CLAIMS

1. A method of drying a semiconductor substrate, the method comprising:

applying a drying agent to a semiconductor substrate, wherein the drying agent wets the semiconductor substrate;

heating a chamber housing the semiconductor substrate to a temperature above an atmospheric pressure boiling point of the drying agent until vapor-liquid equilibrium of the drying agent is reached within the chamber;

reducing the pressure within the chamber to control the rate evaporation of the drying agent to maintain a contact angle of greater than or about 50°; and

venting the chamber, wherein the venting vaporizes the drying agent liquid phase from the semiconductor substrate.

2. The method of drying a semiconductor substrate of claim 1, further comprising:

pressure-sealing the semiconductor substrate within the chamber;

heating the chamber housing the semiconductor substrate, the heating causing vapor and liquid phases of the drying agent to reach equilibrium of vapor partial pressure and liquid saturation pressure; and

continuing to heat the chamber housing the semiconductor substrate to a temperature of at least about 100° C.

3. The method of drying a semiconductor substrate of claim 1, wherein the drying agent is miscible with water.

4. The method of drying a semiconductor substrate of claim 3, wherein the drying agent comprises isopropyl alcohol.

5. The method of drying a semiconductor substrate of claim 1, wherein the semiconductor substrate comprises patterned features having an aspect ratio greater than 5, and wherein the drying agent wets the patterned features completely.

6. The method of drying a semiconductor substrate of claim 1, wherein applying the drying agent fully displaces water from the semiconductor substrate.

7. The method of drying a semiconductor substrate of claim 6, wherein applying the drying agent comprises one or more operations fully displacing any fluid except for the drying agent from the semiconductor substrate.

8. The method of drying a semiconductor substrate of claim 1, wherein the heating is performed by:

hermetically closing the chamber with the semiconductor substrate including the applied drying agent housed within the chamber;

heating the chamber causing equilibrium to be reached between the drying agent liquid and vapor phases; and

heating the chamber to the temperature above the atmospheric pressure boiling point of the drying agent.

9. The method of drying a semiconductor substrate of claim 1, further comprising purging the chamber with an inert precursor subsequent the venting.

10. A method of drying a semiconductor substrate, the method comprising:

applying a drying agent to the semiconductor substrate, wherein the drying agent wets the semiconductor substrate;

heating a chamber in which the semiconductor substrate is housed to cause an equilibrium to be reached between liquid and vapor phases of the drying agent, wherein the heating maintains at least a portion of the drying agent in a liquid form having a contact angle of greater than or about 50°; and

exposing the chamber to vacuum conditions, wherein the vacuum conditions evaporate and purge the drying agent from the chamber.

11. The method of drying a semiconductor substrate of claim 10, wherein heating the chamber is performed to a temperature below about 150° C.

12. The method of drying a semiconductor substrate of claim 10, further comprising:

subsequent exposing the chamber to vacuum, venting the chamber to atmospheric conditions.

13. The method of drying a semiconductor substrate of claim 12, further comprising purging the chamber with air or an inert gas.

14. The method of drying a semiconductor substrate of claim 10, wherein the drying agent comprises isopropyl alcohol or acetone.

15. The method of drying a semiconductor substrate of claim 10, wherein exposing the chamber to vacuum conditions comprises reducing the pressure within the chamber from atmospheric conditions to a pressure of less than about 100 Torr.

16. The method of drying a semiconductor substrate of claim 15, wherein reducing the pressure within the chamber occurs in a time period of less than about 5 minutes.

17. A method of drying a substrate, the method comprising:

applying a drying agent to the substrate, wherein the drying agent wets the substrate;

hermetically sealing a chamber housing the substrate;

forming a vapor-liquid equilibrium of the drying agent within the chamber;

increasing the temperature within the chamber to reduce the drying agent surface tension for a liquid fraction of the drying agent below a predetermined threshold and achieving a new vapor-liquid equilibrium; and

depressurizing the chamber, wherein the depressurizing substantially removes liquid drying agent from the substrate.

18. The method of drying a substrate of claim 17, wherein the predetermined threshold comprises a drying agent surface tension of about 20 mN/m.

19. The method of drying a substrate of claim 17, wherein the substrate comprises a plurality of patterned features characterized by an aspect ratio greater than 5, and wherein applying the drying agent comprises coating the substrate with the drying agent above a height of the patterned features.

20. The method of drying a substrate of claim 17, wherein the drying agent is characterized by a surface tension of less than about 25 mN/m at about 21° C.