CLAIMS

1. A method for forming a light emitting diode (LED), comprising:

exposing a surface of a substrate to a nitrogen-containing composition, the substrate having a substrate material;

transferring nitrogen atoms from the nitrogen-containing composition to the substrate by adsorption onto the surface of the substrate, diffusion into the surface of the substrate, or both, at a temperature and/or energy level selected to prevent formation of a nitrodizing product of the substrate material;

forming a nitrogen-polar material on the surface of the substrate after transferring the nitrogen atoms, wherein the nitrogen atoms at least partially cause the nitrogen-polar material to form with nitrogen polarity and wherein the nitrogen-polar material is N-type gallium nitride (GaN); and

forming a LED structure by sequentially depositing the N-type gallium nitride, indium-gallium nitride (InGaN), and P-type GaN on the surface of the substrate, wherein the LED structure has an improved lattice quality relative to an LED structure with formation of a nitrodizing product of the substrate material.

2. The method of claim 1, wherein:

the substrate includes a silicon wafer;

the substrate material includes silicon (Si);

exposing the surface of the substrate includes—

generating a nitrogen plasma, and

directing the nitrogen plasma toward the surface of the silicon wafer;

transferring the nitrogen atoms includes adsorbing the nitrogen atoms from the nitrogen plasma onto the surface of the silicon wafer via Van der Waals forces.

3. The method of claim 1, wherein:

the substrate includes a silicon wafer;

the substrate material includes silicon (Si);

exposing the surface of the substrate includes depositing silicon nitride (SiN) on the surface of the silicon wafer, the deposited silicon nitride containing the nitrogen (N) atoms;

transferring the nitrogen atoms includes causing the nitrogen (N) atoms to migrate into the surface of the silicon wafer via heating and/or radiation; and

the method further includes removing the deposited silicon nitride (SiN) from the surface of the silicon wafer;

the nitrogen-polar material is N-type gallium nitride (GaN); and

the method further includes forming an LED structure by sequentially depositing the N-type GaN, InGaN, and P-type GaN on the surface of the silicon wafer after the silicon nitride (SiN) is removed from the surface of the silicon wafer.

4. The method of claim 1, wherein:

the substrate includes a silicon wafer;

the substrate material includes silicon (Si); and

the temperature and/or energy level is a temperature and/or energy level selected to prevent the nitrogen-containing composition from reacting with silicon at the surface of the silicon wafer to form silicon nitride (SiN).

5. The method of claim 1 wherein:

the substrate includes a silicon wafer; and

transferring the nitrogen atoms includes adsorbing the nitrogen (N) atoms onto the surface of the silicon wafer without forming silicon nitride (SiN) on the surface of the silicon wafer.

6. The method of claim 1 wherein:

the substrate includes a silicon wafer—

exposing the surface of the substrate includes:

generating a nitrogen plasma, and

directing the nitrogen plasma toward the surface of the silicon wafer; and

transferring the nitrogen atoms includes adsorbing the nitrogen (N) atoms from the nitrogen plasma onto the surface of the silicon wafer without forming silicon nitride (SiN) on the surface of the silicon wafer.

7. The method of claim 1, wherein:

the substrate includes a silicon wafer;

the substrate material includes silicon (Si);

exposing the surface of the substrate includes:

generating a nitrogen plasma; and

directing the nitrogen plasma toward the surface of the silicon wafer;

transferring the nitrogen atoms includes adsorbing the nitrogen (N) atoms from the nitrogen plasma onto the surface of the silicon wafer; and

the temperature and/or energy level is a temperature and/or energy level selected to prevent the nitrogen plasma from reacting with silicon at the surface of the silicon wafer to form silicon nitride (SiN).

8. The method of claim 1 wherein:

the substrate includes a silicon wafer having a lattice structure;

exposing the surface of the substrate includes depositing silicon nitride (SiN) on the surface of the silicon wafer, the deposited silicon nitride containing the nitrogen (N) atoms; and

transferring the nitrogen atoms includes causing at least some of the nitrogen (N) atoms to migrate into the surface of the silicon wafer, the migrated nitrogen (N) atoms being trapped in the

lattice structure of the silicon wafer without forming a silicon nitride (SiN) crystal structure with silicon (Si) in the silicon wafer.

9. The method of claim 1 wherein:

the substrate includes a silicon wafer;

exposing the surface of the substrate includes depositing silicon nitride (SiN) on the surface of the silicon wafer, the deposited silicon nitride containing the nitrogen (N) atoms;

transferring the nitrogen atoms includes causing the nitrogen (N) atoms to migrate into the surface of the silicon wafer; and

the method further includes removing the deposited silicon nitride (SiN) from the surface of the silicon wafer before forming the nitrogen-polar material.

10. The method of claim 1 wherein:

the substrate includes a silicon wafer having a lattice structure;

exposing the surface of the substrate includes depositing silicon nitride (SiN) on the surface of the silicon wafer, the deposited silicon nitride containing the nitrogen (N) atoms;

transferring the nitrogen atoms includes causing the nitrogen (N) atoms to migrate into the surface of the silicon wafer, the migrated nitrogen (N) atoms being trapped in the lattice structure of the silicon wafer without forming a silicon nitride (SiN) crystal structure with silicon (Si) in the silicon wafer; and

the method further includes removing the deposited silicon nitride (SiN) from the surface of the silicon wafer before forming the nitrogen-polar material.

11. A method for forming an LED, comprising:

exposing a surface of a substrate to a nitrogen-containing composition, the substrate having a substrate material;

increasing a nitrogen (N) concentration in the substrate at least proximate the surface of the substrate by transferring nitrogen atoms from the nitrogen-containing composition to the substrate at a temperature and/or energy level selected to prevent formation of a nitrodizing product of the substrate material; and

forming an LED structure on the surface of the substrate after increasing the nitrogen (N) concentration, the LED structure having a nitrogen polarity, wherein the nitrogen atoms at least partially cause the nitrogen polarity and wherein the LED structure has an improved lattice quality relative to an LED structure with formation of a nitrodizing product of the substrate material.

12. The method of claim 11 wherein:

the substrate includes a silicon wafer;

the substrate material includes silicon (Si); and

increasing the nitrogen (N) concentration includes adsorbing the nitrogen (N) atoms onto the surface of the silicon wafer without forming silicon nitride (SiN) on the surface of the silicon wafer.

13. The method of claim 11 wherein:

the substrate includes a silicon wafer;

the substrate material includes silicon (Si); and

increasing the nitrogen (N) concentration includes—

contacting the surface of the silicon wafer with a nitrogen plasma, and

adsorbing the nitrogen (N) atoms from the nitrogen plasma onto the surface of the silicon wafer without forming silicon nitride (SiN) on the surface of the silicon wafer.

14. The method of claim 11 wherein:

the substrate includes a silicon wafer;

the substrate material includes silicon (Si); and

increasing the nitrogen (N) concentration includes—

applying a nitrogen plasma to the surface of the silicon wafer,

adsorbing the nitrogen (N) atoms from the nitrogen plasma onto the surface of the silicon wafer, and

controlling the energy of the applied nitrogen plasma such that the nitrogen plasma does not react with silicon (Si) in the silicon wafer to form silicon nitride (SiN) on the surface of the silicon wafer.

15. The method of claim 11 wherein:

the substrate includes a silicon wafer;

the substrate material includes silicon (Si); and

increasing the nitrogen (N) concentration includes—

applying a nitrogen plasma to the surface of the silicon wafer,

adsorbing the nitrogen (N) atoms from the nitrogen plasma onto the surface of the silicon wafer, and

controlling the energy of the applied nitrogen plasma such that the nitrogen atoms are adsorbed on the surface of the silicon wafer via a molecular interaction having an interaction energy less than about 10 kcal/mol.

16. The method of claim 11 wherein:

the substrate includes a silicon wafer;

the substrate material includes silicon (Si); and

increasing the nitrogen (N) concentration includes—

applying a nitrogen plasma to the surface of the silicon wafer,

attaching the nitrogen (N) atoms from the nitrogen plasma onto the surface of the silicon wafer, and

controlling the energy of the applied nitrogen plasma such that the nitrogen atoms are attached on the surface of the silicon wafer not via a molecular interaction having an interaction

energy greater than about 50 kcal/mol.

17. The method of claim 11 wherein:

the substrate includes a silicon wafer;

the substrate material includes silicon (Si); and

increasing the nitrogen (N) concentration includes migrating the nitrogen (N) atoms into the surface of the silicon wafer without forming silicon nitride (SiN) on the surface of the silicon wafer.

18. The method of claim 11 wherein:

the substrate includes a silicon wafer;

the substrate material includes silicon (Si);

the method further includes depositing silicon nitride (SiN) onto the surface of the silicon wafer; and

increasing the nitrogen (N) concentration includes migrating the nitrogen (N) atoms from the deposited silicon nitride (SiN) into the surface of the silicon wafer without forming silicon nitride (SiN) on the surface of the silicon wafer.

19. The method of claim 11 wherein:

the substrate includes a silicon wafer;

the substrate material includes silicon (Si);

the method further includes depositing silicon nitride (SiN) onto the surface of the silicon wafer;

increasing the nitrogen (N) concentration includes migrating the nitrogen (N) atoms from the deposited silicon nitride (SiN) into the surface of the silicon wafer without forming silicon nitride (SiN) on the surface of the silicon wafer; and

the method further includes removing the deposited silicon nitride (SiN) from the surface of the silicon wafer before forming the LED structure.

20. A method for forming an LED on a substrate having a substrate material, comprising:

forming a nitrogen-rich portion of the substrate at a temperature and/or energy level selected to prevent formation of a nitrodizing product with the substrate material on the surface of the substrate; and

forming an LED structure with a nitrogen polarity by sequentially depositing N-type gallium nitride (GaN), indium-gallium nitride (InGaN), and P-type GaN on the nitrogen-rich portion of the substrate after forming the nitrogen-rich portion, wherein the nitrogen-rich portion at least partially causes the nitrogen polarity and wherein the LED structure has an improved lattice quality relative to an LED structure with formation of a nitrodizing product with the substrate material on the surface of the substrate.

21. The method of claim 20 wherein forming the nitrogen-rich portion includes adsorbing a

plurality of nitrogen (N) atoms onto a surface of the substrate without nitrodizing the substrate material on the surface of the substrate.

22. The method of claim 20 wherein forming the nitrogen-rich portion includes adsorbing nitrogen atoms on the surface of the substrate via a molecular interaction having an interaction energy less than about 10 kcal/mol.

23. The method of claim 20 wherein forming the nitrogen-rich portion includes adsorbing nitrogen atoms on the surface of the substrate without forming ionic or covalent bonds with the substrate material.

24. The method of claim 20 wherein forming the nitrogen-rich portion includes causing nitrogen atoms to migrate into the surface of the substrate without forming ionic or covalent bonds with the substrate material.

25. A method for forming a light emitting diode (LED), comprising:

generating a nitrogen plasma;

directing the nitrogen plasma toward the surface of a silicon wafer;

exposing the surface of the silicon wafer to the nitrogen plasma;

adjusting at least one of a plasma charge density and a plasma temperature such that the nitrogen plasma does not react with silicon (Si) at the surface of the silicon wafer to form silicon nitride (SiN);

adsorbing the nitrogen atoms from the nitrogen plasma onto the surface of the silicon wafer via Van der Waals forces; and

forming an LED structure by sequentially depositing N-type gallium nitride (GaN), indium-gallium nitride (InGaN), and P-type GaN on the surface of the silicon wafer after adsorbing the nitrogen atoms from the nitrogen plasma onto the surface of the silicon wafer, wherein the nitrogen atoms at least partially cause the N-type gallium nitride to form with nitrogen polarity, wherein the LED structure has an improved lattice quality relative to an LED structure with SiN formed at the surface of the silicon wafer.

26. A method for forming a light emitting diode (LED), comprising:

exposing a surface of a substrate to a nitrogen-containing composition, the substrate having a substrate material;

transferring nitrogen atoms from the nitrogen-containing composition to the substrate by adsorption onto the surface of the substrate, diffusion into the surface of the substrate, or both, while preventing formation of a nitrodizing product of the substrate material;

forming a nitrogen-polar material on the surface of the substrate after transferring the nitrogen atoms, wherein the nitrogen atoms at least partially cause the nitrogen-polar material to form with nitrogen polarity and wherein the nitrogen-polar material is N-type gallium nitride (GaN); and

forming an LED structure by sequentially depositing the N-type gallium nitride, indium-gallium nitride (InGaN), and P-type GaN on the surface of the substrate, wherein the LED structure has an improved lattice quality relative to an LED structure with formation of a nitrodizing product of the substrate material.