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(54) **PLATED LEAD FRAME INCLUDING DOPED SILVER LAYER**

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H01L 23/495	(2006.01)
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USPC 174/255, 524; 428/637, 645–647, 656, 428/671; 438/637; 257/88, 98, 99, 477, 257/666, 676, 690, 697, 762, 784; 205/50, 109, 194, 205, 238, 263, 518
See application file for complete search history.

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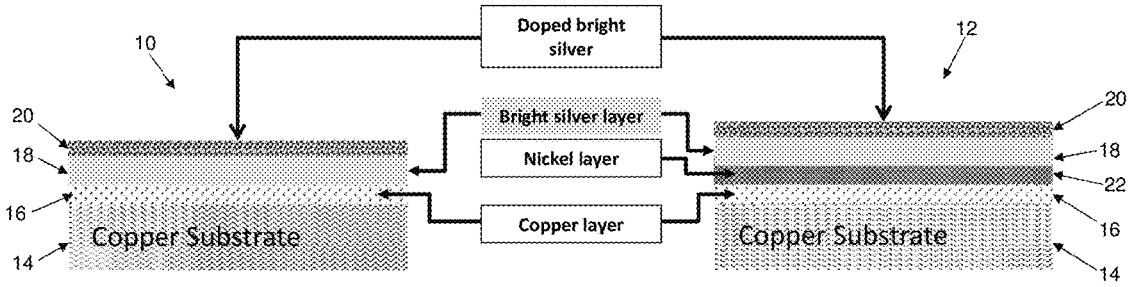
(57) **ABSTRACT**

A lead frame comprises a substrate comprising copper and includes a layer of bright silver is plated onto the substrate. A layer of doped bright silver is thereafter plated over a top surface of the layer of bright silver for enhancing the performance of LED devices utilizing the lead frame.

9 Claims, 1 Drawing Sheet



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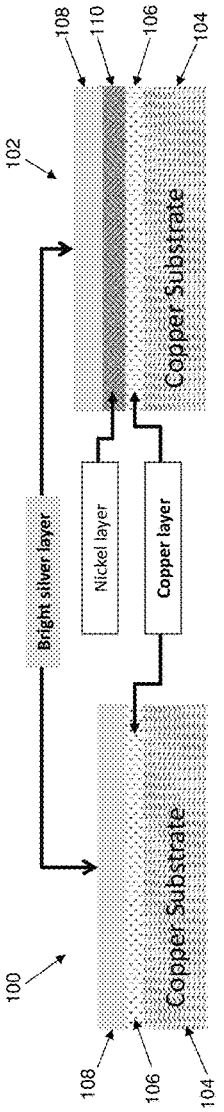

FIG. 1 (Prior Art)

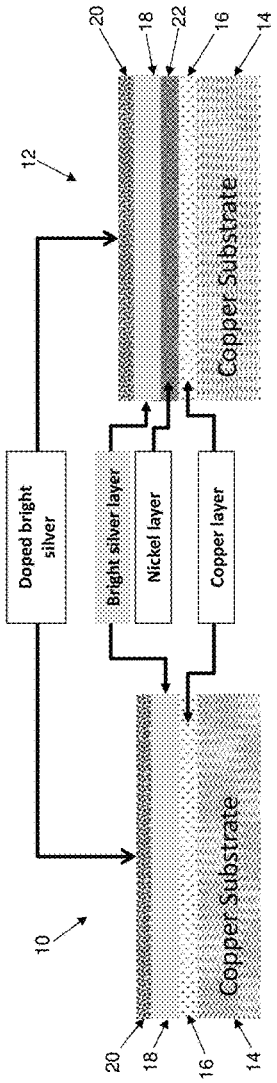

FIG. 2

PLATED LEAD FRAME INCLUDING DOPED SILVER LAYER

FIELD OF THE INVENTION

The invention relates to lead frames for the assembly of semiconductor devices, and in particular to lead frames that are adapted for the assembly of light-emitting device ("LED") related products.

BACKGROUND AND PRIOR ART

In lead frames used for the assembly of LED-related products, a bright silver plating is typically plated on a copper lead frame, or a bright silver plating is plated on a nickel plating layer such that the nickel plating layer is located between the bright silver plating layer and the copper lead frame.

FIG. **1** illustrates prior art plating schemes for the manufacture of bright silver LED devices. A first typical prior art plating scheme for a lead frame **100** comprises a base copper substrate **104** which is plated with copper to form a copper layer **106** over the base copper substrate **104**. The copper layer **106** is further plated with a bright silver layer **108** comprising silver.

A second typical prior art plating scheme for a lead frame **102** comprises a base copper substrate **104** which is plated with copper to form a copper layer **106** over the base copper substrate **104**. Nickel is then plated over the copper layer **106** to form a nickel layer **110** on top of it. Finally, the lead frame **102** is plated with a bright silver layer **108** on top of the nickel layer **110**.

For both plating schemes used to fabricate the respective lead frames **100**, **102**, copper plating is applied on the surface of the base copper substrate **104** prior to conducting bright silver plating or nickel plating onto the lead frame surface.

In the typical plating schemes described above, it has been found that silver or silver ion migration occurs on the bright silver layer **108**. Such silver or silver ion migration is a major problem because it causes tarnishing of the bright silver layer **108**, leading to a decrease in the lumen or emission of visible light from the LED device. The foregoing events deteriorate LED performance in the final product.

SUMMARY OF THE INVENTION

It is thus an object of the invention to seek to improve the LED performance in LED devices by retarding migration of silver or silver ions to the surface of the lead frame.

According to a first embodiment of the invention, there is provided a method of manufacturing a lead frame, comprising the steps of: providing a substrate comprising copper; plating a layer of bright silver onto the substrate; and thereafter plating a layer of doped bright silver over a top surface of the layer of bright silver.

According to a second embodiment of the invention, there is provided a lead frame comprising: a substrate comprising copper; a layer of bright silver; and a layer of doped bright silver over a top surface of the layer of bright silver.

It would be convenient hereinafter to describe the invention in greater detail by reference to the accompanying drawings which illustrate specific preferred embodiments of the invention. The particularity of the drawings and the related description is not to be understood as superseding the generality of the broad identification of the invention as defined by the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Examples of plating processes in accordance with the invention will now be described with reference to the accompanying drawings, in which:

FIG. **1** illustrates prior art plating schemes for the manufacture of bright silver LED devices; and

FIG. **2** illustrates plating schemes for the manufacture of bright silver LED devices according to the preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE INVENTION

FIG. **2** illustrates plating schemes for the manufacture of bright silver LED devices according to the preferred embodiment of the invention. One embodiment of a lead frame **10** fabricated according to the plating scheme comprises a base copper substrate **14** which is plated with copper to form a copper layer **16** over the base copper substrate **14**. Thereafter, a bright silver layer **18** comprising silver is plated onto the copper layer **16**. Thereafter, a doped bright silver layer **20** is further formed over a top surface of the underlying bright silver layer **18**.

In another embodiment of a lead frame **12** manufactured according to the plating scheme, a base copper substrate **14** is plated with copper to form a copper layer **16** over the base copper substrate **14**. A layer of nickel is then plated over the copper layer **16** to form a nickel layer **22** on top of it. Thereafter, the nickel layer **22** is plated with a bright silver layer **18** on top of the nickel layer **22**. A doped bright silver layer **20** is then further formed over the underlying bright silver layer **18**.

According to the preferred embodiment, the plating to form the copper layer **16** may be performed in an aqueous solution comprising: 10-80% Copper sulfate, 0.1-1% brightener, 0.1-1% leveler and 0.1-1% carrier. The carrier may be made from a polymeric material, such as Polyethylene Glycol (PEG) or Polyalkylene Glycol (PAG). The brightener may comprise organic sulfides, disulfides, thioether or thiocarbamates, and the leveler may comprise quaternary nitrogen compounds.

The plating to form the nickel layer **22** may be conducted in an aqueous solution comprising: 30-80% nickel sulfamate, 15-30% nickel chloride and 5-10% boric acid.

The plating of the bright silver layer **18** may be conducted in an aqueous solution comprising: 20-60% Potassium silver cyanide, 10-15% potassium cyanide, 0.5-5% brightener, and 20-30% potassium phosphate.

The dopant used to form the doped bright silver layer **20** may comprise either palladium or gold. In case palladium is used as the dopant, plating of the doped bright silver layer **20** is conducted in an aqueous solution comprising: 2-20% ammonium tetrachloropalladate, and 40-60% ammonium phosphate. Alternatively, where palladium is used as the dopant, plating may also be conducted in an aqueous solution comprising: 2-20% ammonium tetrachloropalladate, 40-60% ammonium phosphate, and 1-5% brightener.

Where gold is used as the dopant, plating is conducted in an aqueous solution comprising: 2-20% potassium gold cyanide and 20-40% potassium phosphate.

It should be appreciated that a dopant comprising palladium and/or gold integrated in bright silver layer can improve the performance of LED as the GAM (gamma brightness) of silver is increased and the doped silver retards silver or silver ion migration. The dopant thus promotes the

GAM of silver as well as improves GAM stability by minimizing silver or silver ion migration.

With the addition of the dopant, the GAM of silver can be improved by 0.2 GAM, and stronger thermal stability of the lead frame **10**, **12** is achieved since the GAM of silver can thereby be preserved even after heating the lead frame **10**, **12** at 360° C. for 20 seconds.

The invention described herein is susceptible to variations, modifications and/or additions other than those specifically described and it is to be understood that the invention includes all such variations, modifications and/or additions which fall within the spirit and scope of the above description.

The invention claimed is:

1. Method of manufacturing a lead frame, comprising the steps of:

providing a substrate comprising copper;

plating a layer of bright silver onto the substrate;

after plating the layer of bright silver onto the substrate, plating a layer of doped bright silver over a top surface of the layer of bright silver; and

plating a layer of copper onto the substrate prior to plating the layer of bright silver, such that the layer of bright silver is plated over the layer of copper;

wherein the step of plating the layer of copper is conducted in an aqueous solution comprising copper sulfate, a brightener, a leveler and a carrier.

2. Method of manufacturing a lead frame as claimed in claim **1**, wherein the carrier comprises Polyethylene Glycol (PEG) or Polyalkylene Glycol.

3. Method of manufacturing a lead frame, comprising the steps of:

providing a substrate comprising copper;

plating a layer of bright silver onto the substrate;

after plating the layer of bright silver onto the substrate, plating a layer of doped bright silver over a top surface of the layer of bright silver; and

plating a layer of nickel prior to plating the layer of bright silver, such that the layer of bright silver is plated over the layer of nickel;

wherein the step of plating the layer of nickel is conducted in an aqueous solution comprising nickel sulfamate, nickel chloride and boric acid.

4. Method of manufacturing a lead frame, comprising the steps of:

providing a substrate comprising copper;

plating a layer of bright silver onto the substrate; and thereafter

plating a layer of doped bright silver over a top surface of the layer of bright silver;

wherein the step of plating the layer of bright silver is conducted in an aqueous solution comprising potassium silver cyanide, potassium cyanide, a brightener, and potassium phosphate.

5. Method of manufacturing a lead frame as claimed in claim **4**, wherein the dopant used for doping the layer of doped bright silver comprises palladium.

6. Method of manufacturing a lead frame as claimed in claim **5**, wherein the step of plating the layer of doped bright silver is conducted in an aqueous solution comprising ammonium tetrachloropalladate and ammonium phosphate.

7. Method of manufacturing a lead frame as claimed in claim **5**, wherein the step of plating the layer of doped bright silver is conducted in an aqueous solution comprising ammonium tetrachloropalladate, ammonium phosphate, and a brightener.

8. Method of manufacturing a lead frame as claimed in claim **4**, wherein the dopant used for doping the layer of doped bright silver comprises gold.

9. Method of manufacturing a lead frame as claimed in claim **8**, wherein the step of plating the layer of doped bright silver is conducted in an aqueous solution comprising potassium gold cyanide and potassium phosphate.

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