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WET TIME ETCHING

FIELD OF INVENTION

The invention relates to a process for performing a wet time etch and in particular a process for performing a wet time etch on a micro electromechanical (MEMS) device.

BACKGROUND

Wet etching of silicon wafers is commonly used in many micro electromechanical devices for form thin membranes, cantilever beams, and holes. Chemicals such as potassium hydroxide (KOH), sodium hydroxide (NaOH), TMAH and EDB are widely used in industry. In forming thin membranes on a silicon wafer generally three critical parameters need to be considered; precise thickness control, uniformity of thickness in the entire wafer, a protection of active devices and metalization from being attacked by the etchant.

In order to achieve precise thickness, industries have implemented etch stop technology such as heavily doped p+ layer, oxide etch stop and electrochemical etch stop. All of these technologies pose complications in the fabrication of CMOS integrated circuits and widely used CMOS processes.

Because of the complications in the processes mentioned above time etching is a best technique for etching CMOS integrated circuit wafers. However, time etching also has problems. Using time etching it is hard to control the thickness and uniformity of wafers. As the wafer size increases uniformity becomes a more critical factor to control. Both the temperature gradient and the depletion of etchant concentration in the bath make time etching difficult to control.

SUMMARY OF INVENTION

It is the object of the invention to provide an improved time etching process or to at least provide the public with a useful choice.

In broad terms in one aspect the invention comprises an apparatus for etching micro electromechanical wafers including an etch bath arranged to contain a wafer holder and a mixture of etchant and deionised water, sensor means arranged to determine when the level of liquid in the etch bath falls below a predetermined level, a deionised water feeder arranged to provide deionised water to the etch bath, a rotation means arranged to rotate the wafer holder about a horizontal axis, wherein the wafer holder is arranged to accommodate a plurality of wafers in a row with space between the wafers.

Preferably the speed of rotation of the wafer holder is constant.

Preferably the rotation period can be adjusted.

Preferably the apparatus further includes a circulation pump arranged to provide uniform concentration of etchant when replenishing deionised water and to keep the temperature in the etch bath constant.

Preferably the etchant is potassium hydroxide. Alternatively the etchant may be sodium hydroxide or TMAH.

Preferably the apparatus further includes a wafer fixture into which wafers are clamped before being placed in the wafer holder.

Preferably the apparatus further includes means for lowering the wafer holder into the etch bath.

In broad terms in a further aspect the invention comprises a method for etching micro electromechanical wafers including the steps of providing an etch bath containing a wafer holder and a mixture of etchant and deionised water, sensing when the liquid level in the etch bath falls below a predetermined limit, providing deionised water to the etch bath when the liquid level falls below the predetermined limit, rotating the wafer holder around a horizontal axis and wherein the wafer holder is arranged to accommodate a plurality of wafers in a row with space between the wafers.

BRIEF DESCRIPTION OF DRAWINGS

A preferred form wet time etching method and apparatus of the invention is described with reference to the accompanying drawings, by way of reference only and without intending to be limiting, in which:

Figure 1 is a cut away view of an etch bath of the invention;

Figure 2A shows the back of a wafer fixture; and

Figure 2B shows the front of the wafer fixture of Figure 2A.

DETAILED DESCRIPTION

Figure 1 shows a portion of an etch bath 1. Wafers to be etched are placed in wafer fixtures 3 in holder 2. Wafer holder 2 can be raised and lowered into etch bath 1 by used of mechanism 6. The wafer bath also contains as rotation device for rotating the wafers. In the embodiment shown in Figure 1 the rotation device includes motor 1 and cogs 5. The motor is designed to rotate the cogs at constant

speed. The bottom cog is attached to wafer holder 2 and rotates wafer holder 2. The etch bath also includes a level sensor 7, and a deionised water feeder (not shown). In one embodiment the etch bath also includes a circulation pump (not shown).

The motor is powered by an external power source (not shown). The power source may be any suitable power source. Alternatively a different means may be used to rotate the wafer holder.

The motor can be arranged to provide different periods of rotation to the cogs and thus to the wafer holder. Different rotations periods are used as the uniformity and thickness requirements of the etched wafers differ. This provides flexibility to the wet etch system. The motor may be controlled by a control device (such as a microprocessor) that allows a user to set the rotation speed of the wafer holder, and hence the motor speed. The user may also be able to specify the time during which the wafer holder is rotated. For example a user may set the rotation speed of the wafer holder to 3 rpm and the time for rotation to 3 minutes. Alternatively different means may be used to set the speed and time of rotation.

Wafer holder 2 is designed to hold the wafers in a row with spaces between each wafer. The wafers are held vertically and the spaces allow the flow of etchant between the wafers so that each wafer is subjected to substantially the same conditions as all the other wafers. The wafer holder also includes spaces in the top, bottom and sides of the holder to further promote the flow of etchant around the wafers. The wafer holder is arranged to rotate with the rotation of cogs 5 about a horizontal axis.

Mechanism 6 may be any suitable mechanism that assists in the placing and removing wafer holder 2 from the etch bath. Mechanism 6 may further be arranged to assist in the alignment of wafer holder 2 within etch bath 1.

Level sensor 7 is used to assess the level of liquid in the etch bath. Level sensor 7 is arranged to assess whether the level of liquid in the bath has fallen below a predetermined lower level. The level sensor is also arranged to assess whether the level of liquid in the bath has reached a predetermined upper level. Level sensor 7 may be connected to a controller that operates a deionised water feeder in response to the indications from the level sensor. If the level sensor detects the lower liquid level the controller may send a signal to the deionised water feeder to begin feeding deionised water into the etch bath. When the level sensor 7 detects the upper liquid level the controller may send a signal to the deionised water feeder the stop feeding deionised water into the etch bath. The level sensor may be any suitable sensor and is not limited in placement to the position shown in Figure 1.

In another embodiment the level sensor only detects the lower liquid level and an overflow is provided at the upper liquid level so that any excess liquid flows out the overflow. In this embodiment when the level sensor detects the lower liquid level the controller may send a signal to the deionised water feeder to feed deionised water into the etch bath. In this embodiment either the controller sends a stop signal to the deionised water feeder after a predetermined period or the deionised water feeder arranged to stop feeding deionised water to the etch bath after a predetermined period of time.

The etch bath may further include a circulation pump arranged to pump the liquid in the etch bath. This promotes etchant flow in the etch bath and assists in reducing

the temperature gradient within the etch bath. The circulation pump may have its inlet within the etch bath or may use an overflow as the inlet.

In use, one the wafers and wafer holder are immersed in liquid in the etch bath the motor is operated to begin rotation of the wafer holder. The rotation speed can be set and the motor is arranged to rotate the wafer holder at the constant set rotation speed. As the wafer holder rotates the liquid in the etch bath moves around the bath and around the wafers in the wafer holder. The movement of liquid around the bath assists in reducing any temperature gradient within the etch bath. In a high temperature etching bath where the etching liquid contains and etchant (such as KOH, NaOH, TMAH or EDB) and deionised water, some of the deionised water evaporates. As this occurs the liquid level in the etch bath decreases. When the level sensor detects the liquid level below a predetermined level a deionised water feeder is activated and deionised water is added to the etchant bath to increase the level of liquid in the bath. The deionised water feeder may either stop feeding water to the etch bath after a predetermined amount of time or may be shut off when the level sensor detects the liquid level in the bath at an upper level.

By rotating the wafer holder and by optional use of a circulation pump the liquid in the etch bath moves around the bath. This reduces the temperature gradient in the bath which assists in providing a consistent etch rate over the wafer. Keeping the level of fluid in the bath above a predetermined level by the addition of deionised water as the level drops assists in keeping the concentration of the etchant constant.

A wafer onto which a cantilevered beam is to be etched is clamped into the wafer fixture before being placed in the wafer holder. The silicon wafer includes areas that have been covered by silicon nitride (SIN) that is not etched by the etchant and areas not covered by silicon nitride that will be etched by the etchant. The wafer

holder containing the wafer is lowered into the etch bath in which the etchant is KOH. The wafer holder is rotated at a constant speed of 7.5 rpm for 1 minute following which the wafer holder is removed from the etch bath. The wafer fixture is then washed in a washing solution to remove any remaining etchant. This process evenly etched the beam in the wafer.

Figures 2A and 2B show a wafer fixture for holding wafers before the wafers are placed in the wafer holder and etch bath. The wafer fixture of Figures 2A and 2B is arranged to cater for high temperature etching. Figure 2A shows the back of the wafer fixture and Figure 2B shows the front of the wafer fixture.

The back of the wafer fixture, shown in Figure 2A includes a back plate 21, a plurality of apertures for clamps 22 and two grooves 23 and 24. These are shown in the cross-sectional view at the bottom of Figure 2A.

The back plate 21 is solid and sits against or close to the back of the wafer. Grooves 23 and 24 are arranged to accommodate O-rings. The O-rings prevent etching from seeping through the fixture to the back of the wafer that may contain CMOS circuits. Figure 2A shows 16 apertures for clamps to clamp the two portions of the wafer fixture together. Preferably the clamps are screws but alternatively different clamps may be used.

Figure 2B shows the front plate of the wafer fixture. The front plate includes a central aperture, a plurality of apertures for clamps 22, and groove 26. These are also shown in the cross-sectional view at the bottom of Figure 2B.

The central aperture in the front plate 25 provides the opening for the face of the wafer to be etched. Groove 26 is arranged to accommodate an O-ring. Again the O-ring acts as a barrier to prevent the etchant from seeping through the fixture and

etching surfaces of the wafer other than the front surface. In one embodiment the inner most O-ring, sitting on top of the wafer, takes up a space of 5mm on the wafer with respect to the edge of it so as to maximise usage of the entire wafer.

In use the wafer is placed between the plates so that the surface of the wafer to be etched is in the central aperture of the front plate. The plate is arranged so that O-ring 26 completely surrounds part of the face of the wafer to be etched. The two plates are then clamped together using screws, or nuts and bolts through the apertures. The wafer fixture is then placed in the wafer holder.

The foregoing describes the invention including preferred forms thereof. Alterations and modifications as will be obvious to those skilled in the art are intended to be incorporated within the scope hereof as defined by the accompanying claims.

CLAIMS

1. An apparatus for etching micro electromechanical wafers including:

an etch bath arranged to contain a wafer holder and a mixture of etchant and deionised water,

sensor means arranged to determine when the level of liquid in the etch bath falls below a predetermined level,

a deionised water feeder arranged to provide deionised water to the etch bath,

rotation means arranged to rotate the wafer holder about a horizontal axis, wherein

the wafer holder is arranged to accommodate a plurality of wafers in a row with space between the wafers.

2. An apparatus for etching micro electromechanical wafers as claimed in claim 1 wherein the speed of rotation of the wafer holder is constant.

3. An apparatus for etching micro electromechanical wafers as claimed in claim 1 or claim 2 wherein the rotation period of the wafer holder can be adjusted.

4. An apparatus for etching micro electromechanical wafers as claimed in any one of claims 1 to 3 further including a circulation pump arranged to provide uniform concentration of etchant.

5. An apparatus for etching micro electromechanical wafers as claimed in any one of claims 1 to 4 further including a wafer fixture into which wafers are clamped before being placed in the wafer holder.

6. An apparatus for etching micro electromechanical wafers as claimed in any one of claims 1 to 5 further including means to lower the wafer holder into the etch bath.

7. An apparatus for etching micro electromechanical wafers as claimed in any one of claims 1 to 6 wherein the etchant is potassium hydroxide.

8. An apparatus for etching micro electromechanical wafers as claimed in any one of claims 1 to 6 wherein the etchant is sodium hydroxide.

9. An apparatus for etching micro electromechanical wafers as claimed in any one of claims 1 to 6 wherein the etchant is TMAH.

10. An apparatus for etching micro electromechanical wafers as claimed in any one of claims 1 to 6 wherein the etchant is EDB.

11. A method for etching micro electromechanical wafers including the steps of:

providing an etch bath containing a wafer holder and a mixture of etchant and deionised water,

sensing when the liquid level in the etch bath falls below a predetermined limit,

providing deionised water to the etch bath when the liquid level falls below the predetermined limit,

rotating the wafer holder around a horizontal axis and wherein

the wafer holder is arranged to accommodate a plurality of wafers in a row with space between the wafers.

12. A method for etching micro electromechanical wafers as claimed in claim 11 including the step of rotating the wafer holder at a constant speed.

13. A method for etching micro electromechanical wafers as claimed in claim 11 or claim 12 wherein the rotation period of the wafer holder can be adjusted.

14. A method for etching micro electromechanical wafers as claimed in any one of claims 11 to 13 further including a circulation pump arranged to provide uniform concentration of etchant.

15. A method for etching micro electromechanical wafers as claimed in any one of claims 11 to 14 further including the step of clamping the wafers into a wafer fixture before placing the wafers in the wafer holder.

16. A method for etching micro electromechanical wafers as claimed in any one of claims 11 to 15 further including means to lower the wafer holder into the etch bath.

17. A method for etching micro electromechanical wafers as claimed in any one of claims 11 to 16 wherein the etchant is potassium hydroxide.

18. A method for etching micro electromechanical wafers as claimed in any one of claims 11 to 16 wherein the etchant is sodium hydroxide.

19. A method for etching micro electromechanical wafers as claimed in any one of claims 11 to 16 wherein the etchant is TMAH.

20. A method for etching micro electromechanical wafers as claimed in any one of claims 11 to 16 wherein the etchant is EDB.