CLAIMS

1. A system comprising:

a load-lock chamber (LLC) of a substrate processing system, the LLC comprising one or more valves regulating a flow of gas directed into the LLC or out of the LLC; and

a controller configured to:

with the LLC sealed from an outside environment, initiate the flow of gas through the one or more valves; and

cause a rate of the flow of gas to correspond, at each of a plurality of times, to a respective reference flow rate (RFR) of a plurality of RFRs, wherein the plurality of RFRs comprise at least three RFRs and are determined to minimize occurrence of one or more contaminants within an environment of the LLC.

2. The system of claim 1, wherein the plurality of RFRs are determined in view of an initial pressure, a final pressure, and a target duration of a transition of the environment of the LLC from the initial pressure to the final pressure.

3. The system of claim 1, wherein the one or more contaminants appear in the environment of the LLC during a transition of the environment of the LLC from an initial pressure to a final pressure.

4. The system of claim 3 further comprising:

a pressure sensor communicatively coupled to the controller, wherein the controller is further to:

receive, from the pressure sensor, a current pressure reading;

obtain a difference of the received current pressure reading and a respective reference pressure value of a plurality of reference pressure values, the respective reference pressure value associated with a current instance of time; and

adjust the rate of the flow of gas through the one or more valves to mitigate the obtained difference.

5. The system of claim 1, wherein the one or more valves are configured to continuously regulate the flow of gas.

6. The system of claim 1, wherein the flow of gas is directed into the LLC, and wherein the plurality of RFRs are selected to minimize resuspension, within the environment of the LLC, of a particulate matter from an inner surface of the LLC.

7. The system of claim 1, wherein the flow of gas is directed out of the LLC, and wherein the plurality of RFRs are selected to prevent aerosol formation within the environment of the LLC.

8. A system comprising:

a substrate processing system (SPS) comprising a first chamber and a second chamber;

a first gate configured to selectively seal and unseal the first chamber of the SPS from the second chamber of the SPS;

a first valve configured to continuously regulate a flow of gas into the first chamber of the SPS; and

a controller communicatively coupled to the first gate and the first valve, the controller configured to:

cause the first gate to seal the first chamber of the SPS from the second chamber of the SPS; and

cause the first valve to receive a first input signal, wherein the first input signal is configured to cause the first valve to continuously regulate the flow of gas into the first chamber of the SPS over a first time period causing a pressure inside the first chamber of the SPS to follow a temporal sequence of target pressure values.

9. The system of claim 8, wherein the temporal sequence of the target pressure values is determined to reduce a degree of resuspension of particles in the first chamber of the SPS during the first time period.

10. The system of claim 8, wherein the controller is further to cause the first valve to receive a second input signal, wherein the second input signal is configured to cause the first valve to continuously regulate the flow of gas out of the first chamber of the SPS over a second time period.

11. The system of claim 10, wherein the second input signal is configured to cause a pressure inside the first chamber of the SPS to follow a temporal sequence of target pressure values,
wherein the temporal sequence of the target pressure values is determined to reduce condensation in the first chamber of the SPS during the second time period.

12. The system of claim 8, wherein the first valve is a proportional valve.

13. The system of claim 12, wherein the first valve comprises a coil, and wherein the first input signal is configured to cause the coil to produce a continuously varying magnetic field over the first time period.

14. The system of claim 8, further comprising a second valve configured to regulate an orifice of the first valve, wherein the controller is further configured to cause the second valve to receive a second input signal, wherein the second input signal is configured to cause the second valve to regulate the orifice of the first valve.

15. The system of claim 8, wherein the flow of gas into the first chamber of the SPS over the first time period is to increase to a target flow after a pressure inside the first chamber of the SPS has exceeded a target pressure.

16. The system of claim 8, further comprising a pressure sensor that continuously detects pressure inside the first chamber of the SPS and communicates the detected pressure to the controller, wherein the controller is configured to cause the first input signal to be adjusted in view of the communicated pressure.

17. The system of claim 16, wherein the first input signal is adjusted to cause the pressure inside the first chamber of the SPS to follow a temporal curve determined to minimize occurrence of one or more contaminants within the first chamber of the SPS.

18. The system of claim 8, wherein the first valve comprises a gauge that continuously detects a state of the first valve and communicates the detected state of the first valve to the controller, wherein the controller is configured to cause the first input signal to be adjusted in view of the communicated state of the first valve.

19. The system of claim 8, wherein the SPS further comprises:

a second gate configured to selectively seal and unseal the first chamber of the SPS from a third chamber of the SPS; and

a second valve configured to continuously regulate a flow of gas out of the first chamber of the SPS;

wherein the controller is communicatively coupled to the second gate and the second valve and further configured to:

cause the second gate to seal the first chamber of the SPS from the third chamber of the SPS; and

cause the second valve to receive a first input signal, wherein the first input signal is configured to cause the second valve to continuously regulate the flow of gas out of the first chamber of the SPS over a second time period.

20. A method to transfer a substrate from a first partition of a substrate processing system (SPS) to a second partition of the SPS, the method comprising;

opening a first gate between the first partition and a third partition of the SPS;

transferring the substrate from the first partition to the third partition;

closing the first gate to isolate the third partition from the first partition;

controlling a second gate to isolate the third partition from the second partition;

initiating a flow of a gas, wherein the flow of the gas is one of (i) a flow of the gas into the third partition or (ii) a flow of the gas out of the third partition;

causing a rate of the flow of the gas to have, at each of a plurality of times, a respective target reference flow rate (RFR) of a plurality of RFRs, wherein the plurality of RFRs are determined based on a modeling that minimizes occurrence, caused by the flow of the gas, of contaminant particles in the third partition; and

responsive to a pressure in the third partition changing from an initial pressure to a final pressure, opening the second gate, and transferring the substrate from the third partition to the second partition.

21. The method of claim 20, wherein the flow of the gas is into the third partition, wherein the modeling uses a first model that characterizes drag forces acting on contaminant particles adsorbed on a surface of the third partition, and wherein an input into the first model comprises:

a viscosity of the gas; and

a velocity of the gas near the surface of the third partition, the velocity of the gas determined based on the rate of the flow of the gas into the third partition.

22. The method of claim 21, wherein the modeling uses a second model that characterizes affinity of the contaminant particles to the surface of the third partition, and wherein the modeling comprises:

determining, using outputs of the first model and the second model, an instantaneous probability of resuspension of the contaminant particles from the surface of the third partition; and

determining a fraction of the contaminant particles that remain adsorbed on the surface of the third partition after a target duration of changing the pressure in the third partition from the initial pressure to the final pressure.

23. The method of claim 21, wherein the plurality of RFRs are further determined based on (i) a target duration of changing the pressure in the third partition from the initial pressure to the final pressure, and (ii) a target fraction of contaminant particles that are to remain adsorbed on the surface of the third partition.

24. The method of claim 20, wherein the flow of the gas is out of the third partition and the contaminant particles are water particles, and wherein the modeling comprises:

determining, at each of the plurality of times, a respective threshold pressure of a plurality of threshold pressures associated with condensation of the water particles.