

SEMICONDUCTOR PROCESS DEVICE AND PNEUMATIC VALVE CONTROL METHOD THEREFOR

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TECHNICAL FIELD

[0001] The present disclosure relates to, but is not limited to, the field of semiconductor process technology, and particularly relates to a semiconductor process device and a pneumatic valve control method therefor.

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BACKGROUND

[0002] At present, the epitaxial growth of silicon carbide is mainly performed by Chemical Vapor Deposition (CVD), and involves the specific chemical reactions that SiH_4 (or SiHCl_3) and C_2H_4 (or C_3H_8) have a cracking reaction at a high temperature (above 1600°C) to generate Si atoms and C atoms and then the Si atoms and the C atoms recombine on a wafer surface to form SiC. The atoms participating in the chemical reactions for the epitaxial growth are introduced into a process chamber with process gases, that is, as shown in FIG. 1, a gas ratio of the process gases SiH_4 and C_2H_4 (taken as an example) is adjusted by setting flow values of Mass Flow Controllers (MFCs), so that the target chemical reactions may be achieved in the process chamber under the conditions of specific temperatures and pressures. Pneumatic valves V1, V2 shown in FIG. 1 are mainly configured to control the corresponding process gases SiH_4 and C_2H_4 to enter the process chamber 10 through opening and closing thereof.

[0003] However, in an existing pneumatic valve control method, different process gases cannot synchronously enter the process chamber due to different response durations of different pneumatic valves, such that the process gases cannot fully react in the process chamber, which greatly reduces utilization of the process gases and also causes many process defects to the whole process.

SUMMARY

[0004] The embodiments of the present disclosure provide a semiconductor process device and a pneumatic valve control method therefor, so as to solve the technical problems that many process defects are caused to the whole process and the utilization of the process gases is greatly reduced due to the fact that the process gases cannot synchronously enter the process chamber and thus cannot fully react in the process chamber because the existing pneumatic valve control method cannot achieve simultaneous opening or simultaneous closing of a plurality of pneumatic valves.

[0005] In a first aspect, an embodiment of the present disclosure provides a pneumatic valve control method for a semiconductor process device for achieving synchronous opening or synchronous closing of a plurality of pneumatic valves of the semiconductor process device, including:

acquiring a plurality of pneumatic valves that need to simultaneously complete a same pneumatic valve action command in a current process step, and obtaining a response duration of each pneumatic valve corresponding to the pneumatic valve action command; calculating a command issuance delay value of each pneumatic valve based on a longest response duration among response durations of the plurality of pneumatic valves; and

sending the corresponding pneumatic valve action command to each pneumatic valve in chronological order based on the command issuance delay value of each pneumatic valve to control the plurality of pneumatic valves to simultaneously complete the same pneumatic valve action command.

[0006] Optionally, in some embodiments, the pneumatic valve action command is a pneumatic valve open command or a pneumatic valve close command; and the response duration is a first response duration corresponding to the pneumatic valve open command or a second response duration corresponding to the pneumatic valve close command.

[0007] Optionally, in some embodiments, before acquiring the plurality of pneumatic valves that need to simultaneously complete the same pneumatic valve action command in the current process step, and obtaining the response duration of each pneumatic valve corresponding to the pneumatic valve action command, the pneumatic valve control method further includes:

receiving a target pneumatic valve action command set uniformly issued by an upper computer, the target pneumatic valve action command set including pneumatic valve action commands for the plurality of pneumatic valves that need to simultaneously complete the same pneumatic valve action command in the current process step.

5 [0008] Optionally, in some embodiments, acquiring the plurality of pneumatic valves that need to simultaneously complete the same pneumatic valve action command in the current process step, and obtaining the response duration of each pneumatic valve corresponding to the pneumatic valve action command includes:

10 finding out a name of each pneumatic valve that needs to simultaneously complete the same pneumatic valve action command in the current process step based on the target pneumatic valve action command set; and

based on the name of each pneumatic valve and the pneumatic valve action command which needs to be executed simultaneously currently, sequentially finding out the response duration of each pneumatic valve corresponding to the pneumatic valve action
15 command from a response duration information table.

[0009] Optionally, in some embodiments, first response durations and second response durations of all pneumatic valves in the semiconductor process device are recorded in the response duration information table, and generation of the response duration information table includes:

20 synchronously starting timing when a pneumatic valve open command is sent to a target pneumatic valve, and synchronously stopping timing when the target pneumatic valve completes the pneumatic valve open command, so as to acquire a first response duration of the target pneumatic valve and record the first response duration of the target pneumatic valve in the response duration information table; and

25 synchronously starting timing when a pneumatic valve close command is sent to the target pneumatic valve, and synchronously stopping timing when the target pneumatic valve completes the pneumatic valve close command, so as to acquire a second response duration of the target pneumatic valve and record the second response duration of the target pneumatic valve in the response duration information table.

30 [0010] Optionally, in some embodiments, calculating the command issuance delay value of each pneumatic valve based on the longest response duration among the response durations of the plurality of pneumatic valves includes:

sequentially performing a difference operation on the longest response duration and the response durations of the plurality of pneumatic valves to take sequentially obtained differences as command issuance delay values of the corresponding pneumatic valves.

[0011] Optionally, in some embodiments, sending the corresponding pneumatic valve action command to each pneumatic valve in chronological order based on the command issuance delay value of each pneumatic valve to control the plurality of pneumatic valves to simultaneously complete the same pneumatic valve action command includes:

synchronously starting timing when the corresponding pneumatic valve action command is sent to a pneumatic valve having the command issuance delay value of 0, and when a timing value from the timing is equal to the command issuance delay value of any one of the other pneumatic valves, synchronously sending the corresponding pneumatic valve action command to the any one of the other pneumatic valves, so as to control the plurality of pneumatic valves to simultaneously complete the same pneumatic valve action command.

[0012] In a second aspect, an embodiment of the present disclosure provides a semiconductor process device, including a lower computer, a plurality of solenoid valve sets, a plurality of pneumatic valves, and a process chamber provided with a plurality of gas pipelines, the plurality of solenoid valve sets and the plurality of pneumatic valves are disposed in a one-to-one correspondence manner to allow each pneumatic valve to enable, under the control of a corresponding solenoid valve set, one gas pipeline to be opened or closed, the lower computer is respectively connected to the plurality of solenoid valve sets by signals, and the lower computer performs any one of the pneumatic valve control methods when being in operation.

[0013] Optionally, in some embodiments, the semiconductor process device further includes a response duration acquisition module, which is respectively connected to the lower computer and the plurality of pneumatic valves by signals for acquiring and recording a response duration of each pneumatic valve.

[0014] Optionally, in some embodiments, the response duration acquisition module includes a fast response unit, a timer, and a plurality of pneumatic valve state detection sensors; wherein

the plurality of pneumatic valve state detection sensors are respectively connected to the fast response unit by signals, and are disposed in the plurality of pneumatic valves in a one-to-one correspondence manner, so as to acquire state changes of the corresponding

pneumatic valves, and feed corresponding feedback signals back to the fast response unit when states of the corresponding pneumatic valves change; and

the fast response unit is further respectively connected to the lower computer and the timer by signals, so as to send a start signal to the timer to start timing by the timer when the lower computer sends a pneumatic valve action command to any one of the pneumatic valves, and send an end signal to the timer to end the timing of the timer when receiving a feedback signal from any one of the pneumatic valve state detection sensors.

[0015] According to the present disclosure, when synchronous opening or synchronous closing of the plurality of pneumatic valves of the semiconductor process device is achieved, the plurality of pneumatic valves that need to simultaneously complete the same pneumatic valve action command in the current process step are acquired first, and the response duration of each pneumatic valve corresponding to the pneumatic valve action command is obtained. Then, the command issuance delay value of each pneumatic valve is calculated based on the longest response duration among the response durations of the plurality of pneumatic valves. Finally, the corresponding pneumatic valve action command is sent to each pneumatic valve in chronological order based on the command issuance delay value of each pneumatic valve to control the plurality of pneumatic valves to simultaneously complete the same pneumatic valve action command. In this way, with the technical solutions of the present disclosure, the time when the lower computer sends the corresponding pneumatic valve action command to each of the different pneumatic valves can be changed based on the calculation of the command issuance delay values, so that the technical problem that the existing pneumatic valve control method cannot actually achieve simultaneous opening or simultaneous closing of the different pneumatic valves because the different pneumatic valves have the different response durations can be solved well, that is, simultaneous opening or simultaneous closing of the plurality of pneumatic valves can be achieved well, and it can be ensured that the process gases enter the process chamber synchronously to fully react in the process chamber, which improves process quality of the whole process while greatly improving the utilization of the process gases.

BRIEF DESCRIPTION OF DRAWINGS

[0016] The technical solutions and the beneficial effects of the present disclosure will become apparent from the following detailed description of specific implementations of the present disclosure with reference to the drawings.

5 [0017] FIG. 1 is a schematic diagram of gas pipelines for process gases in an existing technology.

[0018] FIG. 2 is a flowchart illustrating a pneumatic valve control method for a semiconductor process device according to an embodiment of the present disclosure.

10 [0019] FIG. 3 is another flowchart illustrating the pneumatic valve control method for the semiconductor process device shown in FIG. 1.

[0020] FIG. 4 is a flowchart of step S110 of the pneumatic valve control method for the semiconductor process device shown in FIG. 1.

[0021] FIG. 5 is a flowchart illustrating a method for generating a response duration information table according to an embodiment of the present disclosure.

15 [0022] FIG. 6 is a schematic structural diagram of a semiconductor process device according to an embodiment of the present disclosure.

DETAIL DESCRIPTION OF EMBODIMENTS

20 [0023] The technical solutions of the embodiments of the present disclosure are clearly and completely described below with reference to the drawings. Apparently, the embodiments described herein are just some embodiments of the present disclosure, rather than all embodiments. All other embodiments, which are derived by those of ordinary skill in the art based on the embodiments in the present disclosure without any inventive work, fall within the scope of the present disclosure. The embodiments below
25 and the technical features therein may be combined with each other if no conflict is incurred.

[0024] At present, the epitaxial growth of silicon carbide is mainly performed by Chemical Vapor Deposition (CVD), and involves the specific chemical reactions that SiH_4 (or SiHCl_3) and C_2H_4 (or C_3H_8) have a cracking reaction at a high temperature
30 (above 1600°C) to generate Si atoms and C atoms and then the Si atoms and the C atoms recombine on a wafer surface to form SiC. The atoms participating in the chemical

reactions for the epitaxial growth are introduced into a process chamber with process gases, that is, as shown in FIG. 1, a gas ratio of the process gases SiH_4 and C_2H_4 (taken as an example) is adjusted by setting flow values of the MFCs, so that the target chemical reactions may be achieved in the process chamber under the conditions of specific temperatures and pressures. The pneumatic valves V1, V2 shown in FIG. 1 are mainly configured to control the corresponding process gases SiH_4 and C_2H_4 to enter the process chamber 10 through opening and closing thereof.

[0025] Since a chemical reaction temperature of silicon carbide is generally from 1500°C to 1800°C during the process, SiH_4 may be decomposed to generate Si atoms within the temperature range, the Si atoms may form Si single crystals if the number of the C atoms is relatively small at the time of generating the Si atoms, and the Si single crystals may be deposited on a surface of a silicon carbide substrate, which causes many defects to an epitaxial layer of a product, and even causes scrapping of the epitaxial product. Therefore, the pneumatic valves V1 and V2 are required to shorten an opening interval as much as possible during the process to perform actions synchronously, so as to ensure full mixing of the two gases. However, with the existing pneumatic valve control method, an upper computer sequentially issues commands to a Programmable Logic Controller (PLC), the PLC outputs control commands simultaneously to different solenoid valve sets corresponding to different pneumatic valves, and the different solenoid valve sets drive the corresponding pneumatic valves to perform switching operations through compressed dry nitrogen (CDN) after receiving the control commands. During the execution of the existing pneumatic valve control method, certain time errors exist when the different solenoid valve sets receive the control commands because transmission paths for the control commands are different, and hardware actions of the different solenoid valve sets may be asynchronous because gas pipelines from the different solenoid valve sets to the corresponding pneumatic valves vary in length, which may finally result in certain time errors when the different pneumatic valves finally execute an open/close action, that is, the different pneumatic valves have different response durations, such that the pneumatic valve control method in the related art cannot actually achieve simultaneous opening or simultaneous closing of the different pneumatic valves, and the different process gases cannot synchronously enter the process chamber and thus cannot fully react in the process chamber. Thus, many process defects

are caused to the whole process while the utilization of the process gases is greatly reduced.

[0026] In view of the above, a new solution to the pneumatic valve control method is needed for solving the technical problems that many process defects are caused to the whole process and the utilization of the process gases is greatly reduced due to the fact that the different process gases cannot synchronously enter the process chamber and thus cannot fully react in the process chamber because the existing pneumatic valve control method cannot achieve simultaneous opening or simultaneous closing of the different pneumatic valves.

[0027] In an embodiment, as shown in FIG. 2, the present disclosure provides a pneumatic valve control method for a semiconductor process device for achieving synchronous opening or synchronous closing of a plurality of pneumatic valves of the semiconductor process device, and the pneumatic valve control method may include the following steps S110 to S130.

[0028] At step S110, a plurality of pneumatic valves that need to simultaneously complete a same pneumatic valve action command in a current process step are acquired, and a response duration of each pneumatic valve corresponding to the pneumatic valve action command is obtained.

[0029] It should be understood that a plurality of different process gases need to be introduced into a process chamber when the semiconductor process device performs a semiconductor process such as an epitaxial growth process of silicon carbide, the different process gases are generally introduced into the process chamber through different gas pipelines, and in order to control introduction flow and introduction time of the different process gases, corresponding pneumatic valves are disposed on the different gas pipelines to realize on-off control of the corresponding gas pipelines, so as to enable the introduction of the corresponding process gases into the process chamber or interrupt the introduction of the corresponding process gases into the process chamber. As can be seen, the semiconductor process device is generally provided with a plurality of different pneumatic valves, and the different pneumatic valves may control states in which the different process gases are introduced into the process chamber. Therefore, when the semiconductor process device performs a semiconductor process, for different process steps, the semiconductor process device needs to send corresponding pneumatic valve action commands to the different pneumatic valves through a lower computer (which

may specifically be a PLC) based on current process requirements, so as to introduce the process gases meeting the current process requirements into the process chamber. This may involve the situation that some of the different pneumatic valves need to be simultaneously opened or simultaneously closed in a certain process step, that is, some of the different pneumatic valves need to simultaneously complete a same pneumatic valve action command, and the pneumatic valve action command may specifically be a pneumatic valve open command or a pneumatic valve close command. As can be seen from the above, the different pneumatic valves have different response durations due to various factors, which may significantly affect the simultaneous opening or the simultaneous closing of the different pneumatic valves. In view of this, according to the embodiment of the present disclosure, before each process step is performed, the plurality of pneumatic valves that need to simultaneously complete the same pneumatic valve action command in the current process step are acquired first, and the response duration of each pneumatic valve corresponding to the pneumatic valve action command is obtained. The response duration specifically refers to a duration from the lower computer sending the pneumatic valve action command to the corresponding pneumatic valve to the corresponding pneumatic valve completing the pneumatic valve action command, and the response duration may be acquired in advance and recorded and stored in the semiconductor process device for being called by the lower computer of the semiconductor process device at any time.

[0030] In addition, since a pneumatic valve has slightly different response durations when executing different pneumatic valve action commands, the response duration may specifically be a first response duration corresponding to the pneumatic valve open command or a second response duration corresponding to the pneumatic valve close command. In this case, when the same pneumatic valve action command to be simultaneously executed by the plurality of pneumatic valves in the current process step is the pneumatic valve open command, the first response duration of each pneumatic valve may be synchronously obtained. When the same pneumatic valve action command to be simultaneously executed by the plurality of pneumatic valves in the current process step is the pneumatic valve close command, the second response duration of each pneumatic valve may be synchronously obtained.

[0031] At step S120, a command issuance delay value of each pneumatic valve is calculated based on the longest response duration among the response durations of the plurality of pneumatic valves.

5 [0032] It should be understood that after the response duration (the first response duration or the second response duration) of each pneumatic valve that needs to simultaneously complete the same pneumatic valve action command in the current process step is obtained at step S110, the response durations of the pneumatic valves may be compared to find out the longest response duration and the corresponding pneumatic valve, and the command issuance delay value of each pneumatic valve may be
10 calculated based on the longest response duration, with the command issuance delay value specifically referring to a delay for the lower computer to send the corresponding pneumatic valve action command to each pneumatic valve that needs to simultaneously complete the same pneumatic valve action command as a first pneumatic valve after the lower computer sends the corresponding pneumatic valve action command to the first
15 pneumatic valve. The reason why the command issuance delay value of each pneumatic valve is calculated based on the longest response duration at step S120 is that the pneumatic valve corresponding to the longest response duration takes the longest time to complete the corresponding pneumatic valve action command, and in order to ensure that all the pneumatic valves complete the same pneumatic valve action command
20 simultaneously, the durations for the other pneumatic valves to complete the corresponding pneumatic valve action command need to be prolonged by taking the time taken by the pneumatic valve corresponding to the longest response duration as a reference, that is, end time points when the other pneumatic valves complete the corresponding pneumatic valve action command are adjusted to be the same as an end
25 time point when the pneumatic valve corresponding to the longest response duration completes the corresponding pneumatic valve action command.

[0033] At step S130, the corresponding pneumatic valve action command is sent to each pneumatic valve in chronological order based on the command issuance delay value of each pneumatic valve to control the plurality of pneumatic valves to simultaneously
30 complete the same pneumatic valve action command.

[0034] It should be understood that the corresponding pneumatic valve action command may be sent to each pneumatic valve in chronological order based on the command issuance delay value of each pneumatic valve after the command issuance delay value of

each pneumatic valve is obtained at step S120, so as to control the plurality of pneumatic valves to simultaneously complete the same pneumatic valve action command. Differences between the durations for the different pneumatic valves to complete the corresponding pneumatic valve action command can be compensated by staggering start
5 time points of sending the corresponding pneumatic valve action command to the pneumatic valves different, thereby enabling the different pneumatic valves to complete the corresponding pneumatic valve action command at the same end time points.

[0035] In this way, in the embodiment of the present disclosure, the time when the lower computer sends the corresponding pneumatic valve action command to each of the
10 different pneumatic valves can be changed based on the calculation of the command issuance delay values, so that the technical problem that the pneumatic valve control method in the related art cannot actually achieve simultaneous opening or simultaneous closing of the different pneumatic valves because the different pneumatic valves have the different response durations can be solved well, that is, simultaneous opening or
15 simultaneous closing of the plurality of pneumatic valves can be achieved well, and it can be ensured that the process gases enter the process chamber synchronously to fully react in the process chamber, which improves process quality of the whole process while greatly improving the utilization of the process gases.

[0036] In some examples, as shown in FIG. 3, before the step of “acquiring a plurality of
20 pneumatic valves that need to simultaneously complete a same pneumatic valve action command in a current process step, and obtaining a response duration of each pneumatic valve corresponding to the pneumatic valve action command” of the pneumatic valve control method provided in the embodiment of the present disclosure is performed, the pneumatic valve control method further includes:

25 step S100, receiving a target pneumatic valve action command set uniformly issued by the upper computer, with the target pneumatic valve action command set including pneumatic valve action commands for the plurality of pneumatic valves that need to simultaneously complete the same pneumatic valve action command in the current process step.

30 [0037] It should be understood that when performing a semiconductor process, the lower computer of the semiconductor process device generally performs all process steps in sequence based on a process menu related to the semiconductor process in the upper computer, thereby completing the whole semiconductor process. Therefore, before the

semiconductor process is performed, the upper computer may perform predefined logic judgment on a process menu of the semiconductor process to be currently performed to obtain a pneumatic valve action information table of the semiconductor process. The pneumatic valve action information table may be a virtual table concept or a real table, and when the pneumatic valve action information table is a real table, the pneumatic valve action information table may respectively record based on each process step of the semiconductor process to be currently performed, so as to specifically record information of pneumatic valve action commands to be executed by all the pneumatic valves in the semiconductor process device when a corresponding process step is performed, especially for the plurality of pneumatic valves that need to simultaneously complete the same pneumatic valve action command in the current process step. After the pneumatic valve action information table is obtained, the upper computer may uniformly issue the target pneumatic valve action command set corresponding to the current process step to the lower computer based on the pneumatic valve action information table before each process step of the semiconductor process is performed.

[0038] In this way, before the step of “acquiring a plurality of pneumatic valves that need to simultaneously complete a same pneumatic valve action command in a current process step, and obtaining a response duration of each pneumatic valve corresponding to the pneumatic valve action command” of the pneumatic valve control method provided in the embodiment of the present disclosure is performed, the target pneumatic valve action command set uniformly issued by the upper computer may be received, and the target pneumatic valve action command set includes the pneumatic valve action commands for the plurality of pneumatic valves that need to simultaneously complete the same pneumatic valve action command in the current process step.

[0039] As can be seen, at the steps of the pneumatic valve control method provided in the embodiment of the present disclosure, the upper computer completes logic judgment for all process menus to uniformly issue all the pneumatic valve action commands (i.e., the target pneumatic valve action command set) to the lower computer, that is, the lower computer can receive the target pneumatic valve action command set uniformly issued by the upper computer, so that a control time error caused by sequentially receiving the commands can be effectively avoided by simultaneously receiving the commands.

[0040] In some examples, as shown in FIG. 4, the step of “acquiring a plurality of pneumatic valves that need to simultaneously complete a same pneumatic valve action

command in a current process step, and obtaining a response duration of each pneumatic valve corresponding to the pneumatic valve action command” of the pneumatic valve control method provided in the embodiment of the present disclosure may specifically include:

5 step S111, finding out a name of each pneumatic valve that needs to simultaneously complete the same pneumatic valve action command in the current process step based on the target pneumatic valve action command set; and

10 step S112, based on the name of each pneumatic valve and the pneumatic valve action command which needs to be executed simultaneously currently, sequentially finding out the response duration of each pneumatic valve corresponding to the pneumatic valve action command from a response duration information table.

[0041] It should be understood that as can be seen from the above description, the target pneumatic valve action command set may specifically include the pneumatic valve action commands for the plurality of pneumatic valves that need to simultaneously
15 complete the same pneumatic valve action command in the current process step, so that the name of each pneumatic valve that needs to simultaneously complete the same pneumatic valve action command in the current process step can be found out based on the target pneumatic valve action command set. That is, which pneumatic valves (which may be specifically named by labels and the like) need to simultaneously complete the
20 same pneumatic valve action command in the current process step can be found out.

After the names of the pneumatic valves are found, the response duration of each pneumatic valve corresponding to the pneumatic valve action command can be sequentially found out from the response duration information table based on the name of each pneumatic valve and the pneumatic valve action command which needs to be
25 executed simultaneously currently. As can be seen from the above description, the response duration may be acquired in advance and recorded and stored in the semiconductor process device for being called by the lower computer of the semiconductor process device at any time, which may be specifically embodied in the present example by the response duration information table, that is, the first response
30 durations (corresponding to the pneumatic valve open command) and the second response durations (corresponding to the pneumatic valve close command) of all the pneumatic valves in the semiconductor process device are recorded in the response duration information table. Thus, according to the examples of the present disclosure, the

step of “acquiring a plurality of pneumatic valves that need to simultaneously complete a same pneumatic valve action command in a current process step, and obtaining a response duration of each pneumatic valve corresponding to the pneumatic valve action command” of the pneumatic valve control method provided in the embodiment of the present disclosure can be implemented well by means of looking up the table.

[0042] In some examples, in order to achieve generation of the response duration information table well, as shown in FIG. 5, the generation of the response duration information table may specifically include:

step S11, synchronously starting timing when the pneumatic valve open command is sent to a target pneumatic valve, and synchronously stopping timing when the target pneumatic valve completes the pneumatic valve open command, so as to acquire the first response duration of the target pneumatic valve and record the first response duration of the target pneumatic valve in the response duration information table; and

step S12, synchronously starting timing when the pneumatic valve close command is sent to the target pneumatic valve, and synchronously stopping timing when the target pneumatic valve completes the pneumatic valve close command, so as to acquire the second response duration of the target pneumatic valve and record the second response duration of the target pneumatic valve in the response duration information table.

[0043] It should be understood that in order to acquire the response durations of all the pneumatic valves in the semiconductor process device well to generate the response duration information table described in the above examples, a response duration acquisition module may be added to the semiconductor process device, the response duration acquisition module is respectively connected to the lower computer and the plurality of pneumatic valves by signals for acquiring and recording the response durations of each pneumatic valve, and a specific structure of the response duration acquisition module will be described in detail below. Before a semiconductor process is performed, the response duration acquisition module may perform open/close tests on all the pneumatic valves of the semiconductor process device to generate the response duration information table, which includes synchronously starting timing when the pneumatic valve open command is sent to the target pneumatic valve, and synchronously stopping timing when the target pneumatic valve completes the pneumatic valve open command, so as to acquire the first response duration of the target pneumatic valve and record the first response duration of the target pneumatic valve in the response duration

information table; and synchronously starting timing when the pneumatic valve close command is sent to the target pneumatic valve, and synchronously stopping timing when the target pneumatic valve completes the pneumatic valve close command, so as to acquire the second response duration of the target pneumatic valve and record the second
5 response duration of the target pneumatic valve in the response duration information table. In this way, it can be ensured that the first response durations (corresponding to the pneumatic valve open command) and the second response durations (corresponding to the pneumatic valve close command) of all the pneumatic valves in the semiconductor process device are accurately recorded in the response duration information table.

10 [0044] In some examples, the step of “calculating a command issuance delay value of each pneumatic valve based on the longest response duration among the response durations of the plurality of pneumatic valves” of the pneumatic valve control method provided in the embodiment of the present disclosure may specifically include: sequentially performing a difference operation on the longest response duration and the
15 response durations of the plurality of pneumatic valves to take sequentially obtained differences as the command issuance delay values of the corresponding pneumatic valves. Thus, the command issuance delay value of the pneumatic valve corresponding to the longest response duration is 0, and the command issuance delay value of the pneumatic valve corresponding to the shortest response duration is the maximum. In this
20 way, the calculation of the command issuance delay values can provide an accurate time basis for a specific time when the lower computer subsequently sends the corresponding pneumatic valve action command to each pneumatic valve, thereby ensuring that the pneumatic valves can simultaneously complete the same pneumatic valve action command.

25 [0045] In some examples, the step of “sending the corresponding pneumatic valve action command to each pneumatic valve in chronological order based on the command issuance delay value of each pneumatic valve to control the plurality of pneumatic valves to simultaneously complete the same pneumatic valve action command” of the pneumatic valve control method provided in the embodiment of the present disclosure
30 may specifically include: synchronously starting timing when the corresponding pneumatic valve action command is sent to the pneumatic valve having the command issuance delay value of 0, and when a timing value from the timing is equal to the command issuance delay value of any one of the other pneumatic valves, synchronously

5 sending the corresponding pneumatic valve action command to the corresponding pneumatic valve, so as to control the plurality of pneumatic valves to simultaneously complete the same pneumatic valve action command. In this way, the command issuance delay value of the pneumatic valve corresponding to the longest response duration is 0, and the pneumatic valve corresponding to the longest response duration is the object to which the lower computer sends the pneumatic valve action command first; and the command issuance delay value of the pneumatic valve corresponding to the shortest response duration is the maximum, and the pneumatic valve corresponding to the shortest response duration is the object to which the lower computer sends the pneumatic valve action command last, that is, the timing may be ended after the lower computer sends the corresponding pneumatic valve action command to the last pneumatic valve. Finally, by sending the corresponding pneumatic valve action command to the pneumatic valves with the above method, it can be ensured that the pneumatic valves can simultaneously complete the same pneumatic valve action command.

15 [0046] In the other aspect of the present disclosure, as shown in FIG. 6, an embodiment of the present disclosure further provides a semiconductor process device 100, including a lower computer 120 (which may specifically be a PLC), a plurality of solenoid valve sets 130, a plurality of pneumatic valves 140, and a process chamber 150 provided with a plurality of gas pipelines 151, and the plurality of solenoid valve sets 130 and the plurality of pneumatic valves 140 are disposed in a one-to-one correspondence manner, so that each pneumatic valve 140 may enable, under the control of the corresponding solenoid valve set 130, one gas pipeline 151 to be opened or closed. The lower computer 120 is respectively connected to the plurality of solenoid valve sets 130 by signals, and may include at least one processor and at least one storage device having a computer program stored therein, and when the lower computer 120 operates, that is, when the computer program is executed by the processor, the pneumatic valve control method provided in the above embodiment is implemented, which will not be repeated here.

25 [0047] Optionally, the semiconductor process device 100 may further include an upper computer 110 connected to the lower computer 120 by signals.

30 [0048] Thus, in the embodiment of the present disclosure, when the semiconductor process device 100 performs synchronous control on the different pneumatic valves 140, the time when the lower computer 120 sends a corresponding pneumatic valve action command to each of the different pneumatic valves 140 can be changed based on a

calculation of command issuance delay values, so that the technical problem that the existing pneumatic valve control method cannot actually achieve simultaneous opening or simultaneous closing of the different pneumatic valves 140 because the different pneumatic valves 140 have different response durations can be solved well, that is, simultaneous opening or simultaneous closing of the plurality of pneumatic valves 140 can be achieved well, and it can be ensured that process gases enter the process chamber 150 synchronously to fully react in the process chamber 150, which improves process quality of the whole process while greatly improving utilization of the process gases.

[0049] In some examples, in order to achieve acquiring response durations of the different pneumatic valves 140 in advance and recording and storing the response durations in the semiconductor process device 100 for being called by the lower computer 120 of the semiconductor process device 100 at any time, as shown in FIG. 6, the semiconductor process device 100 in the present examples further specifically includes a response duration acquisition module 160, which is respectively connected to the lower computer 120 and the plurality of pneumatic valves 140 by signals for acquiring and recording the response duration of each pneumatic valve 140. Further, the response duration acquisition module may specifically include a fast response unit, a timer, and a plurality of pneumatic valve state detection sensors. The plurality of pneumatic valve state detection sensors are respectively connected to the fast response unit by signals, and are disposed in the plurality of pneumatic valves 140 in a one-to-one correspondence manner, so as to acquire state changes of the corresponding pneumatic valves 140, and feed corresponding feedback signals back to the fast response unit when the states of the corresponding pneumatic valves 140 change. The fast response unit is further respectively connected to the lower computer 120 and the timer by signals, so as to send a start signal to the timer to start timing by the timer when the lower computer 120 sends a pneumatic valve action command to any one of the pneumatic valves 140, and send an end signal to the timer to end the timing of the timer when receiving a feedback signal from any one of the pneumatic valve state detection sensors.

[0050] It should be understood that the pneumatic valve state detection sensors may feed back open states and closed states of the corresponding pneumatic valves 140, and state signals from the pneumatic valve state detection sensors may change after the pneumatic valves 140 are switched from the open states to the closed states or from the closed states to the open states, and at this time, the feedback signals from the pneumatic valve state

detection sensors are received by the fast response unit (since the fast response unit has high receiving frequency which is generally up to several tens of Hertz, a signal acquisition error is almost negligible), and the timer is turned off, which can achieve the acquisition of the response durations of the corresponding pneumatic valves 140 well.

5 [0051] Although the present disclosure is illustrated and described by one or more implementations, equivalent variations and modifications may be envisaged by those of ordinary skill in the art based on reading and understanding of the description and the drawings of the present disclosure. The present disclosure includes all those modifications and variations, and is limited only by the scope of the appended claims. In
10 particular, for each function performed by the aforesaid components, the terms used to describe the components are intended to be corresponding to any component which performs the specified function (e.g., an equivalent function) of the described components (unless otherwise indicated), even if the any component has a structure different from the disclosed structure which performs the function in the exemplary
15 implementations illustrated herein.

[0052] That is, what is described above is just the embodiments of the present disclosure, and is not intended to limit the scope of the present disclosure, and all equivalent structures or equivalent flow transformations derived from the contents of the description and the drawings of the present disclosure, such as the combinations of the
20 technical features of the embodiments or direct or indirect applications of the technical features of the embodiments to other related technical fields, are included in the scope of the present disclosure.

[0053] In addition, in the description of the present disclosure, it should be understood that the orientations or positional relationships indicated by the terms “center”,
25 “longitudinal”, “lateral”, “length”, “width”, “thickness”, “above”, “below”, “front”, “back”, “left”, “right”, “vertical”, “horizontal”, “top”, “bottom”, “inner”, “outer” and the like are the orientations or positional relationships based on the drawings, and those terms are used simply for conveniently describing the present disclosure and simplifying the description, rather than indicating or implying that the device or element referred to
30 must have a particular orientation or must be constructed and operated in a particular orientation, and therefore, those terms should not be considered as limitation to the present disclosure. In addition, the structural elements having the same or similar characteristics can be identified by the same or different reference numerals in the

present disclosure. Further, the terms “first” and “second” are used only for the purpose of description, and should not be interpreted as indicating or implying relative importance or implicitly indicating the number of the technical features referred to. Thus, a feature defined by “first” or “second” may explicitly or implicitly include one or more features. In the description of the present disclosure, unless specifically limited otherwise, “a plurality” means two or more.

[0054] In the present disclosure, the word “exemplary” is used to mean “serving as an example, instance, or illustration”. Any embodiment described herein as being “exemplary” is not necessarily to be interpreted as being preferred or being advantageous over the other embodiments. The above description is provided to enable those of ordinary skill in the art to implement or use the present disclosure. In the above description, various details are listed for the purpose of explanation. It should be understood by those of ordinary skill in the art that the present disclosure may be implemented without using these specific details. In other embodiments, well-known structures and processes are not described in detail, so as to prevent the description of the present disclosure from being obscure due to unnecessary details. Thus, the present disclosure is not intended to be limited to the embodiments described herein, but falls within the widest scope of the principle and features disclosed herein.

What is claimed is:

1. A pneumatic valve control method for a semiconductor process device for achieving synchronous opening or synchronous closing of a plurality of pneumatic valves of the semiconductor process device, comprising:

acquiring a plurality of pneumatic valves that need to simultaneously complete a same pneumatic valve action command in a current process step, and obtaining a response duration of each pneumatic valve corresponding to the pneumatic valve action command;

calculating a command issuance delay value of each pneumatic valve based on a longest response duration among response durations of the plurality of pneumatic valves; and

sending the corresponding pneumatic valve action command to each pneumatic valve in chronological order based on the command issuance delay value of each pneumatic valve to control the plurality of pneumatic valves to simultaneously complete the same pneumatic valve action command.

2. The pneumatic valve control method of claim 1, wherein the pneumatic valve action command is a pneumatic valve open command or a pneumatic valve close command; and the response duration is a first response duration corresponding to the pneumatic valve open command or a second response duration corresponding to the pneumatic valve close command.

3. The pneumatic valve control method of claim 1, wherein before acquiring the plurality of pneumatic valves that need to simultaneously complete the same pneumatic valve action command in the current process step, and obtaining the response duration of each pneumatic valve corresponding to the pneumatic valve action command, the pneumatic valve control method further comprises:

receiving a target pneumatic valve action command set uniformly issued by an upper computer, the target pneumatic valve action command set comprising pneumatic valve action commands for the plurality of pneumatic valves that need to simultaneously complete the same pneumatic valve action command in the current process step.

4. The pneumatic valve control method of claim 3, wherein acquiring the plurality of pneumatic valves that need to simultaneously complete the same pneumatic valve action command in the current process step, and obtaining the response duration of each pneumatic valve corresponding to the pneumatic valve action command comprises:

finding out a name of each pneumatic valve that needs to simultaneously complete the same pneumatic valve action command in the current process step based on the target pneumatic valve action command set; and

based on the name of each pneumatic valve and the pneumatic valve action command which needs to be executed simultaneously currently, sequentially finding out the response duration of each pneumatic valve corresponding to the pneumatic valve action command from a response duration information table.

5. The pneumatic valve control method of claim 4, wherein first response durations and second response durations of all pneumatic valves in the semiconductor process device are recorded in the response duration information table, and generation of the response duration information table comprises:

synchronously starting timing when a pneumatic valve open command is sent to a target pneumatic valve, and synchronously stopping timing when the target pneumatic valve completes the pneumatic valve open command, so as to acquire a first response duration of the target pneumatic valve and record the first response duration of the target pneumatic valve in the response duration information table; and

synchronously starting timing when a pneumatic valve close command is sent to the target pneumatic valve, and synchronously stopping timing when the target pneumatic valve completes the pneumatic valve close command, so as to acquire a second response duration of the target pneumatic valve and record the second response duration of the target pneumatic valve in the response duration information table.

6. The pneumatic valve control method of claim 1, wherein calculating the command issuance delay value of each pneumatic valve based on the longest response duration among the response durations of the plurality of pneumatic valves

comprises:

sequentially performing a difference operation on the longest response duration and the response durations of the plurality of pneumatic valves to take sequentially obtained differences as command issuance delay values of the corresponding pneumatic valves.

7. The pneumatic valve control method of claim 1, wherein sending the corresponding pneumatic valve action command to each pneumatic valve in chronological order based on the command issuance delay value of each pneumatic valve to control the plurality of pneumatic valves to simultaneously complete the same pneumatic valve action command comprises:

synchronously starting timing when the corresponding pneumatic valve action command is sent to a pneumatic valve having the command issuance delay value of 0, and when a timing value from the timing is equal to the command issuance delay value of any one of the other pneumatic valves, synchronously sending the corresponding pneumatic valve action command to the any one of the other pneumatic valves, so as to control the plurality of pneumatic valves to simultaneously complete the same pneumatic valve action command.

8. A semiconductor process device, comprising a lower computer, a plurality of solenoid valve sets, a plurality of pneumatic valves, and a process chamber provided with a plurality of gas pipelines, wherein the plurality of solenoid valve sets and the plurality of pneumatic valves are disposed in a one-to-one correspondence manner to allow each pneumatic valve to enable, under the control of a corresponding solenoid valve set, one gas pipeline to be opened or closed, the lower computer is respectively connected to the plurality of solenoid valve sets by signals, and the lower computer performs the pneumatic valve control method of any one of claims 1 to 7 when being in operation.

9. The semiconductor process device of claim 8, further comprising a response duration acquisition module, which is respectively connected to the lower computer and the plurality of pneumatic valves by signals for acquiring and recording a response duration of each pneumatic valve.

10. The semiconductor process device of claim 9, wherein the response duration acquisition module comprises a fast response unit, a timer, and a plurality of pneumatic valve state detection sensors; wherein

5 the plurality of pneumatic valve state detection sensors are respectively connected to the fast response unit by signals, and are disposed in the plurality of pneumatic valves in a one-to-one correspondence manner, so as to acquire state changes of the corresponding pneumatic valves, and feed corresponding feedback signals back to the fast response unit when states of the corresponding pneumatic
10 valves change; and

 the fast response unit is further respectively connected to the lower computer and the timer by signals, so as to send a start signal to the timer to start timing by the timer when the lower computer sends a pneumatic valve action command to any one of the pneumatic valves, and send an end signal to the timer to end the timing of the
15 timer when receiving a feedback signal from any one of the pneumatic valve state detection sensors.