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SIDE BLOCKS FOR GAS ACTIVATION, AND RELATED PROCESSING CHAMBERS, PROCESS KITS, AND METHODS

Abstract

Embodiments of the present invention relate to blocks for gas activation, related substrate processing chambers, process kits, and methods. In some embodiments, a processing chamber applicable for use in semiconductor manufacturing includes a chamber body at least partially defining an internal volume, one or more heat sources operable to heat the internal volume, and a substrate support disposed in the internal volume. The processing chamber further includes one or more inlet openings configured to direct a gas across a gas flow path over the substrate support and to one or more exhaust outlets and a process kit disposed in the internal volume. The process kit includes a first flow guide block and a second flow guide block disposed opposite the first flow guide block with respect to the gas flow path. The first flow guide block and the second flow guide block respectively include one or more opaque outer surfaces.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION [0001] This application claims priority to U.S. provisional patent application Ser. No. 63/553,513, filed Feb. 14, 2024, which is herein incorporated by reference in its entirety.

BACKGROUND

Field

[0002] Embodiments of the present invention generally relate to blocks for gas activation, and related substrate processing chambers, process kits, and methods.

Description of the Related Art

[0003] Semiconductor substrates are processed for a wide variety of applications, including the fabrication of integrated devices and microdevices. During processing, various parameters can affect the uniformity of material deposited on the substrate. For example, the temperature of the substrate and/or temperature(s) of processing chamber component(s) can affect deposition uniformity.

[0004] It can be difficult to adjust parameters (such as gas flow rates and gas pressures) for deposition uniformity. Rotation of the substrate, if used, can exacerbate adjustment difficulties. Relatively low rotation speeds, high pressures, and low flow rates can also exacerbate adjustment difficulties. Moreover, it can be difficult to clean components of processing chambers. Additionally, it can be difficult to activate processing gases. The activation of processing gases can be non-uniform, which can cause non-uniform processing.

[0005] Therefore, a need exists for improved process kits and related methods and processing chambers.

SUMMARY

[0006] Embodiments of the present invention generally relate to blocks for gas activation, and related substrate processing chambers, process kits, and methods.

[0007] In one or more embodiments, a processing chamber applicable for use in semiconductor manufacturing includes a chamber body at least partially defining an internal volume, one or more heat sources operable to heat the internal volume, and a substrate support disposed in the internal volume. The processing chamber further includes one or more inlet openings configured to direct a gas across a gas flow path over the substrate support and to one or more exhaust outlets and a process kit disposed in the internal volume. The process kit includes a first flow guide block and a second flow guide block disposed opposite the first flow guide block with respect to the gas flow path. The first flow guide block and the second flow guide block respectively include one or more opaque outer surfaces.

[0008] In one or more embodiments, a process kit applicable for use in semiconductor manufacturing includes a plate, a first block operable to support at least a first portion of the plate, and a second block operable to support at least a second portion of the plate. The first block and the second block respectively include one or more opaque outer surfaces.

[0009] In one or more embodiments, a method of processing substrates includes heating a substrate positioned on a substrate support and flowing one or more process gases over the substrate to form one or more layers on the substrate. The flowing of the one or more process gases over the substrate includes flowing the one or more process gases over a pair of blocks having opaque surfaces defining a rectangular flow opening.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only exemplary embodiments and are therefore not to be considered limiting of its scope, and may admit to other equally effective embodiments.

[0011] FIG. **1** is a partial schematic side cross-sectional view of a processing chamber, according to one or more embodiments.

[0012] FIG. **2** is a partial schematic side cross-sectional view of a processing chamber, according to one or more embodiments.

[0013] FIG. **3** is a schematic partial perspective view of the process kit according to one or more embodiments.

[0014] FIG. **4** is a partial schematic side cross-sectional view of an isolation plate within a processing chamber, according to one or more embodiments.

[0015] FIG. **5** is a schematic partial perspective view of a process kit, according to one or more embodiments.

[0016] FIG. **6** is a schematic block diagram view of a method of processing substrates, according to one or more embodiments.

[0017] FIGS. **7**A-**7**C are schematic partial perspective views of elements of a process kit, according to one or more embodiments.

[0018] FIG. **8**A is schematic cross-sectional top view of a processing chamber, according to one or more embodiments.

[0019] FIG. **8**B is schematic cross-sectional side view of a processing chamber, according to one or more embodiments.

[0020] FIG. **8**C is schematic cross-sectional top view of the processing chamber shown in FIG. **8**B, according to one or more embodiments.

[0021] FIG. **9**A is a graphical representation of the deposition rate on a substrate during an epitaxial deposition process using various implementations, according to one or more embodiments.

[0022] FIG. **9**B is a graphical representation of the phosphorous content on a substrate during an epitaxial deposition process using various implementations, according to one or more embodiments.

[0023] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. It is contemplated that elements and features of one embodiment may be beneficially incorporated in other embodiments without further recitation.

DETAILED DESCRIPTION

[0024] The present disclosure relates to a semiconductor processing chamber, and more particularly, to one or more methods of apparatuses for introducing purge gas within a processing chamber.

[0025] FIG. **1** is a partial schematic side cross-sectional view of a processing chamber **1000**, according to one or more embodiments. The processing chamber **1000** is a deposition chamber. In one or more embodiments, the processing chamber **1000** is an epitaxial deposition chamber. The processing chamber **1000** is utilized to grow an epitaxial film on a substrate **102**. The processing chamber **1000** creates a cross-flow of precursors across a top surface of the substrate **102**. The processing chamber **1000** is shown in a processing condition in FIG. **1**.

[0026] The processing chamber **1000** includes an upper body **156**, a lower body **148** disposed below the upper body **156**, a flow module **112** disposed between the upper body **156** and the lower body **148**. The upper body **156**, the flow module **112**, and the lower body **148** form a chamber body. Disposed within the chamber body is a substrate support **106**, an upper window **108** (such as an upper dome), a lower window **110** (such as a lower dome), a plurality of upper heat sources **141**, and a plurality of lower heat sources **143**. As shown, a controller **120** is in communication with the processing chamber **100** and is used to control processes and methods, such as the operations of the methods described herein. The present disclosure contemplates that each of the heat sources described herein can include one or more of: lamp(s), resistive heater(s), light emitting diode(s) (LEDs), and/or laser(s). The present disclosure contemplates that other heat sources can be used.

[0027] The substrate support **106** is disposed between the upper window **108** and the lower window **110**. The substrate support **106** includes a support face **123** that supports the substrate **102**. The plurality of upper heat sources **141** are disposed between the upper window and a lid **154**. The plurality of upper heat sources **141** form a portion of the upper heat source module **155**. The lid **154** may include a plurality of sensors disposed therein or thereon for measuring the temperature within the processing chamber **100**. The plurality of lower heat sources **143** are disposed between the lower window **110** and a floor **152**. The plurality of lower heat sources **143** form a portion of a lower heat source module **145**. In one or more embodiments, the upper window **108** is an upper dome and is formed of an energy transmissive material, such as quartz. In one or more embodiments, the lower window **110** is a lower dome and is formed of an energy transmissive material, such as quartz. A pre-heat ring **302** is disposed outwardly of the substrate support **106**. The pre-heat ring **302** is supported on a ledge of the lower liner **311**. A stop **304** includes a plurality of arms **305***a*, **305***b* that each include a lift pin stop on which at least one of the lift pins **132** can rest when the substrate support **106** is lowered (e.g., lowered from a process position to a transfer position).

[0028] The internal volume has the substrate support **106** disposed therein. The substrate support **106** includes a top surface on which the substrate **102** is disposed. The substrate support **106** is attached to a shaft **118**. The shaft **118** is connected to a motion assembly **121**. The motion assembly **121** includes one or more actuators and/or adjustment devices that provide movement and/or adjustment for the shaft **118** and/or the substrate support **106**.

[0029] The substrate support **106** may include lift pin perforations **107** disposed therein. The lift pin perforations **107** are sized to accommodate a lift pin **132** for lifting of the substrate **102** from the substrate support **106** either before or after a deposition process is performed.

[0030] A process kit **1010** includes an isolation plate **321** having a first face **1012** and a second face **1013** opposing the first face **1012**. The second face **1013** faces the substrate support **106**. The process kit **1010** includes an upper liner **1020**. The upper liner **1020** includes an annular section **1021**. The upper liner **1020** includes one or more inlet openings **1023** extending to an inner surface **1024** of the annular section **1021** on a first side of the upper liner **1020**, and one or more outlet openings **1025** extending to the inner surface **1024** of the annular section **1021** on a second side of the upper liner **1020**.

[0031] The one or more inlet openings **1023** extend from an outer surface **1026** of the annular section **1021** of the upper liner **1020** to the inner surface **1024**. The one or more outlet openings **1025** extend from a lower surface **1029** of the upper liner **1020** to the inner surface **1024**. The upper liner **1020** includes a first extension **1027** and a second extension **1028** disposed outwardly of the lower surface **1029** of the upper liner **1020**. At least part of the annular section **1021** of the upper liner **1020** is aligned with the first extension **1027** and the second extension **1028**. In the embodiment shown in FIG. **1**, a lowermost end of the isolation plate **321** is aligned above a lowermost end of the upper liner **1020**. In one or more embodiments, as shown in FIG. **1**, the lowermost end of the isolation plate **321** is part of the second face **1013**, and the lowermost end of the upper liner **1020** is part of the first extension **1027** and/or the second extension **1028**. The present disclosure contemplates that the lowermost end of the upper liner **1020** can be part of the lower surface **1029**.

[0032] The isolation plate **321** is in the shape of a disc, and the annular section **1021** is in the shape of a ring. It is contemplated, however, that the isolation plate **321** and/or the annular section **1021** can be in the shape of a rectangle, or other geometric shapes. The isolation plate **321** at least partially fluidly isolates the upper portion **136***b* from the lower portion **136***a*. The lower portion **136***a* has a smaller volume than the upper portion **136***b*. A ratio of the volume of the lower portion **136***a* relative to the volume of the upper portion **136***b* is less than 0.25.

[0033] The flow module **112** (which can define at least part of one or more sidewalls of the processing chamber **1000**) includes one or more first inlet openings **1014** in fluid communication with the lower portion **136***a* of the processing volume **136**. The flow module **112** includes one or more second inlet openings **1015** in fluid communication with the upper portion **136***b* of the processing volume **136**. The one or more first inlet openings **1014** are in fluid communication with one or more flow gaps between the upper liner **1020** and the lower liner **311**. The one or more second inlet openings **1015** are in fluid communication with the one or more inlet openings **1023** of the upper liner **1020**. The one or more inlet openings **1014** are fluidly connected to one or more process gas sources **151** and one or more cleaning gas sources **153**. The purge gas inlet(s) **164** are fluidly connected to one or more purge gas sources **162**. The one or more exhaust outlets **116** are fluidly connected to an exhaust pump **157**. One or more process gases supplied using the one or more process gas sources **151** can include one or more reactive gases (such as one or more of silicon-containing, phosphorus-containing, and/or germanium-containing gases, and/or one or more carrier gases (such as one or more of nitrogen (N.sub.2) and/or hydrogen (H.sub.2)). One or more purge gases supplied using the one or more purge gas sources **162** can include one or more inert gases (such as one or more of argon (Ar), helium (He), and/or nitrogen (N.sub.2)). One or more cleaning gases supplied using the one or more cleaning gas sources **153** can include one or more of hydrogen and/or chlorine. In one or more embodiments, the one or more process gases include silicon phosphide (SiP) and/or phospine (PH.sub.3), and the one or more cleaning gases include hydrochloric acid (HCl).

[0034] The one or more exhaust outlets **116** are further connected to or include an exhaust system **178**. The exhaust system **178** fluidly connects the one or more exhaust outlets **116** and the exhaust pump **157**. The exhaust system **178** can assist in the controlled deposition of a layer on the substrate **102**. The exhaust system **178** is disposed on an opposite side of the processing chamber **100** relative to the flow module **112**. The one or more inlet openings **114** are configured to direct a gas (such as the process gas(es) P1) across a gas flow path over the substrate support **106** and to the one or more exhaust outlets **116**.

[0035] In one or more embodiments, as shown in FIG. **1**, the one or more inlet openings **1023** are oriented in a horizontal orientation and the one or more outlet openings **1025** are oriented in an angled orientation. The present disclosure contemplates that the one or more inlet and/or outlet openings **1023**, **1025** can be oriented in a horizontal orientation, oriented in an angled (e.g., non-parallel to horizontal) orientation, and/or can include one or more turns (such as the turns shown for the one or more first inlet openings **1014** and the one or more exhaust outlets **116**).

[0036] During a deposition operation (e.g., an epitaxial growth operation), the one or more process gases P**1** flow through the one or more first inlet openings **1014**, through the one or more gaps, and into the lower portion **136***a* of the processing volume **136** to flow across a gas flow path over the substrate **102**. During the deposition operation, one or more purge gases P**2** flow through the one or more second inlet openings **1015**, through the one or more inlet openings **1023** of the upper liner **1020**, and into the upper portion **136***b* of the processing volume **136**. The one or more purge gases P**2** flow simultaneously with the flowing of the one or more process gases P**1**. The flowing of the one or more purge gases P**2** through the upper portion **136***b* facilitates reducing or preventing flow of the one or more process gases P**1** into the upper portion **136***b* that would contaminate the upper portion **136***b*. The one or more process gases P**1** are exhausted through gaps between the upper liner **1020** and the lower liner **311**, and through the one or more exhaust outlets **116**. The one or more purge gases P**2** are exhausted through the one or more outlet openings **1025**, through the same gaps between the upper liner **1020** and the lower liner **311**, and through the same one or more exhaust outlets **116** as the one or more process gases P**1**. The present disclosure contemplates that that one or more purge gases P**2** can be separately exhausted through one or more second gas exhaust outlets that are separate from the one or more exhaust outlets **116**.

[0037] The present disclosure also contemplates that one or more purge gases can be supplied to the purge volume **138** (through the plurality of purge gas inlets **164**) during the deposition operation, and exhausted from the purge volume **138**.

[0038] FIG. **2** is a partial schematic side cross-sectional view of a processing chamber **2000**, according to one or more embodiments. The processing chamber **2000** is similar to the processing chamber **1000** shown in FIG. **1**, and includes one or more of the aspects, features, components, properties, and/or operations thereof. The processing chamber **2000** is shown in a processing condition in FIG. **2**.

[0039] The processing chamber **2000** includes a window **2008** that at least partially defines the processing volume **136**. The window **2008** includes a first face **2011** that is concave or flat (in the embodiment shown in FIG. **2**, the first face **2011** is flat). The window **2008** includes a second face **2012** that is convex. The second face **2012** faces the substrate support **106**.

[0040] The processing chamber **2000** includes a liner **2020**. The liner **2020** is similar to the upper liner **1020** shown in FIG. **1**, and includes one or more of the aspects, features, components, properties, and/or operations thereof. The processing chamber **2000** incudes a process kit **310** (shown in FIG. **3**), which includes a first block **331**, a second block **332** (shown in FIG. **3**), and an isolation plate **321**. The isolation plate **321** and the blocks **331**, **332** can function as a flow guide for the processing volume **136**. The blocks **331**, **332** are disposed below an isolation plate **321** and above the substrate support **106**. In one or more embodiments, the blocks **331**, **332** are parallel to each other. The blocks **331**, **332** assist with flow of process gas P**1** over the substrate **102** to facilitate improving deposition uniformity. In one or more embodiments, the isolation plate **321** and/or the blocks **331**, **332** are supported by and/or coupled to the upper liner **1020** and/or the pre-heat ring **302**. In one or more embodiments, the isolation plate **321** and/or the blocks **331**, **332** rest on the upper liner **1020** and/or the pre-heat ring **302**. In one or more embodiments the plate **321** has a thickness that is 20 mm or less, such as within a range of 10 mm to 20 mm.

[0041] The window **2008** includes an inner section **2013** and an outer section **2014**. The first face **2011** and the second face **2012** are at least part of the inner section **2013**. In one or more embodiments, the inner section **2013** is transparent and the outer section **2014** is opaque. The outer section **2014** is received at least partially in one or more sidewalls (such as in the flow module **112** and/or the upper body **156**) of the processing chamber **2000**. The blocks **331**, **332** can be used in relation to the process kit **1010** shown in FIG. **1**.

[0042] FIG. **3** is a schematic partial perspective view of the process kit **310**, according to one or more embodiments. The process kit **310** includes the isolation plate **321**, the first block **331**, and the second block **332**. The first block **331** and the second block **332** are disposed opposite one another and at least partially define an inlet **352** therebetween that receives gas(es) from the one or more inlet openings **114**. In one or more embodiments, the first block **331** and the second block **332** are flow guide blocks. The process kit **310** has a circular shape, and other geometric configurations (such as a rectangular shape) are contemplated.

[0043] The isolation plate **321** includes a first side **322** and a second side **323** opposing the first side **322** along a first direction D**1**. Each of the first side **322** and the second side **323** is arcuate. In one or more embodiments, the direction D**1** is parallel to the direction of gas flow in the process chambers **1000**, **2000** of FIGS. **1** and **2** in order to guide process gas P**1** within the rectangular flow opening **350** defined between a planar inner face **333** of the first block **331** and a planar inner face **334** of the second block **332**.

[0044] In one or more embodiments, the first block **331** extends outwardly from and couples to a third side **324** of the isolation plate **321**, and the second block **332** extends outwardly from and couples to a fourth side **325** of the isolation plate **321**. The third side **324** is opposite the fourth side **325** along a direction D**2**, which is perpendicular to direction D**1**. The third side **324** and the fourth side **325** are linear, as are surfaces of the first block **331** and the second block **332** which mate with the third side **324** and the fourth side **325** of the isolation plate **321**.
[0045] It is contemplated that the first block **331** and the second block **332** may be omitted from the process kit **310** (as shown in FIG. **1**). The isolation plate **321** can be supported by the upper liner **1020** and/or the isolation plate **321** may be secured in the interior of the processing chamber via another attachment mechanism. In one or more embodiments the first block **331** and second block **332** are coupled to a curved section of the upper liner **1020**. In one or more embodiments, the isolation plate **321** can be omitted and the blocks **331**, **332** can be used.
[0046] The first block **331** and the second block **332** include one or more opaque outer surfaces defined at least partially by an opaque material. In one or more embodiments, all outer surfaces of the first block **331** and the second block **332** are opaque. In one or more embodiments, at least the inner face **333**, **334** and/or an outer face **335**, **336** of the respective block **331**, **332** is opaque (for example opaque to infrared energy). The outer faces **335**, **336** can be planar or curved (as shown in FIG. **3**). In one or more embodiments, the isolation plate **321** is formed of a transparent material (such as transparent quartz).
[0047] In one or more embodiments, the first block **331** and the second block **332** include of graphite coated with an opaque material. A thickness of the opaque material is at least 50 microns, such as at least 100 microns, such as at least 0.5 mm, such as at least 1.0 mm, such as at least 1.5 mm, such as at least 2.0 mm, such as at least 2.5 mm, such as at least 3.0 mm, such as at least 3.5 mm, such as at least 4.0 mm, such as at least 4.5 mm, such as at least 5.0 mm. In one or more embodiments, the thickness of the opaque material is within a range of about 30 microns to about 200 microns. The opaque material has an average surface roughness (Ra) that is at least 10 micro-inches, such as at least 15 micro-inches, such as at least 20 micro-inches, such as at least 50 micro-inches, such as at least 75 micro-inches, such as at least 100 micro-inches, such as at least 125 micro-inches, such as at least 150 micro-inches, such as at least 175 micro-inches, such as at least 200 micro-inches, such as at least 225 micro-inches, such as at least 250 micro-inches In one or more embodiments, the average surface roughness of the opaque material is within a range of about 0.5 microns to about 50 microns. In one or more embodiments, the opaque material has an atomic structure that is non-crystalline (e.g., amorphous or polymorphous). In one or more embodiments the opaque material includes silicon carbide (SiC). The present disclosure contemplates that other materials, for example opaque quartz (such as white quartz, grey quartz, clear quartz impregnated with Si particles or SiC particles, and/or black quartz) can be used for the opaque material. In one or more embodiments, the opaque material has an atomic structure of 3C (e.g., 3C-SiC). In one or more embodiments, the atomic structure is 4H (e.g., 4H-SiC), or 6H (e.g., 6H-SiC). In one or more embodiments the first block **331** and the second block **332** are formed of an opaque material. In one or more embodiments the first block **331** and the second block **332** are formed of silicon carbide (SiC).
[0048] It is contemplated that the size of the parallel blocks may be varied to increase or decrease the lower portion **136*a*** of the processing volume **136**. It is also contemplated that the first and second blocks **331**, **332** may include actuating supports configured to mechanically move the isolation plate **321** up and down. In one or more embodiments the first block **331** and the second block **332** have a rectangular shape. In one or more embodiments, the first block **331** and the second block **332** have a semi-circular shape. The first block **331** and the second block **332** are supported on the pre-heat ring **302** (FIG. **1**).
[0049] During processing, one or more process gases (such as process gas P**1** of FIGS. **1** and **2**) flow through the rectangular flow opening **350** when flowing through the lower portion **136*a*** and

over the substrate **102**. The rectangular flow opening **350** facilitates adjustability of process gases (such as deposition gases and/or cleaning gases) and/or purge gases (such as adjustability pressure and flow rate), to facilitate process uniformity and deposition uniformity while providing a path for cleaning gases to the upper portion **136***b*. As an example, the rectangular flow opening **350** facilitates using high pressures and low flow rates for the process gases and the cleaning gases. The rectangular flow opening **350** also facilitates mitigation of the effects that rotation of the substrate **102** has on process uniformity and film thickness uniformity during a deposition operation. As an example, the rectangular flow opening mitigates or removes the effects of gas vortex. The blocks **331**, **332** are disposed on opposing sides of the rectangular flow opening **350**.

[0050] In FIG. **3**, the isolation plate **321** includes a plurality of perforations **360** formed therethrough. It is contemplated that the plurality of perforations **360** can be omitted (as shown in FIG. **5**). The perforations **360** are sized, spaced (e.g., for hole density) and angled to allow gas (e.g., purge gas P**2** of FIGS. **1** and **2**) to flow from a top side thereof to a bottom side thereof during processing. The perforations **360** can be circular or another shape. During processing, purge gas P**2** flows through the perforations of the isolation plate **321** from the upper portion **136***b* to the lower portion **136***a* (see FIGS. **1** and **2**). The purge gas P**2** can form a relatively thin gas curtain along the bottom surface (e.g., the surface facing substrate **102**) of the isolation plate. The gas curtain reduces material deposition on the isolation plate **321**, extending time between cleaning operations. In addition, the gas curtain allows a substrate to be positioned closed to the isolation plate **321** during processing, thus reducing the processing volume and the amount of processing gas utilized.

[0051] The blocks **331**, **332** also include a plurality of perforations **362**. It is contemplated that the plurality of perforations **362** can be omitted (as shown FIG. **5**). The perforations **362** can be circular or another shape. The perforations **362** are operatively and fluidly coupled to a gas source for supplying a gas. For example, the perforations **362** may receive a purge gas from the purge gas source **162**. The gas provided through the perforations **362** in the direction D**2** facilitates improved gas flow along the direction D**1**. In one or more embodiments, the gas provided through perforations **362** concentrates gas flow of a process gas P**1** (see FIGS. **1** and **2**) flowing in a direction D**1**, thus facilitating improving deposition uniformity on a substrate. In one or more embodiments, the gas provided through perforations **362** facilitates flowing process gas P**1** nearer to the substrate **102** (see FIGS. **1** and **2**), reducing or eliminating diversive flow of the process gas P**1**, and reducing or eliminating flowing of the process gas P**1** up into the upper portion **136***b*.

[0052] Although, in FIG. **3**, both the isolation plate **321** and the blocks **331**, **332** have perforations **360**, **362**, it is contemplated that perforations **360**, **362** can utilized on only the isolation plate, only the first block **331**, only the second parallel block, **332**, or any combination thereof. As shown in FIG. **5** both the perforations **360** and the perforations **362** can be omitted. Additionally, it is to be noted that while perforations **362** are shown in the second block **332** in FIG. **3** for clarity, perforations **362** are also formed in the first block **331**.

[0053] FIG. **4** is a partial schematic side cross-sectional view of an isolation plate **321** within a processing chamber **1000**, **2000**, according to one or more embodiments. The one or more inlet openings **1014** allow flow of the one or more process gases P**1** into the process chamber. The one or more second inlet openings **1015** allow flow of the purge gas P**2** into the upper portion **136***b* of the process chamber. The perforations (shown in FIG. **3**) in the isolation plate **321** allow for at least a portion of the purge gas P**2** to flow from the upper portion **136***b* of the process chamber into the lower portion **136***a*. The flow of the process gas P**1** directs the flow of the purge gas P**2** towards an exhaust of the process chamber as a flow P**3**. The flow P**3** travels along a lower surface of the isolation plate **321**, reducing or preventing deposition of material from the process gas P**1** onto the isolation plate **321**. The flowrate of the flow P**3** is determined in part by the flow rate of the purge gas P**2** and the location, number, size, and shape of the perforations **360** in the isolation plate **321**. The present disclosure contemplates that the purge gas P**2** can be replaced with a cleaning gas (e.g., hydrochloric acid).

[0054] Without being limited to theory, the flow P**3** can reduce the potential for deposition on the isolation plate **321** by forming a gas curtain and or diluting the process gas P**1** concentration adjacent the isolation plate **321**. The flow P**3** also pushes the process gas flow P**1** towards the substrate surface, increasing the gas speed delta between the peak speed and the speed at the substrate surface.

[0055] FIG. **5** is a schematic partial perspective view of a process kit **510**, according to one or more embodiments. The process kit **510** is similar to the process kit **310** shown in FIG. **3**, and includes one or more of the aspects, features, components, properties, and/or operations thereof.

[0056] The process kit **510** omits the plurality of perforations **360**, **362** shown in FIG. **3**. During processing, one or more process gases (such as process gas P**1** of FIGS. **1** and **2**) flow through the rectangular flow opening **350** when flowing through the lower portion **136***a* and over the substrate **102**. The rectangular flow opening **350** facilitates adjustability of process gases, purge gases, and/or cleaning gases (such as pressure and flow rate), to facilitate process uniformity and deposition uniformity while providing a path for cleaning gases to the upper portion **136***b*.

[0057] During processing, purge gas P**2** flows over the isolation plate **321** in the upper portion **136***b* (see FIGS. **1** and **2**). The isolation plate **321** separates the process gas P**1** and the purge gas P**2**. The flowing of the one or more purge gases P**2** through the upper portion **136***b* facilitates reducing or preventing flow of the one or more process gases P**1** into the upper portion **136***b* that would contaminate the upper portion **136***b*.

[0058] FIG. **6** is a schematic block diagram view of a method **600** of processing substrates **102**, according to one or more embodiments.

[0059] Operation **610** includes heating a substrate positioned on a substrate support. In one more embodiments, the substrate is heated using heat sources and the substrate support is a pedestal, such as a susceptor which absorbs radiation from the heat sources and transfers thermal energy to the substrate. In one or more embodiments, the substrate support includes one or more ring segments. In one or more embodiments the blocks **331**, **332** described above are heated. In one or more embodiments, the substrate is heated to a temperature within a range of 650 degrees Celsius to 700 degrees Celsius.

[0060] Operation **620** includes flowing one or more process gases over the substrate to form one or more layers on the substrate. The flowing of the one or more process gases over the substrate includes guiding the one or more process gases through a rectangular flow opening of a flow guide insert. The rectangular flow opening can be defined at least partially, for example, by the blocks **331**, **332** and the isolation plate **321** described above. In one or more embodiments, the one or more process gases are supplied at a pressure that is 300 Torr or greater, such as within a range of 300 Torr to 600 Torr, or greater. In one or more embodiments, the one or more process gases are supplied at a flow rate that is less than 5,000 standard cubic centimeters per minute (SCCM). In one or more embodiments, the substrate is rotated at a rotation speed that is less than 20 rotations-per-minute (RPM) during the flowing of the one or more process gases over the substrate. In one or more embodiments, the rotation speed is about 16 RPM. The one or more purge gases can flow into the processing chamber before, during, and/or after one or more of operation **610**, operation **630**, operation **640**, and/or operation **650**.

[0061] Operation **630** includes flowing one or more purge gases into the processing chamber. The one or more purge gases can flow into the processing chamber before, during, and/or after one or more of operation **610**, operation **620**, operation **640**, and/or operation **650**. The one or more purge gases can flow over the isolation plate described above. The one or more purge gases can flow from perforations (if used) in the isolation plate or perforations (if used) in the blocks, as described above. In one or more embodiments, operation **630** includes simultaneous flow of purge gas from the isolation plate and the parallel blocks for the entirety of operation **630**. In one or more embodiments, operation **630** includes introducing purge gas into the lower portion of the processing area only from the isolation plate or the blocks. In one or more embodiments, operation

630 includes flow of purge gas from the isolation plate and the blocks for portions of operation **630**.

[0062] In one or more embodiments, the method **600** includes lifting and/or lowering the isolation plate **321** by moving the blocks **331**, **332** using the substrate support **106**. In one or more embodiments, the method **600** includes lifting and/or lowering the isolation plate **321** relative to the blocks **331**, **332** by moving the plurality of lift pins **132** disposed in the substrate support **106**. The blocks **331**, **332** can support the isolation plate **321**.

[0063] While flowing the one or more process gases in operation **620** and the one or more purge gases in operation **630**, the one or more process gases are thermally decomposed to form an epitaxial layer on an upper surface of a substrate.

[0064] Operation **640** includes exhausting the one or more process gases. Operation **640** may occur before, during, and/or after one or more of operation **620**, operation **630**, and/or operation **650**.

[0065] Operation **650** includes exhausting the one or more purge gases. Operation **650** may occur before, during, and/or after one or more of operation **610**, operation **620**, operation **630**, and/or operation **640**. Operation **650** can occur simultaneously with operation **640**.

[0066] FIGS. **7**A-7C are schematic partial perspective views of elements of a process kit **700**, according to one or more embodiments.

[0067] FIG. **7**A is a schematic partial perspective view of the liner **2020** and blocks **331**, **332** of the process kit **700**, according to one or more embodiments. The blocks **331**, **332** are coupled to the liner **2020**. In one or more embodiments, the blocks **331**, **332** and the liner **2020** are manufactured together as a single integral part of the processing chamber **2000** such that the blocks **331**, **332** and the liner **2020** are part of the same opaque body. In one or more embodiments, the blocks **331**, **332** are manufactured as separate bodies from the liner **2020**, and the blocks **331**, **332** are fused to the liner **2020** in a fusing operation. In one or more embodiments, the blocks **331**, **332** are welded to the liner **2020**.

[0068] As shown in FIG. **7**A, in one or more embodiments, the blocks **331**, **332** includes optional slots **720**. It is contemplated that the slots **720** may be omitted from the blocks **331**, **332**. The blocks **331**, **332** respectively include one or more alignment extensions **721**, **722** extending relative to the respective block **331**, **332**. The alignment extensions **721**, **722** can include, for example, columns (such as cylindrical rods and/or rectangular rods). The one or more alignment extensions **721**, **722** can be omitted.

[0069] FIG. **7**B is a schematic partial perspective view of the isolation plate **321** of the process kit **700**, according to one or more embodiments. In one or more embodiments, the isolation plate **321** includes notches **730**. It is contemplated that the notches **730** may be omitted from the isolation plate **321**. In one or more embodiments, the notches **730** of the isolation plate **321** and the slots **720** of the blocks **331**, **332** are used to position the isolation plate **321** on the blocks **331**, **332** and one or more inner ledges **1022** of the liner **2020**. For example, transfer equipment (such as heads of lift pins) can extend through the notches **730** and into slots **720** when the isolation plate **321** is lowered onto the upper liner **1020**. The lift pins can be part of the alignment extensions, and the alignment extensions **721**, **722** can be movable relative to the blocks **331**, **332**. The alignment extensions **721**, **722** can be coupled to the blocks **331**, **332**, and the alignment extensions **721 722** can extend through the notches **730** to align the isolation plate **321** relative to the blocks **331**, **332**.

[0070] FIG. **7**C is schematic partial perspective view of the isolation plate **321** and the liner **2020** of the process kit **700**, according to one or more embodiments. In one or more embodiments, the notches **730** and/or the alignment extensions **721**, **722** vertically align with the slots **720** when the isolation plate **321** is positioned on the blocks **331**, **332** and/or the one or more inner ledges **1022**, and/or when the isolation plate **321** is fused to the blocks **331**, **332** and/or the one or more inner ledges **1022**. In one or more embodiments, the isolation plate **321** is fused to the blocks **331**, **332** and/or the one or more inner ledges **1022**. In one or more embodiments, the blocks **331**, **332** and/or the one or more inner ledges **1022** are welded to the isolation plate **321**. The liner **2020** can be formed of the same material as the blocks **331**, **332** and/or the isolation plate **321**.

[0071] FIG. **8**A is schematic cross-sectional top view of a processing chamber **8000**, according to one or more embodiments. The processing chamber **8000** is similar to the processing chamber **1000** shown in FIG. **1**, and processing chamber **2000** shown in FIG. **2**, and includes one or more of the aspects, features, components, properties, and/or operations thereof. The isolation plate **321**, the lid **154**, the upper window **108**, and other components are not shown for visual clarity purposes.

[0072] The processing chamber includes the first block **331** and the second block **332** shown in FIG. **3** and FIG. **5**. In the implementation shown in FIG. **5**, the first block **331** and the second block include one or more embedded heating elements **820**. In one or more embodiments, the one or more embedded heating elements **820** function as resistive heaters for the first block **331** and the second block **332**. During a deposition process and/or a cleaning process an electric current runs through the one or more embedded heating elements **820**. The electric current heats the respective block **331**, **332**. The one or more embedded heating elements **820** heat the first block **331** and the second block **332** during the deposition process and/or the cleaning process.

[0073] The heated first block **331** and second block **332** help activate the process gas (such as P**1**) during the deposition process and/or the cleaning process. The activation of the blocks **331**, **332** can be used in addition to the heating of the pre-heat ring **302**. The activation of the blocks **331**, **332** can facilitate reduced or eliminated edge roll-off of processing on the substrate **102**. The activation can mitigate effects arising from temperature loss along areas of the substrate support **106** and/or the pre-heat ring **302**. In one or more embodiments, the embedded heaters include electrical wires formed of metallic alloys including but not limited to nickel (Ni) alloys, nickel-chrome (NiCr) alloys, iron-crome-aluminum (FeCrAl) alloys, copper-nickel (CuNi) alloys, molybdenum (Mo) alloys, and/or tungsten (W) alloys. In one or more embodiments, the embedded heaters include electrical wires formed of non-metalic materials such as carbon (C). In one or more embodiments, an electric current is run through the first block **331** and the second block **332** to generate a voltage across the respective block **331**, **332**, which can heat the respective block **331**, **332**. The embedded heaters can be embedded in the respective block **331**, **332** itself, or in a piece of material disposed in the respective block **331**, **332**. As an example where the first block **331** and the second block **332** are formed of SiC, then the embedded heaters are embedded in the SiC of the blocks **331**, **332**, and an entirety of the first block **331** and the second block **332** may act as resistive heaters when a current is applied to the first block **331** and the second block **332**. As another example where the first block **331** and the second block **332** are formed of graphite coated with SiC, the embedded heaters can be embedded in the graphite or in a piece of material (such as SiC or quartz) disposed in the graphite. In one or more embodiments, a width W**1** of the respective blocks **331**, **332** is within a range of about 10 mm to about 50 mm, such as about 15 mm.

[0074] FIG. **8**B is schematic cross-sectional side view of a processing chamber **8500**, according to one or more embodiments. The processing chamber **8500** is similar to the processing chamber **1000** shown in FIG. **1**, processing chamber **2000** shown in FIG. **2**, and processing chamber **8000** shown in in FIG. **8**A, and includes one or more of the aspects, features, components, properties, and/or operations thereof. The lift pins **132**, the lid **154**, and other components are not shown, for visual clarity purposes. FIG. **8**B shows processing chamber **8500** rotated by an angle (such as 90 degrees) from processing chamber **1000** shown in FIG. **1** and processing chamber **2000** shown in FIG. **2**.

[0075] Processing chamber **8500** includes one or more transparent (quartz) windows **830** disposed inwardly or in one or more openings of one or more sidewalls of the chamber body. In one or more embodiments, the one or more quartz windows **830** are disposed between the upper body **156** and the lower body **148**. A gap **840** is formed between the upper body **156** and the lower body **148**. One or more heating elements **850** are disposed outside of the processing chamber **8500** aligned with the one or more quartz windows **830**. It is contemplated that in one or more embodiments the heating elements **850** are laser sources. In one or more embodiments the heating elements **850** are light-emitting diodes (LED), laser sources, and/or infrared lamps. Other energy sources are

contemplated.
[0076] During a deposition process, the one or more heating elements **850** emit light L**1** (such as light beams). The light L**1** are emitted through the one or more quartz windows **830** and the gap **840** to the lower liner **311**. In one or more embodiments the lower liner **311** is formed of a transparent material such as clear quartz in order for the light L**1** to be able to emit through the lower liner **311** to the first block **331** and the second block **332**. As discussed above, the first block **331** and the second block **332** are at least partially formed of the opaque material, which absorbs the energy from the light L**1**. The energy from the one or more light beams L**1** causes the first block **331** and the second block **332** to heat up. The heated first block **331** and second block **332** help activate the process gas during the deposition process. It is contemplated that the heating elements **850** and the light L**1** may be used in conjunction with the embedded heating elements **820** shown in FIG. **8**A. In one or more embodiments, a height H**1** of the respective blocks **331**, **332** is within a range of about 5 mm to about 20 mm, such as about 12 mm.
[0077] FIG. **8**C is a schematic cross-sectional top view of the processing chamber **8500** shown in FIG. **8**B, according to one or more embodiments. The isolation plate **321**, the lid **154**, the upper window **108**, and other components are not shown, for visual clarity purposes.
[0078] FIG. **8**C depicts the processing chamber **8500** with a plurality of (e.g., three) heating elements **850** used together to light L**1** to the first block **331** and a plurality of (e.g., three) heating elements **850** used together to emit light L**1** to the second block **332**. The light L**1** is emitted through one or more quartz windows **830**. In one or more embodiments, the quartz window(s) **830** are disposed in opening(s) formed in the upper body **156** and/or lower body **148**, so that the light L**1** could be emitted from any direction. The light L**1** emits through the one or more quartz windows **830** and through the lower liner **311**. FIG. **8**C depicts the lower liner **311** formed entirely from clear quartz. It is contemplated that in one or more embodiments the lower liner **311** is partially made from an opaque material and partially made from clear quartz. In one or more embodiments the lower liner includes a clear quartz widow similar to the quartz window **830** in the chamber body. Although a total of six heating elements **850** are shown in FIG. **8**C, it should be understood that any number of heating elements **850** can be used, including 1 heating element, 2 heating elements, 4 heating elements, or 8 heating elements. The blocks **331**, **332** are shown as rectangular in FIG. **8**C. The one or more heating elements **850** are disposed radially outwardly of the first and second flow guide blocks **331**, **332** and the one or more quartz windows **830**.
[0079] The present disclosure contemplates that power supplied to the heating elements **820**, **850** can be controlled independently of the heat sources **141**, **143** (FIG. **1**) that heat the substrate **102**. The present disclosure contemplates that the blocks **331**, **332** can be heated by absorbing light from the heat sources **141**, **143** in addition to or in place of the light L**1** from the heating elements **850**.
[0080] FIG. **9**A is a graphical representation of the deposition rate on a substrate during an epitaxial deposition process using various implementations, according to one or more embodiments.
[0081] Line **910** represents the deposition rate on a substrate without the use of blocks (such as blocks **331**, **332**). The deposition rate decreases on the outer portions of the radius of the substrate. Line **920** represents a deposition rate on a substrate using blocks. The deposition rate of line **920** is more uniform compared to line **910** (such as in a direction from a middle of the substrate toward an outer radius of the substrate). Line **930** represents a deposition rate on a substrate with blocks described herein (such as block **331**, **332**). The deposition rate of line **930** is higher than the deposition rate of line **920**, and exhibits a more uniform deposition compared to line **910** (such as in a direction from a middle of the substrate toward an outer radius of the substrate).
[0082] FIG. **9**B is a graphical representation of the phosphorous content on a substrate during an epitaxial deposition process using various implementations, according to one or more embodiments.
[0083] Line **911** shows a phosphorous content on a substrate without the use of blocks (such as blocks **331**, **332**). Line **921** represents the phosphorus content on a substrate using blocks. Line **931**

represents a phosphorus content on a substrate with blocks described herein (such as block **331**, **332**). Both line **921** and line **931** show a higher phosphorus content than line **911**, and a higher phosphorus content uniformity (such as in a direction from a middle of the substrate and towards the outer radius of the substrate).

[0084] Benefits of the present disclosure include enhanced gas activation (such as by enhanced pre-heating); reduced diversive flow of process gases; gas savings; heating savings; enhanced deposition thicknesses; enhanced processing uniformities; and increased throughput and efficiency.

[0085] It is contemplated that one or more aspects disclosed herein may be combined. As an example, one or more aspects, features, components, operations and/or properties of the processing chamber **1000**, the processing chamber **2000**, the process kit **310**, the process kit **510**, the method **600**, the process kit **700**, the processing chamber **8000**, and/or the processing chamber **8500** may be combined. Moreover, it is contemplated that one or more aspects disclosed herein may include some or all of the aforementioned benefits.

[0086] While the foregoing is directed to embodiments of the present disclosure, other and further embodiments of the disclosure may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

Claims

1. A processing chamber applicable for use in semiconductor manufacturing, comprising: a chamber body at least partially defining an internal volume; one or more heat sources operable to heat the internal volume; a substrate support disposed in the internal volume; one or more inlet openings configured to direct a gas across a gas flow path over the substrate support and to one or more exhaust outlets; and a process kit disposed in the internal volume, the process kit comprising: a first flow guide block; and a second flow guide block disposed opposite the first flow guide block with respect to the gas flow path, the first flow guide block and the second flow guide block respectively comprising one or more opaque outer surfaces.

2. The processing chamber of claim 1, wherein the process kit further comprises: a plate disposed in the internal volume and at least partially fluidly isolating a processing section of the internal volume from an outward section of the internal volume, wherein the first flow guide block supports least a first portion of the plate and the second flow guide block supports at least a second portion of the plate.

3. The processing chamber of claim 1, wherein the first flow guide block and the second flow guide block are supported on a pre-heat ring disposed outwardly of the substrate support.

4. The processing chamber of claim 2, wherein the first flow guide block and the second flow guide block are coupled to a curved section of a liner disposed outwardly of, and the first flow guide block and the second flow guide block are fused to or integrally formed with the curved section of the liner.

5. The processing chamber of claim 1, wherein the first flow guide block and the second flow guide block define a rectangular flow opening between a first planar inner face of the first flow guide block and a second planar inner face of the second flow guide block.

6. The processing chamber of claim 4, wherein the first flow guide block and the second flow guide block are movable relative to the liner.

7. The processing chamber of claim 1, further comprising one or more heating elements operable to heat the first flow guide block and the second flow guide block.

8. The processing chamber of claim 7, further comprising quartz material disposed outwardly of the first flow guide block, wherein the one or more heating elements are disposed outside of the quartz material.

9. The processing chamber of claim 8, wherein the one or more heating elements are disposed radially outwardly of the first and second flow guide blocks and the quartz material, and the one or more heating elements respectively comprise one or more of a laser source, a light-emitting diode (LED), or a lamp.

10. The processing chamber of claim 7, wherein the one or more heating elements are disposed at least partially in the first flow guide block and the second flow guide block.

11. The processing chamber of claim 10, wherein the one or more heating elements include one or more electrical wires that include one or more of carbon or metal.

12. A process kit applicable for use in semiconductor manufacturing comprising: a plate; a first block operable to support at least a first portion of the plate; and a second block operable to support at least a second portion of the plate, the first block and the second block respectively comprising one or more opaque outer surfaces.

13. The process kit of claim 12, wherein the first block and the second block are sized and shaped to define a rectangular flow opening defined between a first planar inner face of the first block and a second planar inner face of the second block.

14. The process kit of claim 12, wherein the first block and the second block respectively are formed of graphite coated with an opaque material.

15. The process kit of claim 14, wherein a thickness of the opaque material is within a range of about 30 microns to about 200 microns.

16. The process kit of claim 12, wherein the first block and the second block respectively is formed of an opaque material.

17. The process kit of claim 16, wherein the opaque material includes silicon carbide (SiC).

18. The process kit of claim 12, wherein at least one of the one or more opaque outer surfaces have an average surface roughness within a range of about 0.5 microns to about 50 microns.

19. A method of processing substrates, comprising: heating a substrate positioned on a substrate support; and flowing one or more process gases over the substrate to form one or more layers on the substrate, the flowing of the one or more process gases over the substrate comprising flowing the one or more process gases over a pair of blocks having opaque surfaces defining a rectangular flow opening.

20. The method of claim 19, further comprising heating the pair of blocks.
