LEAD-FREE, SILVER-FREE SOLDER ALLOYS

BACKGROUND OF THE DISCLOSURE

The present disclosure is directed to methods of joining electrical or mechanical components, and more particularly to methods of attaching electronic components and associated devices onto circuit boards and other electronic substrates.

Electronic assemblers were required to adopt lead-free solder alloys in 2006. One example of an existing lead-free solder alloy can be found in U.S. Patent Application Publication No. 2008/0292492 A1, which is incorporated herein by reference in its entirety for all purposes. However, the solder alloy disclosed in this reference contains silver. The most popular lead-free alloys contain up to 4 % by weight silver. The market price of silver has increased steadily in the last several years resulting in substantial increases in solder costs for many electronics assemblers. Many studies have been performed on the acceptability of low silver (less than 1 % by weight) and silver-free alloys for certain types of electronic assemblies. Additionally, many assemblers have successfully been using silver-free alloys for several years thereby gaining acceptance within the industry. As a result of the high cost of silver bearing alloys and the industry's growing experience with using silver-free alloys there is a growing demand for these types of alloys in the market.

SUMMARY OF THE DISCLOSURE

One aspect of the present disclosure is directed to a lead-free, silver-free solder alloy comprising 0.001 to 0.800 % by weight copper, 0.080 to 0.120 % by weight bismuth, 0.030 to 0.050 % by weight nickel, 0.008 to 0.012 % by weight phosphorus, 0.10 % by weight maximum silver, 0.05 % by weight maximum lead and balance tin, together with unavoidable impurities. Embodiments of the solder alloy further may comprise one or more of the following: 0.10 % by weight maximum silver; 0.05 % by weight maximum lead; 0.05 % by weight maximum antimony; 0.030 % by weight maximum arsenic; 0.001 % by weight maximum cadmium; 0.001 % maximum zinc; 0.020 % by weight maximum iron; 0.001 % by weight maximum aluminum; 0.050 % by weight maximum indium; 0.050 % by weight maximum gold; 0.10 % by weight maximum chromium; and 0.10 % by weight maximum mercury. In another embodiment, copper is 0.600 to 0.800 % by weight of the solder alloy.

The solder alloy may be in the form of one of a bar, a stick, a solid or flux cored wire, a foil or strip, or a powder or paste, or solder spheres for use in ball grid arrays or chip scale packages, or other pre-formed solder pieces.

The solder alloy may be used to fabricate a solder joint. Thus, in an aspect, there is provided a solder joint formed by the solder alloy as disclosed above. In another aspect, a method of forming a solder joint with the solder alloy as disclosed above is also disclosed.

Another aspect of the present disclosure is directed to a lead-free, silver-free solder alloy consisting of 0.001 to 0.800 % by weight copper, 0.001 to 0.050 % by weight nickel, 0.001 to 0.012 % by weight phosphorus, 0.001 to 0.008 % by weight gallium, 0.10 % by weight maximum silver, 0.05 % by weight maximum lead and balance tin, together with unavoidable impurities. In one embodiment, copper is 0.600 to 0.800 % by weight of the solder alloy.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

There are a number of requirements for a solder alloy to be suitable for use in wave soldering, reflow soldering, hot air levelling processes, ball grid arrays, and other assembly processes. For example, the alloy must exhibit good wetting characteristics in relation to a variety of substrate materials such as copper, nickel, nickel phosphorus ("electroless nickel"). Such substrates may be coated to improve wetting, for example by using tin alloys, gold or organic coatings (OSP). Good wetting also enhances the ability of the molten solder to flow into a capillary gap, and to climb up the walls of a through-plated hole in a printed wiring board, to thereby achieve good through hole filling.

Solder alloys tend to dissolve the substrate and to form an intermetallic compound at the interface with the substrate. For example, tin in the solder alloy may react with the substrate at the interface to form an inter metallic compound layer. If the substrate is copper, then a layer of Cu_6Sn_5 will be formed. Such a layer typically has a thickness of from a fraction of a micron to a few microns. At the interface between this layer and the copper substrate an intermetallic compound of Cu_3Sn may be present. The interface intermetallic layers will tend to grow during aging, particularly where the service is at higher temperatures, and the thicker intermetallic layers, together with any voids that may have developed may further contribute to premature fracture of a stressed joint.

Other factors are: (i) the presence of intermetallics in the alloy itself, which results in improved mechanical properties; (ii) oxidation resistance, which is important in solder spheres

CLAIMS

1. A lead-free, silver-free solder alloy comprising:

0.001 to 0.800 % by weight copper;

0.080 to 0.120 % by weight bismuth;

0.030 to 0.050 % by weight nickel;

0.008 to 0.012 % by weight phosphorus;

0.10 % by weight maximum silver;

0.05 % by weight maximum lead; and

balance tin, together with unavoidable impurities.

2. The solder alloy of claim 1, further comprising one or more of the following:

0.05 % by weight maximum antimony;

0.030 % by weight maximum arsenic;

0.001 % by weight maximum cadmium;

0.001 % maximum zinc;

0.020 % by weight maximum iron;

0.001 % by weight maximum aluminum;

0.050 % by weight maximum indium;

0.050 % by weight maximum gold;

0.10 % by weight maximum chromium; and

0.10 % by weight maximum mercury.

3. The solder alloy of claim 1, further comprising 0.05 % by weight maximum antimony.

4. The solder alloy of claim 1, further comprising 0.030 % by weight maximum arsenic.

5. The solder alloy of claim 1, further comprising 0.001 % by weight maximum cadmium.

6. The solder alloy of claim 1, further comprising 0.001 % maximum zinc.

7. The solder alloy of claim 1, further comprising 0.020 % by weight maximum iron.

8. The solder alloy of claim 1, further comprising 0.001 % by weight maximum aluminum.

9. The solder alloy of claim 1, further comprising 0.050 % by weight maximum indium.

10. The solder alloy of claim 1, further comprising 0.050 % by weight maximum gold.

11. The solder alloy of claim 1, further comprising 0.10 % by weight maximum chromium.

12. The solder alloy of claim 1, further comprising 0.10 % by weight maximum mercury.

13. The solder alloy of claim 1, wherein the solder alloy is in the form of one of a bar, a stick, a solid or flux cored wire, a foil or strip, or a powder or paste, or solder spheres for use in ball grid arrays or chip scale packages, or other pre-formed solder pieces.

14. The solder alloy of claim 1, wherein copper is 0.600 to 0.800 % by weight of the solder alloy.

15. A solder joint formed by the solder alloy set forth in claim 1.

16. A method of forming a solder joint with the solder alloy set forth in claim 1.

17. A lead-free, silver-free solder alloy consisting of:
0.001 to 0.800 % by weight copper;
0.001 to 0.050 % by weight nickel;
0.001 to 0.012 % by weight phosphorus;
0.001 to 0.008 % by weight gallium;
0.10 % by weight maximum silver;
0.05 % by weight maximum lead; and
balance tin, together with unavoidable impurities.

18. The solder alloy of claim 17, wherein copper is 0.600 to 0.800 % by weight of the solder alloy.