

MULTI-LAYER PLATED LEAD FRAME

Background of the Invention

The present invention relates to a lead frame, and more particularly, to a multi-layer plated lead frame in which the structure of a plating layer is improved, such that a pre-plated frame (PPF) process is applied to a substrate made of an ferroalloy (Fe).

A semiconductor lead frame is an important element of a semiconductor package, together with the semiconductor chip. The lead frame connects the inside of the semiconductor package to the outside thereof, and supports the semiconductor chip. In general, such a semiconductor lead frame is manufactured by stamping or etching method.

According to the stamping method, a thin plate material is formed into a predetermined shape using a press molding apparatus. Such stamping method is mainly applied for mass producing lead frames.

Meanwhile, the etching method is a chemical etching in which a predetermined portion of the material is eroded using a chemical, and is used to manufacture small quantities of lead frames.

A semiconductor lead frame manufactured by one of the above methods has various structures according to the mounting type of lead frame on the substrate. FIG. 1 shows a general structure of the semiconductor lead

frame.

In FIG. 1, the lead frame includes a die pad 11 for mounting and fixing a memory chip thereon, an inner lead 12 connected to the chip by wire bonding, and an outer lead 13 for connection with an external circuit.

The semiconductor lead frame having the above structure forms a semiconductor package through assembly with other parts of the semiconductor, e.g., a memory chip.

In order to improve wire bonding between the semiconductor chip and the inner lead 12 of the lead frame, the die pad 11 and the inner lead 12 are plated with a metal. Also, in order to improve solderability, a solder plating is performed on a predetermined portion of the outer lead 13.

However, during the solder plating, a plating solution frequently encroaches on a region of the inner lead 12, so that an extra step of removing the unwanted plating solution is necessary.

To solve the problem, a pre-plated frame (PPF) method has been suggested. According to the pre-plated frame method, a material having excellent solder wettability is coated on a substrate prior to the semiconductor packaging process, to form a plating layer. Structures of the plating layer obtained by the above method are shown in FIGs. 2, 3 and 4.

Referring to FIG. 2, a nickel (Ni) plating layer

22, and a palladium (Pd) or Pd/Ni alloy plating layer 23, are sequentially formed on a copper (Cu) substrate 21, forming a multi-layer plating layer.

5 The lead frame of FIG. 3 includes a Ni plating layer 32, a Pd/Ni alloy plating layer 33, a Ni plating layer 34, and a Pd plating layer 35, wherein the plating layers 32, 33, 34 and 35 are sequentially formed on a Cu substrate 31.

10 According to the lead frame of FIG. 4, a Ni plating layer 42 and a Pd or gold (Au) plating layer 43, are sequentially formed on a Cu substrate 41. Also, a Pd/Ni alloy plating layer 44, a Pd or Au plating layer 43' and a Pd plating layer 45 are formed on the Pd or Au plating layer 43.

15 However, the lead frames of FIGs. 2 through 4 are manufactured according to a pre-plated frame process by using Cu or Cu alloy as the substrate material, and it is difficult to apply the pre-plated frame process used for forming the lead frames of FIGs. 2 through 4 to a
20 substrate made of alloy 42. Here, Alloy 42 consists of Ni, Fe and minor amount of other elements, and is widely used as a lead frame substrate material. However, Alloy 42 is seriously corroded by the assembly process of salty atmosphere. This is due to galvanic corrosion
25 caused by the great difference in electrochemical potential between Fe of the alloy 42 and Pd of the plating layer.

Summary of the Invention

To solve the above problem, it is an object of the present invention to provide a lead frame having an excellent anti-corrosion property, as well as good soldering and wire bonding properties, by improving the structure of plating layers thereof.

To achieve the above object, there is provided a multi-layer plated lead frame comprising a substrate made of ferroalloy, and a first precious metal plating layer, an intermediate plating layer, and a second precious metal plating layer, which are sequentially formed on the substrate.

Preferably, the intermediate plating layer includes a copper (Cu) plating layer and a nickel (Ni) plating layer.

Brief Description of the Drawings

The above object and advantages of the present invention will become more apparent by describing in detail a preferred embodiment thereof with reference to the attached drawings in which:

FIG. 1 is a plan view of the structure of a general lead frame;

FIGS. 2, 3 and 4 are sectional views showing the structure of plating layers of a conventional lead frame;

FIG. 5 is an Evans diagram; and

FIG. 6 is a sectional view showing the structure of plating layers of a lead frame according to the present invention.

Detailed Description of the Invention

5 The present invention is characterized in that a substrate made of ferroalloy, is initially plated with a precious metal or an alloy thereof. After forming such precious metal plated layer, an intermediate plating layer and an outermost plating layer are formed,
10 completing the plating layers. Here, a palladium (Pd) plating layer may be formed between the intermediate plating layer and the outermost plating layer. Here, the plating layer containing Pd improves adhesion between the intermediate plating layer and the outermost
15 plating layer, as well as reducing surface roughness of the plating layers, thereby improving solderability and wire bonding.

 The principle of the present invention will be described with reference to the Wagner's mixed kinetic
20 electrode theory.

 In the field of electrochemistry, it is general that the corrosion rate of a metal can be expressed by the following equation (1).

$$i = i_0 \exp(\Delta E / \beta) \quad \dots (1)$$

where i_0 is an exchange current density, β is the Tafel constant, and ΔE is the difference between an oxidation reaction potential and a reduction reaction potential.

According to the mixed kinetic electrode theory, a corrosion reaction is composed of an oxidation reaction and a reduction reaction, and the corrosion reaction rate can be determined when the oxidation reaction rate is equal to the reduction reaction rate.

The corrosion behavior of metal can be easily expected by using the Evans diagram of FIG. 5, in which the relationship between ΔE and the current density i of the equation (1) is expressed as a semi-log type.

Generally, corrosion of a metal M having a valence ν occurs by the following oxidation reaction and reduction reaction.

Oxidation reaction (interface between a lead frame and a plating layer) : $M = M^{\nu+} + \nu e^-$

Reduction reaction (interface between the plating layer and atmosphere) : $O_2 + 2H_2O + 4e^- = 4(OH)^-$

The corrosion rate of the metal can be determined at crossing points between " ΔE -vs- $\log i$ " oxidation reaction curve and " ΔE -vs- $\log i$ " reduction reaction curve.

In order to lower the corrosion rate of the metal, an oxidation reaction rate and a reduction reaction rate must both be reduced. However, the reduction reaction is fixed as an oxidation reduction reaction in normal &

salty atmosphere. Thus, it is necessary to change the metal reduction reaction for decreasing the corrosion rate of the metal.

As previously described, the metal oxidation
5 reaction mainly occurs at the interface between a lead frame and the first metal plating layer. So it become critically important to determine what is the magnitude of the electrochemical potential of the first plating layer. The corrosion rate is decreased with decreasing
10 the electrochemical potential difference between the lead frame and the first plating layer.

For example, as shown in FIG 5, the electrochemical potential of the metals are increased in the order of Mn, Fe, Cu and Pd. And, the overall metal corrosion
15 rate is remarkably decreased in the order of Mn, Fe, Cu and Pd.

In the present invention, based on the above principle, it is intended to reduce the oxidation reaction rate by plating a precious strike layer such as
20 palladium (Pd) on an Fe lead frame, thereby slowing down the corrosion rate.

Hereinafter, the structure of a lead frame according to a preferred embodiment of the present invention will be described with reference to FIG. 6.

25 A first precious metal plating layer 62, which is formed of one metal selected from the group consisting of palladium (Pd), gold (Au), platinum (Pt), rhodium

(Rh), silver (Ag), Ruthenium(Ru) and alloys thereof is formed on a substrate 61 made of ferroalloy. Here, it is preferable that the thickness of the substrate is 0.01~5mm.

5 The alloy used for forming the first precious metal plating layer includes a Pd-Au alloy containing 50wt% or less of Au, a Pd-Co alloy containing 50wt% or less of Co, a Pd-W alloy containing 50wt% or less of tungsten (W), a Pd-Ti alloy containing 50wt% or less of titanium
10 (Ti), a Pd-Sn alloy containing 50wt% or less of tin (Sn), a Pd-Ni alloy containing 50wt% or less of nickel (Ni), and a Pd-Mo alloy containing 50wt% or less of molybdenum (Mo). The above percentages are based on the total weight of the alloy. The first precious metal
15 layer reduces the electrochemical potential difference between the oxidation and reduction, as described above, thereby improving the anti-corrosion property. Also, preferably, the first precious metal layer has a thickness of 0.01~10 μ m.

20 A Cu plating layer 63 is formed on the first precious metal plating layer 62, formed of Cu or Cu alloy including Cu as a major component and 50wt% or more of another metal based on the total weight of the alloy. The other metal is selected from the group
25 consisting of Sn, Ni, Mo, Mn and Co. Preferably, the Cu plating layer 63 has a thickness of 0.01~10 μ m.

The Cu plating layer 63 improves the adhesion

between the first precious metal plating layer 62 and a Ni plating layer 64, and prevents the diffusion of metal atoms from the substrate.

The Ni plating layer 64 is formed as an
5 intermediate layer to prevent the generation of a reactive copper product such as copper oxide or copper sulfide, which is obtained by a reaction with Cu atoms diffused to the surface of the outermost layer. The Ni plating layer 64 is formed of Ni or Ni alloy including
10 Ni as a major component and 50wt% or more of another metal based on the total weight of the alloy. The other metal is selected from the group consisting of Cu, Sn, Mo, Mn, Co and W. Preferably, the Ni plating layer 64 has a thickness of 0.01~10 μ m.

15 A Pd plating layer 65 is formed on the Ni plating layer 64, formed of Pd or Pd alloy including Pd as a major component and 50wt% or more of another metal based on the total weight of the alloy. The other metal is selected from the group consisting of Mo, W, Ti, Sn, Ni,
20 Ag and Co. The Pd plating layer 65 has a thickness of 0.01~10 μ m. The Pd plating layer 65 covers pores in the surface of the Ni plating layer 64, to even the surface roughness of the Ni plating layer 64. Accordingly, the thickness of the outermost layer, to be formed by a
25 subsequent step, can be evenly maintained.

The above-described Pd plating layer 65 markedly decreases local corrosion in salty atmosphere,

increasing the binding force between the Ni plating layer 64 and a second precious metal plating layer 62' as the outermost plating layer. Accordingly, in trimming and forming steps after mounting a
5 semiconductor chip on a pad of the lead frame, the generation or widening of cracks can be minimized. As a result, solderability and wire bonding properties, as well as anti-corrosion properties, are improved by preventing the diffusion of Ni from the Ni containing
10 plated layer 64.

The second precious metal plating layer 62' is formed on the Pd plating layer 65, formed of one metal selected from the group consisting of Pd, Au, Pt, Ag, Ru, Rh and alloys thereof. As the outermost plating
15 layer, the Pd plating layer 65 protects underlying layers and prevents the oxidation of all other plating layers and improves the solderability and wire bonding property.

Here, preferably, the second precious metal plating
20 layer 52' has a thickness of 0.01~10 μ m.

In the lead frame having the above structure, a wire bonding region, or the entire lead frame including the wire bonding region, is plated.

Hereinafter, the present invention will be
25 described in detail with reference to examples, but the present invention is not limited to the following examples.

<Example>

After performing a pretreatment on a Fe-Ni substrate, a Pd strike layer was formed to a thickness of approximately $3\mu\text{inch}$. After plating the Pd strike
5 layer with Cu to a thickness of approximately $2\mu\text{m}$, the resultant structure having the Cu plating layer was sequentially plated with Ni and Ni-Pd alloy, in approximately $1\mu\text{m}$ thickness and approximately $3\mu\text{inch}$, respectively. Then, a Pd plating layer having a
10 thickness of approximately $3\mu\text{inch}$ was formed on the plated Ni-Pd alloy plating layer. The Mo. GL-2(S) (Degussa Co.) was used for Pd plating and Ni-Pd plating, copper pyrophosphate solution (Poong Won Chemical Co.) for Cu plating, and
15 the Mo. 6450 (Degussa Co.) for Ni plating.

<Comparative Example 1>

After performing a pretreatment on a substrate made of Alloy 42, the substrate was sequentially plated with Cu, Ni and Pd, thereby completing a lead frame having
20 the structure of three plating layers.

<Comparative Example 2>

After performing a pretreatment on a substrate made of Alloy 42, the substrate was sequentially plated with Ni, Cu, Ni and Pd, thereby completing a lead frame
25 having the structure of four plating layers.

Then, solderability test (MIL-STD-883D, Method 2003.7), salt water spray test (MIL-STD-883D, Method 1009.8) for evaluating anti-corrosion properties under salty atmosphere, and a wire bonding test, were
 5 performed on the multi-layer plated lead frames manufactured by the Example and Comparative Examples 1 and 2. The results are shown in Table. 1.

Table 1

	sample	solderability	wire bonding property	anti- corrosion
10	Example	good	12.01gf (excellent)	good
	Comparative Example 1	poor	4.61gf (poor)	poor
	Comparative Example 2	poor	8.40gf (moderate)	poor

15 From Table 1, it is can be seen that the lead frame manufactured by the Example has better solderability, wire bonding property and anti-corrosion property than those of Comparative Examples 1 and 2.

20 As described above, the lead frame according to the present invention has improvements in all characteristics such as wire bonding, anti-corrosion and

solderability. Thus, a high yield is expected in the semiconductor package process, improving productivity.



What is claimed is:

1. A multi-layer plated lead frame comprising a substrate made of ferroalloy, and a first precious metal plating layer, an intermediate plating layer and a
5 second precious metal plating layer, which are sequentially formed on the substrate.
2. The multi-layer plated lead frame of claim 1,
wherein the intermediate plating layer comprises a copper (Cu) plating layer and a nickel (Ni) plating
10 layer.
3. The multi-layer plated lead frame of claim 2,
wherein the Cu plating layer is formed of Cu, or Cu alloy including at least one metal selected from the group consisting of tin (Sn), nickel (Ni), molybdenum
15 (Mo), Manganese (Mn) and cobalt (Co).
4. The multi-layer plated lead frame of claim 2,
wherein the Ni plating layer is formed of Ni, or Ni alloy including at least one metal selected from the group consisting of copper (Cu), tin (Sn), molybdenum
20 (Mo), manganese (Mn), cobalt (Co) and tungsten (W).
5. The multi-layer plated lead frame of claim 2,
further comprising a palladium (Pd) plating layer between the Ni plating layer and the second precious metal plating layer.
- 25 6. The multi-layer plated lead frame of claim 2,
wherein the Pd plating layer is formed of Pd, or Pd alloy including at least one metal selected from the



group consisting of molybdenum (Mo), tungsten (W), titanium (Ti), tin (Sn), nickel (Ni), silver (Ag), gold (Au) and cobalt (Co).

7. The multi-layer plated lead frame of claim 1,
5 wherein the first precious metal plating layer is formed of one metal selected from the group consisting of palladium (Pd), gold (Au), platinum (Pt), rhodium (Rh), Ruthenium(Ru), silver (Ag) and alloys thereof.

8. The multi-layer plated lead frame of claim 1,
10 wherein the second precious metal plating layer is formed of at least one metal selected from the group consisting of palladium (Pd), gold (Au), platinum (Pt), rhodium (Rh), Ruthenium(Ru), silver (Ag) and alloys thereof.