Claims:

1. A method of cleaning a surface of a substrate, comprising:

providing a hydrogen containing gas to a first chamber having a plurality of filaments disposed therein;

flowing a current through the plurality of filaments to raise a temperature of the plurality of filaments to a process temperature sufficient to decompose at least some of the hydrogen containing gas; and

cleaning the surface of the substrate by exposing the substrate to hydrogen atoms formed from the decomposed hydrogen containing gas.

2. The method of claim 1, wherein the hydrogen containing gas comprises hydrogen (H_2), hydrogen (H_2) and nitrogen (N_2), or ammonia (NH_3).

3. The method of claim 1, further comprising one of:

preheating the substrate in a preheat chamber prior to cleaning the surface of the substrate in a cleaning chamber different than the preheat chamber; or

preheating the substrate in a cleaning chamber prior to cleaning the surface of the substrate in the cleaning chamber.

4. The method of any of claims 1 to 3, wherein the first chamber is the same chamber where the substrate surface is cleaned, or wherein the first chamber is a different chamber than where the substrate surface is cleaned and the hydrogen atoms formed in the first chamber are provided to the chamber in which the substrate surface is cleaned.

5. The method of any of claims 1 to 3, further comprising, prior to providing the hydrogen containing gas to the first chamber, pre-treating the plurality of filaments by:

providing a hydrogen containing pre-treat gas to the first chamber;

heating the plurality of filaments to a first pre-treat temperature; and

cooling the plurality of filaments to a second pre-treat temperature.

6. The method of claim 5, wherein the hydrogen containing pre-treat gas comprises hydrogen (H_2) gas, hydrogen (H_2) and nitrogen (N_2), or ammonia (NH_3).

7. The method of claim 5, further comprising:

repeatedly heating the plurality of filaments to the first pre-treat temperature and cooling the plurality of filaments to the second pre-treat temperature.

8. A substrate cleaning system, comprising:

a process chamber having an internal volume;

a substrate support disposed in the internal volume of the process chamber to support a substrate to be cleaned in the process chamber;

an atomic hydrogen source configured to provide atomic hydrogen to the surface of the substrate during operation, the atomic hydrogen source comprising a plurality of filaments and a terminal to couple the plurality of filaments to a power source to heat the plurality of filaments to a temperature sufficient to produce atomic hydrogen from a hydrogen gas; and

a hydrogen gas source coupled to the atomic hydrogen source to provide hydrogen gas to the atomic hydrogen source.

9. The substrate cleaning system of claim 8, further comprising:

a gas distribution plate disposed between the atomic hydrogen source and the internal volume of the process chamber such that atomic hydrogen provided by the atomic hydrogen source passes through the gas distribution plate to reach the internal volume of the process chamber.

10. The substrate cleaning system of claim 8, wherein the atomic hydrogen source is separate from the process chamber.

11. The substrate cleaning system of claim 8, wherein the atomic hydrogen source is disposed within the process chamber.

12. The substrate cleaning system of claim 8, wherein the atomic hydrogen source is integrated into a process chamber lid that is removably coupleable to the process chamber.

13. The substrate cleaning system of claim 12, wherein the process chamber lid comprises:

a body having a recess formed in a lower surface of the body, wherein the plurality of filaments are disposed within the recess;

a gas inlet disposed above the plurality of filaments to provide the hydrogen gas to the plurality of filaments; and

a gas distribution plate coupled to the body beneath the plurality of filaments, the gas distribution plate having a plurality of holes to fluidly couple the recess to the internal volume.

14. The substrate cleaning system of claim 13, wherein the process chamber lid further comprises a liner disposed on the inner surface of the recess.

15. The substrate cleaning system of claim 8, wherein the plurality of filaments comprise tantalum (Ta), tungsten (W), or iridium (Ir), and optionally a silicon (Si) dopant.

Claims:

1. A method of cleaning a surface of a substrate, comprising:

pre-treating a plurality of filaments disposed in a first chamber by:

providing a hydrogen containing pre-treat gas to the first chamber;

heating the plurality of filaments to a first pre-treat temperature;

cooling the plurality of filaments to a second pre-treat temperature;

wherein the hydrogen containing pre-treat gas comprises hydrogen (H_2) gas, hydrogen (H_2) and nitrogen (N_2), or ammonia (NH_3);

providing a hydrogen containing gas to the first chamber;

flowing a current through the plurality of filaments to raise a temperature of the plurality of filaments to a process temperature sufficient to decompose at least some of the hydrogen containing gas; and

cleaning the surface of the substrate by exposing the substrate to hydrogen atoms formed from the decomposed hydrogen containing gas.