

PATENT SPECIFICATION

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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

A Method for Plating a support for a Silicon Wafer in the Manufacture of Semiconductor Devices.

We, TEXAS INSTRUMENTS INCORPORATED, a Corporation organized according to the laws of the State of Delaware, United States of America, of 13500 North Central Expressway, Dallas, Texas, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates generally to a method of manufacturing a semiconductor device such as a rectifier or a transistor in which a silicon wafer is secured to a support including a header and a high heat conducting metal intermediate the header and the silicon wafer. More particularly, the invention relates to a method of plating the support prior to securing the wafer thereto.

In the manufacture of a diffused silicon power transistor, it is general practice to secure the collector region of the silicon wafer to a support which includes a copper header having a molybdenum contact attached thereto intermediate the silicon wafer and the copper header. The purpose of such a support is rapidly and efficiently to dissipate the heat developed in the transistor during its use. While silicon has the ability to provide good electrical operation at high temperatures, its most efficient electrical operation occurs at lower temperatures. Therefore by reason of its high thermal conductance, the support dissipates the heat developed in the transistor and maintains the latter at its most efficient operating temperature. Additionally the molybdenum contact intermediate the

has a thermal coefficient of expansion similar to that of the silicon wafer and thus minimizes mechanical stress therein.

The manufacture of a semiconductor power device and in particular the securing of the silicon wafer to the support has resulted in many difficult problems, some of which are the protection of the silicon wafer against impurity contamination from adjacent materials and the reliability of the device during its life as effected by the materials adjacent the wafer.

Accordingly, it is an object of the invention to provide a method of plating a support in a novel manner prior to securing a silicon wafer thereto, whereby the silicon wafer is protected against impurity contamination from adjacent material when it is being secured to the support.

The word "coating" used herein is to be construed in the generic sense as meaning either the resulting structure, or the act of placing a layer of protective material on a surface; the surface may then be said to be "coated". The word "plating" and related words of the same derivation used herein and in the claims is to be construed in a specific sense as meaning either the resulting structure, or the act of placing of a layer of metal on a surface by chemical or electrical means; the surface may then be said to be "plated", for example, gold-plated. The word "cladding" and related words of the same derivation, used herein and in the claims is to be constructed in a specific sense as meaning either the resulting structure or the act of placing a thin veneer of metal on a surface principally by mechanical means; the surface then may be said to be "clad", for example, nickel-clad. Each of the above techniques

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protects the surface upon which it is placed.

The present invention is a method of plating a support on which a silicon wafer is to be secured, which support includes a header and a metal contact attached thereto, comprising the steps of masking a portion of the exposed face of the contact, nickel-plating the header and the unmasked surface of the contact, removing the mask, and gold-plating the header and said portion of the contact.

The header is preferably of copper and the contact of molybdenum. The silicon wafer may have a nickel plate bonded on one surface and the molybdenum contact be nickel-clad.

The present invention is also in a method of manufacturing a silicon power transistor, wherein the collector region of a silicon wafer is secured to a high thermal conductance support including a header and metal contact attached thereto intermediate the header and wafer, the steps of plating the support prior to securing the wafer comprising masking a portion of the exposed face of the contact, nickel-plating the header and the unmasked surface of the contact, removing the mask, and gold-plating the header and the said portion of the contact.

The present invention is also a semiconductor support comprising a copper header, a nickel-clad molybdenum contact attached to said header, nickel plating on the entire area of said header except the area covered by said contact, and gold plating on the entire area of said nickel plating, and on and in direct contact with the exposed area of said contact.

The present invention also provides an assembly comprising a semiconductor support as defined in the next preceding paragraph, a semiconductor wafer in direct contact with the gold plating adjacent said contact, and an insulating material covering the exposed area of said semiconductor wafer.

Plating the support in the manner disclosed herein and then securing the silicon wafer thereto results in a semiconductor device having the copper header nickel-plated and gold-plated and the contact face to which the wafer is to be secured only gold-plated. Generally, the silicon wafer will have a nickel-plate bonded to its surface adjacent the contact and the contact will have a nickel-clad thereon adjacent the wafer. It is the purpose of the invention to exclude the nickel-plate which is applied to the copper header from the area between the wafer and the contact because said nickel-plate in this area would laminate with the gold and the material

of the contact during operation and result in an unreliable device.

An embodiment of the invention will now be described with reference to the accompanying drawing, in which:

Figure 1 illustrates a conventional support including a copper header and nickel-clad molybdenum contact attached thereto;

Figure 2 illustrates a mask applied to the exposed face of the molybdenum contact according to one step of the invention;

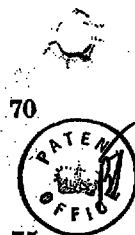
Figure 3 and 4 illustrate plating steps according to the invention; and

Figure 5 illustrates the silicon wafer secured to the plated support.

Referring now to the drawing, Figure 1 illustrates a support to be plated, which includes a copper header 1 and a molybdenum contact 2 having a nickel-clad surface, the nickel being brazed thereon. The support is characterised by its high thermal conductance and its low electrical resistance. Such a support is conventional for a semiconductor wafer in a silicon transistor power device and need not be described in further detail.

Figures 2 to 4 illustrate generally the masking and plating of the support according to the invention. A mask 3 is applied to the exposed face of the molybdenum contact as shown in Fig. 2, the mask may be any means which prevents nickel-plating from adhering to the masked face of the molybdenum contact. A suitable mask would be number 470 type masking tape produced by the Minnesota Mining and Manufacturing Company. After the exposed face of the molybdenum contact is masked, the copper header and the unmasked surface of the contact are nickel-plated and the resulting structure is illustrated in Figure 3. The mask is then removed and the support is gold-plated, the resulting structure being shown in Figure 4. It can be seen from Figure 4 that the face of the contact to be secured to the silicon wafer is only gold-plated and the copper header is both nickel-plated and gold-plated.

Referring to Figure 5, in the manufacture of a power transistor, the collector region of the silicon wafer 6 having a thin nickel plate bonded to its lower surface is secured to the exposed face of the molybdenum contact by placing the wafer on the contact, applying varnish 7 over the wafer and baking the unit, for example, at 270°C for 72 hours. The nickel-plating around the copper header has particular utility in the baking operation since it acts as a diffusion barrier between the copper header and the gold-plate and silicon wafer, thus protecting the silicon wafer from im-



Figures

purity contamination in the baking operation.

Summarizing, the nickel-plate 4 is excluded from the area between the contact and the wafer, whereby the semiconductor device is made more reliable during its life. Additionally the nickel-plate 4 around the copper header acts as a diffusion barrier and protects the silicon wafer against impurity contamination from adjacent materials.

By way of example, a detailed procedure for plating a support such as that illustrated in Figure 1 is given below:

Assume that the effective surface area of the support is 1.7 square inches; the applied nickel-plate thickness is to be 100 ± 15 micro inches and the gold-plate thickness is to be 70 ± 20 micro inches.

DETAILED PROCEDURE

I. CLEAN SUPPORT

- A. Degrease 3—5 minutes
- B. Alkaline cleaner for 2—3 minutes
- C. Two-stage water rinse, 5 seconds each stage
- D. Bright dip using a nitric sulphuric acid mixture for 2—3 seconds
- E. Two-stage water rinse, 5 seconds each stage
- F. Descale
- G. Two-stage water rinse, 5 seconds each stage
- H. Light acid gold strike by electroplating using 8—9 volts for 5 minutes to prevent copper header from oxidizing due to the bright dip (a process step which prevents the copper header from oxidizing and places about 8 to 10 microinches of gold on the surface of the header)
- I. Two-stage water rinse at room temperature (20°), 5 seconds each stage
- J. Rinse with warm water, that is, water above room temperature, for 10 seconds
- K. Dry gently with compressed air

II. MASK EXPOSED FACE OF MOLYBDENUM CONTACT

III. PREPARE FOR NICKEL-PLATING

- A. Activate unmasked surface of the support with solution containing 50% by weight HCL for 2—3 minutes
- B. Two-stage water rinse, 5 seconds each stage
- C. Light acid gold strike by electroplating using 8—9 volts for 3 minutes (a process step which prevents the copper header from oxidizing and places about 8 to 10 microinches of gold on the surface of the header)

- D. Water rinse at room temperature (20°), 5 seconds

IV. NICKEL-PLATE UNMASKED SURFACE ON THE SUPPORT BY ELECTROPLATING USING 13 AMPS FOR 40 MINUTES OR 520 AMP MINUTES

V. CLEAN NICKEL SUPPORT

- A. Two-stage water rinse, 5 seconds each stage
- B. Warm water, that is, water about room temperature, rinse
- C. Dry with air

VI. REMOVE MASK

VII. PREPARE FOR GOLD-PLATING

- A. Hot trichlorethylene spray or ultrasonically clean with hot trichlorethylene for 5 minutes
- B. Cyanide wash with agitation for 2 minutes
- C. Water rinse, 5 seconds
- D. Activate nickel-plated support with solution containing 50% by weight HCl for 2—3 minutes.
- E. Water at room temperature (20°) rinse, 5 seconds
- F. Light acid gold strike by electroplating using 8—9 volts for 4 minutes (a process step which prevents the copper header from oxidizing and places about 8 to 10 microinches of gold on the surface of the header)
- G. Two-stage water rinse, 5 seconds each stage

VIII. ACID GOLD-PLATE NICKEL-PLATED SUPPORT BY ELECTROPLATING USING 3.5 AMPS FOR 38 MINUTES OR 134 AMP MINUTES

IX. CLEAN

- A. Rinse, suitably with water, and save so as to reclaim gold
- B. Two-stage rinse with de-ionized water, 5 seconds each stage
- C. Hot water rinse, 10 seconds
- D. Dry

WHAT WE CLAIM IS:—

1. A method of plating a support on which a silicon wafer is to be secured, which support includes a header and a metal contact attached thereto, comprising the steps of masking a portion of the exposed face of the contact, nickel-plating the header and the unmasked surface of the contact, removing the mask, and gold-plating the header and said portion of the contact.

2. A method according to claim 1, in



purity contamination in the baking operation.

Summarizing, the nickel-plate 4 is excluded from the area between the contact and the wafer, whereby the semiconductor device is made more reliable during its life. Additionally the nickel-plate 4 around the copper header acts as a diffusion barrier and protects the silicon wafer against impurity contamination from adjacent materials.

By way of example, a detailed procedure for plating a support such as that illustrated in Figure 1 is given below:

Assume that the effective surface area of the support is 1.7 square inches; the applied nickel-plate thickness is to be 100 ± 15 micro inches and the gold-plate thickness is to be 70 ± 20 micro inches.

DETAILED PROCEDURE

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- C. Two-stage water rinse, 5 seconds each stage
- D. Bright dip using a nitric sulphuric acid mixture for 2—3 seconds
- E. Two-stage water rinse, 5 seconds each stage
- F. Descale
- G. Two-stage water rinse, 5 seconds each stage
- H. Light acid gold strike by electroplating using 8—9 volts for 5 minutes to prevent copper header from oxidizing due to the bright dip (a process step which prevents the copper header from oxidizing and places about 8 to 10 microinches of gold on the surface of the header)
- I. Two-stage water rinse at room temperature (20°), 5 seconds each stage
- J. Rinse with warm water, that is, water above room temperature, for 10 seconds
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II. MASK EXPOSED FACE OF MOLYBDENUM CONTACT

III. PREPARE FOR NICKEL-PLATING

- A. Activate unmasked surface of the support with solution containing 50% by weight HCL for 2—3 minutes
- B. Two-stage water rinse, 5 seconds each stage
- C. Light acid gold strike by electroplating using 8—9 volts for 3 minutes (a process step which prevents the copper header from oxidizing and places about 8 to 10 microinches of gold on the surface of the header)

- D. Water rinse at room temperature (20°), 5 seconds

IV. NICKEL-PLATE UNMASKED SURFACE ON THE SUPPORT BY ELECTROPLATING USING 13 AMPS FOR 40 MINUTES OR 520 AMP MINUTES

V. CLEAN NICKEL SUPPORT

- A. Two-stage water rinse, 5 seconds each stage
- B. Warm water, that is, water about room temperature, rinse
- C. Dry with air

VI. REMOVE MASK

VII. PREPARE FOR GOLD-PLATING

- A. Hot trichlorethylene spray or ultrasonically clean with hot trichlorethylene for 5 minutes
- B. Cyanide wash with agitation for 2 minutes
- C. Water rinse, 5 seconds
- D. Activate nickel-plated support with solution containing 50% by weight HCl for 2—3 minutes.
- E. Water at room temperature (20°) rinse, 5 seconds
- F. Light acid gold strike by electroplating using 8—9 volts for 4 minutes (a process step which prevents the copper header from oxidizing and places about 8 to 10 microinches of gold on the surface of the header)
- G. Two-stage water rinse, 5 seconds each stage

VIII. ACID GOLD-PLATE NICKEL-PLATED SUPPORT BY ELECTROPLATING USING 3.5 AMPS FOR 38 MINUTES OR 134 AMP MINUTES

IX. CLEAN

- A. Rinse, suitably with water, and save so as to reclaim gold
- B. Two-stage rinse with de-ionized water, 5 seconds each stage
- C. Hot water rinse, 10 seconds
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WHAT WE CLAIM IS:—

1. A method of plating a support on which a silicon wafer is to be secured, which support includes a header and a metal contact attached thereto, comprising the steps of masking a portion of the exposed face of the contact, nickel-plating the header and the unmasked surface of the contact, removing the mask, and gold-plating the header and said portion of the contact.

2. A method according to claim 1, in



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Step

- which the header is of copper and the contact is of molybdenum.
3. A method according to claim 1 or 2, further including the steps of securing a silicon wafer to the gold-plated face of the contact.
4. A method according to claim 2 or claims 2 and 3, in which the silicon wafer has a nickel plate bonded on one surface and the molybdenum contact is nickel-clad.
5. In a method of manufacturing a silicon power transistor, wherein the collector region of a silicon wafer is secured to a high thermal conductance support including a header and metal contact attached thereto intermediate the header and wafer, the steps of plating the support prior to securing the wafer comprising masking a portion of the exposed face of the contact, nickel-plating the header and the unmasked surface of the contact, removing the mask, and gold-plating the header and the said portion of the contact.
6. A method according to claim 5, wherein the header is of copper, the metal contact is nickel-clad molybdenum, and the collector region of the silicon wafer has a nickel plate bonded to its surface, which surface is secured to the gold-plated portion of said contact.
7. A support for a semiconductor wafer when plated by the method claimed in claim 1 or 2.
8. A semiconductor support and wafer assembly when made by the method claimed in claim 3, 4, 5, or 6.
9. A semiconductor support comprising a copper header, a nickel-clad molybdenum contact attached to said header, nickel plating on the entire area of said header except the area covered by said contact and gold plating on the entire area of said nickel plating and on and in direct contact with the exposed area of said contact.
10. An assembly comprising a semiconductor support according to claim 9, a semiconductor wafer in direct contact with the gold plating on said contact, and an insulating material covering the exposed area of said semiconductor wafer.
11. A semiconductor support and wafer assembly, substantially as hereinbefore described with reference to Fig. 5 of the accompanying drawing.
12. A support onto which a silicon wafer may be secured, substantially as hereinbefore described with reference to Fig. 4 of the accompanying drawing.

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