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Title: Method for the electrolytic removal of plastic mold flash or bleed from the metal surfaces of semiconductor devices or similar electronic components and the solution composition to be used with this method.

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The invention relates to a method for the electrolytic removal of plastic flash or bleed from the metal surfaces of semiconductor devices and similar electronic components by immersing such components in a water based solution of one or more organic solvents, conducting salts and a wetting agent and connecting the components to be cleaned to the negative pole of a source of direct current of which the positive pole is connected to a counter electrode in the same solution. The invention also relates to the composition of the solution to be used for immersing the components.

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In the manufacturing process of the majority of semiconductors, integrated circuits, transistors and the like, for briefness's sake further called semiconductor components, the following production steps can be distinguished. A carrier, called a leadframe is stamped or etched from a copper alloy, nickel-iron alloy or another metal. A leadframe comprises generally a pad and a number of leads.

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The central part of the leadframe consisting of pad and leadtips is subsequently selectively electroplated with metals such as gold, silver, palladium, copper or nickel. In the next step a chip is bonded to the leadframe pad and electric wire connections are made between chip and leadtips (wirebonding), followed by encapsulating the central area containing the chip and wirebonded leadtips by injection molding with a plastic, usually an epoxy based plastic. The manufacturing process is further explained by the enclosed drawing in which an integrated circuit (IC) is shown manufactured as described above and of which the outer leads are contaminated with plastic bleed.

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In the drawing, the plastic encapsulation, which contains the bonded chip and the wirebonded leadtips is indicated with numeral 1, the outer leads with 2. Numeral 3 indicates spaces which usually fill up with plastic during molding of encapsulation 1, whilst numeral 4 indicates places where very thin films of plastic (normally called "bleed") can contaminate the metal surface of the outer leads and which must be



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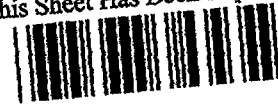
removed. Numeral 5 indicates parts of the leadframe serving interconnection during manufacturing and which will be removed before the IC is used.

5 The method of this invention is designed to remove the plastic bleed as indicated in the drawing with numeral 4. Such plastic bleed films on the metal surface of the leads are thin, usually less than 10 micrometer, but must be carefully removed to avoid uncoated areas during subsequent tin-lead plating, necessary to enable reliable solder connections to be made to other parts of an electronic circuit.

10 The traditional way to remove the plastic bleed films from the molded components is to submit the components to abrasive blasting with ground cherry or apricot stones, fine, relatively hard plastic grains or glass beads and the like. Sometimes the blasting operations is preceded by softening of the plastic bleed in organic solvents or by extended
15 treatment in diluted warm acids. A disadvantage of blasting with fine particles is that some of these particles will be embedded in the metal surface of the leads and must be carefully removed before plating with a solderable coating and that the blasting operation will create roughness of the metal surface.

20 US Patent 4,968,397 describes an electrolytic anodic process with which embedded blasting particles can be removed, whilst simultaneously metal bleed, such as silver, extending on the leads outside the plastic encapsulation is dissolved, resulting in a clean surface of the leads. To accomplish this effect a solution of lactic acid and a metal
25 hydroxide is used, in which the components are connected to the positive pole of a source of direct current and whereby simultaneously an improved surface condition of copper based metal leads is obtained.

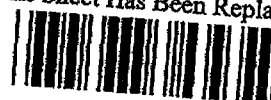
30 US Patent 4,781,804 describes a method to remove plastic bleed from the leads of semiconductor components by means of an electrolytic treatment in a solution containing an alkali metal hydroxide, detergent, a glycol compound, alkali-metal bicarbonate, ethoxylated furfuryl alcohol, tetrahydro furfuryl alcohol and a fluorinated surfactant in water and whereby the components are connected as a cathode to a source
35 of direct current so that hydrogen is generated on the metal surface upon current passages. In practice it appears that this solution contains aggressive components attacking the material of the plastic encapsulation.



According to the present invention an improved method is obtained for removing plastic bleed from outer leads of encapsulated semiconductor components whereby the encapsulating material is not attacked and whereby no additional surface treatments are necessary before subsequent solderplating. In the state of the art it was frequently necessary to subject the metal surface to a chemical or electrolytic polishing treatment after plastic bleed removal.

These objectives are obtained by applying the method according to the invention and this method is characterised in that, during passage of a current through the solution, the pH of the liquid film directly adjacent to the cathodic metallic surface is raised to a value at which the solvent in the solution causes a softening action on the plastic bleed, which is sufficient to enable the hydrogen gas generated simultaneously on the cathode to remove the plastic mold flash or bleed from the metal surface. At the high pH in the layer of metal-liquid the solvents present in the electrolyte, supported by the wetting agent, soften the plastic bleed to such an extent that the hydrogen gas generated at the metal surface simultaneously is able to mechanically scrub the surface clean of the softened plastic bleed. Possible remnants of the softened plastic bleed can be easily removed by a subsequent pressure rinse or by a pressurised air jet. As a wetting agent 2-amino 2-methyl propanol proved to be extremely suitable since it combined good wetting properties with low foaming characteristics. This wetting agent can be used in concentrations of 0.5 - 2.5% by volume.

As solvents, esters of lactic acid are added to the water based solution. Preferred esters are methyl, ethyl, isopropyl or butyl lactate. The alkyl esters with the lower number of carbon atoms are best soluble in water. At a pH value over 7 relative rapid hydrolysis of the lactate esters takes place resulting in the formation of lactic acid. Preferably the water based solution contains 10 - 20% by volume alkyl lactate. Salts which must be added to obtain sufficient conductivity of the solution can be organic or inorganic but are preferably potassium, sodium or ammonium salts of acetic or lactic acid, whilst suitable inorganic salts are the potassium, sodium and ammonium salts of sulphuric, phosphoric or carbonic acids. Chlorides would also be suitable but are usually not permitted in the manufacturing process of semiconductors. The



concentration of conducting salts must be adequate to provide a pH between 10 - 13 in the catholyte when a direct current is applied with a cathodic current density of 25 - 40 A/dm² and at which the pH of the bulk of the electrolyte is maintained between 6 and 7.

5 Preferably lactates are used as conducting salts to reduce the number of ions in the solution and to reduce the hydrolyses of the alkyl lactate. The softening effect of alkyl esters of lactic acid on plastic bleed could be further improved by the addition of other water soluble solvents, particularly by addition of 0.5 - 2.5 ml/liter
10 4-methyl-2-pentanol.

The invention will be further explained by means of the following examples and experiments.

Example I

15 Several solutions were prepared and examined on their ability to soften plastic encapsulations of semiconductor components as indicated on the enclosed drawing. These components were immersed in the following solutions:

- 1) Pure ethyl lactate.
- 2) 98% ethyl lactate with 2% 4-methyl-2-pentanol.
- 20 3) 90% ethyl lactate with 10% water.
- 4) 90% ethyl lactate with 10% of a concentrated KOH solution. (appr. 250 g/l KOH).
- 5) 88% ethyl lactate with 2% 4-methyl-2-pentanol and 10% concentrated KOH solution.

25 The pH of solutions 1, 2 and 3 was well below 7 whilst the pH of solutions 4 and 5 was over 12. The immersion of the components in the solution took place at ambient temperature.

30 After exposure for 1 hour the components were rinsed and the black encapsulation plastic was rubbed with soft white tissue paper. The intensity of the black contamination on the tissue paper after 4 rubs was considered as a measure for the degree of attack on the plastic.

In freshly prepared solutions 1, 2 and 3 no attack was visible after 1 minute exposure, nor after 1 hour exposure.

35 Only after 24 hours immersion a very slight attack on the encapsulation material was observed.



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The freshly made up solutions 4 and 5 showed considerable attack of the plastic encapsulating already after 1 minute exposure. The degree of attack was considered sufficient for solution 4 and very good for solution 5.

5 When the test with solutions 4 and 5 were repeated the next day, no attack of the plastic was noticeable after one minute nor after one hour exposure. Even after 24 hours, attack of the plastic was hardly noticeable. This phenomenon can probably be explained by the hydrolyses of the ethyl lactate at the high pH of solutions 4 and 5, rendering them
10 inactive.

 When passing a direct current through an electrolyte the pH in the cathode film (catholyte) will increase and in the anode film (anolyte) will decrease compared to the pH of the bulk of the solution, the deviation being dependent upon the type of solution and upon the local
15 current density (A/dm^2). The higher the C.D., the larger the pH difference will be between the bulk of the solution and catholyte or anolyte.

 The method of the present invention utilises this phenomena for removal of plastic bleed from metal surfaces by employing a solution with a pH between 6.5 and 7.5. At this pH, hydrolysis of alkyl lactates is
20 negligeable. When direct current is passed through the solution at which the components are cathodic and the C.D. has a value between 30 - 40 A/dm^2 the pH in the catholyte will increase to a value well over 12. These high pH values are created only in the areas where metal is exposed, such as in the pores of the plastic bleed and the immediate area surrounding the
25 pores. There will be no pH increase at the surface of the bulk of plastic encapsulating material. The result of this is zero attack on the encapsulating plastic, whilst the bleed, which normally is less than 10 micrometer thick and hence is very porous will be exposed to a high pH environment which almost instantly softens the bleed. The vigorous
30 evolution of fine hydrogen bubbles formed simultaneously acts as a scrubber and removes the plastic bleed at large. Any remaining loosely adhering remnants of the plastic bleed are completely removed in a subsequent pressurised water rinse or air jet.

 The method for removing plastic bleed from metal surfaces
35 utilises a solution with a temperature between 35 and 50 °C, preferably at appr. 45 °C for appr. 1 minute. Even after longer exposure times no attack



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of plastic encapsulating material will take place, in areas other than the plastic bleed film which must be removed.

Example II

Leadframes for integrated circuits were manufactured and assembled in the standard industrial way, and finally encapsulated with an epoxy based plastic. These leadframes showed plastic bleed on the outer lead metal surfaces. This plastic bleed film was removed using the method of this invention as will be explained hereafter. The process time for removing the plastic bleed was 1 minute and 15 seconds and followed by a pressurised water rinse during 5 seconds, after which a final treatment took place in the form of electroplating with tin-lead alloy.

After electroplating the samples were inspected for detection of bare spots in the electroplated coating, which would indicate incomplete removal of the plastic bleed film.

In a parallel test using a known composition for electrocleaning metal surfaces (containing sodium hydroxyde, potassium phosphate, sodium gluconate and sodium pyrophosphate) 30 - 40% of the original plastic bleed area was not removed and showed up bare spots after tin-lead plating.

According to the invention different compositions 1 - 4 as indicated in the table were used.

<u>Ingredient</u>	<u>Sol. 1</u>	<u>Sol. 2</u>	<u>Sol. 3</u>	<u>Sol. 4</u>
Ethyl lactate	10%	--	10%	20%
Isopropyl lactate	--	15%	--	--
Tri potassium phosphate	60 g/l	--	--	12 g/l
Sodium acetate	--	75 g/l	--	--
Potassium lactate	--	--	20%	20%
2-Amino-2-methylpropanol	1%	2%	2%	1%
4-Methyl-2-pentanol	0.5 ml/l	1 ml/l	2 ml/l	1 ml/l

Leadframes were obtained with the solutions 1 - 4 listed in the table which were completely free of plastic bleed on the metal surfaces of the outer leads. During the treatments, the temperature of the solutions was maintained at 40 - 50 °C. The method could also be successfully used at lower temperatures at which higher bath voltages were



needed.

At the temperatures of 40 - 50 °C the current densities applied were between 25 - 35 A/dm². At C.D. below 20 A/dm² the removal of the plastic bleed was not complete.

5 All experiments were carried out at pH values between 6.5 and 7. When pH was below 6.5 a slight attack of the anode material was noticed, so it is recommended to maintain a pH value not below 6.5, whilst at pH values over 7.5 danger exists for the hydrolysis of the alkyl lactates. The treatment time was varied between 30 seconds and 2 minutes; 10 whereby a treatment of 30 seconds gave already adequate results.

Example for comparison

The tests described in example II were repeated under identical conditions and solution compositions, except that the encapsulated leadframes with plastic bleed on the outer lead metal 15 surfaces were connected to the positive pole of the direct current source and hence were exposed as anodes.

It was estimated that the pH of the anolyte, the electrolyte film directly adjacent to the metal surface, was well below 4.

20 After the treatment the leadframes were electroplated with tin-lead and inspected for bare spots. All leadframes showed numerous bare spots and were identical to a sample which was tin-lead plated without being submitted to a deflash treatment.

25 Surprisingly it was also found that the plastic bleed residues had hardened which is believed to be caused by the reaction of the oxygen, developed at the anode surface, with the epoxy bleed films. It was also noted that the subsequent tin-lead coatings were of an inferior coarser structure than those on the leadframes of example II, which was to all probability caused by the etching of the metal surfaces during the anodic treatment.



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CLAIMS

1. Method for the electrolytic removal of plastic mold flash or bleed from the metal surfaces of semiconductor devices and similar electronic components by immersing such components in a water based solution of one or more organic solvents, conducting salts and a wetting agent and connecting the components to be cleaned to the negative pole of a source of direct current of which the positive pole is connected to a counter electrode in the same solution, characterized in that during passage of a current through the solution the pH-value of the liquid film directly adjacent to the cathodic metallic surface is raised to a value at which the solvent in the solution causes a softening action on the plastic bleed, which is sufficient to enable the hydrogen gas, generated simultaneously on the cathode to remove the plastic mold flash or bleed from the metal surface.
2. Method according to claim 1, characterized in that 10-20% alkyl lactate, in which the alkyl group comprises 1-4 carbon atoms, is added to the solution.
3. Method according to claim 1, characterized in that as organic solvent 0.5-2 ml/l 4-methyl-2-pentanol is added.
4. Method according to claims 1-3, characterized in that 10-20 vol.% alkyl lactate and 0.5-2 ml/l 4-methyl-2-pentanol is added to the solution as solvent.
5. Method according to claims 1-4, characterized in that a sodium-, potassium- or ammonium salt of an inorganic acid is added to the solution.
6. Method according to claims 1-4, characterized in that a sodium-, potassium- or ammonium salt of an organic acid is added to the solution.
7. Method according to claim 6, characterized in that sodium-, potassium- or ammonium acetate is used as the conducting salt.
8. Method according to claim 6, characterized in that potassium-, sodium- or ammonium lactate is used as a conducting salt.
9. Method according to claims 1-8, characterized in that the concentration of the conducting salt is such that during applying the current density of 25-40 A/dm² the pH-value of the catholyte is raised to



a value higher than 10.

10. Method according to claims 1-9, characterized in that the pH-value of the solution is maintained at 6.5-7.5.

5 11. Method according to claims 1-10, characterized in that 0.5-2.5 vol.% wetting agent is added to the solution.

12. Method according to claim 11, characterized in that 2-amino-2-methyl propanol is added as the wetting agent.

10 13. Composition of an aqueous solution to be used in a process according to claim 1, characterized in that this aqueous solution comprises 0.5-2.5 ml/l 4-methyl-2-pentanol, 0.5-2.5 vol.% 2-amino-2-methyl propanol, 10-20 vol.% alkyl lactate in which the alkyl group comprises 1-4 carbon atoms and a salt in the form of ammonium-, potassium- and/or sodium lactate in an amount of 5-25 wt.%.

15 14. Composition according to claim 13, characterized in that the lactate salt is at least partly replaced by a phosphate.

15. Composition according to claim 13, characterized in that the lactate salt is at least partly replaced by an acetate.