DESCRIPTION

TITLE OF INVENTION: CONTACT PROBE AND ELECTRICAL CONNECTION JIG

TECHNICAL FIELD

[0001]

The present invention relates to a contact probe and an electrical connection jig.

BACKGROUND ART

[0002]

A continuity test has been performed in various technical fields. For example, the continuity test is performed on a semiconductor integrated circuit, an electronic device board or a circuit wiring board of a flat panel display, and the like. This test is performed by using an inspection apparatus including a large number of contact probes and bringing the contact probes into contact with electrodes of a specimen. As the specimens become smaller, higher in density, and higher in performance, there is a need for fine contact probes.

[0003]

JP 4572303 B2 discloses a method for producing a contact probe for use in a continuity testing jig. In this producing method, after a gold-plated layer is formed on an outer periphery of a core through plating, a Ni electroformed layer is formed on an outer periphery of the

gold-plated layer through electroforming. A spring structure is formed at a part of the Ni electroformed layer through photolithography. Thereafter, the core is removed while leaving the gold-plated layer on an inner periphery of the Ni electroformed layer. According to this producing method, it is possible to manufacture an ultra-slim and thin contact probe for use in a continuity testing jig, the contact probe having an electroformed spring structure, with increased accuracy and precision.

CITATIONS LIST

PATENT LITERATURE

[0004]

Patent Literature 1: JP 4572303 B2

SUMMARY OF INVENTION

[0005]

The continuity test is performed in a high temperature environment of 120°C or more in some cases. The preset inventors have found that there is a problem that a spring shrinks to an extent that a total length of the spring is not allowable when probing is performed in a high temperature environment in the contact probe including the spring structure. When a portion (i.e., spring portion) including the spring structure is used in the high temperature environment and the spring portion is released

from a shrunk state, the spring does not return to an original spring shape, and a spring length becomes short.

[0006]

An object of the present invention is to provide a contact probe with improved durability by reducing shrinkage after probing is performed, even when the probing is performed in a high temperature environment.

[0007]

A contact probe according to an aspect of the present invention includes a Ni pipe including a coiled spring structure. The Ni pipe contains 0.5 to 10 wt% of phosphorus (P).

[0008]

In the contact probe according to the aspect of the present invention, a content of the P in the Ni pipe is preferably 1 to 5 wt%.

[0009]

In the contact probe according to the aspect of the present invention, a content of the P in the Ni pipe is more preferably 2 to 4 wt%.

[0010]

The contact probe according to the aspect of the present invention may further include a plunger connected to the Ni pipe.

[0011]

Preferably, an electrical connection jig according to another aspect of the present invention includes any one of the contact probes described above.

BRIEF DESCRIPTION OF DRAWINGS

[0012]

Fig. 1 is a side view of a contact probe according to an embodiment of the present invention.

Fig. 2 is a flowchart illustrating an example of a method for producing a Ni pipe.

Fig. 3A is a diagram for describing the method for producing the Ni pipe.

Fig. 3B is a diagram for describing the method for producing the Ni pipe.

Fig. 3C is a diagram for describing the method for producing the Ni pipe.

Fig. 3D is a diagram for describing the method for producing the Ni pipe.

Fig. 4 is a side view of a contact probe according to a modification example.

Fig. 5 is a perspective view of a jig (housing) for use in a durability evaluation test in a high temperature environment.

Fig. 6 is a schematic diagram illustrating a state during the test.

Fig. 7A is a cross-sectional view taken along line VII-VII of Fig. 6.

Fig. 7B is a cross-sectional view taken along line VII-VII of Fig. 6.

Fig. 8 is a graph illustrating the relationship between an evaluation temperature and shrinkage.

Fig. 9 is a diagram illustrating an example of an electrical connection jig including the contact probe.

DESCRIPTION OF EMBODIMENTS

[0013]

The present inventors have examined a method of reducing shrinkage after probing is repeated in a high temperature environment in a contact probe including a Ni pipe including a coiled spring structure. As a result, the present inventors have found that the Ni pipe contains 0.5 to 10 wt% of phosphorus (P), and thus, the shrinkage can be reduced.

[0014]

The present invention has been completed based on the aforementioned findings. Hereinafter, an embodiment of the present invention will be described in detail with reference to the drawings. In the drawings, the same or equivalent portions will be assigned the same reference signs, and the description thereof will not be repeated. Dimensional ratios between components illustrated in the

drawings do not necessarily indicate actual dimensional ratios.

[0015]

[Structure of Contact Probe]

[0016]

Fig. 1 is a side view of a contact probe 1 according to an embodiment of the present invention. The contact probe 1 includes a Ni pipe 11, and a plunger 12.

[0017]

The contact probe 1 can be suitably used as a contact probe of an electrical connection jig that electrically connects an inspection point set on an inspection object and an inspection apparatus that inspects the inspection object to each other. For example, the electrical connection jig can exemplify an IC socket that accommodates an IC or an LSI such that the IC and LSI are replaceable and performs an electrical inspection, a board inspection jig that electrically connects a board and a board inspection apparatus to each other, or a probe card that electrically connects a semiconductor wafer and a semiconductor inspection apparatus to each other. Fig. 9 illustrates a structure example of a probe card 100 as an example of the electrical connection jig including the contact probe 1. The probe card is a jig for use in the electrical inspection of an LSI chip formed on a silicon

wafer in a wafer inspection process of producing the LSI. The probe card is attached to a wafer prober (not illustrated), and functions as a connector that connects an electrode of the LSI chip and an LSI tester which is a measurement device to each other. The determination of whether a product is good or bad is performed by bringing the contact probe 1 into contact with the electrode of the LSI chip and performing the electrical inspection. Fig. 9 is merely the example, and the electrical connection jig including the contact probe 1 is not limited to this example.

[0018]

The Ni pipe 11 has, for example, a substantially cylindrical shape, and has a coiled spring structure 11a formed at at least a part thereof. The present embodiment is not limited to this example, and it is particularly suitable when the Ni pipe 11 is an extremely thin pipe of which an outside diameter is 32 to 500 μm and a thickness of about 2 to 50 μm.

[0019]

For example, the Ni pipe 11 is formed through electroplating. The Ni pipe 11 contains 0.5 to 10 wt% of phosphorus (P). The details of the composition (content of P) of the Ni pipe 11 will be described below.

[0020]

The plunger 12 is formed by using a conductor, and has, for example, a substantially columnar shape. Examples of a material of the plunger 12 include platinum, rhodium, or an alloy thereof, and a beryllium-copper alloy or tungsten plated with gold on nickel.

[0021]

In the example illustrated in Fig. 1, a tip end of the plunger 12 has a taper shape. However, the tip end of the plunger 12 has any shape, and can have various shapes such as a semicircular shape, a flat shape, and crown shape depending on the purpose of use.

[0022]

For example, the Ni pipe 11 and the plunger 12 are connected to each other at a portion represented by a reference sign A of Fig. 1 while the plunger 12 is inserted into the Ni pipe 11. For example, the connection method can be performed through crimping, welding, or bonding.

[0023]

With such a structure, when a specimen is brought into contact with the tip end of the plunger 12 and is pushed in a direction of the Ni pipe 11, a portion of the coiled spring structure 11a of the Ni pipe 11 shrinks, and the tip end of the plunger 12 and the specimen are brought into contact with each other with a predetermined pressure due to a restoring force at the same portion. The contact

probe 1 and the specimen can thus be brought into resilient contact with each other.

[0024]

The contact probe 1 may further include a gold-containing layer on an inner periphery of the Ni pipe 11.

[0025]

[Method for Producing Contact Probe 1]

[0026]

As stated above, the contact probe 1 can be produced by connecting the Ni pipe 11 and the plunger 12 to each other while the plunger 12 is inserted into the Ni pipe 11. Hereinafter, an example of the method for producing the Ni pipe 11 will be described in detail with reference to Figs. 2 and 3A to 3D. Note that the method for producing the Ni pipe 11 is not limited to this example.

[0027]

Fig. 2 is a flowchart illustrating the example of the method for producing the Ni pipe 11. This producing method includes a process of forming a Ni electroformed layer (step S1), a process of patterning the Ni electroformed layer (step S2), and a process of removing a core (step S3).

[0028]

Initially, a core 15 is prepared (see Fig. 3A). Examples of the core 15 include metal wires made of stainless steel, aluminum, and so on. A Ni electroformed

layer 10 is formed on an outer periphery of the core 15 through electroplating (see Fig. 3B). A thickness of the Ni electroformed layer 10 is not particularly limited, but is, for example, 2 to 50 μm. The electroplating method is not particularly limited, but a typical method can be used.

[0029]

The Ni electroformed layer 10 contains 0.5 to 10 wt% of P. To cause the Ni electroformed layer 10 to contain P, a phosphorus compound such as a phosphoric acid or a phosphorous acid may be mixed into a plating solution, for example. For example, in an example to be described below, the phosphorous acid is mixed into the plating solution. For example, the Ni electroformed layer can be produced by mixing the phosphorous acid with a quantity of 35.0 g/L or less into the plating solution.

[0030]

The Ni pipe 11 including the coiled spring structure 11a is formed by patterning the Ni electroformed layer 10 (see Fig. 3C). Photolithography, for example, may be used for the patterning. Specifically, a resist layer (not illustrated) is first formed on an outer periphery of the Ni electroformed layer 10 (Fig. 3B). Then, the resist layer is exposed to laser light while the core 15 is being rotated, to define a spiral groove in the resist layer. The Ni electroformed layer 10 is subjected to etching with

the resist layer remaining on the outer periphery of the Ni electroformed layer 10 used as a mask. Accordingly, the coiled spring structure 11a is formed.

[0031]

After the coiled spring structure 11a is formed, the core 15 is removed (see Fig. 3D). For example, the removal of the core 15 can be accomplished by pulling the core 15 from one side or from both sides to deform the core 15 such that the cross-sectional area of the core 15 is reduced, and pulling out the core 15 in this condition.

[0032]

Through the aforementioned processes, it is possible to produce the Ni pipe 11 which includes the coiled spring structure 11a and contains 0.5 to 10 wt% of P.

[0033]

It is preferable that a thin gold-containing layer (not illustrated) is formed on the outer periphery of the core 15 through plating before the Ni electroformed layer 10 is formed. A thickness of the gold-containing layer is, for example, 0.2 to 1 μm. That is, it is preferable that the gold-containing layer is formed on the outer periphery of the core 15, and then, the Ni electroformed layer 10 is formed on an outer periphery of the gold-containing layer. The formation of the gold-containing layer will contribute to preventing an etchant from reaching an inner periphery

of the Ni electroformed layer 10 during the patterning (step S2). When the core 15 is made of stainless steel, it is possible to easily pull out the core 15 while leaving the gold-containing layer on an inner surface of the Ni electroformed layer 10 during the removal of the core (step S3) by using the fact that adhesion of the stainless steel to the gold-containing layer is bad.

[0034]

In the case where the gold-containing layer is formed on the outer periphery of the core 15, a synthetic resin wire made of, for example, nylon or polyethylene may be used as the core 15. In this case, the gold-containing layer may be formed by electroless plating. In addition, the removal of the core 15 (step S3) can be accomplished by immersing the core 15 in a strong alkaline solution or the like.

[0035]

An example of the method for producing the Ni pipe 11 has been described above. In this example, it has been described that the Ni pipe 11 is produced through electroforming. However, the Ni pipe 11 may be produced by a method other than the electroforming.

[0036]

[Composition of Ni Pipe 11]

[0037]

The Ni pipe 11 contains 0.5 to 10 wt% of phosphorus (P). 0.5 to 10 wt% of P is contained in the Ni pipe, and thus, it is possible to suppress the shrinkage of the contact probe 1 after probing in a high temperature environment.

[0038]

The content of P in the Ni pipe 11 can be adjusted by appropriately increasing or decreasing the quantity of phosphorus compounds (for example, phosphorous acid) to be mixed into the plating solution.

[0039]

The content of P in the Ni pipe 11 can be measured by performing energy-dispersive X-ray spectroscopy (EDX) on a surface of the Ni pipe 11. In this measuring method, a plurality of specific points are set on the Ni pipe 11, and the average of values measured at the plurality of specific points is calculated. The specific points may be set in any desired manner. For example, the specific points may be set at regular intervals along the length of the Ni pipe 11. As illustrated in Fig. 1, one or more points can be set from the coiled spring structure 11a and two cylindrical portions formed with the coiled spring structure 11a interposed therebetween. Specifically, the P content in the Ni pipe is measured by performing the EDX on the surface while the Ni layer is exposed. Before the

measurement, the surface of the object is washed with ethanol. An apparatus that has a scanning electron microscope (SEM) and EDX integrated therein, for example, may be used for the measurement. An electron beam of 25 kV and 80 μA may be used. The content of P is measured at five points along the length of the Ni pipe (i.e., along a pipe axial direction), and the average thereof is calculated.

[0040]

The content of P in the Ni pipe 11 is preferably 0.5 to 7 wt%, and more preferably 1 to 5 wt%. The content of P falls within this range, and thus, it is possible to further reduce shrinkage. The content of P in the Ni pipe 11 is even more preferably 2 to 4 wt%.

[0041]

As will be described below, a contact probe in which the Ni pipe 11 does not substantially contain P is difficult to be used in an environment of 125°C or more. In contrast, when the content of P in the Ni pipe 11 is 0.5 to 10 wt%, it is possible to obtain a contact probe capable of being used even in an environment in which a temperature is up to 125°C. When the content of P in the Ni pipe 11 is 0.5 to 7 wt%, it is possible to obtain a contact probe capable of being used even in an environment in which a temperature is up to 140°C. When the content of P in the

Ni pipe 11 is 1 to 5 wt%, it is possible to obtain a contact probe capable of being used even in an environment in which a temperature is up to 150°C. When the content of P in the Ni pipe 11 is 2 to 4 wt%, it is possible to obtain a contact probe capable of being used even in an environment in which a temperature is up to 220°C. The relationship between the contents of P in the Ni pipe 11 and the temperatures at which the contact probe is available will be described in detail in the fields of Example.

[0042]

It is preferable that the amount of impurities mixed in the producing process is small. Note that additional elements may be added.

[0043]

The structure and producing method of the contact probe 1 according to the embodiment of the present invention and the composition of the Ni pipe 11 have been described above. With the structure of the contact probe 1 having the composition of the Ni pipe 11, it is possible to reduce the shrinkage in the high temperature environment.

[0044]

[Modification Example of Contact Probe 1]

[0045]

Fig. 4 is a side view of a contact probe 2 according to Modification Example of the contact probe 1. The contact probe 2 includes a Ni pipe 13 instead of the Ni pipe 11 of the contact probe 1 (Fig. 1). Similarly to the Ni pipe 11, the Ni pipe 13 also contains 0.5 to 10 wt% of P. The Ni pipe 13 is different from the Ni pipe 11 in that two coiled spring structures 13a are formed. The number of coiled spring structures 13a may be three.

[0046]

The same advantageous effects as those of the contact probe 1 are obtained by the contact probe 2. As stated above, the number or positions of coiled spring structures of the Ni pipe are optional. The overall Ni pipe may have the coiled spring structure.

Examples

[0047]

Hereinafter, the present invention will be described in detail by way of examples. The present invention is not limited to these examples.

[0048]

A Ni pipe which includes a coiled spring structure and of which an outside diameter is 70 μm, an inside diameter is 54 μm, and a total length is 3850 μm was produced by the method described in "Method for Producing Contact Probe 1]. More specifically, a gold-plated layer

was formed as a gold-containing layer on an outer periphery of a core made of stainless steel. A thickness of the gold-containing layer was 0.2 μm. Subsequently, a Ni electroformed layer was formed on an outer periphery of the gold-containing layer through electroplating. After the Ni electroformed layer is patterned through photolithography, the Ni pipe was obtained by pulling out the core while leaving the gold-containing layer on an inner surface of the Ni electroformed layer. A portion of a coiled spring structure was formed in the center of the Ni pipe in a longitudinal direction. Both end portions of the Ni pipe had a cylindrical shape. A length of the coiled spring structure was 2136 μm the maximum stroke amount in design was 330 μm, the number of windings of a spring was 24, a band width of the spring was 54 μm, and a thickness of the spring was 8 μm.

[0049]

Ni pipes having different contents of P were produced while changing the quantity of phosphorus compounds to be mixed into a plating solution. Specifically, Ni pipes of which contents of P are 1.5 wt%, 2 wt%, 3 wt%, and 8 wt% were produced by appropriately adjusting the quantity of phosphorous acid mixed into the plating solution (nickel sulfamate bath). As Comparative Example, a Ni pipe which is substantially pure Ni having a content of P less than a

detection limit (hereinafter, referred to as "0 wt%) was produced by using a plating solution without containing phosphorous acid. An apparatus that has an SEM (SU-1500 manufactured by Hitachi High-Technologies Corporation) and EDX (APEX2A10+60 manufactured by AMETEK, Inc.) integrated therein was used for the measurement of the content of P in the Ni pipe. The content of P in the Ni pipe according to Comparative Example was 0 wt% (less than a detection limit using the EDX).

[0050]

A plunger of which an outside diameter is 48 μm and a total length is 5800 μm was inserted into the Ni pipe. One end portion of the plunger had a substantially conical shape. Subsequently, contact probes were produced by connecting one cylindrical portion of the Ni pipe close to the conical-shaped end portion of the plunger and the plunger to each other through electric resistance welding. Spring constants of all the produced contact probes were about 0.125 N/mm.

[0051]

Durability for the produced contact probes in the high temperature environment was evaluated as follows.

[0052]

Fig. 5 is a perspective view of a jig (housing) 50 for use in a durability evaluation test in the high

temperature environment. Fig. 6 is a schematic diagram illustrating a state during the test. Figs. 7A and 7B are cross-sectional views taken along line VII-VII of Fig. 6.

[0053]

Referring to Fig. 5, the housing 50 is made of a metal, and is in the shape of a box. A plurality of holes 51, each of which is arranged to accommodate the contact probe 1 therein, are defined at one surface of the housing 50. Referring to Fig 7A, the contact probe 1 is accommodated in the corresponding hole 51 with the plunger 12 thereof arranged on the opening side. At this time, a tip of the plunger 12 protrudes from the hole 51.

[0054]

The housing 50 is mounted on a hot plate 60 with an opening portion of each hole 51 facing downward and the hot plate 60 set at a predetermined evaluation temperature. The length of a portion of the plunger 12 which protrudes from the hole 51 is set so that the Ni pipe 11 will be compressed by a distance substantially equal to a maximum stroke (i.e., 330 μm) thereof. Thus, when a weight (not illustrated) having a predetermined weight is placed on the housing 50, for example, the contact probe 1 can be maintained in the state of being compressed by the distance substantially equal to the maximum stroke as illustrated in Fig. 7B.

[0055]

The contact probe 1 is maintained in this state for 20 hours. Thereafter, the contact probe 1 is removed from the hole 51 in an ordinary temperature environment, and an overall length of the contact probe 1 is measured with the contact probe 1 oriented horizontally and no load applied to the contact probe 1. A difference between the measured overall length and an overall length of the contact probe before being maintained in the aforementioned state for the aforementioned time is defined as a "shrinkage" for the evaluation temperature. Lower values of the shrinkage mean greater durability in a high temperature environment.

[0056]

The shrinkage for each evaluation temperature was measured with respect to thirty contact probes, and the average thereof was determined as the shrinkage for the evaluation temperature. The present evaluation test was performed in order to obtain a shrinkage of 50 μm or less (0.05 mm or less). When the shrinkage exceeds 50 μm, a contact load of the contact probe with an electrode of a specimen of a continuity test decreases, and electrical contact becomes unstable. Thus, when the shrinkage is 50 μm or less, it was determined that the contact probe is available in the evaluation temperature.

[0057]

In Table 1, measurement values of the shrinkage at different contents of P were represented. Each blank field of Table 1 represents that the corresponding measurement is not performed. In Fig. 8, these values are plotted, and the relationship between the evaluation temperature (horizontal axis) and the shrinkage (vertical axis) was illustrated.

[0058]

[Table 1]

	Shrinkage (mm)				
Evaluation temperature (°C)	P:0%	P:1.5%	P:2%	P:3%	P:8%
125	0.085	0.041	0.016	0.008	0.021
140	0.100	0.042	0.011	0.014	
150					0.037
160	0.116	0.049	0.016	0.020	
175					0.056
180	0.128	0.064	0.027	0.024	
200	0.153	0.070	0.031	0.021	0.109
220	0.197	0.083	0.037	0.036	
240	0.223		0.054	0.045	

[0059]

As illustrated in Table 1 and Fig. 8, the contact probe in which the Ni pipe contains P had a small shrinkage at all the evaluation temperatures at which the measurement has been performed when compared to a case where the Ni pipe does not contain P (the content of P is less than the detection limit using the EDX). The shrinkage at the evaluation temperature of 125°C could be 50 μm or less in

the contact probe in which the Ni pipe contains P, whereas the shrinkage could not be 50 μm or less in the contact probe in which the Ni pipe does not contain P.

[0060]

A difference in shrinkage between the contact probe in which the Ni pipe contains P and the contact probe in which the Ni pipe dose not contain P was remarkable as the evaluation temperature becomes higher. That is, in the contact probe in which the Ni pipe does not P (the content of P is less than the detection limit using the EDX), as the evaluation temperature becomes higher, the shrinkage sharply increased. In contrast, in the contact probe in which the Ni pipe contains P, an increase in shrinkage with a rise in evaluation temperature was smooth. In the contact probe of which the content of P is 8 wt%, the shrinkage could be 50 μm or less even at the evaluation temperature of 150°C. In the contact probe of which the content of P is 1.5 wt%, the shrinkage could be 50 μm or less even at the evaluation temperature of 160°C. In the contact probe of which the content of P is 2 wt% and 3 wt%, the shrinkage could be 50 μm or less even at the evaluation temperature of 220°C.

[0061]

It is apparent from these results that the content of P in the Ni pipe is 0.5 to 10 wt%, preferably 0.5 to 7 wt%,

more preferably 1 to 5 wt%, and even more preferably 2 to 4 wt%, and thus, it is possible to improve the durability in the high temperature environment of the contact probe.

[0062]

That is, according to the embodiment of the present embodiment, the contact probe with improved durability is obtained by reducing the shrinkage after probing is performed even when the probing is performed in the high temperature environment.

[0063]

Hereinafter, the embodiment of the present invention has been described. The aforementioned embodiment is merely the example for implementing the present invention. Thus, the present invention is not limited to the aforementioned embodiment, and can be performed by appropriately modifying the aforementioned embodiment without departing the gist of the present invention. For example, an outer shape of the contact probe can be a prism shape. The shape of the plunger can be a shape such as a prism, a cone, or a pyramid.

[0064]

This application claims priority to Japanese Patent Application No. 2016-244683 filed on December 16, 2016, the entire contents of which being incorporated herein by reference. The specific embodiments or examples described

in "DESCRIPTION OF EMBODIMENTS" are merely intended to clarify the technical content of the present disclosure, and the present disclosure should not be interpreted in a narrow sense by limiting to such specific examples.

REFERENCE SIGNS LIST

[0065]

1, 2	contact probe
11, 13	Ni pipe
11a, 13a	coiled spring structure
12	plunger
50	housing
60	hot plate

CLAIMS

1. A contact probe comprising a Ni pipe including a coiled spring structure, wherein

the Ni pipe contains 0.5 to 10 wt% of phosphorus (P).

2. The contact probe according to claim 1, wherein a content of the P in the Ni pipe is 1 to 5 wt%.

3. The contact probe according to claim 1, wherein a content of the P in the Ni pipe is 2 to 4 wt%.

4. The contact probe according to any one of claims 1 to 3, further comprising a plunger connected to the Ni pipe.

5. An electrical connection jig comprising the contact probe according to any one of claims 1 to 4.