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(54) **METHOD AND APPARATUS FOR SUBSTRATE TRANSFER IN A THERMAL TREATMENT CHAMBER**

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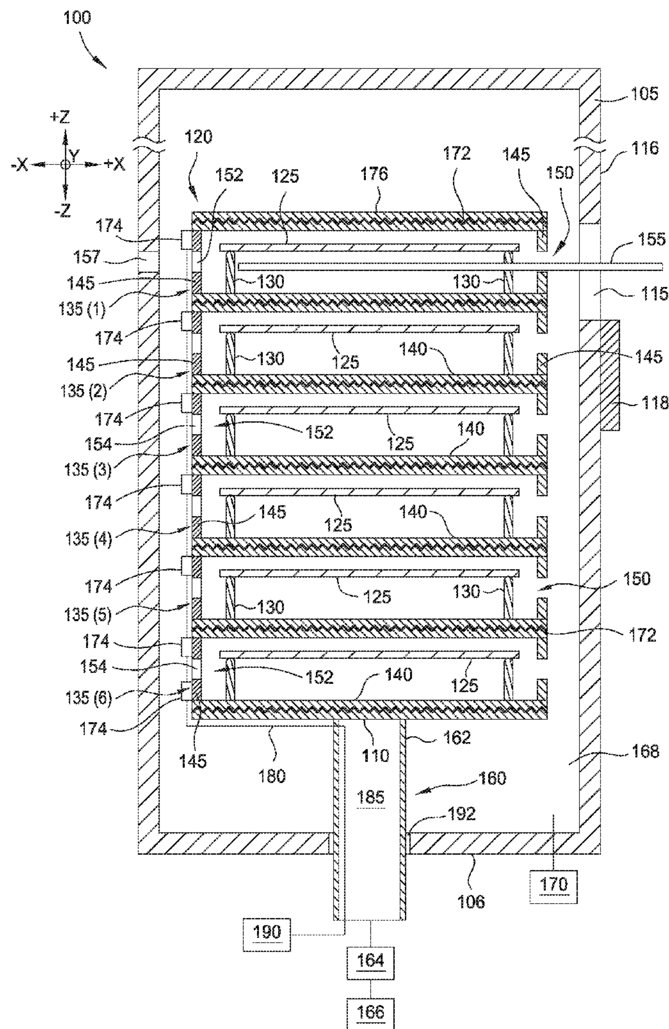
(57) **ABSTRACT**

The present disclosure generally relates to methods and apparatus for heating a substrate as well as a slot management method for a thermal treatment chamber that in one embodiment includes providing a first substrate to a first slot of a carrier in the thermal treatment chamber via a transfer opening formed in the thermal treatment chamber, the first substrate having a specified anneal time, heating the substrate, moving the carrier to a lowermost position in the thermal treatment chamber using an elevator mechanism coupled to the carrier, and moving the carrier such that the first slot is in a position adjacent to the transfer opening using the elevator mechanism within a carrier transfer time period and transferring the first substrate out of the thermal treatment chamber at a determined time period for anneal.



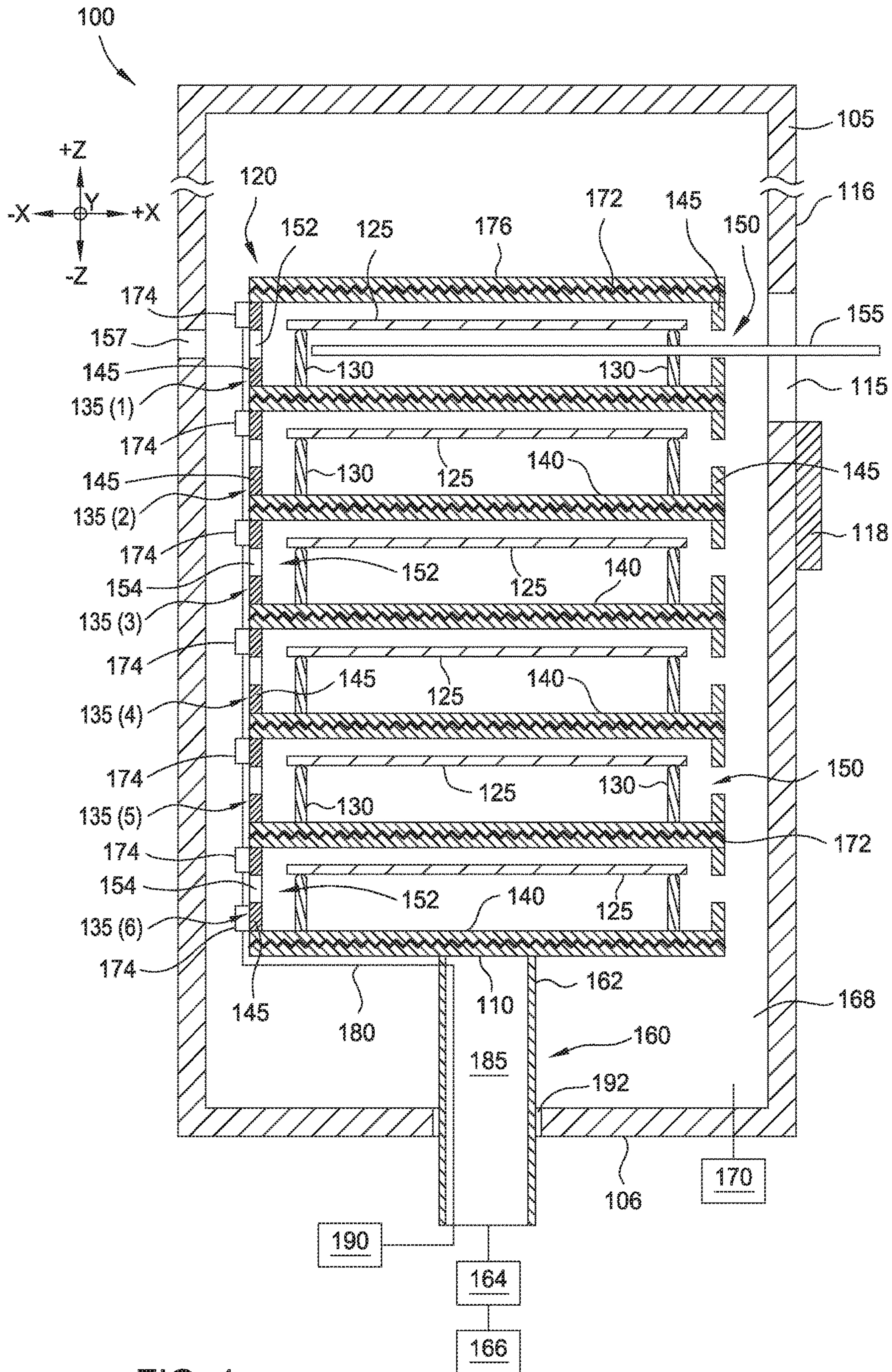


FIG. 1

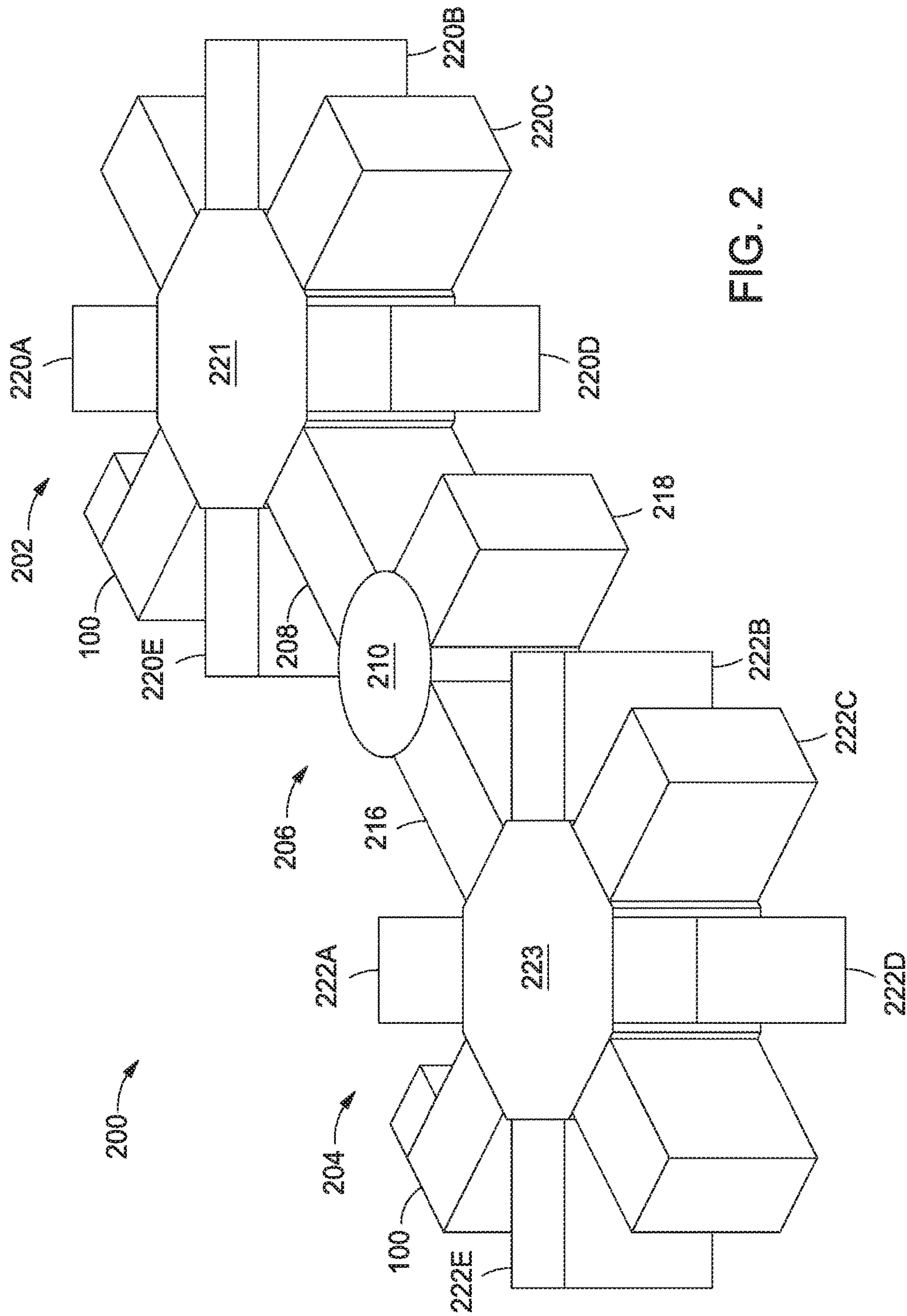


FIG. 2

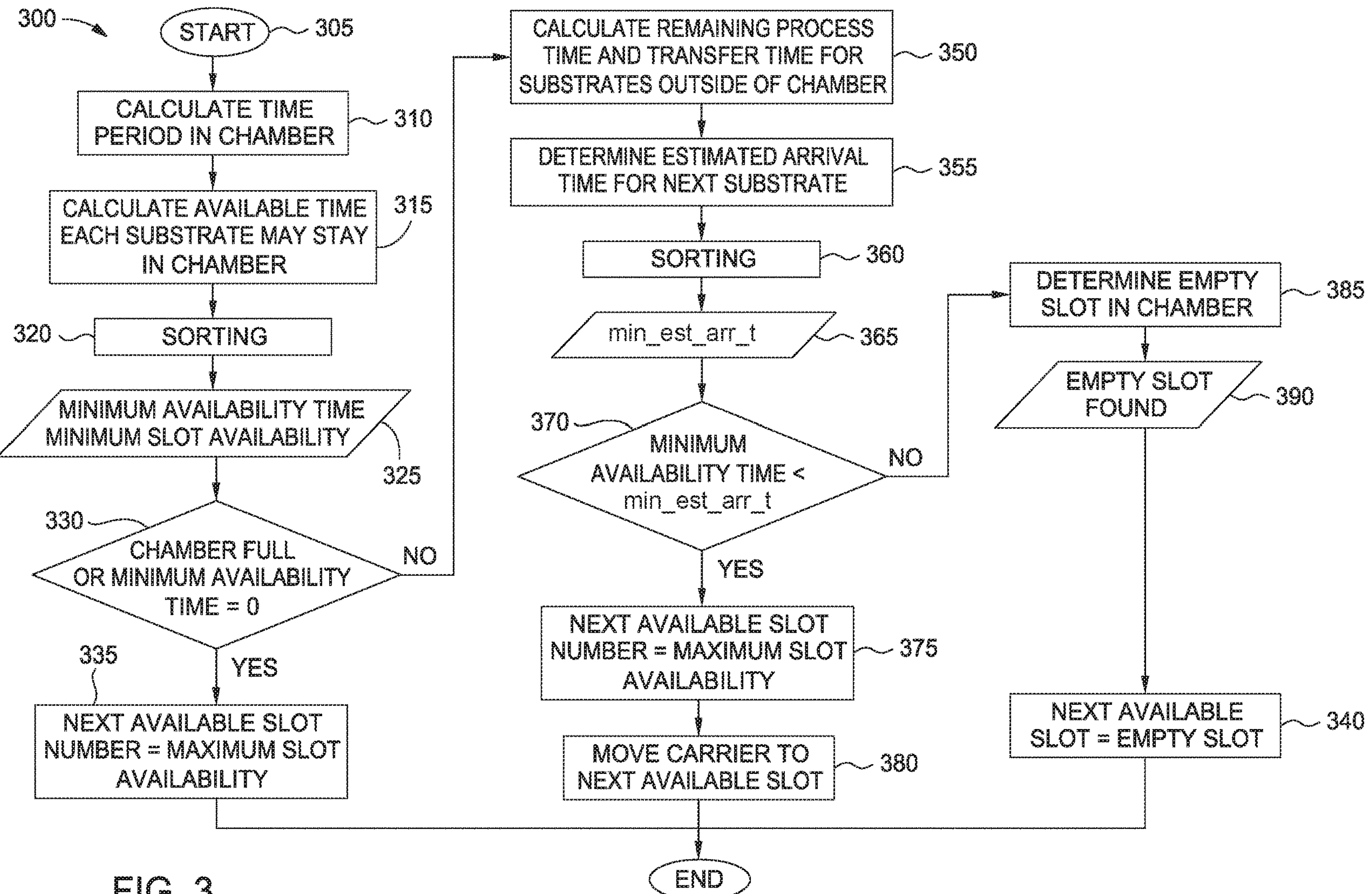


FIG. 3

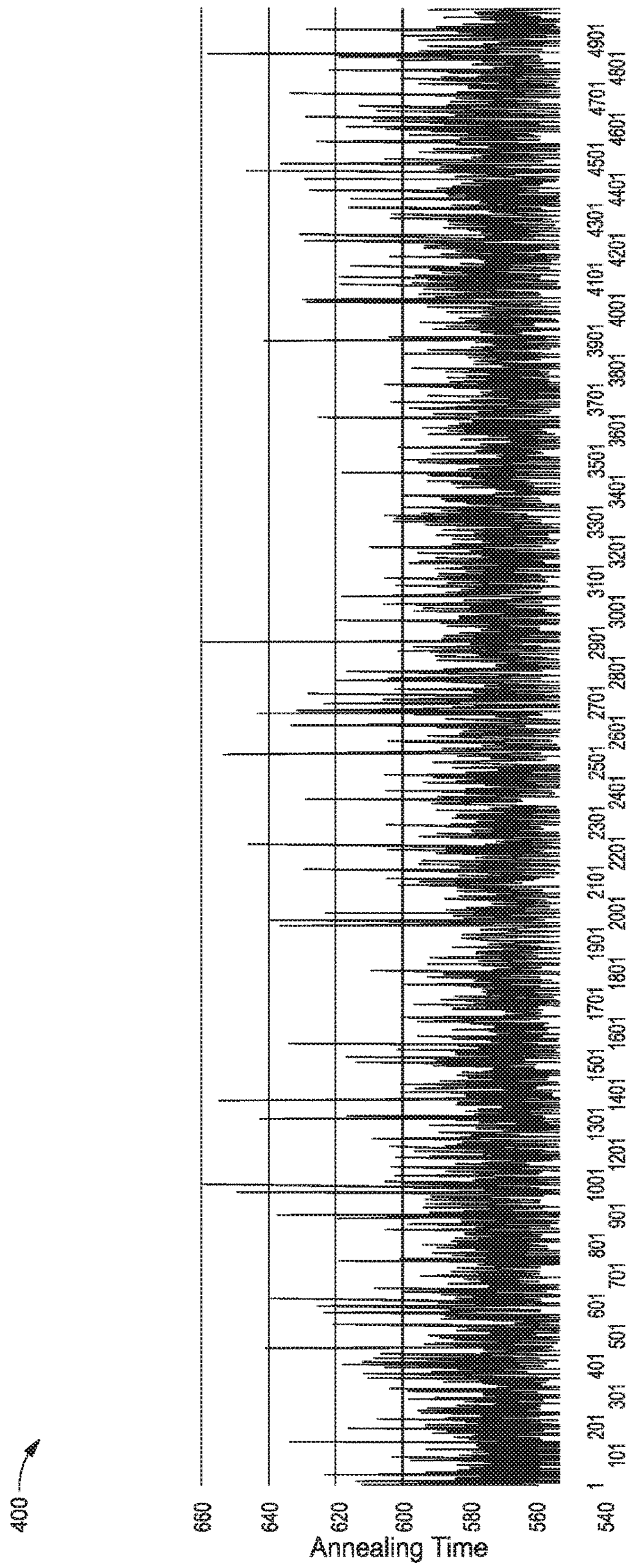


FIG. 4A

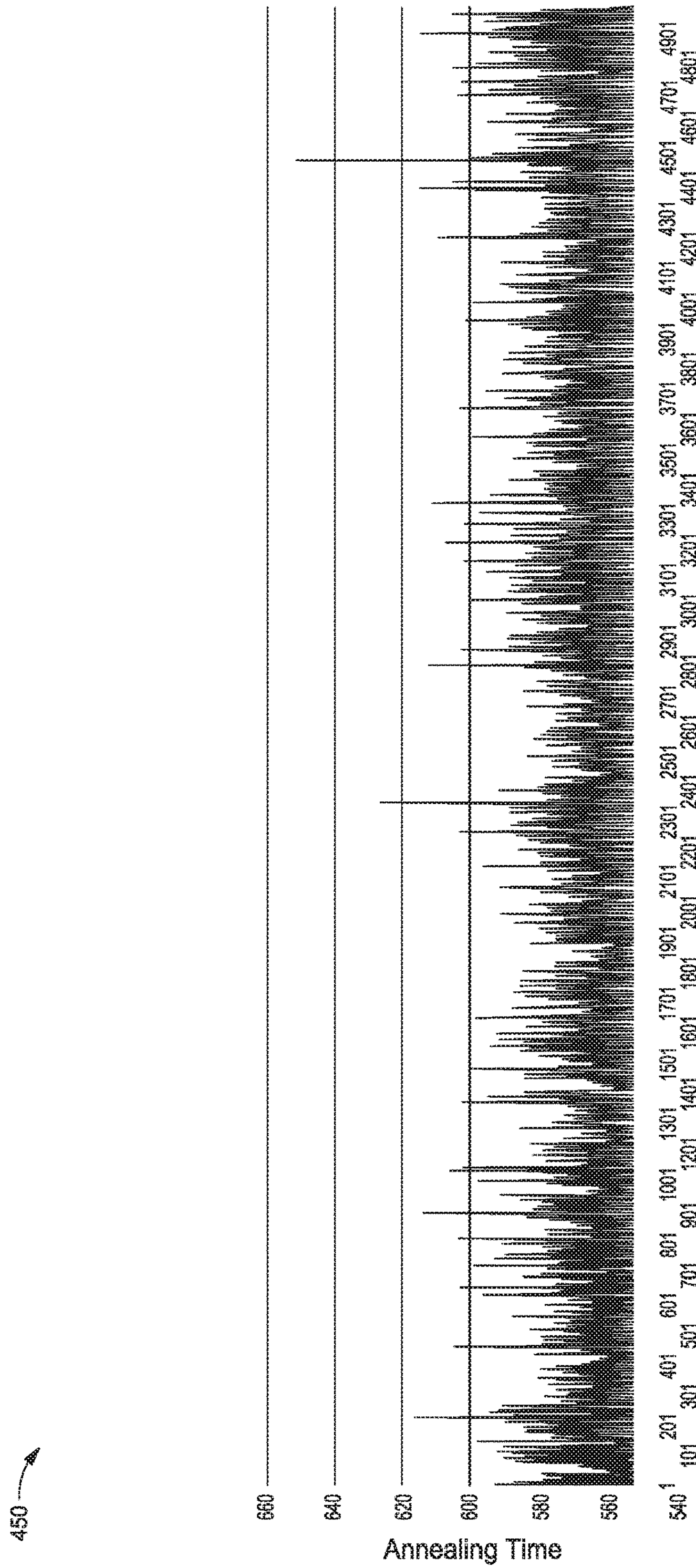
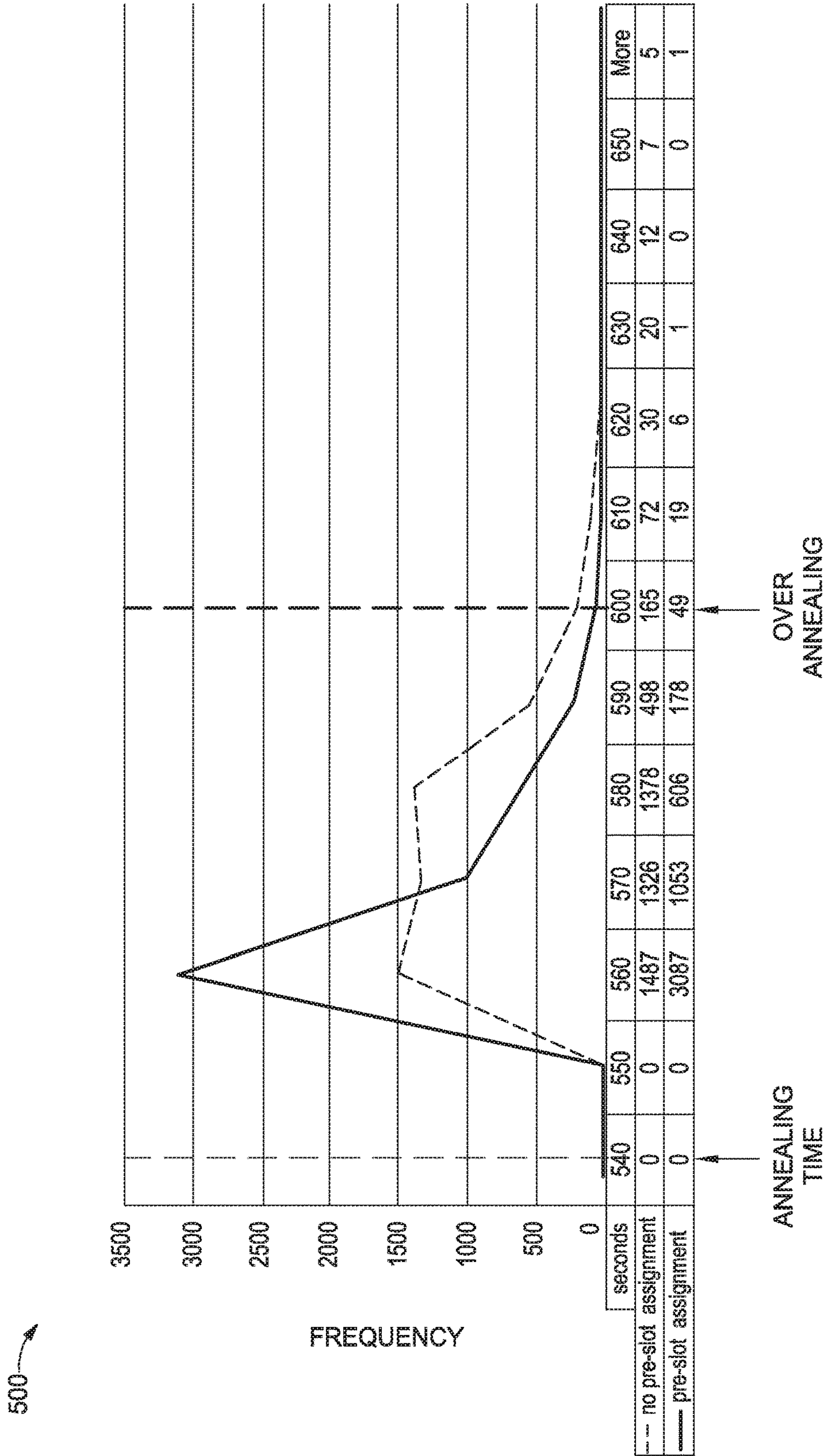


FIG. 4B



seconds	540	550	560	570	580	590	600	610	620	630	640	650	More
no pre-slot assignment	0	0	1487	1326	1378	498	165	72	30	20	12	7	5
pre-slot assignment	0	0	3087	1053	606	178	49	19	6	1	0	0	1

FIG. 5

METHOD AND APPARATUS FOR SUBSTRATE TRANSFER IN A THERMAL TREATMENT CHAMBER

BACKGROUND

Field

[0001] Embodiments of the present disclosure generally relate to methods and apparatus for heating substrates in a thermal treatment chamber, such as an annealing chamber that processes large area flat media, such as large area substrates. More specifically, embodiments disclosed herein relate to improved substrate transfer processes in a thermal treatment chamber.

Description of the Related Art

[0002] Flat media, such as rectangular, flexible sheets of glass, plastic, silicon, ceramic, or other material, is typically used in the manufacture of flat panel displays and solar devices, among other applications. Materials to form electronic devices, films and other structures on the flat media are deposited onto the flat media by numerous processes. Typically, thermal processes, such as an annealing process, are performed on the substrate prior to or after deposition in a thermal treatment chamber.

[0003] In the thermal treatment chamber, a plurality of substrates may be heated at the same time. However, each substrate must be heated at a specified temperature for a specified anneal time period to prevent over-annealing. Each substrate is typically supported on a respective substrate support within the thermal treatment chamber. Some of these substrate supports may include a heater to heat the substrate to temperatures of about 200 degrees Celsius to about 600 degrees Celsius, or greater, for the specified anneal time period. Each of the substrate supports may be coupled to a positioning mechanism that positions one of the substrate supports in proximity to a slit valve or port to facilitate substrate transfer. However, over-annealing of substrates is common due to mis-management of the thermal treatment chamber.

[0004] Therefore, there is a need in the art for an apparatus and methods for improved timing of substrate transfer in a thermal treatment chamber.

SUMMARY OF THE DISCLOSURE

[0005] The present disclosure generally relates to methods and apparatus for heating a substrate as well as a slot management method for a thermal treatment chamber that in one embodiment includes providing a first substrate to a first slot of a carrier in the thermal treatment chamber via a transfer opening formed in the thermal treatment chamber, the first substrate having a specified anneal time, heating the substrate, moving the carrier to a lowermost position in the thermal treatment chamber using an elevator mechanism coupled to the carrier, and moving the carrier such that the first slot is in a position adjacent to the transfer opening using the elevator mechanism within a carrier transfer time period and transferring the first substrate out of the thermal treatment chamber at a determined time period for anneal.

[0006] In another embodiment, a method for managing a substrate processing tool is disclosed and includes providing a first substrate to a first slot of a carrier in a thermal treatment chamber via a transfer opening formed in the thermal treatment chamber in selective communication with a transfer chamber, the first substrate having a first specified anneal time, heating the substrate, moving the carrier to a lowermost position in the thermal treatment chamber using an elevator mechanism coupled to the carrier, and moving the carrier such that the first slot is in a position adjacent to the transfer opening using the elevator mechanism within a carrier transfer time period and transferring the first substrate out of the thermal treatment chamber at a determined time period for anneal.

[0007] In another embodiment, a method for managing a substrate processing tool is provided and includes staggering transfer of a first substrate, a second substrate, and a third substrate to a respective first slot, a respective second slot, and a respective third slot of a carrier in a thermal treatment chamber via a transfer opening formed in the thermal treatment chamber in selective communication with a transfer chamber, the first substrate, the second substrate, and the third substrate each having a respective specified anneal time. The method also includes moving the carrier to a lowermost position in the thermal treatment chamber using an elevator mechanism coupled to the carrier after each of the first substrate, the second substrate, and the third substrate have been transferred, and timing movement of the carrier from the lowermost position to a position adjacent to the transfer opening using the elevator mechanism such that each of the first substrate, the second substrate, and the third substrate are transferred out of the thermal treatment chamber at a respective determined time period for anneal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] 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 typical embodiments of this disclosure and are therefore not to be considered limiting of its scope, for the disclosure may admit to other equally effective embodiments.

[0009] FIG. **1** is a cross-sectional view of a thermal treatment chamber.

[0010] FIG. **2** illustrates a schematic, perspective view of a processing system having a thermal treatment chamber thereon.

[0011] FIG. **3** is a flow chart showing one embodiment of a slot assignment method.

[0012] FIG. **4**A is a graph showing anneal processes on multiple substrates versus time using typical slot management techniques.

[0013] FIG. **4**B is a graph showing anneal processes on multiple substrates versus time using the slot assignment method as described herein.

[0014] FIG. **5** is a histogram of annealing processes on multiple substrates comparing time versus frequency.

[0015] 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 disclosed in one embodiment may be beneficially utilized on other embodiments without specific recitation.

DETAILED DESCRIPTION

[0016] Embodiments of the present disclosure generally relate to methods and apparatus for heating a substrate in a thermal treatment chamber. The thermal treatment chamber is exemplarily described herein as an annealing chamber. Suitable chambers that may be modified to practice the disclosure are available from AKT, a subsidiary of Applied Materials, Inc., Santa Clara, Calif. It is to be understood that the embodiments disclosed herein are suitable for use on chambers available from other manufacturers as well.

[0017] FIG. **1** is a cross-sectional view of a thermal treatment chamber **100** utilized for heating multiple substrates, for example in an annealing process. The thermal treatment chamber **100** comprises a chamber body **105** having a bottom **106** and a slit valve opening **115** in a sidewall **116** (e.g., a transfer opening). The slit valve opening **115** is selectively sealed by a door **118**. A carrier **120** for supporting one or more substrates **125** is disposed in an interior volume of the chamber body **105**. The substrates **125** may be supported within the carrier **120** by pins **130**.

[0018] The carrier **120** includes a plurality of heated substrate slots **135**. Each of the heated substrate slots **135** includes a bottom **140** and sidewalls **145**. Each of the heated substrate slots **135** is configured to support a substrate **125** in a spaced-apart relation from the bottom **140** of each of the heated substrate slots **135** utilizing the pins **130**. Substrates **125** are transferred into and out of the heated substrate slots **135** though an opening **150** in the sidewall **145** and the slit valve opening **115**. When open, the slit valve opening **115** permits an end effector **155** to enter and exit the thermal treatment chamber **100** and deliver or retrieve a substrate **125**. The carrier **120** is coupled to an elevator mechanism **160** that moves the carrier **120** in the Z direction relative to the slit valve opening **115**. The elevator mechanism **160** includes a shaft **162** disposed through the bottom **106** of the chamber body **105** that is coupled to an actuator **164**. The actuator **164** is coupled to a controller **166**. In the position shown in FIG. **1**, the elevator mechanism **160** lowers the carrier **120** in the −Z direction so that the substrate **125** contacts the end effector **155**. The elevator mechanism **160** lowers the carrier **120** slightly more in the −Z direction such that the substrate **125** is moved out of contact with the pins **130** while supported on the end effector **155**. Once the substrate **125** is moved away from the pins **130**, the end effector **155** can remove the substrate **125** in the +X direction.

[0019] Loading of a new substrate may be accomplished by moving the end effector **155** in the −X direction into the heated substrate slot **135** through the slit valve opening **115**. The elevator mechanism **160** raises the carrier **120** in the +Z direction such that the new substrate contacts and is supported by the pins **130**. Thereafter, the end effector **155** moved out of the chamber body **105**. The door **118** can then be closed and an interior volume **168** of the chamber body **105** may be pumped down using a vacuum pump **170**. Pressures within the interior volume **168** can cycle between ambient pressure to the milliTorr range. The substrates **125** disposed in the heated substrate slots **135** are in communication with the pressure or vacuum of the interior volume **168** through at least the openings **150**. In some embodiments, each heated substrate slot **135** includes an opening **152** that aligns with an opening **154** in the sidewall **145** of the carrier **120**. The openings **152** and **154** may be utilized as view windows when aligned with an opening **157** formed in the sidewall **116** of the chamber body **105**.

[0020] Each of the heated substrate slots **135** include a heater **172**. The heater **172** may be embedded or positioned on at least the bottoms **140** of the heated substrate slots **135**. In some embodiments, a top **176** of the carrier **120** includes a heater **172**. Each of the heaters **172** are coupled to a connector **174** disposed outside of the heated substrate slots **135** and within the interior volume **168** of the chamber body **105**. Leads **180** for each of the heaters **172** are routed through a channel **185** formed in the shaft **162**. The leads **180** are coupled to a power supply **190** outside of the chamber body **105**.

[0021] The heated substrate slots **135** may be referred to as slots **1-6** from the +Z direction to the −Z direction. The substrates **125** can be transferred to each slot from a transfer chamber (shown as **221** and **223** in FIG. **2**) having the end effector **155**. For example, an un-annealed substrate may be transferred into the slot **6** in FIG. **1**. Once an individual substrate **125** is loaded, and the door **118** is closed, an anneal time period begins for that substrate. As an example, an anneal time period may be about 540 seconds with a tolerance of about +20 seconds (e.g., a maximum anneal time of about 600 seconds). Other substrates **125** may be transferred to empty slots or removed from slots during the anneal time period for the substrate **125** in slot **6**.

[0022] However, during the anneal time period, the elevator mechanism **160** lowers the carrier **120** to a position adjacent the bottom **106** (e.g., the lowermost position). The lowering of the carrier **120** positions portions of the shaft **162** outside the environment of the interior volume **168**. Temperatures in the interior volume **168** may cause the shaft **162** to expand when the shaft **162** is exposed to elevated temperatures in the interior volume **168** for extended periods. Undesirable thermal expansion of the shaft **162** may cause damage to a vacuum seal **192** disposed about the shaft **162**. Thus, lowering of the carrier **120** to the lowermost position minimizes exposure of the shaft **162** to the interior volume **168**, which protects the shaft **162** and the vacuum seal **192**.

[0023] However, lowering of the carrier **120** extends travel time of the carrier **120** when substrates are transferred. For example, moving the carrier **120** from the lowermost position to a position where the slot **6** is adjacent to the slit valve opening **115** (e.g., a carrier transfer time period) may take about 30 seconds when the elevator mechanism **160** is operated at a suitable speed (e.g., velocity and acceleration). A suitable transfer speed of the elevator mechanism **160** is a velocity and acceleration where vibration of the substrates **125** does not occur (excessive vibration may cause breakage of the substrates **125**).

[0024] FIG. **2** illustrates a schematic, perspective view of a processing system **200**. In one embodiment, the thermal treatment chamber **100** may be beneficially incorporated into the processing system **200**. The processing system **200** includes a first cluster tool **202** and a second cluster tool **204** joined by intermediate chambers **206**. The intermediate chambers **206** include a first pass through chamber **208**, a turn chamber **210**, a second pass through chamber **216**, and an optional buffer chamber **218**. In some embodiments, the buffer chamber **218** may be replaced by the thermal treatment chamber **100** on one or both of the first cluster tool **202** and the second cluster tool **204** as one or more substrates may be stored therein.

[0025] The first cluster tool **202** may include one or more processing chambers **220**A-**220**E, a first transfer chamber **221**, and the thermal treatment chamber **100**. The processing chambers **220**A-**220**E and the thermal treatment chamber **100** may be coupled to the first transfer chamber **221** and disposed radially thereabout. The second cluster tool **204** may include one or more processing chambers **222**A-**222**E, a second transfer chamber **223**, and the thermal treatment chamber **100**. Similar to the first cluster tool **202**, the processing chambers **222**A-**222**E and the thermal treatment chamber **100** may be coupled to the second transfer chamber **223** and disposed radially thereabout.

[0026] In operation, one or more substrates are transferred to the thermal treatment chamber **100** by a robot disposed in the first transfer chamber **221** and undergo an annealing process therein. Each of the one or more substrates are transferred (inserted) into the thermal treatment chamber **100** at different times in order to reduce heat loss from the thermal treatment chamber **100** though the slit valve opening **115**. Thereafter, substrates are retrieved from the thermal treatment chamber **100** by the robot disposed in the first transfer chamber **221** and positioned in the processing chambers **220**A-**220**E. Each of the one or more substrates are transferred out of the thermal treatment chamber **100** at different times in order to reduce heat loss from the thermal treatment chamber **100** though the slit valve opening **115**. Substrates are processed in the processing chambers **220**A-**220**E to deposit one or more layers on the substrates. After deposition of the one or more layers, the substrates are transferred to the second cluster tool **204** through the first pass through chamber **208**, the turn chamber **210**, and the second pass through chamber **216**. Prior to processing the substrates in the second cluster tool **204**, a robot disposed in the second transfer chamber **223** can optionally retrieve substrates from the thermal treatment chamber **100** coupled to the transfer chamber **220** and position the substrates in the processing chambers **222**A-**222**E. The robot disposed in the second transfer chamber **223** can receive the substrates from the second pass through chamber **216** and position the substrates in the processing chambers **222**A-**222**E to deposit one or more layers on the substrates. It is to be understood that while the transfer chambers **221**, **223** have been shown as eight sided transfer chambers able to accommodate up to eight chambers coupled thereto, other sized transfer chambers are contemplated such as six sided transfer chambers. Additionally, it is to be understood that the processing chambers **220**A-**220**E, **222**A-**222**E may comprise suitable chambers for processing substrates such as PECVD, CVD, ALD, PVD, etching, and other chambers.

[0027] As discussed above, movement and/or sequencing of the carrier **120** of FIG. **1** may be improved as described herein. For example, the carrier **120** may be moved by the elevator mechanism to sequence substrates for loading and unloading at a velocity where minimal to no vibration occurs during movement thereof to prevent breakage of substrates and anneal times are achieved. The improved sequencing may prevent over-annealing of substrates **125**, reduce the waiting time of the end effector **155**, prevent or minimize heat loss from the interior volume **168** during transfer, as well as improve overall throughput of a processing system, such as the processing system **200**. Additionally, embodiments disclosed herein may be more environmentally friendly because of reduced usage of the actuator **164** to move the carrier **120**, which may also result in longer lifetime of the actuator **164**.

[0028] To improve movement of the carrier **120** as well as manage the loading and unloading of substrates **125** to and from the slots **1**-**6** shown in FIG. **1**, the inventors have devised and tested a slot assignment method as will be described below.

[0029] FIG. **3** is a flow chart showing one embodiment of a slot assignment method **300**. The slot assignment method **300** may be performed by a controller with associated hardware and software configured to perform the actions as described herein. The slot assignment method starts at **305** and, as an example, the thermal treatment chamber **100** may have three substrates housed therein in a respective slot. In the example, one substrate may occupy slot **1**, another substrate may occupy slot **2**, and another substrate may occupy slot **3** of the carrier **120** at **305**. In the example, slots **4**-**6** are empty. The time of insertion into the thermal treatment chamber **100** of each substrate may be referred to as "entrance time". Further, each of the three substrates in the respective slots **1**-**3** have a specified annealing time period, such as about 100 seconds. If the specified annealing time period is exceeded, over-annealing may occur.

[0030] The slot assignment method **300** continues at **310** where a time period for each substrate **125** in the thermal treatment chamber **100** is calculated (e.g., a "duration time"). The duration time may be defined as the time a particular substrate may remain in its current location in the thermal treatment chamber **100**. The duration time may be determined by subtracting the entrance time from the current time (i.e., duration time=current time−entrance time). For example, if the substrate in slot **1** entered the thermal treatment chamber **100** at 17:20:15 and the current time is 17:20:45, the duration time is 30 seconds.

[0031] The slot assignment method **300** continues at **315** where an "available" time is calculated for each substrate in the thermal treatment chamber **100**. Available time may be defined as the time period a substrate may remain in its current location in the thermal treatment chamber **100**. Available time may be determined by subtracting duration time from the annealing time period for each substrate (i.e., available time=specified annealing time period−duration time).

[0032] In the example above wherein a substrate occupies each of slots **1**-**3** (i.e., 3 substrates) and slots **4**-**6** are empty, if the duration time of the substrate in slot **1** is 30 seconds, the duration time of the substrate in slot **2** is 25 seconds, and the duration time of the substrate in slot **3** is 50 seconds, then the available time of the substrate in slot **1** is 70 seconds, the available remaining time of the substrate in slot **2** is 75 seconds, and the available remaining time of the substrate in slot **3** is 50 seconds. The slot assignment method **300** then continues at **320** where a sort process is provided.

[0033] At **320**, a sorting occurs of occupied slots in the thermal treatment chamber **100** (i.e., slots **1**-**3** in the example) based on available time. In one implementation of the sorting, the time to complete the heating process for each substrate is calculated and the substrates are sorted from minimum to maximum, and the substrate with the smaller minimum available time gets higher priority. In the example above, a list is developed after 320 which may include slot **3**: 50 seconds; slot **1**: 70 seconds; and slot **2**: 75 seconds.

[0034] At **325**, the slot having a minimum availability time out of the occupied slots (i.e., slots **1-3** in the example) is determined. For example, minimum availability time is the minimal of all available time in occupied slots (i.e., slots **1-3** in the example), and a minimum slot availability, which indicates the slot number having the substrate with a minimum available time, is determined. In the example above, slot **3** has the minimum slot availability based on the minimum availability time (i.e., 50 seconds).

[0035] At **330** a decision is determined based on whether the thermal treatment chamber **100** is full (i.e., no unoccupied slots) or whether the minimum availability time=0.

[0036] If YES, then the slot assignment method **300** moves to **335** where a next available slot number is determined based on minimum slot availability (block **325**) and the result is used to move the carrier **120** (via the elevator mechanism **160**) to a position for the next transfer. In the example above, if the thermal treatment chamber **100** is full or the minimum availability time is equal to 0, the next available slot number is slot **3**. Accordingly, the carrier **120** is moved to a position for transfer of the substrate from slot **3**. Alternatively, if minimum availability time is less than a minimal estimated arrival time of a substrate from its current location in the first cluster tool **202** or the second cluster tool **204** to the thermal treatment chamber **100** (i.e. "min_est_arr_t") to the next empty slot in the thermal treatment chamber **100**, then the carrier **120** would be moved to a position for transfer of a substrate to slot **4** (i.e., the next available slot or empty slot (block **340**)).

[0037] If NO, the slot assignment method **300** continues at **350** where remaining processing time of a substrate (e.g., "substrate A") in the first cluster tool **202** or the second cluster tool **204** is calculated along with a transfer time for the substrate from the first cluster tool **202** or the second cluster tool **204** to the thermal treatment chamber **100**. For example, if substrate A is being processed in one of the processing chambers **220**A-**220**E or the processing chambers **222**A-**222**E of FIG. **2**, the remaining processing time of substrate A as well as the transfer time of substrate A from the processing chambers **220**A-**220**E or the processing chambers **222**A-**222**E to the thermal treatment chamber **100** is determined.

[0038] As an example, substrate A is transferred into one of the processing chambers **220**A-**220**E or the processing chambers **222**A-**222**E at 17:20:00, and the process recipe time for substrate A is 100 seconds. If the current time is 17:20:15, then the remaining processing time for substrate A is 85 seconds. The transfer time to transport substrate A from one of the processing chambers **220**A-**220**E or the processing chambers **222**A-**222**E is for example, 10 seconds. In this specific example, the result of block **350** would be 95 seconds (i.e., 85 seconds+10 seconds).

[0039] Next, the slot assignment method **300** continues at **355** where estimated arrival time for the next substrate to be transferred to the thermal treatment chamber **100** is determined. The estimated arrival time is the remaining processing time+the transfer time for each of the substrates B-D. As an example, if the processing chambers **220**A-**220**C are processing three substrates (e.g., substrates B-D), the estimated arrival time for each of the substrates B-D to the thermal treatment chamber **100** can be calculated. Specifically, in one example, the estimated arrival time for substrate B may be 95 seconds, the estimated arrival time for substrate C may be 60 seconds, and the estimated arrival time for substrate D may be 105 seconds.

[0040] The substrates B-D are then sorted according to estimated arrival time at **360**. For example, the time when substrates will arrive at the thermal treatment chamber **100** is calculated and the substrates are sorted from minimum to maximum, and the substrate with the least minimum arrival time gets higher priority.

[0041] At **370**, the next substrate to be transferred into the thermal treatment chamber **100** based on the min_est_arr_t is determined. In the specific example using the estimated arrival time for substrates B-D, substrate C, having the shortest estimated arrival time, would be queued for transfer into the thermal treatment chamber **100**.

[0042] At **375**, the minimum availability time is compared with the min_est_arr_t. If the minimum availability time is less than the min_est_arr_t (YES), the slot assignment method **300** continues at **380** wherein a next available slot number is determined based on minimum slot availability and the result is used to move the carrier **120** (via the elevator mechanism **160**) to a position for the next transfer. In the example above, the substrate in slot **3** having a minimum availability time of 50 seconds meets this condition (i.e., minimum availability time (50 seconds) is less than min_est_arr_t (60 seconds (substrate C))). Thus, in the example, the carrier **120** is moved to a position for transferring the substrate from slot **3** out of the thermal treatment chamber **100** and transferring substrate C into the thermal treatment chamber **100**. This transfer may be accomplished within the specified anneal time period for the substrate in slot **3** and thus prevents over-annealing.

[0043] If the condition of **375** is not met (i.e., the minimum availability time is not less than the min_est_arr_t (NO)), the slot assignment method **300** continues at **385** where an empty slot in the thermal treatment chamber **100** is determined. Then, when an empty slot is found at **390**, the slot assignment method **300** continues at **340** where the next available slot or empty slot is determined and the carrier **120** is moved to the next available slot. In the example above, slots **4-6** are determined to be empty and available for substrates B-D.

[0044] Simulations of the slot assignment method **300** were performed and the results are shown in FIGS. **4**A, **4**B and **5**.

[0045] FIG. **4**A is a graph showing anneal processes on multiple substrates (abscissa) versus time (ordinate) using conventional slot management techniques. FIG. **4**B is a graph showing anneal processes on multiple substrates (abscissa) versus time (ordinate) using the slot assignment method **300** as described herein. Both of the anneal processes in FIGS. **4**A and **4**B have an anneal time period of 600 seconds. As seen in FIG. **4**B, over-annealing was significantly reduced, indicated by fewer substrates exceeding the 600 second mark using the slot assignment method **300**.

[0046] FIG. **5** is a histogram illustrating annealing processes on multiple substrates comparing time versus frequency. As shown, over-annealing was significantly reduced using the slot assignment method **300** as described herein. Thus, throughput may be optimized according to embodiments disclosed herein as the substrate(s) will be removed out of the thermal treatment chamber **100** on-time, which opens slots for new substrates.

[0047] Embodiments of the disclosure have resulted in reducing over-annealing by about 82%, improved throughput by about 4%, and improved standard deviation by about 21%.

[0048] 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.

1. A method for managing a thermal treatment chamber, comprising:

providing a first substrate to a first slot of a carrier in the thermal treatment chamber via a transfer opening formed in the thermal treatment chamber, the first substrate having a specified anneal time;

heating the substrate;

moving the carrier to a lowermost position in the thermal treatment chamber using an elevator mechanism coupled to the carrier; and

moving the carrier such that the first slot is in a position adjacent to the transfer opening using the elevator mechanism within a carrier transfer time period and transferring the first substrate out of the thermal treatment chamber at a determined time period for anneal.

2. The method of claim **1**, wherein, during the heating, a second substrate is transferred to a second slot of the carrier.

3. The method of claim **2**, wherein the carrier is at the lowermost position prior to the second substrate being transferred.

4. The method of claim **3**, wherein the carrier is moved from the lowermost position to position the second slot adjacent to the transfer opening prior to the second substrate being transferred.

5. The method of claim **2**, further comprising:

moving the carrier to the lowermost position after transferring the second substrate into the thermal treatment chamber.

6. The method of claim **5**, further comprising:

moving the carrier such that the second slot is in a position adjacent to the transfer opening using the elevator mechanism and transferring the second substrate out of the thermal treatment chamber

7. The method of claim **1**, wherein the carrier transfer time period is based on a transfer speed of the elevator mechanism such that minimal to no vibration of the first substrate occurs during movement of the carrier.

8. The method of claim **1**, further comprising:

depositing films onto one or more second substrates in a cluster tool; and

determining an arrival time of the one or more second substrates to the thermal treatment chamber.

9. The method of claim **8**, wherein determining the arrival time further comprises:

calculating remaining processing time and a transfer time for the one or more substrates in the cluster tool to the thermal treatment chamber.

10. A method for managing a substrate processing tool, comprising:

providing a first substrate to a first slot of a carrier in a thermal treatment chamber via a transfer opening formed in the thermal treatment chamber in selective communication with a transfer chamber, the first substrate having a first specified anneal time;

heating the substrate;

moving the carrier to a lowermost position in the thermal treatment chamber using an elevator mechanism coupled to the carrier; and

moving the carrier such that the first slot is in a position adjacent to the transfer opening using the elevator mechanism within a carrier transfer time period and transferring the first substrate out of the thermal treatment chamber at a determined time period for anneal.

11. The method of claim **10**, further comprising:

depositing films onto one or more second substrates in the substrate processing tool; and

determining an arrival time of the one or more second substrates to the thermal treatment chamber.

12. The method of claim **11**, wherein determining the arrival time further comprises:

calculating remaining processing time and a transfer time for the one or more substrates in the substrate processing tool to the thermal treatment chamber.

13. The method of claim **10**, further comprising:

transferring a second substrate into a second slot of the thermal treatment chamber during the first specified anneal time, the second substrate having a second specified anneal time.

14. The method of claim **13**, wherein the first and second specified anneal times are the same.

15. The method of claim **13**, further comprising:

transferring a third substrate into a third slot of the thermal treatment chamber during the first and second specified anneal times, the third substrate having a third specified anneal time.

16. The method of claim **15**, further comprising:

moving the carrier such that the third slot is in a position adjacent to the transfer opening using the elevator mechanism and transferring the third substrate out of the thermal treatment chamber at or prior to conclusion of the third specified anneal time.

17. A method for managing a substrate processing tool, comprising:

staggering transfer of a first substrate, a second substrate, and a third substrate to a respective first slot, a respective second slot, and a respective third slot of a carrier in a thermal treatment chamber via a transfer opening formed in the thermal treatment chamber in selective communication with a transfer chamber, the first substrate, the second substrate, and the third substrate each having a respective specified anneal time;

moving the carrier to a lowermost position in the thermal treatment chamber using an elevator mechanism coupled to the carrier after each of the first substrate, the second substrate, and the third substrate have been transferred; and

timing movement of the carrier from the lowermost position to a position adjacent to the transfer opening using the elevator mechanism such that each of the first substrate, the second substrate, and the third substrate are transferred out of the thermal treatment chamber at a respective determined time period for anneal.

18. The method of claim **17**, further comprising:

depositing films onto a fourth substrate in the substrate processing tool; and

determining an arrival time of the fourth substrate to the thermal treatment chamber.

19. The method of claim **18**, wherein determining the arrival time further comprises:

calculating remaining processing time and a transfer time for the fourth substrate in the substrate processing tool to the thermal treatment chamber.

20. The method of claim **19**, further comprising:

transferring the fourth substrate into a fourth slot of the thermal treatment chamber during the respective specified anneal time for each of the first substrate, the second substrate, and the third substrate.

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