

Patent document 3: JP 2013-43268 A
Patent document 4: JP 2000-052226 A
Patent document 5: JP 2011-255475 A
Patent document 6: WO 2005/036629 A1
Patent document 7: JP 2004-503081 A
Patent document 8: JP 09-270400 A
Patent document 9: JP 2004-63954 A
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~~SUMMARY OF THE INVENTION~~

~~PROBLEMS TO BE SOLVED BY THE INVENTION~~

[0014] The present ~~disclosureinvention~~ has been made in view of the aforementioned actual situation. It is an object of the present ~~disclosureinvention~~ to provide a silicon wafer for solar cells having a low reflectance and less uneven brightness made by using a slice piece obtained by slicing polycrystalline silicon ingots employing fixed abrasive grain slicing and a production method thereof.

~~MEANS FOR SOLVING THE PROBLEMS~~

[0015] The inventors of the present ~~disclosureinvention~~ have found out that it is possible to obtain a silicon wafer for solar cells having a low reflectance and less uneven brightness by etching a polycrystalline silicon slice piece sliced by a fixed abrasive grain wire saw by use of a specific etching solution to reach the present invention. More specifically, the present ~~disclosureinvention~~ relates to a method for

producing a silicon wafer for solar cells which comprises the step of etching a polycrystalline silicon slice piece sliced by a fixed abrasive grain wire saw with an etching solution containing mixed acid composed of hydrofluoric acid, nitric acid, and sulfuric acid at a specific ratio.

[0016] The summary of the present ~~disclosureinvention~~ is described as below.

According to the present ~~disclosureinvention~~, there is provided a method for producing a silicon wafer for solar cells which includes the step of etching a slice piece made of polycrystalline silicon with an etching solution consisting essentially of mixed acid, wherein the slice piece is sliced by a fixed abrasive grain wire saw, the mixed acid is composed of hydrofluoric acid represented by chemical formula HF , nitric acid represented by chemical formula HNO_3 , and sulfuric acid represented by chemical formula H_2SO_4 , a composition range of the mixed acid is within a region surrounded by four line segments for connecting points in the sequence set forth in a triangular diagram that expresses the composition in weight %, the points include: point A, in which the hydrofluoric acid is 2.82 weight %, the nitric acid is 0.18 weight %, and the sulfuric acid is 97 weight %; point B, in which the hydrofluoric acid is 0.18 weight %, the nitric acid is 2.82 weight %, and the sulfuric acid is 97 weight %; point C, in which the hydrofluoric acid is 8.47 weight %, the nitric acid is 0.53 weight %, and the sulfuric acid is 91

weight %; and point D, in which the hydrofluoric acid is 0.53 weight %, the nitric acid is 8.47 weight %, and the sulfuric acid is 91 weight %, wherein the etching solution has a water concentration of 0 weight % to 10.5 weight %.

[0016a] The present disclosure provides a method for producing a silicon wafer for solar cells, comprising the step of etching a slice piece obtained by slicing polycrystalline silicon using a fixed abrasive grain wire saw with an etching solution consisting essentially of mixed acid,

the mixed acid is composed of hydrofluoric acid represented by chemical formula HF, nitric acid represented by chemical formula HNO_3 , and sulfuric acid represented by chemical formula H_2SO_4 ,

a composition range of the mixed acid is within a region surrounded by four line segments connected in the sequence set forth in a triangular diagram that expresses the composition in weight %, the four line segments comprising:

point A, in which the hydrofluoric acid is 2.82 weight %, the nitric acid is 0.18 weight %, and the sulfuric acid is 97 weight %;

point B, in which the hydrofluoric acid is 0.18 weight %, the nitric acid is 2.82 weight %, and the sulfuric acid is 97 weight %;

point C, in which the hydrofluoric acid is 8.47 weight %, the nitric acid is 0.53 weight %, and the sulfuric acid is 91 weight %; and

point D, in which the hydrofluoric acid is 0.53 weight %, the nitride acid is 8.47 weight %, and the sulfuric acid is 91 weight %, and

wherein the etching solution has a water concentration of 0 weight % to 10.5 weight %,

a surface of the silicon wafer has uneven parts formed of a plurality of bowl bottom-shaped concave holes formed on throughout the whole area of the surface thereof by etching the slice piece made of polycrystalline silicon obtained by being sliced by the fixed abrasive grain wire saw with the etching solution,

the plurality of concave holes each have an opening diameter of 2 μm to 15 μm , and

a plurality of fine holes each have an opening diameter of 0.1 μm to 1.5 μm formed on inner walls of the concave holes.

[0017] In the method for producing a silicon wafer for solar cells, particularly in the case where the slice piece is a polycrystalline silicon wafer sliced by a resin-bond wire saw, a silicon wafer for solar cells having a low reflectance and less brightness unevenness is obtainable.

According to the method for producing a silicon wafer for solar cells, a silicon wafer for solar cells, in which a surface of the silicon wafer has uneven parts formed of a plurality of bowl bottom-shaped concave holes, the plurality of concave holes

each have an opening diameter of 2 μm to 15 μm , and a plurality of fine holes each have an opening diameter of 0.1 μm to 1.5 μm formed on inner walls of the concave holes, is obtainable.

In the method for producing a silicon wafer for solar cells, the etching solution is to be used for etching the slice piece made of polycrystalline silicon sliced by the fixed abrasive grain wire saw, the etching solution consists essentially of mixed acid, the mixed acid is composed of hydrofluoric acid represented by a chemical formula HF , nitric acid represented by a chemical formula HNO_3 , and sulfuric acid represented by a chemical formula H_2SO_4 , a composition range of the mixed acid is within a region surrounded by four line segments for connecting

points in the sequence set forth in a triangular diagram that expresses the composition in weight %, the points include: point A, in which the hydrofluoric acid is 2.82 weight %, the nitric acid is 0.18 weight %, and the sulfuric acid is 97 weight %; point B, in which the hydrofluoric acid is 0.18 weight %, the nitric acid is 2.82 weight %, and the sulfuric acid is 97 weight %; point C, in which the hydrofluoric acid is 8.47 weight %, the nitric acid is 0.53 weight %, and the sulfuric acid is 91 weight %; and point D, in which the hydrofluoric acid is 0.53 weight %, the nitric acid is 8.47 weight %, and the sulfuric acid is 91 weight %, and the etching solution has a water concentration of 0 weight % to 10.5 weight %. The etching solution has a temperature of 0°C to 45°C when the etching is conducted.

[0018] In the etching solution, a saw wire to be used for the fixed abrasive grain wire saw may be a resin-bond wire saw.

ADVANTAGES OF THE INVENTION

[0019] The present ~~disclosure~~invention provides a silicon wafer for solar cells having a low reflectance and less bright unevenness made by the use of a slice piece obtained by slicing a polycrystalline silicon ingot employing fixed abrasive grain slicing and a method for producing thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

CLAIMS

1. A method for producing a silicon wafer for solar cells, comprising the step of etching a slice piece obtained by slicing made of polycrystalline silicon using a fixed abrasive grain wire saw with an etching solution consisting essentially of mixed acid,

~~wherein the slice piece is sliced by a fixed abrasive grain wire saw,~~

the mixed acid is composed of hydrofluoric acid represented by chemical formula HF, nitric acid represented by chemical formula HNO_3 , and sulfuric acid represented by chemical formula H_2SO_4 ,

a composition range of the mixed acid is within a region surrounded by four line segments connected in the sequence set forth in a triangular diagram that expresses the composition in weight %, the four line segments comprising:

point A, in which the hydrofluoric acid is 2.82 weight %, the nitric acid is 0.18 weight %, and the sulfuric acid is 97 weight %;

point B, in which the hydrofluoric acid is 0.18 weight %, the nitric acid is 2.82 weight %, and the sulfuric acid is 97 weight %;

point C, in which the hydrofluoric acid is 8.47 weight %, the nitric acid is 0.53 weight %, and the sulfuric acid is 91 weight %; and

point D, in which the hydrofluoric acid is 0.53 weight %, the nitride acid is 8.47 weight %, and the sulfuric acid is 91 weight %, and

wherein the etching solution has a water concentration of 0 weight % to 10.5 weight %,

a surface of the silicon wafer has uneven parts formed of a plurality of bowl bottom-shaped concave holes formed on throughout the whole area of the surface thereof by etching the slice piece made of polycrystalline silicon obtained by being sliced by the fixed abrasive grain wire saw with the etching solution,

the plurality of concave holes each have an opening diameter of 2 μm to 15 μm , and

a plurality of fine holes each have an opening diameter of 0.1 μm to 1.5 μm formed on inner walls of the concave holes.

2. The method for producing a silicon wafer for solar cells according to claim 1, wherein a saw wire to be used for the fixed abrasive grain wire saw is a resin-bond wire saw.

3. The method for producing a silicon wafer for solar cells according to claim 1 or claim 2, wherein the etching solution has a temperature of 0°C to 45°C when the etching is conducted.

~~4. A silicon wafer for solar cells, where a polycrystalline silicon wafer sliced by a fixed abrasive grain wire saw is formed by etching with the etching solution according to any one of claims 1 to 3,~~

~~wherein a surface of the silicon wafer has uneven parts formed of a plurality of bowl bottom shaped concave holes formed on throughout the whole area of the surface thereof,~~

~~the plurality of concave holes each have an opening diameter of 2 μm to 15 μm , and~~

~~a plurality of fine holes each have an opening
diameter of 0.1 μm to 1.5 μm formed on inner walls of the
concave holes.~~