

in a volumetric ratio between 1:1 and 10:1 or from 2:1 to 8:1 or about 4:1 (e.g., at the respective 65 wt/wt% and 40 wt/wt% strengths noted below). Nitric acid and hydrofluoric acid may be added at any suitable strength. For example, nitric acid may be added at a strength of 65 wt/wt% and hydrofluoric acid may be added at a strength of 40 wt/wt%. The nitric acid concentration in the first etchant solution may be from 50 to 55 wt/wt% and/or the hydrofluoric acid concentration may be from 6 to 8 wt/wt%. The first etchant solution may be free of chromium. The temperature of the first etchant solution may range between 20°C and 50°C or from 20°C and 40°C.

[0023] The structure may be contacted with the first etchant solution by immersing the structure with the solution. The amount of etchant solution (expressed as total silicon surface area of the structure per total volume of first etchant) may be from 40 cm²/liter to 85 cm²/liter. The length of time at which the structure 5 is contacted with the first etchant solution may be at least 30 minutes or at least 40 minutes (e.g., 30 to 45 minutes). In some embodiments, the structure is rotated during contact with the etchant solution to promote etching uniformity.

[0024] In accordance with some embodiments of the present disclosure, less than 150 µm of material is removed from the surface of the structure during contact with the first etching solution (at the 40 cm²/liter to 85 cm²/liter usage rate of first etchant).

C. Metal Coating

[0025] In step S_3 , the structure is coated with a composition comprising a metal. The metal is capable of diffusing through silicon to form a coated surface. The metal may be selected from copper, lithium and silver. In some embodiments, the metal is copper. When copper is used as the metal, the composition comprising copper may be a copper nitrate solution. For example, the solution may be $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$ (e.g., 0.1M).

[0026] The structure may be coated with the metal composition in any suitable manner that allows the metal to diffuse into the structure upon a subsequent anneal. For example, the metal composition may be brushed or sprayed onto the structure surface (e.g., the front surface or back surface only). Alternatively, the structure may be immersed in the metal composition. Once the structure is coated with the metal composition, the structure may be dried (e.g., for at least 20 minutes).

D. Anneal

[0027] After the structure is coated with the metal composition, the structure is annealed in step S_4 . The anneal causes the metal to diffuse from the surface and into the bulk region of the structure. The anneal may be at a temperature from 800°C to 950°C . The anneal may be for at least 20 minutes (e.g., from about 20 minutes to about 1 hour). Any suitable furnace may be used for the anneal (e.g., belt or muffle furnace). After annealing, the structure may be cooled (e.g., by air quenching).

E. Defect Delineation

C. Metal Coating

[0039] In step S3, the structure is coated with a composition comprising a metal. The metal is capable of diffusing through silicon to form a coated surface. The metal may be selected from copper, lithium and silver. In some embodiments, the metal is copper. When copper is used as the metal, the composition comprising copper may be a copper nitrate solution. For example, the solution may be $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$ (e.g., 0.1M).

[0040] The structure may be coated with the metal composition in any suitable manner that allows the metal to diffuse into the structure upon a subsequent anneal. For example, the metal composition may be brushed or sprayed onto one or more surfaces of the structure (e.g., the front surface or back surface only). Alternatively, the structure may be immersed in the metal composition. Once the structure is coated with the metal composition, the structure may be dried (e.g., for at least 20 minutes).

D. Anneal

[0041] After the structure is coated with the metal composition, the structure is annealed in step S₄. The anneal causes the metal to diffuse from the surface and into the bulk region of the structure. The anneal may be at a temperature from 800°C to 950°C. The anneal may be for at least 20 minutes (e.g., from about 20 minutes to about 1 hour). Any suitable furnace may be used for the anneal (e.g., belt or muffle furnace). After annealing, the structure may be cooled (e.g., by air quenching).

E. Defect Delineation

CLAIMS:

1. A method for detecting defects in an antimony-doped single crystal silicon structure having a front surface and a back surface, the method comprising:

immersing the structure in an ultrasonic bath;

contacting the structure with a first etchant solution comprising nitric acid and hydrofluoric acid to form an etched surface;

coating the etched surface with a composition comprising a metal capable of diffusing through silicon to form a coated surface;

annealing the structure comprising the coated surface to diffuse the metal into a bulk region of the structure; and

contacting the structure with a second etchant solution comprising nitric acid and hydrofluoric acid to delineate defects in the structure.

2. The method as set forth in claim 1 wherein the defects comprise slip dislocations, vacancy clusters, or oxygen-induced stacking faults.

3. The method as set forth in claim 1 wherein the structure is contacted with the first etchant solution at a first etchant solution temperature and the structure is contacted with the second etchant solution at a second etchant solution temperature, the second etchant solution temperature being less than the first etchant solution temperature.

4. The method as set forth in claim 3 wherein the first etchant solution temperature is between 20°C and

50°C and the second etchant solution temperature is between 15°C and 22°C.

5. The method as set forth in claim 4 wherein the second etchant solution temperature is between 15°C and 18°C.

6. The method as set forth in claim 1 wherein the structure has a <100> Orientation.

7. The method as set forth in claim 6 wherein the structure is an antimony-doped structure that has a <100> orientation, the first and second etchant solutions being different solution.

8. The method as set forth in claim 1 further comprising inspecting the structure for defects.

9. The method as set forth in claim 8 wherein inspecting the structure for defects comprises illuminating the structure to reveal pits formed on a surface of the structure.

10. The method as set forth in claim 8 wherein inspecting the structure for defects comprises viewing the structure with an optical microscope.

11. The method as set forth in claim 1 wherein the first etchant solution and second etchant solution are free of chromium.

12. The method as set forth in claim 1 wherein the ultrasonic bath comprises an alkaline detergent.

13. The method as set forth in claim 1 wherein the first etchant solution comprises nitric acid and hydrofluoric acid in a volumetric ratio between 1:1 and 10:1.

14. The method as set forth in claim 1 wherein the first etchant solution comprises between 50 and 55 wt/wt% nitric acid and between 6 to 8 wt/wt% hydrofluoric acid.

15. The method as set forth in claim 1 wherein the structure is a slug or wafer cut from a single crystal silicon ingot.

16. The method as set forth in claim 15 wherein the structure is not processed after being cut from an ingot and before being immersed in the ultrasonic bath.

17. The method as set forth in claim 1 wherein the metal is copper.

18. The method as set forth in claim 17 wherein the composition comprising the copper is a copper nitrate solution.

19. The method as set forth in claim 1 wherein the structure is annealed at a temperature from 800°C to 950°C.

20. The method as set forth in claim 19 wherein the structure is annealed for at least about 20 minutes.