CLAIMS

1. A system or an apparatus comprising:

at least one preclean chamber comprising a substrate support configured to support a substrate;

at least one epitaxy chamber comprising a substrate support configured to support a substrate;

a plasma source;

at least one outlet for coupling to a vacuum;

one or more process gas inlets coupled to one or more fluorine-containing reactant sources;

one or more process gas inlets coupled to one or more hydrogen-containing reactant sources or deuterium-containing reactant sources;

one or more process gas inlets coupled to one or more first precursor sources;

one or more process gas inlets coupled to one or more second precursor sources;

one or more optional process gas inlets coupled to one or more optional third precursor sources;

one or more process gas inlets coupled to one or more halogen-containing reactant sources; and

one or more controllers for controlling operations, wherein the one or more controllers comprise machine-readable instructions for performing one or more cycles of:

causing introduction of the one or more fluorine-containing reactants to the preclean chamber;

causing transfer of the substrate from the preclean chamber to the epitaxy chamber under vacuum;

causing introduction of the one or more hydrogen-containing reactants or deuterium-containing reactants to the epitaxy chamber;

causing introduction of at least one of the one or more first precursors, second precursors, or optional third precursors in cycles to the epitaxy chamber;

causing transfer of the substrate out of the epitaxy chamber; and

causing introduction of the one or more halogen-containing reactants to the epitaxy chamber.

2. A system or an apparatus comprising:

at least one preclean chamber comprising a substrate support configured to support a substrate;

at least one pretreat chamber comprising a substrate support configured to support a substrate;

at least one epitaxy chamber comprising a substrate support configured to support a substrate;

a plasma source;

at least one outlet for coupling to a vacuum;

one or more process gas inlets coupled to one or more fluorine-containing reactant sources;

one or more process gas inlets coupled to one or more hydrogen-containing reactant sources or deuterium-containing reactant sources;

one or more process gas inlets coupled to one or more first precursor sources;

one or more process gas inlets coupled to one or more second precursor sources;

one or more optional process gas inlets coupled to one or more optional third precursor sources;

one or more process gas inlets coupled to one or more halogen-containing reactant sources; and

one or more controllers for controlling operations, wherein the one or more controllers comprise machine-readable instructions for performing one or more cycles of:

causing introduction of the one or more fluorine-containing reactants to the preclean chamber;

causing transfer of the substrate from the preclean chamber to the pretreat chamber under vacuum;

causing introduction of the one or more hydrogen-containing reactants or deuterium-containing reactants to the pretreat chamber;

causing transfer of the substrate from the pretreat chamber to the epitaxy chamber under vacuum;

causing introduction of the at least one of one or more first precursors, second precursors, or optional third precursors in cycles to the epitaxy chamber;

causing transfer of the substrate out of the epitaxy chamber; and

causing introduction of the one or more halogen-containing reactants to the epitaxy chamber.

3. The apparatus of any one of claims 1 or 2, wherein causing introduction of the one or more fluorine-containing reactants to the preclean chamber comprises causing delivering of a halogen-containing reagent, a halogen-containing vapor, or a halogen-containing plasma.

4. An apparatus to form heterolayers on a substrate, the apparatus comprising:

a reaction chamber;

a substrate support positioned in the reaction chamber and configured to support a substrate;

a plasma source; and

one or more controllers configured with instructions for performing the following operations:

(a) causing formation of a first layer by flowing a first precursor into the reaction chamber and toward the substrate in the presence of a plasma-generated energetic species, wherein the plasma-generated energetic species reacts with the first precursor to deposit the first layer on the substrate;

(b) causing formation of a second layer by flowing a second precursor and an optional third precursor into the reaction chamber and toward the substrate in the presence of a plasma-generated energetic species, wherein the plasma-generated energetic species reacts with the second precursor and the optional third precursor to deposit the second layer on the substrate; and

(c) causing repetition of (a) and (b) until a predetermined number of layers have been deposited on the substrate,

optionally wherein the first layer has a differing etch behavior than the second layer.

5. The apparatus of claim 4, wherein the plasma-generated energetic species comprises one or more of radicals, plasma-generated radicals, metastables, plasma-generated metastables, ions, or plasma-generated ions.

6. The apparatus of claim 4, wherein the plasma-generated energetic species comprises at least one of hydrogen-containing radicals, deuterium-containing radicals, helium-containing metastables, or argon-containing metastables.

7. The apparatus of claim 4, wherein the plasma-generated energetic species is characterized by a density of at least about 10^8 cm^{-3} at a surface of the substrate.

8. The apparatus of any one of claims 1, 2 or 4, further comprising instructions for (1) causing heating of the substrate using a radiative heat source, or (2) causing providing of an interfacial layer between the first layer and the second layer.

9. The apparatus of any one of claims 1, 2 or 4, further comprising either:

(1) instructions for causing exposing of the substrate to a plasma after operation (a), between operations (a) and (b), or after operation (b); or

(2) before operation (a) or after operation (c), instructions for causing performing of at least one of operation (a′) or (a″):

(a′) precleaning the substrate to provide a precleaned surface of the substrate; or

(a″) pretreating the surface of the substrate to provide a pretreated surface of the substrate; or

(3) before operation (a) or after operation (c), instructions for causing performing of at least one of operation (c′) or (c″):

(c′) performing a reactor clean of the reaction chamber either after removing the substrate from the reaction chamber or before providing the substrate to the reaction chamber by removing contaminants from an environment or a surface within the reaction chamber; or

(c″) instructions for causing performing of a reactor treat of the reaction chamber after operation (c′) by passivating the environment or the surface within the reaction chamber.

10. A method for forming heterolayers on a substrate, the method comprising:

(a) forming a first layer by flowing a first precursor into a reaction chamber and toward a substrate in the presence of an energetic species, wherein the energetic species reacts with the first precursor to deposit the first layer on the substrate, and wherein the substrate is disposed within the reaction chamber;

(b) forming a second layer by flowing a second precursor and an optional third precursor into the reaction chamber and toward the substrate in the presence of an energetic species, wherein the energetic species reacts with the second precursor or the optional third precursor to deposit the second layer on the substrate; and

(c) repeating (a) and (b) until a predetermined number of layers have been deposited on the substrate,

optionally wherein the first layer has a differing etch behavior than the second layer.

11. The method of claim 10, further comprising, before operation (a) or (b):

(a‴) depositing a buffer layer between the substrate and the first layer or between the substrate and the second layer.

12. The method of claim 10, wherein operations (a) and (b) occur subsequent to an initial layer being deposited on the substrate.

13. The method of claim 10, wherein (1) the plasma-generated energetic species is generated in a remote plasma source positioned upstream of the reaction chamber, or (2) the energetic species is generated in situ in a portion of the reaction chamber, or (3) wherein the energetic species is generated by way of plasma.

14. A method for epitaxially depositing a film, the method comprising:

precleaning a surface of a substrate to remove an oxide;

pretreating the surface of the substrate to provide a hydrophobic surface or a passivated surface;

epitaxially depositing at least one of a first layer or a second layer in the presence of plasma on a precleaned and pretreated surface and within an epitaxy chamber;

removing the substrate from the epitaxy chamber; and

performing a reactor clean, wherein the performing the reactor clean is performed at least one of before providing the substrate within the epitaxy chamber or after the removing the substrate from the epitaxy chamber.

15. The method of claim 14, further comprising, before the epitaxially depositing: depositing a buffer layer between the substrate and the first layer or between the substrate and the second layer.

16. A method for forming a stack, the method comprising:

precleaning a substrate to provide a precleaned surface;

pretreating the precleaned surface of the substrate to provide a precleaned, pretreated surface;

epitaxially depositing a plurality of alternating first layers and second layers in the presence of plasma on the precleaned, pretreated surface of the substrate and within an epitaxy chamber;

removing the substrate from the epitaxy chamber; and

performing a reactor clean of the epitaxy chamber, wherein the performing the reactor clean is performed at least one of before providing the substrate within the epitaxy chamber or after the removing the substrate from the epitaxy chamber.

17. The method of claim 16, wherein the precleaning comprises exposing the surface of the substrate with a halogen-containing reagent, a halogen-containing vapor, a halogen-containing plasma, or a hydrogen-containing reagent, a deuterium-containing reagent, a hydrogen-containing plasma, or a deuterium-containing plasma.

18. The method of one of claims 14 or 16, wherein the epitaxially depositing comprises remote plasma.

19. The method of claim 16, further comprising, either (1) after the epitaxially depositing: depositing a hardmask on a surface of the plurality of alternating first layers and second layers; or (2) before the epitaxially depositing: depositing a buffer layer between the substrate and the plurality of alternating first layers and second layers.