

ELECTROCHEMICAL ETCHING METHOD AND

ELECTROCHEMICAL ETCHING APPARATUS

FIELD OF THE INVENTION

The present invention relates to the technical field of semiconductor processing, and more particularly, to an electrochemical etching method and an electrochemical etching apparatus.

BACKGROUND

Electrochemical etching has great application potential in semiconductor processing due to the ability to precisely control the etching rate. Electrochemical etching requires an object to be etched to have high electrical conductivity. When the electrical conductivity of the object to be etched is poor, a severe edge effect occurs on the object to be etched during electrochemical etching. Specifically, the voltage in the central region of the object to be etched differs greatly from the voltage in the edge region, making it impossible to accurately control the potentials at various positions on the surface of the object to be etched. Therefore, electrochemical etching results in poor evenness when the object to be etched has poor electrical conductivity, and thus cannot be widely applied in semiconductor processing.

SUMMARY

In order to solve the above-mentioned problem existing in the prior art, the present invention provides an electrochemical etching method and an electrochemical etching apparatus.

The present invention solves the above technical problem through the following technical solutions:

An electrochemical etching method, comprising:

performing a metallization treatment on the back surface of an object to be etched, where the back surface does not need to be etched, so as to form a metal layer on the

back surface of the object to be etched;

performing an electrochemical etching treatment on the front surface of the object to be etched, where the front surface needs to be etched.

Preferably, before performing the metallization treatment on the back surface of the object to be etched, where the back surface does not need to be etched, the electrochemical etching method further comprises depositing a barrier layer on the back surface of the object to be etched.

Preferably, before depositing the barrier layer on the back surface of the object to be etched, the electrochemical etching method further comprises cleaning the back surface of the object to be etched.

Preferably, after performing the electrochemical etching treatment on the front surface of the object to be etched, where the front surface needs to be etched, the electrochemical etching method further comprises:

removing the metal layer on the back surface of the object to be etched;

removing the barrier layer on the back surface of the object to be etched.

Preferably, after performing the electrochemical etching treatment on the front surface of the object to be etched, where the front surface needs to be etched, the electrochemical etching method further comprises removing the metal layer on the back surface of the object to be etched.

Preferably, the thickness of the metal layer is equal to or more than 10 nm.

Preferably, the material of the barrier layer is any one of tantalum oxide, tantalum nitride, tantalum, titanium, titanium nitride, or cobalt.

Preferably, the thickness of the barrier layer is equal to or less than 1 nm.

Preferably, in the step of performing the electrochemical etching treatment on the front surface of the object to be etched, where the front surface needs to be etched, a

surface contact manner is adopted to supply power to the metal layer.

Preferably, in the step of performing the electrochemical etching treatment on the front surface of the object to be etched, where the front surface needs to be etched, the etching solution used for electrochemical etching is any one of potassium hydroxide (KOH), hydrofluoric acid (HF), or tetramethylammonium hydroxide (TMAH).

Preferably, in the step of performing the electrochemical etching treatment on the front surface of the object to be etched, where the front surface needs to be etched, the object to be etched is placed on a chuck of an electrochemical etching apparatus in an edge-clamping manner.

An electrochemical etching apparatus, comprising:

a plating module, configured to perform a metallization treatment on the back surface of the object to be etched, so as to form a metal layer on the back surface of the object to be etched;

an electrochemical etching module, configured to perform an electrochemical etching treatment on the front surface of the object to be etched;

a control module, including:

a transmission mechanism, configured to convey the object to be etched to the plating module and transfer the object to be etched from the plating module to the electrochemical etching module;

a controller, configured to send a work instruction to the transmission mechanism, the plating module, and the electrochemical etching module;

the controller controls the transmission mechanism to first convey the object to be etched to the plating module, when the object to be etched reaches the plating module, the controller sends a work instruction to the plating module, and the plating module performs the metallization treatment on the back surface of the object to be etched;

after the plating module finishes the work, the controller controls the transmission mechanism to transfer the object to be etched from the plating module to the electrochemical etching module;

when the object to be etched reaches the electrochemical etching module, the controller sends a work instruction to the electrochemical module, and controls the electrochemical etching module to perform the electrochemical etching treatment on the front surface of the object to be etched.

The positive and progressive effects of the present invention are as follows: In the present invention, before an electrochemical etching treatment, a metallization treatment is first performed on the back surface of an object to be etched, which can greatly reduce the resistance of the object to be etched, thereby effectively avoiding the edge effect on the object to be etched; during the electrochemical treatment, by supplying power to the metal layer on the back surface of the object to be etched, the potentials at various positions on the surface of the object to be etched can be accurately controlled, so that the potentials at all positions of the object to be etched remain consistent. The above effects avoid the uneven distribution of current density during the etching process, thereby enabling accurate control of the etching rate of the object to be etched and greatly reducing the difficulty of electrochemical etching for the object to be etched with poor electrical conductivity.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and performance of the present invention are further described by the following embodiments and the accompanying drawings of the embodiments.

FIG. 1 is a schematic flow diagram of the electrochemical etching method according to Embodiment 1 of the present invention;

FIG. 2 is a schematic flow diagram of the electrochemical etching method according to Embodiment 2 of the present invention.

PREFERRED EMBODIMENTS OF THE INVENTION

In order to describe the technical content, structural features, achieved objectives,

and effects of the present invention in detail, the following detailed description is made with reference to the embodiments and the accompanying drawings, but the present invention is not limited to the scope of the described embodiments.

Embodiment 1

The electrochemical etching process can precisely control the etching rate by selecting an appropriate electrolyte and controlling the potential and current of a working electrode. Therefore, the electrochemical etching process has great application potential in semiconductor processing. The objects of electrochemical etching are usually materials with high electrical conductivity. For materials with high electrical conductivity, the potential consistency at different positions is excellent, and the etching evenness is excellent. For materials with poor electrical conductivity, regions with high resistance are prone to forming higher local potential during the etching process, leading to uneven etching. In addition, poor electrical conductivity also causes a decrease in the etching rate and prolongs the etching time. For example, silicon has very poor electrical conductivity; even when cut into small pieces of 2 cm × 2 cm, the resistance can be as high as 1 MΩ. For materials with poor electrical conductivity, the method of increasing the voltage is usually used to improve the etching rate during electrochemical etching, but the problem of etching evenness still cannot be solved. At present, for materials with poor electrical conductivity, no effective method for electrochemical etching exists.

The embodiment of the present invention provides an electrochemical etching method, which can be applied to materials with poor electrical conductivity. The object to be etched in the embodiment of the present invention is a silicon wafer; however, the object to be etched is not limited thereto and can also be other materials with poor electrical conductivity.

As shown in FIG. 1, the electrochemical etching method comprises the following steps:

S100: Perform a metallization treatment on the back surface of a silicon wafer, where the back surface does not need to be etched, so as to form a metal layer on the back surface of the silicon wafer.

S200: Perform an electrochemical etching treatment on the front surface of the silicon wafer, where the front surface needs to be etched.

Before the electrochemical etching treatment, the metallization treatment is first performed on the back surface of the silicon wafer, which can greatly reduce the resistance of the silicon wafer, thereby effectively avoiding the edge effect on the silicon wafer. During the electrochemical treatment, by supplying power to the metal layer on the back surface of the silicon wafer, the potentials at various positions on the surface of the silicon wafer can be accurately controlled, so that the potentials at all positions of the silicon wafer remain consistent. The above method avoids the uneven distribution of current density during the etching process, thereby enabling the electrochemical etching rate of the front surface of the silicon wafer to remain consistent. Therefore, this embodiment greatly reduces the difficulty of etching the silicon wafer by the electrochemical method, optimizes the performance and effect of the electrochemical silicon etching process, and enables the process of etching the silicon wafer by the electrochemical method to achieve mass production.

In this embodiment, metals with high electrical conductivity, such as copper, silver, aluminum, etc., are selected.

The thickness of the metal layer is equal to or more than 10 nm. A thicker metal layer can provide lower resistance, enhance the electrical conductivity of the object to be etched, and maintain the consistency of the potentials at all positions of the object to be etched after power is supplied. Besides, the metal layer is not easily damaged during the power supply process, which helps to improve the stability during the electrochemical etching process. In addition, the thicker metal layer can provide improved structural support and stability to a certain extent, which can increase the mechanical strength of the back surface of the object to be etched and reduce the risk of deformation or cracking.

In step S200, a surface contact manner is adopted to supply power to the metal layer. Compared with the point contact manner, the surface contact manner not only does not easily damage the metal layer but also provides a more stable power supply.

In step S200, the etching solution used for electrochemical etching is any one of

KOH, HF, or TMAH.

In step S200, the object to be etched is placed on a chuck of an electrochemical etching apparatus in an edge-clamping manner. The edge-clamping manner can avoid damage to the metal layer on the back surface of the object to be etched, which would otherwise affect the difference in resistance on the back surface of the object to be etched and ultimately affect the evenness of electrochemical etching.

In this embodiment, the metallization treatment on the silicon wafer is performed by means of deposition to grow a metal layer on the surface of the silicon wafer. Since metal may penetrate into the silicon wafer during the metallization treatment on the silicon wafer, which affects subsequent production processes, step S90 (depositing a barrier layer on the back surface of the silicon wafer) is further included before step S100. Depositing the barrier layer can effectively control the diffusion of metal and prevent metal from entering the interior of the silicon wafer. In addition, depositing the barrier layer can also provide improved metal adhesion; the barrier layer can increase the adhesion between the metal and the back surface of the silicon wafer, ensuring improved contact between the metallized layer and the back surface of the silicon wafer.

Wherein, the material of the barrier layer can be any one of tantalum oxide, tantalum nitride, tantalum, titanium, titanium nitride, or cobalt.

In addition, the thickness of the barrier layer needs to be equal to or less than 1 nm. A thin barrier layer can not only prevent the metal layer from diffusing into the interior of the object to be etched, but also ensure the consistency of the potentials at all positions of the object to be etched after power is supplied.

In addition, step S80 (cleaning the back surface of the silicon wafer) is further included before step S90. This step helps to remove impurities on the back surface of the silicon wafer and enhance the bonding between the barrier layer and the silicon wafer.

Finally, after step S200, the electrochemical etching method further comprises:

S300: Remove the metal layer on the back surface of the silicon wafer.

S400: Remove the barrier layer on the back surface of the silicon wafer.

Certainly, if it is necessary to retain the metal layer after the completion of etching, steps S300 and S400 may not be performed.

Embodiment 2

In this embodiment of the present invention, if metal is not likely to penetrate into the interior of an object to be etched during the metallization treatment on the back surface of the object to be etched, step S90 may not be performed. As shown in FIG. 2, the electrochemical etching method at this time comprises:

S100: Perform a metallization treatment on the back surface of a silicon wafer, where the back surface does not need to be etched, so as to form a metal layer on the back surface of the silicon wafer;

S200: Perform an electrochemical etching treatment on the front surface of the silicon wafer, where the front surface needs to be etched;

S300: Remove the metal layer on the back surface of the silicon wafer.

In this embodiment, aluminum can be selected for deposition as the metal layer, and the aluminum is doped with 1% to 2% silicon.

In other embodiments, the manner of performing a metallization treatment on the back surface of the silicon wafer is not limited thereto; a metal sheet with high surface flatness can also be prepared and directly attached to the back surface of the silicon wafer.

Certainly, if it is necessary to retain the metal layer after the completion of etching, step S300 may not be performed.

Certainly, in this embodiment, the back surface of the silicon wafer may also be cleaned before Step S100 to increase the bonding ability between the metal layer and the silicon wafer.

Embodiment 3

The embodiment of the present invention provides an electrochemical etching apparatus. The electrochemical etching apparatus comprises a plating module, an electrochemical etching module, and a control module. The plating module is configured to perform a metallization treatment on the back surface of an object to be etched, so as to form a metal layer on the back surface of the object to be etched. The electrochemical etching module is configured to perform an electrochemical etching treatment on the front surface of the object to be etched.

The control module includes a transmission mechanism for conveying the object to be etched to the plating module and transferring the object to be etched from the plating module to the electrochemical etching module. The control module also includes a controller for sending a work instruction to the transmission mechanism, the plating module, and the electrochemical etching module. The controller controls the transmission mechanism to first convey the object to be etched to the plating module. When the object to be etched reaches the plating module, the controller sends a work instruction to the plating module, and the plating module performs the metallization treatment on the back surface of the object to be etched; after the plating module finishes the work, the controller controls the transmission mechanism to transfer the object to be etched from the plating module to the electrochemical etching module. When the object to be etched reaches the electrochemical etching module, the controller sends a work instruction to the electrochemical module and controls the electrochemical etching module to perform the electrochemical etching treatment on the front surface of the object to be etched.

The plating module can adopt an existing electroplating apparatus to perform the metallization treatment on the back surface of the object to be etched by means of the electroplating method. The electrochemical etching module can adopt an existing electrochemical etching machine. The transmission mechanism can adopt an existing transmission system, such as a manipulator.

Before the electrochemical etching module performs the etching treatment on the front surface of the object to be etched, the metallization treatment is first performed on the back surface of the object to be etched through the plating module to reduce the

resistance on the back surface of the object to be etched. Thus, the potentials at various positions on the surface of the object to be etched can be accurately controlled, so that the potentials at all positions of the object to be etched remain consistent, avoiding the uneven distribution of current density during the etching process, and further enabling the electrochemical etching rate of the front surface of the object to be etched to remain consistent.

Although the specific embodiments of the present invention have been described above, those skilled in the art should understand that these embodiments are merely examples, and various changes or modifications can be made to these embodiments without departing from the principle and essence of the present invention. Therefore, the protection scope of the present invention is defined by the appended claims.

What is claimed is:

1. An electrochemical etching method, comprising:

performing a metallization treatment on the back surface of an object to be etched, where the back surface does not need to be etched, so as to form a metal layer on the back surface of the object to be etched;

performing an electrochemical etching treatment on the front surface of the object to be etched, where the front surface needs to be etched.

2. The electrochemical etching method according to claim 1, wherein, before performing the metallization treatment on the back surface of the object to be etched, where the back surface does not need to be etched, the electrochemical etching method further comprises depositing a barrier layer on the back surface of the object to be etched.

3. The electrochemical etching method according to claim 2, wherein, before depositing the barrier layer on the back surface of the object to be etched, the electrochemical etching method further comprises cleaning the back surface of the object to be etched.

4. The electrochemical etching method according to claim 2, wherein, after performing the electrochemical etching treatment on the front surface of the object to be etched, where the front surface needs to be etched, the electrochemical etching method further comprises:

removing the metal layer on the back surface of the object to be etched;

removing the barrier layer on the back surface of the object to be etched.

5. The electrochemical etching method according to claim 1, wherein, after performing the electrochemical etching treatment on the front surface of the object to be etched, where the front surface needs to be etched, the electrochemical etching method further comprises removing the metal layer on the back surface of the object to be etched.

6. The electrochemical etching method according to claim 1, wherein the thickness of the metal layer is equal to or more than 10 nm.

7. The electrochemical etching method according to claim 2, wherein the material of the barrier layer is any one of tantalum oxide, tantalum nitride, tantalum, titanium, titanium nitride, or cobalt.

8. The electrochemical etching method according to claim 2, wherein the thickness of the barrier layer is equal to or less than 1 nm.

9. The electrochemical etching method according to claim 1, wherein, in the step of performing the electrochemical etching treatment on the front surface of the object to be etched, where the front surface needs to be etched, a surface contact manner is adopted to supply power to the metal layer.

10. The electrochemical etching method according to claim 1, wherein, in the step of performing the electrochemical etching treatment on the front surface of the object to be etched, where the front surface needs to be etched, the etching solution used for electrochemical etching is any one of KOH, HF, or TMAH.

11. The electrochemical etching method according to claim 1, wherein, in the step of performing the electrochemical etching treatment on the front surface of the object to be etched, where the front surface needs to be etched, the object to be etched is placed on a chuck of an electrochemical etching apparatus in an edge-clamping manner.

12. An electrochemical etching apparatus, comprising:

a plating module, configured to perform a metallization treatment on the back surface of the object to be etched, so as to form a metal layer on the back surface of the object to be etched;

an electrochemical etching module, configured to perform an electrochemical etching treatment on the front surface of the object to be etched;

a control module, including:

a transmission mechanism, configured to convey the object to be etched to the plating module and transfer the object to be etched from the plating module to the electrochemical etching module;

a controller, configured to send a work instruction to the transmission mechanism, the plating module, and the electrochemical etching module;

the controller controls the transmission mechanism to first convey the object to be etched to the plating module, when the object to be etched reaches the plating module, the controller sends a work instruction to the plating module, and the plating module performs the metallization treatment on the back surface of the object to be etched;

after the plating module finishes the work, the controller controls the transmission mechanism to transfer the object to be etched from the plating module to the electrochemical etching module;

when the object to be etched reaches the electrochemical etching module, the controller sends a work instruction to the electrochemical module, and controls the electrochemical etching module to perform the electrochemical etching treatment on the front surface of the object to be etched.