CLAIMS

1. A method of preparing a multilayer structure, the method comprising:

(a) forming a front handle silicon dioxide layer on a front handle surface of a single crystal silicon handle wafer and a back handle silicon dioxide layer on a back handle surface of a single crystal silicon handle wafer, wherein the single crystal silicon handle wafer comprises two major, generally parallel surfaces, one of which is the front handle surface of the single crystal silicon handle wafer and the other of which is the back handle surface of the single crystal silicon handle wafer, a circumferential edge joining the front handle surface and the back handle surface of the single crystal silicon handle wafer, a central plane between the front handle surface and the back handle surface of the single crystal silicon handle wafer, and a bulk region between the front and back handle surfaces of the single crystal silicon handle wafer;

(b) forming a front handle silicon nitride layer on the front handle silicon dioxide layer;

(c) bonding the front handle silicon nitride layer to a donor silicon dioxide layer on a front donor surface of a single crystal silicon donor wafer to thereby form a bonded structure, wherein the single crystal silicon donor wafer comprises two major, generally parallel surfaces, one of which is the front donor surface of the single crystal silicon donor wafer and the other of which is the back donor surface of the single crystal silicon donor wafer, a circumferential edge joining the front donor surface and the back donor surface of the single crystal silicon donor wafer, a central plane between the front donor surface and the back donor surface of the single crystal silicon donor wafer, and a bulk region between the front and back donor surfaces of the single crystal silicon donor wafer, and further wherein the single crystal silicon donor wafer comprises a damage layer formed by ion implantation; and

(d) removing the back handle silicon dioxide layer.

2. The method of claim 1, wherein step (c) occurs before step (d).

3. The method of claim 1, wherein step (d) occurs before step (c).

4. The method of claim 1, wherein the back handle silicon dioxide layer is removed by wet etching.

5. The method of claim 1, wherein the front handle silicon dioxide layer is formed on the front handle surface of the single crystal silicon handle wafer and the back handle silicon dioxide layer on a back handle surface of the single crystal silicon handle wafer by thermal oxidation or by plasma enhanced chemical vapor deposition.

6. The method of claim 1, wherein the front handle silicon nitride layer is formed on the front handle silicon dioxide layer by plasma enhanced chemical vapor deposition or by low pressure chemical vapor deposition.

7. The method of claim 1, further comprising annealing the single crystal silicon handle wafer comprising the front handle silicon dioxide layer, the back handle silicon dioxide layer, and the front handle silicon nitride layer at a temperature and duration sufficient to densify the front handle silicon dioxide layer, the back handle silicon dioxide layer, or the front handle silicon nitride layer, or each of the front handle silicon dioxide layer, the back handle silicon dioxide layer, and the front handle silicon nitride layer.

8. The method of claim 1, further comprising ion milling the surface of the front handle silicon nitride layer prior to bonding the front handle silicon nitride layer to the donor silicon dioxide layer on the front donor surface of a single crystal silicon donor wafer.

9. The method of claim 1, further comprising chemical mechanical polishing the surface of the front handle silicon nitride layer prior to bonding the front handle silicon nitride layer to the donor silicon dioxide layer on the front donor surface of a single crystal silicon donor wafer.

10. The method of claim 1, further comprising annealing the bonded structure at a temperature and for a duration sufficient to strengthen the bond between the front handle silicon nitride layer and the donor silicon dioxide layer.

11. The method of claim 1, further comprising mechanically cleaving the bonded structure at the damage layer of the single crystal silicon donor wafer to thereby prepare a cleaved structure comprising the single crystal silicon handle wafer, the handle silicon dioxide layer, the handle silicon nitride layer, the donor silicon dioxide layer, and a single crystal silicon device layer.

12. A method of preparing a multilayer structure, the method comprising the following steps in order:

(a) forming a front handle silicon dioxide layer on a front handle surface of a single crystal silicon handle wafer and a back handle silicon dioxide layer on a back handle surface of a single crystal silicon handle wafer, wherein the single crystal silicon handle wafer comprises two major, generally parallel surfaces, one of which is the front handle surface of the single crystal silicon handle wafer and the other of which is the back handle surface of the single crystal silicon handle wafer, a circumferential edge joining the front handle surface and the back handle surface of the single crystal silicon handle wafer, a central plane between the front handle surface and the back handle surface of the single crystal silicon handle wafer, and a bulk region between the front and back handle surfaces of the single crystal silicon handle wafer;

(b) forming a front handle silicon nitride layer on the front handle silicon dioxide layer;

(c) applying a mask to the front handle silicon nitride layer on the front handle silicon dioxide layer;

(d) removing the back handle silicon dioxide layer;

(e) removing the mask; and

(f) bonding the front handle silicon nitride layer to a donor silicon dioxide layer on a front donor surface of a single crystal silicon donor wafer to thereby form a bonded structure, wherein the single crystal silicon donor wafer

comprises two major, generally parallel surfaces, one of which is the front donor surface of the single crystal silicon donor wafer and the other of which is the back donor surface of the single crystal silicon donor wafer, a circumferential edge joining the front donor surface and the back donor surface of the single crystal silicon donor wafer, a central plane between the front donor surface and the back donor surface of the single crystal silicon donor wafer, and a bulk region between the front and back donor surfaces of the single crystal silicon donor wafer, and further wherein the single crystal silicon donor wafer comprises a damage layer formed by ion implantation.

13. The method of claim 12, wherein the back handle silicon dioxide layer is removed by wet etching.

14. The method of claim 12, wherein the front handle silicon dioxide layer is formed on the front handle surface of the single crystal silicon handle wafer and the back handle silicon dioxide layer on a back handle surface of the single crystal silicon handle wafer by thermal oxidation or by plasma enhanced chemical vapor deposition.

15. The method of claim 12, wherein the front handle silicon nitride layer is formed on the front handle silicon dioxide layer by plasma enhanced chemical vapor deposition or by low pressure chemical vapor deposition.

16. The method of claim 12, further comprising annealing the single crystal silicon handle wafer comprising the front handle silicon dioxide layer, the back handle silicon dioxide layer, and the front handle silicon nitride layer at a temperature and duration sufficient to densify the front handle silicon dioxide layer, the back handle silicon dioxide layer, or the front handle silicon nitride layer, or each of the front handle silicon dioxide layer, the back handle silicon dioxide layer, and the front handle silicon nitride layer.

17. The method of claim 12, further comprising ion milling the surface of the front handle silicon nitride layer prior to bonding the front handle silicon nitride layer to the donor silicon dioxide layer on the front donor surface of a single crystal silicon donor wafer.

18. The method of claim 12, further comprising chemical mechanical polishing the surface of the front handle silicon nitride layer prior to bonding the front handle silicon nitride layer to the donor silicon dioxide layer on the front donor surface of a single crystal silicon donor wafer.

19. The method of claim 13, further comprising annealing the bonded structure at a temperature and for a duration sufficient to strengthen the bond between the front handle silicon nitride layer and the donor silicon dioxide layer.

20. The method of claim 13, further comprising mechanically cleaving the bonded structure at the damage layer of the single crystal silicon donor wafer to thereby prepare a cleaved structure comprising the single crystal silicon handle wafer, the handle silicon dioxide layer, the handle silicon nitride layer, the donor silicon dioxide layer, and a single crystal silicon device layer.

21. A method of preparing a multilayer structure, the method comprising the following steps in order:

(a) forming a front handle silicon dioxide layer on a front handle surface of a single crystal silicon handle wafer and a back handle silicon dioxide layer on a back handle surface of a single crystal silicon handle wafer by thermal oxidation of the single crystal silicon handle wafer, wherein the single crystal silicon handle wafer comprises two major, generally parallel surfaces, one of which is the front handle surface of the single crystal silicon handle wafer and the other of which is the back handle surface of the single crystal silicon handle wafer, a circumferential edge joining the front handle surface and the back handle surface of the single crystal silicon handle wafer, a central plane between the front handle surface and the back handle surface of the single crystal silicon handle wafer, and a bulk region between the front and back handle surfaces of the single crystal silicon handle wafer;

(b) forming a front handle silicon nitride layer on the front handle silicon dioxide layer and a back handle silicon nitride layer on the back handle silicon dioxide layer by low pressure chemical vapor deposition;

(c) removing the back handle silicon nitride layer by plasma etching;

(d) removing the back handle silicon dioxide layer by etching; and

(e) bonding the front handle silicon nitride layer to a donor silicon dioxide layer on a front donor surface of a single crystal silicon donor wafer to thereby form a bonded structure, wherein the single crystal silicon donor wafer comprises two major, generally parallel surfaces, one of which is the front donor surface of the single crystal silicon donor wafer and the other of which is the back donor surface of the single crystal silicon donor wafer, a circumferential edge joining the front donor surface and the back donor surface of the single crystal silicon donor wafer, a central plane between the front donor surface and the back donor surface of the single crystal silicon donor wafer, and a bulk region between the front and back donor surfaces of the single crystal silicon donor wafer, and further wherein the single crystal silicon donor wafer comprises a damage layer formed by ion implantation.

22. The method of claim 21, further comprising annealing the single crystal silicon handle wafer comprising the front handle silicon dioxide layer and the front handle silicon nitride layer at a temperature and duration sufficient to densify the front handle silicon dioxide layer, the front handle silicon nitride layer, or both, wherein the anneal occurs prior to bonding the front handle silicon nitride layer to the donor silicon dioxide layer on the front donor surface of a single crystal silicon donor wafer.

23. The method of claim 21, further comprising ion milling the surface of the front handle silicon nitride layer prior to bonding the front handle silicon nitride layer to the donor silicon dioxide layer on the front donor surface of a single crystal silicon donor wafer.

24. The method of claim 21, further comprising chemical mechanical polishing the surface of the front handle silicon nitride layer prior to bonding the front handle silicon nitride layer to the donor silicon dioxide layer on the front donor surface of a single crystal silicon donor wafer.

25. The method of claim 21, further comprising annealing the bonded structure at a temperature and for a duration sufficient to strengthen the bond between the front handle silicon nitride layer and the donor silicon dioxide layer.

26. The method of claim 21, further comprising mechanically cleaving the bonded structure at the damage layer of the single crystal silicon donor wafer to thereby prepare a cleaved structure comprising the single crystal silicon handle wafer, the handle silicon dioxide layer, the handle silicon nitride layer, the donor silicon dioxide layer, and a single crystal silicon device layer.