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(54) Title: LEAD-FREE SOLDER ALLOY

(57) Abstract: The present invention relates to a lead-free solder alloy on base of alloy from a group alloy comprising of an alloy of bismuth and tin, an alloy of copper, nickel and tin, and an alloy of copper, silver and tin, containing 0.005 to 1 wt.% phosphorous.

Lead-free solder alloy

Technical Field

The present invention relates to a lead-free solder alloy on base of alloy from a group alloy comprising of an alloy of bismuth and tin, an alloy of copper, nickel and tin, and an alloy of copper, silver and tin. The lead-free solder according to the invention may be in the shape of a wire, a tube filled with flux and produced by pressing, a casting, a block and a bar.

Background of the invention

Generally recognised lead-free solder alloys, the composition of which is described in standards and patent literature, contains a high content of tin and requires high working temperatures. As a result of the combination of the high content of tin and higher working temperatures lead-free solder alloy is more easily subject to oxidation than conventional lead-containing tin solder alloys. This disadvantage can be partially avoided by increasing the amount of flux used during the soldering process. For example, in the case of tubular solder, which contains 63 wt.% lead and the balance tin, 97.4 wt.% solder and 2.6 wt.% flux is sufficient for soldering. In comparison, when using an alloy containing 97 wt.% tin and 3 wt.% copper then 3.5 wt.% flux and 96.5 wt.% solder in the shape of a tube is required to achieve the same effect. Similarly it is necessary to increase the content of flux, for example, when soldering in a wave soldering bath. Burnt flux residue on the soldered joint significantly increases with a growing amount of flux. Each contamination of the soldered joint, also from flux residue, negatively influences the reliability and correct functioning of the equipment containing the soldered joints. In a number of cases it is therefore impossible to increase the amount of flux in order to ensure that a device will function correctly. The number of soldered joints requiring cleaning also increases and thus for devices containing many soldered joints the manufacturing costs increase significantly. Another disadvantage is that the process for cleaning residue from soldered joints generally requires the use of organic solvents which need to be disposed of

in an environmentally friendly manner. Whilst handling these solvents it is necessary to extract and catch their vapours. This also leads to an increase in manufacturing costs for devices containing soldered joints.

Subject of the Invention

The present invention aims to remove or at least significantly decrease the abovementioned disadvantages.

This task can be resolved if the alloy forming the above-mentioned lead-free solder also contains 0.005 to 1 wt.% phosphorous. Phosphorous is a deoxidiser. According to the invention it is contained in the solder in such a quantity that during soldering it protects the lead-free solder, based on at least 80 wt.% tin, against air oxidation under heat. Based on these self-reducing abilities of the solder it is possible to decrease the content of flux to a value common in lead-containing tin solder, and thus the consumption of flux is reduced. For this reason flux is primarily used for deoxidising soldered metals because solder deoxidises automatically. The deoxidising capabilities of the solder begin to appear on reaching a content of 0.005 wt.% phosphorous and increase up to a value of 1 wt.% of phosphorous. Higher amounts of phosphorous over 1 wt.% do not bring about any significant further improvements.

In practice a lead-free solder alloy can be considered, the alloy comprising from 1.5 to 18 wt.% bismuth, 0.2 to 1.8 wt.% copper or 0.1 to 1.8 wt.% silver, 0.005 to 1 wt.% phosphorous and the balance tin. In preference the alloy may comprise of 1.5 to 18 wt.% bismuth, 0.2 to 1.8 wt.% silver, 0.005 to 1 wt.% phosphorous and the balance tin. According to the next version of the invention the lead-free solder alloy comprises of 1.5 to 18 wt.% bismuth, 0.1 to 1.8 wt.% copper, 0.005 to 1 wt.% phosphorous and the balance tin. In the next version of the invention the alloy forming the lead-free solder may comprise of 0.001 to 2 wt.% nickel, 0.2 to 4 wt.% copper, 0.005 to 1 wt.% phosphorous and the balance tin. The alloy may also preferentially comprise of 0.2 to 2.5 wt.% copper, 2 to 4 wt.% silver, 0.005 to 1 wt.%

phosphorous and the balance tin. The tin used is of industrial quality, i.e. with a purity of 98.5 to 99.99 %, together with unavoidable impurities.

Phosphorous is added as an elementary element into the metal smelt, or is used in the form of a pre-alloy, e.g. a pre-alloy comprising from 96 wt.% tin and 4 wt.% phosphorous. The alloy is then cast into moulds of the desired shape, whereas the casting then represents ready-to-use lead-free solder or a semi-finished product from which wire or tube is formed by pressing, which is then filled with flux.

Examples of the Invention

Example 1

Lead-free solder is formed from an alloy comprising 1.5 wt.% bismuth, 0.2 wt.% silver, 1 wt.% phosphorous and the balance tin.

Example 2

Lead-free solder is formed from an alloy comprising 0.001 wt.% nickel, 0.2 wt.% copper, 1 wt.% phosphorous and the balance tin.

Example 3

Lead-free solder is formed from an alloy comprising 2.5 wt.% copper, 4 wt.% silver, 0.005 wt.% phosphorous and the balance tin.

Claims

1. A lead-free solder alloy on base of alloy from a group alloy comprising of an alloy of bismuth and tin, an alloy of copper, nickel and tin, and an alloy of copper, silver and tin, **characterised in that** the alloy also contains 0.005 to 1 wt.% phosphorous.

2. A lead-free solder alloy as claimed in claim 1, **characterised in that** the alloy also contains 1.5 to 18 wt.% bismuth, 0.2 to 1.8 wt.% copper or 0.1 to 1.8 wt.% silver, 0.005 to 1 wt.% phosphorous and the balance tin.

3. A lead-free solder alloy as claimed in claim 2, **characterised in that** the alloy also contains 1.5 to 18 wt.% bismuth, 0.2 to 1.8 wt.% silver, 0.005 to 1 wt.% phosphorous and the balance tin.

4. A lead-free solder alloy as claimed in claim 1, **characterised in that** the alloy also contains 1.5 to 18 wt.% bismuth, 0.1 to 1.8 wt.% copper, 0.005 to 1 wt.% phosphorous and the balance tin.

5. A lead-free solder alloy as claimed in claim 1, **characterised in that** the alloy also contains 0.001 to 2 wt.% nickel, 0.2 to 4 wt.% copper, 0.005 to 1 wt.% phosphorous and the balance tin.

6. A lead-free solder alloy as claimed in claim 1, **characterised in that** the alloy also contains 0.2 to 2.5 wt.% copper, 2 to 4 wt.% silver, 0.005 to 1 wt.% phosphorous and the balance tin.