Therefore, when a molten solder solidifies by cooling, the stress is concentrated in the solder joint. If the bonding strength of the solder joint is weak, the solder joint breaks.

Thus, the solder alloy used to form the solder joint needs to satisfy the bonding strength as a mechanical property simultaneously in addition to pin contact performance for confirming an electrical property of the solder joint.

[0012] Although the solder alloys described in Patent Documents 1 to 4 are considered to be optimized to achieve each purpose, content of each constituent element that composes the solder alloy ~~contents of the solder alloys~~ must be optimized according to the purpose because the solder joints need to satisfy various properties. Therefore, in order to solve the above-described problems, alloy compositions of the solder alloys described in Patent Documents 1 to 4 must be reexamined in detail.

[0013] An object of the present invention is to provide a solder alloy, a solder ball, and a solder joint which have a high yield due to their excellent pin contact performance and exhibit high bonding strength.

Solution to Problem

[0014] In a pre-production continuity test, it is necessary to confirm the continuity of several thousand to several tens of thousands of bonded sections on a printed circuit board. In a conventional continuity test, for example, a pin contact test is conducted by sticking a pin at a probe tip into a solder alloy constituting a solder joint. In a case where the pin does not be stuck in the solder alloy easily, it is judged to have a continuity failure and thus its testing yield deteriorates. For this reason, it must be ensured that the solder joint that is originally conductive is not judged to be non-conductive. An object of the present invention is to provide a solder alloy in which a bonded section having high bonding strength is obtained in addition to being hardly judged to have a continuity failure, as mentioned above. The present inventors have focused on the fact that "the pin can easily be stuck in the solder alloy" as one of the means to solve the problems of the present invention and studied it based on metallurgical findings of the solder alloy.

[0015] The ease of the pin sticking is not improved even if a probe pin or a measuring device is improved because it depends on alloy compositions of the solder alloys. Therefore, improvement must be inevitably made by the alloy compositions of the solder alloys in the current situation.

[0016] The present inventors have first focused on an influence of the grain size of crystalline phases constituting the solder alloy in order to improve the pin contact performance. It is presumed that when the crystal grain size is large, the pin can easily be

wherein Ag, Cu, Ni, and P in the relation (3) each represent the contents (mass%) thereof in the alloy composition.

[0022] (6) A solder ball comprising the solder alloy according to any one of (1) to (5) above.

(7) A solder joint comprising the solder alloy according to any one of (1) to (5) above.

Brief Description of Drawing

[0023] FIGURE is a graph showing a DSC schematic curve to illustrate the solidification temperature in the present invention.

Description of Embodiments

[0024] The present invention is described in more detail below. In the present description, "%" relating to the solder alloy composition refers to "mass%" unless otherwise specified.

1. Alloy Composition

(1) Ag: 0.8 to 1.5%

Ag is an element that lowers the melting point of a solder alloy and improves the wettability thereof. If the Ag content is less than 0.8%, the bonding strength deteriorates since compounds with Sn are not sufficiently produced, and a large amount of compounds with ~~excess~~ Sn and Cu is formed at the bonded interface. The melting point rises too high, and the solder alloy is difficult to melt. Furthermore, the bonding strength is reduced by a decrease in wettability. In terms of the lower limit, the Ag content is 0.8% or more, preferably 1.0% or more, more preferably 1.1% or more, and particularly preferably 1.2% or more. On the other hand, if the Ag content is too large, the pin contact performance deteriorates since the strength of the solder alloy is too high to allow the pins to stick. In terms of the upper limit, the Ag content is 1.5% or less, preferably 1.4% or less, and more preferably 1.3% or less.

[0025] (2) Cu: 0.1 to 1.0%

Cu is an element that improves the bonding strength by forming an appropriate amount of a CuSn compound at the bonded interface. If the Cu content is within the above range, it is possible to maintain high pin contact performance because the solder alloy is appropriately deformed. If the Cu content is less than 0.1%, the bonding strength is not improved since the amount of the CuSn compound precipitated is small. In terms of the lower limit, the Cu content is 0.1% or more, preferably 0.3% or more, more preferably 0.4%

by HIOKI E.E. CORPORATION with a pin push-in depth of 2 mm to contact the tip of the pin with the bump.

When the proportion of energized solder bumps was 95% or more, it was rated as "A", when the proportion of energized solder bumps was less than 95% and 90% or more, it was rated as "B", and when the proportion of energized solder bumps was less than 90%, it was rated as "D".

[0052] (3) Bonding Strength

A solder ball having a diameter of 0.6mm was prepared from each of the solder alloys shown in Table 1. The prepared solder ball was soldered to a substrate having a thickness of 1.2mm and an electrode size of 0.5 mm in diameter (Cu-OSP). The number of solder balls soldered was 5. As for the soldering conditions, a flux (manufactured by SENJU METAL INDUSTRY CO., LTD.: WF-6400) was applied onto an electrode, and soldering was conducted using a reflow apparatus (manufactured by SENJU METAL INDUSTRY CO., LTD.: SNR-615) under a reflow profile with a peak temperature of 245°C and a cooling rate of 2°C/s.

[0053] The prepared test pieces were each subjected to a shear strength test under the conditions of a shear rate of 1,000mm/s in a shear strength measuring device (manufactured by Nordson Dage: SERIES 4000HS).

When the average bonding strength of five pieces was 4.6N or more, it was rated as "A", when the average bonding strength was 3.2N or more and less than 4.6 N, it was rated as "B", and when the average bonding strength was less than 3.2N, it was rated as "D". In the examples, "A" and "B" were evaluated as having no practical problems with bonding strength.

The results are shown in Tables 1 and 2.

In Tables 1 and 2, if the solder composition in each of Examples and Comparative Examples satisfies the relation (1), "○" is marked in the column of "Relation (1)", and if not, "×" is marked. "○" and "×" of the relations (2) and (3) are used in the same intention as the relation (1). The Relations (1) to (3) of the Table 1 and 2 are shown as below.

$2.0 \leq Ag \times Cu \times Ni/P \leq 25$ Relation (1)

$0.500 \leq Sn \times P \leq 0.778$ Relation (2)

$221 \leq (Ag + Cu + Ni)/P \leq 309$ Relation (3)