

fluidly connected to the processing chamber. The processing tool additionally comprises an RPG gas supply system for mixing and delivering gases to the RPG. The RPG gas supply system comprises a first RPG gas line for delivering a first gas at a first flow rate to the RPG, and a second RPG gas line for delivering a second gas at a second flow rate to the RPG, the second flow rate higher than the first flow rate. In some examples, the first RPG gas line may deliver a low flow of nitrogen with a concentration of hydrogen as a precursor gas mixture for forming nitrogen-containing radical species in the RPG. The second RPG gas line may deliver a higher flow of nitrogen for purging the processing chamber. The RPG gas supply system further comprises a junction where the first RPG gas line and second RPG gas line meet. The RPG gas supply system further comprises an orifice in the first RPG gas line, a divert valve on the second RPG gas line for selectively diverting the flow in the second RPG gas line away from the RPG, and a common RPG gas line connecting the junction to the RPG.

[0057] If purge gas flow in the second RPG gas line were ramped up and down by controlling a mass flow controller, significant time may be occupied by the ramp up and ramp down processes in each cycle. However, the divert valve in the second gas line allows purge gas flow in the second RPG gas line to be quickly directed to the RPG for a purge process, and then quickly diverted to exhaust for a reactant deposition cycle. Gas flow in the first RPG gas line may remain at a set, lower level. The orifice in the first RPG gas line prevents back streaming when the divert valve in the second RPG line is switched to provide purge gas to the RPG. This helps, for example, to prevent disruption to the flow of hydrogen that otherwise may occur when switching the divert valve back to operating the divert valve to direct the purge gas to the exhaust. As such, this helps to stabilize gas flows more quickly between ALD cycles.

[0058] Another example provides a processing tool comprising a processing chamber comprising a pedestal well, a pedestal positioned at least partially within the pedestal well, and a below-pedestal purge system configured to introduce a flow of a purge gas into the pedestal well beneath the pedestal. Flow of the purge gas from the pedestal well may help to lessen the migration of processing gases into the pedestal well during a precursor adsorption and during a chemical transformation process. The flow of purge gas from beneath the pedestal may help to reduce purge times when switching gas flows. The below-pedestal purge system also may help to increase a residence time of precursor gas and/or reactive species over the substrate surface, as explained in more detail below. These effects may help to increase throughput.

valve 303. In FIGS. 3A, S1, S2, S3 and S4 represent four processing stations in a processing chamber 304A. In FIG. 3B, S1, S2, S3 and S4 represent four processing stations in a processing chamber 304B.

[0082] RPG gas system 300A of FIG. 3A comprises a first RPG gas line 306A and a second RPG gas line 308A. First RPG gas line 306A is configured to provide a flow of a reactant gas 310A. The reactant gas may comprise a gas mixture, such as hydrogen/nitrogen mixture. Second RPG gas line 308A is configured to provide a flow of a purge gas 312A. Nitrogen is an example purge gas. Flow of the purge gas during an ALD process is controlled by a mass flow controller 314A. Reactant gas flow also may be controlled by a mass flow controller (not shown) along first RPG gas line 306A.

[0083] RPG gas system 300B of FIG. 3B comprises a first RPG gas line 306B and a second RPG gas line 308B. First RPG gas line 306B is configured to provide a flow of a reactant gas 310B. The reactant gas may be a gas mixture, such as hydrogen/nitrogen mixture. Second RPG gas line 308B is configured to provide a flow of a purge gas 312B. RPG gas system 300B further comprises divert valve 303 in second RPG gas line 308B. Flow of the purge gas during an ALD process is controlled by divert valve 303 instead of mass flow controller 314B. Reactant gas flow also may be controlled by a mass flow controller (not shown) along first RPG gas line 306B.

[0084] FIG. 4A shows a plot of reactant gas flow to a processing chamber as a function of time for RPG gas system 300A and RPG gas system 300B. Plot 402 is for RPG gas system 300A, in which mass flow controller 314A is used to control purge gas flow rate to processing chamber 304A. Plot 404 is for RPG gas system 300B, in which divert valve 303 is used to control purge gas flow to processing chamber 304B while mass flow controller 314B maintains a set flow. Plot 402 in FIG. 4A shows a relatively greater time lag. This time lag represents the time taken for purge gas to reach the processing chamber after the mass flow controller 314A in FIG. 3A is turned on. The time lag may increase if the mass flow controller 314A is moved further upstream from processing chamber 304A. In contrast, referring to plot 404, the time lag is relatively lower for the use of divert valve 303 in RPG gas system 300B. Placing divert valve 303 and RPG gas manifold 302B physically closer to processing chamber 304B to shorten a gas line between these components may help to further reduce the time lag relative to the use of longer gas lines between these components.

[0085] Next, FIG. 4B shows a plot of purge gas flow out of a processing chamber as a function of time for RPG gas system 300A and RPG gas system 300B.

processing tool components 800 can be used in a same tool as RPG gas manifold 200 of FIG. 2. Further, in some examples, processing tool components 800 can be used in a same processing tool as replacement gas line 508 and replacement divert valve 510 of FIG. 5B. Also, in some examples, processing tool components 800 be used in a same processing tool as showerhead purge gas outlet 726 of FIG. 7.

[00104] Processing tool components 800 comprise a pedestal 802 within a pedestal well 804 formed by a chamber base 805, and a pedestal support 806. Processing tool components 800 also comprise a below-pedestal plenum 814 within pedestal well 804. Below-pedestal plenum 814 comprises an interior to accommodate a purge gas, and a purge gas outlet arranged at a lower portion of below-pedestal plenum 814. Arrows indicate purge gas flow from below-pedestal plenum 814. A below-pedestal purge gas source 810 provides purge gas to the below-pedestal plenum 814. A controller 812 controls purge gas flow. For example, controller 812 may control a mass flow controller or other flow controller of below-pedestal purge gas source 810.

[00105] Purge gas flow from below-pedestal plenum 814 may help to create a back pressure effect to increase precursor and/or reactive species residence time above a substrate. This may help to decrease a time taken to perform an ALD cycle. Further, pedestal well 804 comprises a volume of space beneath pedestal 802. Unreacted precursor and reaction products can diffuse to pedestal well 804 during a deposition process. Thus, purge gas flow from below-pedestal plenum 814 helps to purge such species from pedestal well 804. Below-pedestal plenum 814 also helps to fill volume in pedestal well 804. This reduces a volume of space to be purged. This further may help to reduce a time taken to purge a processing chamber between ALD steps. The below-pedestal purge gas may comprise any suitable gas that does not react with species or surfaces exposed to the purge gas. Example purge gases comprise argon.

[00106] In the depicted example, below-pedestal plenum 814 comprises an annular structure with one or more openings arranged at a lower portion of the below-pedestal plenum 814. Purge gas flows towards the pedestal support 806 and into the pedestal well 804. A height of below-pedestal plenum 814 may vary in different examples. The use of a taller below-pedestal plenum 814 may reduce the open volume within pedestal well 804. This may help to shorten the duration of purge steps in an ALD cycle. A height of below-pedestal plenum 814 can be selected to accommodate a desired range of pedestal height adjustment.

CLAIMS:

1. A processing tool, comprising:
 - a processing chamber;
 - a remote plasma generator (RPG) fluidly connected to the processing chamber;
 - and
 - an RPG gas supply system for mixing and delivering gases to the RPG, the RPG gas supply system comprising:
 - a first RPG gas line for delivering a first gas at a first flow rate to the RPG;
 - a second RPG gas line for delivering a second gas at a second flow rate to the RPG, the second flow rate higher than the first flow rate;
 - a junction connecting the first RPG gas line and the second RPG gas line;
 - an orifice in the first RPG gas line;
 - a divert valve on the second RPG gas line for diverting a flow away from the RPG; and
 - a common RPG gas line connecting the junction to the RPG.
2. The processing tool of claim 1, wherein the second RPG gas line comprises a mass flow controller upstream of the junction connecting the first RPG gas line and the second RPG gas line.
3. The processing tool of claim 1, wherein the processing chamber comprises a showerhead and a pedestal, and the showerhead comprises a showerhead purge gas outlet disposed adjacent to a perimeter of the showerhead.
4. The processing tool of claim 3, further comprising a controller configured to control a flow of inert gas through the showerhead purge gas outlet during a deposition process.
5. The processing tool of claim 4, further comprising a pedestal, and

a below-pedestal purge system comprising one or more openings to flow a purge gas into the processing chamber beneath the pedestal.

6. The processing tool of claim 5, further comprising a controller configured to control a flow of inert gas through the below-pedestal purge system during a deposition process.

7. The processing tool of claim 1, wherein the processing tool comprises a flow over vapor (FOV) chemical supply system for delivering a processing chemical to the processing chamber, the FOV chemical supply system comprising a processing chemical delivery gas line comprising an inner diameter in a range of 0.110-0.430 inch.

8. A processing tool, comprising:
a processing chamber comprising a pedestal well;
a pedestal positioned at least partially within the pedestal well; and
a below-pedestal purge system configured to introduce a flow of a purge gas into the pedestal well beneath the pedestal.

9. The processing tool of claim 8, wherein the below-pedestal purge system comprises a below-pedestal plenum arranged at least partially around a pedestal support of the pedestal, the below-pedestal plenum comprising one or more openings to flow the purge gas into the processing chamber from beneath the pedestal.

10. The processing tool of claim 9, wherein the below-pedestal plenum is annular in shape.

11. The processing tool of claim 9, wherein the below-pedestal plenum comprises a plurality of openings.

12. The processing tool of claim 9, wherein the below-pedestal plenum is additively manufactured.

13. A method of modifying a processing tool, the processing tool comprising a processing chamber and a flow over vapor (FOV) chemical supply system for delivering a processing chemical to the processing chamber, the FOV chemical supply system comprising a gas line for processing chemical delivery to the processing chamber, the method comprising:

replacing an initial gas line with a replacement gas line, the replacement gas line comprising a smaller inner diameter than the initial gas line, thereby decreasing a time that elapses between opening a FOV chemical supply system valve and FOV chemical reaching the processing chamber, and

replacing at least one other FOV chemical supply system component to reduce a dead volume in the FOV chemical supply system.

14. The method of claim 13, wherein the initial gas line comprises an inner diameter of greater than or equal to 0.305 inch, and the replacement gas line comprises an inner diameter in the range of 0.110-0.430 inch.

15. The method of claim 13, wherein replacing at least one other FOV chemical supply system component comprises one or more of shortening a valve connection, removing a charge volume hardware, or replacing a first valve manifold with a second valve manifold with a reduced dead volume.