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(Title of the Invention)

Soft Solder of Pb Alloy for Semiconductor Devices

(Technical Field)

The present invention relates to Pb alloys suitable for use as a soft solder in assembling various parts to fabricate not only ordinary ICs but also VLSIs such as large-capacity memories including 64 KRAM and 256 KRAM.

(Background Art)

An IC with ceramic package, which is shown in cross section in Fig. 1, is extensively used in semiconductor devices. This ceramic package consists of a ceramic case 1 with a cavity of a predetermined configuration, a silicon chip 2 soldered on the bottom of this cavity, aluminum bonding wires 3 and a sealing plate 4 also soldered on the top of the ceramic case 1. This ceramic package is assembled by die-bonding silicon chip 2 and sealing plate 4 with Au-Si alloy or Au-Sn alloy. Solders of these Au alloys ensure high device reliability, but on the other hand, they are costly.

(Disclosure of Invention)

We have therefore made various studies to develop a solder that ensures high device reliability comparable to the conventional Au alloys and which yet is less expensive than the latter.

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In accordance with the present invention there is provided a soft solder of Pb alloy for semiconductor devices that contains 1 to 65 wt % of Sn or In or the combination of Sn and In, and optionally 1 to 10 wt % Ag, the balance being Pb and incidental impurities which include radioisotopes said radioisotopes being present in an amount of less than 50 ppb and the count of radioactive alpha-particles being not more than 0.5 CPH/cm². (ppb stands for parts per billion). When this Pb alloy is used as a solder in assembling semiconductor devices, it exhibits good wettability and adhesive strength, and at the same time, it ensures an extremely high reliability without causing any memory error. As a further advantage, the cost of this alloy is very low since it contains no precious metals such as Au.

The present invention is based on this finding, and the criticality of the contents of the respective components is as follows.

(a) Sn and In

These components provide a soft solder with good wettability and ensure high adhesive strength. If the content of each element is less than 1 wt %, their desired properties are not obtained. If used in amounts exceeding 65 wt %, however, no corresponding improvement is achieved by their presence. Therefore, Sn or In or both are used in an amount ranging from 1 to 65 wt %.

(b) Ag

This element is effective in providing further improved wettability and adhesive strength and may be included if particularly high values of these properties are required. However, if the Ag content is less than 1 wt %, its desired properties are not obtained. If the Ag content exceeds 10 wt %, no further improvement is achieved by its addition. Therefore, from an economical viewpoint, Ag is contained in an amount ranging from 1 to 10 wt %.

(c) Radiactive isotopes as incidental impurities

Lead ingots produced by the conventional refining method contain amounts of radioactive isotopes such as uranium and thorium of at least 50 ppb, and these amounts produce a count of radioactive alpha-particles which can range upward from several CPH/cm² to several hundred CPH/cm². If Pb alloys containing Pb of such high radioactive isotope contents are used as a soft solder in the assembling of semiconductor

devices, it emits radioactive alpha-particles which will cause memory errors and reduce the reliability of the devices.

Therefore, in order to avoid this deleterious effect, the content of radioactive isotopes as incidental impurities must be reduced to less than 50 ppb, thereby reducing the count of radioactive alpha-particles to not more than 0.5 CPH/cm^2 .

(Brief Description of Drawings)

Fig. 1 is a schematic cross section of the conventional IC ceramic package.

(Best Embodiment of Carrying Out the Invention)

Example:

The advantages of the soft solder of Pb alloy of the present invention are hereunder described in comparison with

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the conventional products.

Melts of Samples No. 1 to No. 12 and comparative samples Nos. 1 to 12 of the Pb alloy having the formulations indicated in Table 1 were prepared by the conventional melting process. The melts were cast into ingots under conventional conditions and rolled into 0.05 mm. sheets. The sheets were stamped into soft solders shaped like a window frame measuring 15 mm x 10 mm x 1 mm.

These samples were used in soldering sealing plates onto ceramic cases in assembling IC ceramic packages having the cross section shown in Fig. 1. The adhesive strength and wettability provided by these samples are shown in Table 1. They were also checked for the count of alpha-particles and the occurrence of memory errors. The rating index of wettability was as follows: © when the soft solder covered the entire area necessary, and X when there was left any area that was not covered by the solder.

Table 1

Sample No.	composition (wt%)					α -particle count (CPH/cm ²)	adhesive strength	wet-tability	memory errors
	Sn	In	Ag	radio-isotope (ppb)	Pb				
samples of the present invention	1	1.1	-	-	49.3	bal.	0.45	⊙	no
	2	15.5	-	-	35.2	bal.	0.32	⊙	
	3	31.6	-	-	22.4	bal.	0.24	⊙	
	4	64.6	-	-	11.5	bal.	0.12	⊙	
	5	-	1.2	-	47.2	bal.	0.44	⊙	
	6	-	14.8	-	34.1	bal.	0.34	⊙	
	7	-	30.2	-	24.8	bal.	0.25	⊙	
	8	-	64.7	-	11.2	bal.	0.11	⊙	
	9	5.0	2.5	-	40.7	bal.	0.36	⊙	
	10	10.0	-	1.1	38.6	bal.	0.37	⊙	
	11	-	5.0	6.2	37.2	bal.	0.35	⊙	
	12	3.5	3.0	9.8	30.1	bal.	0.28	⊙	
comparative samples	1	0.8	-	-	119.0	bal.	1.21	X	some
	2	-	0.8	-	714.2	bal.	7.23	X	many
	3	1.1	-	-	799.2	bal.	8.04	⊙	
	4	15.5	-	-	549.3	bal.	6.58	⊙	
	5	64.6	-	-	205.3	bal.	5.83	⊙	
	6	-	1.2	-	1097.8	bal.	11.02	⊙	some
	7	-	30.2	-	732.9	bal.	10.51	⊙	
	8	-	64.7	-	53.2	bal.	0.52	⊙	many
	9	5.0	2.5	-	508.8	bal.	5.54	⊙	
	10	10.0	-	1.1	533.4	bal.	6.07	⊙	some
	11	-	5.0	6.2	524.0	bal.	5.91	⊙	
	12	3.5	3.0	9.8	73.3	bal.	0.83	⊙	some

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As is clear from Table 1, sample Nos. 1 to 12 of the Pb alloy according to the present invention exhibited good wettability and adhesive strength. Furthermore, since they contained less than 50 ppb of radioactive isotopes, they did not emit more than 0.5 CPH/cm² of radioactive alpha-particles. Therefore, none of these samples caused memory error due to radioactive isotopes. On the other hand, comparative samples No. 1 and No. 2 were outside the scope of the present invention in respect to the Sn and In contents. Therefore, they achieved low adhesive strength and poor wettability. Comparative samples No. 3 to No. 12 exhibited high adhesive strength and good wettability. However, they contained so much of radioactive isotopes that they caused some or many memory errors and hence produced devices of low reliability.

20 (Industrial Applicability)

As described in the foregoing, the soft solder of Pb alloy according to the present invention ensures high adhesive strength and good wettability. Furthermore, it does not emit more than 0.5 CPH/cm² of radioactive alpha-particles. Therefore, the solder is highly suitable for use in the assembly of semiconductor devices. In addition, this soft solder can be manufactured at low cost.

CLAIMS

1. A soft solder of Pb alloy for semiconductor devices that contains 1 to 65 wt % of Sn or In or the combination of Sn and In, the balance being Pb and incidental impurities which include radioisotopes said radioisotopes being present in an amount of less than 50 ppb and the count of radioactive alpha-particles being not more than 0.5 CPH/cm^2 .
2. A soft solder of Pb alloy for semiconductor devices that contains 1 to 65 wt % of Sn or In or the combination of Sn and In and 1 to 10 wt % of Ag, the balance being Pb and incidental impurities which include radioisotopes said radioisotopes being present in an amount of less than 50 ppb and the count of radioactive alpha-particles being not more than 0.5 CPH/cm^2 .
3. A soft solder of Pb alloy as claimed in Claim 1 or Claim 2, substantially as described with reference to the Examples.
4. A soft solder of Pb alloy as claimed in Claim 1 or Claim 2, substantially as illustrated by any one of Sample numbers 1 to 12.
5. A method of assembling a semiconductor device using a soft solder wherein as the solder there is used a soft solder of Pb alloy as claimed in any one of Claims 1 to 4.
6. A semiconductor device when obtained by the method claimed in Claim 5.

