit are mixed. The internal circuit may include the short-circuit wiring **331**, the matching circuit **332**, and the loopback wiring **333**, or may further include the relay circuit **334**, for example. Further, the loopback circuit may include the matching circuit **332**. In this way, any circuit can be configured in the internal circuit of the wiring sheet **30**.

[0082] As described above, by mounting, in the electrical connection apparatus **1**, the wiring sheet **30** including the internal circuit in which any circuit configurations are mixed, a plurality of types of measurements can be performed on the object **2** to be inspected with one wiring sheet **30**.

[0083] In the case described above, terminals for inspection that contact signal terminals of the

object **2** to be inspected are the probes **10**. When the terminals for inspection are the probes **10**, it is possible to measure electrical characteristics of an object **2** to be inspected not separated from a wafer or an object **2** to be inspected which is converted into a chip. Meanwhile, the wiring sheet **30** may be mounted in an electrical connection apparatus including a test socket, to support the measurement of electrical characteristics of the object **2** to be inspected performed in a state where the object **2** to be inspected is mounted in a package or the like. The test socket may be arranged on the wiring board **20**, the test socket having a terminal for inspection connected to an external terminal of the package in which the object **2** to be inspected is mounted, instead of the probes **10** in the electrical connection apparatus **1** shown in FIG. **1**, for example.

[0084] In this way, it is needless to say that the present invention includes various embodiments not described above. Therefore, the technical scope of the present invention is defined only by matters specified in the invention that are within the scope of claims appropriate from the above description.

REFERENCE SIGNS LIST

[0085] **1**, **1**A, **1**B Electrical connection apparatus [0086] **10** Probe [0087] **20** Wiring board [0088] **21** First electrode [0089] **22** Second electrode [0090] **30** Wiring sheet [0091] **30**A First wiring sheet [0092] **30**B Second wiring sheet [0093] **31** First connection portion [0094] **32** Second connection portion [0095] **40** Printed board [0096] **41** First end [0097] **42** Second end [0098] **50** Stiffener [0099] **60** Probe head [0100] **200** Internal wiring [0101] **300** Claw portion [0102] **301** Cover film [0103] **302** Conductive film [0104] **303** Insulating film [0105] **310** Support portion [0106] **311** First sheet surface [0107] **312** Second sheet surface [0108] **400** Wiring pattern

Claims

1. An electrical connection apparatus used for inspecting an object to be inspected, the electrical connection apparatus comprising: a terminal for inspection having a tip disposed so as to be in contact with the object to be inspected and a proximal end connected to the tip; a wiring board including a first electrode electrically connected to the terminal for inspection, internal wiring, and a second electrode electrically connected to the first electrode via the internal wiring; and a wiring sheet with flexibility including a first connection portion arranged on a first sheet surface, a second connection portion arranged on a second sheet surface which faces in an opposite direction of the first sheet surface, and an internal circuit electrically connected to at least any one of the first connection portion and the second connection portion, wherein a claw portion with conductivity projecting obliquely relative to a surface perpendicular to a thickness direction of the wiring sheet is arranged on at least any one of the first connection portion and the second connection portion, and the internal wiring of the wiring board and the internal circuit of the wiring sheet are electrically connected via the claw portion.

2. The electrical connection apparatus according to claim 1, further comprising: a printed board including a wiring pattern, wherein the wiring sheet is interposed between the wiring board and the printed board, the claw portion is arranged on the first connection portion and the second connection portion, the first connection portion is connected to the second electrode via the claw portion, and the second connection portion is connected to the wiring pattern via the claw portion.

3. The electrical connection apparatus according to claim 1, further comprising: a probe head for holding the terminal for inspection, wherein the wiring sheet is interposed between the probe head and the wiring board, the claw portion is arranged only on the second connection portion, the second connection portion is connected to the first electrode via the claw portion, and the first connection portion is connected to the proximal end of the terminal for inspection exposed from the probe head without interposing the claw portion therebetween.

4. The electrical connection apparatus according to claim 1, wherein the claw portion can be elastically deformed in the thickness direction.

5. The electrical connection apparatus according to claim 4, wherein at least any one of the first connection portion and the second connection portion includes a support portion fixed to the wiring sheet, and the claw portion has a cantilever structure having a fixed end connected to the support portion and a free end separated from the wiring sheet.
6. The electrical connection apparatus according to claim 5, wherein the claw portion is provided in plurality, and two of the claw portions having the same projecting direction are connected to the support portion.
7. The electrical connection apparatus according to claim 5, wherein the claw portion is provided in plurality, and two of the claw portions having different projecting directions are connected to the support portion.
8. The electrical connection apparatus according to claim 1, wherein the claw portion is provided in plurality, and the claw portions are arranged in a matrix in plan view viewed from a direction normal to the thickness direction.
9. The electrical connection apparatus according to claim 8, wherein the claw portions having mutually opposite projecting directions are adjacent to each other.
10. The electrical connection apparatus according to claim 1, wherein the wiring sheet has a structure in which a laminated body constituted by a conductive film and an insulating film is interposed between cover films of an insulating material.
11. The electrical connection apparatus according to claim 1, wherein the proximal end is provided in plurality, and the wiring board is a space transformer that transforms a distance between the proximal ends of the terminal for inspection when viewed from a direction normal to a main surface of the wiring board.
12. The electrical connection apparatus according to claim 1, wherein the terminal for inspection is a probe having a proximal end connected to the first electrode of the wiring board and a tip in contact with a signal terminal of the object to be inspected.
13. The electrical connection apparatus according to claim 1, wherein the terminal for inspection is arranged in a test socket connected to an external terminal of a package in which the object to be inspected is mounted.