[0005] In addition, Sn-Ag-Cu-Bi-P solder alloys have been studied not only for flow soldering. Patent Document 3 discloses an Sn-Ag-Cu-Bi-P solder alloy for cream solder or rosin solder, and attempts to improve tensile strength, elongation, and thermal fatigue resistance characteristics. Patent Document 4 discloses an Sn-Ag-Cu-Bi-P-based solder alloy for solder balls, and studies drop impact resistance, yellowing, and heat cycle resistance.

[0006] Patent Document 5 discloses an Sn-Ag-Cu-Bi solder alloy in which heat cycle resistance is studied using a mounting substrate on which a solder paste is printed. Patent Document 6 discloses an Sn-Ag-Cu-Bi-P-based solder alloy in which the liquidus-line temperature and the solidus-line temperature are reviewed for pipe bonding and sealing.

Citation List

Patent Document

[0007]

Patent Document 1: Japanese Unexamined Patent Application Publication No. 2007-7732

Patent Document 2: Japanese Unexamined Patent Application Publication No. 2000-288772

Patent Document 3: Japanese Unexamined Patent Application Publication No. H10-34376

Patent Document 4: Japanese Unexamined Patent Application Publication No. 2004-261863

Patent Document 5: Japanese Unexamined Patent Application Publication No. 2011-183430

Patent Document 6: Japanese Unexamined Patent Application Publication No. H2-70033

Summary

Technical Problem

[0008] Conventionally, various effects have been confirmed in the Sn-Ag-Cu-Bi-P solder alloy. Among them, the invention described in Patent Document 1 is an excellent invention exhibiting excellent wettability and high tensile strength. In paragraph 0008 of Patent Document 1, it is described that the tensile strength of the solder alloy is poor when cost reduction is attempted by reducing the content of expensive Ag as a conventional technique.

[0009] In fact, according to the examination result of paragraph 0027 of Patent Document 1,

driving.

[0018] Chip standing is a phenomenon in which, when a solder alloy placed on an electrode melts by heating, if the solder alloy on one electrode starts melting earlier than the solder alloy on the other electrode, an electronic component such as a chip is attracted to the one electrode and also stands upright. This is because, as electronic devices have become lighter, thinner, and shorter in recent years, electronic components mounted on electronic devices have also reduced in size and weight, resulting in more frequent occurrence of chip standing.

[0019] In electromigration, downsizing of electronic components progresses, and as the current density during energization increases, the number of electrons moving in the solder joint also increases. Therefore, in recent years, problems have become apparent. Electromigration can be described as follows. Atoms constituting the solder joint collide with electrons that generate a current, and the momentum is transmitted from the electrons to the atoms. The atoms that have obtained the momentum in an electron flowing direction migrate along the flow of the electrons to the anode side of the solder joint. At this time, in the solder alloy containing Cu, Cu segregates on the anode side, and an empty lattice is generated on the cathode side of the solder joint. Such an empty lattice gradually expands and generates a void. When the void grows, the resistance value increases, and the solder joint generates heat due to Joule heat or the performance of the electronic component is hardly exhibited due to a decrease in current density. Finally, the solder joint is broken.

[0020] As described above, in recent years, in the Sn-Ag-Cu-Bi-P solder alloy, a solder alloy capable of suppressing chip standing and electromigration while maintaining various conventional characteristics is required. Therefore, in regard to the solder alloys described in Patent Documents 1 to 6, it is urgent to conduct studies based on the actual situation of electronic components in recent years.

[0021] An object of the present disclosure is to provide a solder alloy, a solder paste, a solder ball, a solder preform, and a solder joint which have excellent drop impact resistance and heat cycle resistance, can suppress the occurrence of chip standing, bridges and icicles, and can also suppress the occurrence of electromigration.

that the heat cycle resistance was poor.

[0026] In addition, in the above-described solder alloys disclosed in Patent Documents 2 and 6, in addition to the above-described findings, it has also been found that chip standing frequently occurs. Further, it has also been found that electromigration occurs in the above-described solder alloys disclosed in Patent Documents 4 and 6.

[0027] In view of the above findings, it is considered that it is not sufficient to simply increase the Ag content to precipitate a large amount of Ag_3Sn, but it is necessary to adjust the hardness to an appropriate level to improve the drop impact resistance and the heat cycle resistance. In addition, at the time of heating the solder alloy, in a temperature range higher than the solidus-line temperature, it is considered that it is necessary to adjust an alloy composition in which a large endotherm is observed in two stages when the thermal history is measured by a differential scanning calorimeter (DSC), and to suppress chip standing. Further, it is also considered that it is necessary to suppress the occurrence of bridges and icicles by adjusting the viscosity of the molten solder. Additionally, it is considered that electromigration resistance (hereinafter, simply referred to as "EM resistance") needs to be improved by precipitation of appropriate Ag_3Sn and solid solution strengthening of the solder alloy by Bi.

[0028] Here, the effect of the solder alloy is such that the effects of the individual constituent elements are not exhibited separately, but are comprehensively exhibited as one object while mutually contributing. Therefore, if each constituent element is individually adjusted in order to improve each characteristic, various effects cannot be simultaneously exhibited with one composition.

[0029] Therefore, the present inventors have searched for the composition of the Sn-Ag-Cu-Bi-P solder alloy in detail in view of the above findings, etc. As a result, only when each constituent element is within a predetermined range, a solder alloy is obtained which has excellent drop impact resistance and heat cycle resistance, can suppress the occurrence of chip standing, bridges and icicles, and can also suppress the occurrence of electromigration, whereby the present disclosure has been completed.

The present disclosure obtained by these findings is as follows.

above.

[0038a] In an aspect of the present disclosure, there is provided a solder alloy having an alloy composition consisting of, by mass%, Ag: 0.3 to 1.9%, Cu: 0.40 to 1.00%, Bi: 0.5 to 4.9%, P: 0.00100 to 0.02000%, with the balance being Sn.

[0038b] In another aspect of the present disclosure, there is provided a solder paste comprising a solder powder consisting of the solder alloy as disclosed herein.

[0038c] In a further aspect of the present disclosure, there is provided a solder ball consisting of the solder alloy as disclosed herein.

[0038d] In another aspect of the present disclosure, there is provided a solder preform consisting of the solder alloy as disclosed herein.

[0038e] In a further aspect of the present disclosure, there is provided a solder joint comprising the solder alloy as disclosed herein.

Brief Description of Drawings

[0039] FIG. 1 FIG. 1 is a cross-sectional SEM photograph of a solder joint, FIG. 1(a) illustrates Comparative Example 1, and FIG. 1(b) illustrates Example 22.

Description of Embodiments

[0040] The present invention will be described in greater detail below. In the present specification, "%" used for indicating an alloy composition of the solder alloy is "mass%" unless otherwise specified.

[0041] 1. Solder Alloy

(1) Ag: 0.3 to 1.9%

Ag is an element that improves drop impact resistance, heat cycle resistance and EM resistance, and suppresses chip standing. Ag can suppress deformation of the solder alloy by precipitation strengthening of Ag_3Sn, and thus contributes to improvement of heat cycle resistance and drop impact resistance. In addition, due to precipitation of Ag_3Sn, electron transfer is inhibited and EM resistance is improved. Furthermore, in the thermal history using DSC, two large endothermic peaks are shown between the solidus-line temperature and the

liquidus-line temperature during heating.

[0042] When the Ag content is less than 0.3%, due to an insufficient precipitation amount of Ag_3Sn, the heat cycle resistance and the EM resistance deteriorate. In addition, chip standing frequently occurs. In terms of the lower limit, the Ag content is 0.3% or more, preferably 0.4% or more, more preferably 0.5% or more, and further preferably 0.6% or more.

[0043] On the other hand, when the Ag content is more than 1.9%, Ag_3Sn is formed in a network shape, and therefore drop impact resistance deteriorates. In addition, when the Ag content is 2.5% or more, there is one endothermic peak, and chip standing frequently occurs. In terms of the upper limit, the Ag content is 1.9% or less, preferably 1.7% or less, more preferably 1.6% or less, further preferably 1.4% or less, still further preferably 1.3% or less, particularly preferably 1.2% or less, and most preferably 1.1% or less.