

- 1 -

DARK CF₄ FLASH**BACKGROUND OF THE INVENTION****(1) Field of the Invention**

The invention relates to a method of photoresist stripping, and more particularly, to a method of photoresist stripping which also removes polymer buildup and prevents corrosion in the manufacture of integrated circuits.

(2) Description of the Prior Art

In the manufacture of integrated circuit devices, photoresist is often used as a mask when etching metal to form metal lines. After metal etching, photoresist residue remains on the metal lines. A Cl_2 and BCl_3 plasma is often used in etching the metal lines. Chlorine-containing etchant byproducts form on the sidewalls of the metal lines during etching. If these byproducts are left on the sidewalls of the metal lines, they will react with absorbed moisture from the atmosphere to form hydrochloric acid which will corrode the metal lines. The so-called mouse-bite is a kind of pitting corrosion of the metal sidewalls which is triggered by the post-metal etch treatment and magnified during the subsequent solvent clean process.

It is desired to remove the photoresist residue and the polymer buildup on the sidewalls of the metal lines. In current practice, one solution is to preheat the wafer, then rinse it with water and use oxygen ashing to partially strip the photoresist and to remove the polymer. This prevents the corrosion and mouse-bite problems because it forms a homogeneous and thick native oxide layer at the metal sidewalls, but leaves some of the photoresist residue for a downstream process to remove. Even this partial strip can take a long time, as much as 100 seconds.

Many workers in the art have addressed this problem. Conventional stripping methods use a plasma of oxygen and an oxygen-activating gas such as CF_4 . This is sometimes ineffective when a polymeric resist is hardened by exposure to a plasma. Passivation techniques are used to prevent corrosion. The chlorine-etchant byproducts on the sidewalls of the metal lines are exposed to a CF_4 plasma, for example. The CF_4 plasma coats the sidewall polymer, preventing it from reacting to the atmospheric moisture. A wet chemical etchant is often used to strip sidewall deposits. A number of patents use O_2 and CF_4 to remove photoresist and sidewall residues. For example, U.S. Patent 5,545,289 to Chen et al, U.S. Patent 5,382,316 to Hills et al, U.S. Patent 5,174,856 to Hwang et al, U.S. Patent

5,221,424 to Rhoades, and U.S. Patent 5,007,981 to Kawasaki et al all use these two gases. Hwang et al also uses O_2 and NH_3 in a second step. All of these methods use a high power of more than 500 watts. U.S. Patent 5,200,031 to Latchford et al uses NH_3 and O_2 alone to remove photoresist and sidewall residues.

SUMMARY OF THE INVENTION

Accordingly, it is a principal object of the present invention to provide an effective and very manufacturable method of removing photoresist residues and sidewall deposits in the manufacture of integrated circuits.

Another object of the present invention is to provide a method of removing photoresist residues and sidewall deposits and to prevent metal corrosion.

Yet another object of the present invention is to provide a method of removing photoresist residues and sidewall deposits and to prevent metal sidewall voiding.

A further object of the invention is to provide a method of removing photoresist residues and sidewall deposits with improved throughput.

In accordance with the objects of this invention a new method of removing photoresist residues and sidewall deposits is achieved. Semiconductor device structures are provided in and on a semiconductor substrate. The semiconductor device structures are covered with an insulating layer. A metal layer is deposited overlying the insulating layer. The metal layer is covered with a layer of photoresist. The photoresist layer is exposed to actinic light and developed and patterned to form the desired photoresist mask. The metal layer is etched away where it is not covered by the photoresist mask to form metal lines whereby a photoresist residue remains overlying the metal lines and whereby sidewall deposits form on the sidewalls of the metal lines. The wafer is exposed to a plasma comprising O_2 and CF_4 at a low power of less than about 200 watts whereby an upper portion of the photoresist residue and a portion of the sidewall deposits are removed. Thereafter, the wafer is heated and then rinsed whereby all of the sidewall deposits are removed. Thereafter, the wafer is exposed to oxygen ashing whereby all of the photoresist residue is removed.



CLAIMS

1. A method of removing photoresist residue and sidewall deposits from a wafer in the fabrication of an integrated circuit comprising:

5 providing semiconductor device structures in and on a semiconductor substrate;

covering said semiconductor device structures with an insulating layer;

depositing a metal layer overlying said insulating layer;

10 covering said metal layer with a layer of photoresist;

exposing said photoresist layer to actinic light and developing and patterning said photoresist layer to form the desired photoresist mask;

15 etching away said metal layer where it is not covered by said photoresist mask to form metal lines whereby said photoresist residue remains overlying said metal lines and whereby said sidewall deposits form on the sidewalls of said metal lines;

20 exposing said wafer to a plasma comprising O_2 and CF_4 at a low power of less than about 200 watts whereby an upper portion of said photoresist residue and a portion of said sidewall deposits are removed;

thereafter heating said wafer;

25 thereafter rinsing said wafer whereby all of said



sidewall deposits are removed; and

thereafter exposing said wafer to oxygen ashing
whereby all of said photoresist residue is removed
completing said removing said photoresist residue and
30 said sidewall deposits from said wafer in said
fabrication of said integrated circuit.

2. The method according to Claim 1 wherein said
semiconductor device structures include gate electrodes
and source and drain regions.

3. The method according to Claim 1 further comprising
depositing a barrier metal layer underlying said metal
layer.

4. The method according to Claim 1 wherein said metal
layer comprises aluminum.

5. The method according to Claim 1 wherein said metal
layer comprises an aluminum alloy.

6. The method according to Claim 1 further comprising
depositing an antireflective coating layer overlying
said metal layer.

7. The method according to Claim 1 wherein said sidewall deposits include chlorine-containing etchant byproducts.

8. The method according to Claim 1 wherein said step of exposing said wafer to a plasma comprising O_2 and CF_4 comprises flowing O_2 at a rate of between about 200 and 300 sccm and flowing CF_4 at a rate of between about 60 and 90 sccm for less than about 10 seconds.

9. The method according to Claim 1 wherein said upper portion of said photoresist residue removed by exposing said wafer to a plasma comprising O_2 and CF_4 at said low power is a hardened outside layer of said photoresist residue.

10. The method according to Claim 7 wherein said portion of said sidewall deposits removed by exposing said wafer to a plasma comprising O_2 and CF_4 are those deposits having chlorine-containing etchant byproducts.

11. A method of removing photoresist residue and sidewall deposits from a wafer in the fabrication of an integrated circuit comprising:

providing semiconductor device structures in and on a semiconductor substrate;





covering said semiconductor device structures with
an insulating layer;

depositing a barrier metal layer overlying said
insulating layer;

10 depositing a metal layer overlying said
barrier metal layer;

depositing an antireflective coating layer
overlying said metal layer;

15 covering said antireflective coating layer with a
layer of photoresist;

exposing said photoresist layer to actinic light
and developing and patterning said photoresist layer to
form the desired photoresist mask;

20 etching away said metal layer where it is not
covered by said photoresist mask to form metal lines
whereby said photoresist residue remains overlying said
metal lines and whereby said sidewall deposits form on
the sidewalls of said metal lines;

25 exposing said wafer to a plasma comprising O₂ and
CF₄ at a low power of less than about 200 watts whereby
an upper portion of said photoresist residue and a
portion of said sidewall deposits are removed;

thereafter heating said wafer;

30 thereafter rinsing said wafer whereby all of said
sidewall deposits are removed; and



thereafter exposing said wafer to oxygen ashing
whereby all of said photoresist residue is removed
completing said removing said photoresist residue and
said sidewall deposits from said wafer in said
35 fabrication of said integrated circuit.

12. The method according to Claim 11 wherein said
semiconductor device structures include gate electrodes
and source and drain regions.

13. The method according to Claim 11 wherein said metal
layer comprises aluminum.

14. The method according to Claim 11 wherein said metal
layer comprises an aluminum alloy.

15. The method according to Claim 11 wherein said
sidewall deposits include chlorine-containing etchant
byproducts.

16. The method according to Claim 11 wherein said step
of exposing said wafer to a plasma comprising O_2 and CF_4
comprises flowing O_2 at a rate of between about 200 and
300 sccm and flowing CF_4 at a rate of between about 60
5 and 90 sccm for less than about 10 seconds.



17. The method according to Claim 11 wherein said upper portion of said photoresist residue removed by exposing said wafer to a plasma comprising O_2 and CF_4 at said low power is a hardened outside layer of said photoresist residue.

18. The method according to Claim 11 wherein said portion of said sidewall deposits removed by exposing said wafer to a plasma comprising O_2 and CF_4 are those deposits having chlorine-containing etchant byproducts.

19. The method according to Claim 11 wherein said photoresist residue remaining during said step of exposing said wafer to said plasma protects said underlying antireflective coating layer from being etched.

20. A method of removing photoresist residue and sidewall deposits from a wafer in the fabrication of an integrated circuit comprising:

providing semiconductor device structures in and on a semiconductor substrate;

covering said semiconductor device structures with an insulating layer;

depositing a barrier metal layer overlying said



insulating layer;

10 depositing a metal layer overlying said barrier
metal layer;

 depositing an antireflective coating layer
overlying said metal layer;

 covering said antireflective coating layer with a
15 layer of photoresist;

 exposing said photoresist layer to actinic light
and developing and patterning said photoresist layer to
form the desired photoresist mask;

 etching away said metal layer where it is not
20 covered by said photoresist mask to form metal lines
whereby said photoresist residue remains overlying said
metal lines and whereby said sidewall deposits form on
the sidewalls of said metal lines;

 exposing said wafer to a plasma comprising O_2 and
25 CF_4 at a low power of less than about 200 watts
for less than 10 seconds whereby an upper portion of
said photoresist residue and a portion of said sidewall
deposits are removed;

 thereafter heating said wafer;

30 thereafter rinsing said wafer whereby all of said
sidewall deposits are removed; and

 thereafter exposing said wafer to oxygen ashing for
no more than 40 seconds whereby all of said photoresist

residue is removed completing said removing said
35 photoresist residue and said sidewall deposits from said
wafer in said fabrication of said integrated circuit.

21. The method according to Claim 20 wherein said metal
layer comprises aluminum.

22. The method according to Claim 20 wherein said metal
layer comprises an aluminum alloy.

23. The method according to Claim 20 wherein said
sidewall deposits include chlorine-containing etchant
byproducts.

24. The method according to Claim 20 wherein said step
of exposing said wafer to a plasma comprising O_2 and CF_4
comprises flowing O_2 at a rate of between about 200 and
300 sccm and flowing CF_4 at a rate of between about 60
5 and 90 sccm.

25. The method according to Claim 20 wherein said upper
portion of said photoresist residue removed by exposing
said wafer to a plasma comprising O_2 and CF_4 at said low
power is a hardened outside layer of said photoresist
5 residue.



26. The method according to Claim 20 wherein said portion of said sidewall deposits removed by exposing said wafer to a plasma comprising O_2 and CF_4 are those deposits having chlorine-containing etchant byproducts.

27. The method according to Claim 20 wherein said photoresist residue remaining during said step of exposing said wafer to said plasma protects said underlying antireflective coating layer from being etched.

5

