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Description

Method for wafer position data retrieval in semiconductor wafer manufacturing

The invention refers to a method for processing semiconductor products by predefining a sequence of orders and executing product processing steps by product processing tools, during regular processing the product processing steps being executed in compliance with the predefined sequence of orders, wherein multitudes of semiconductor products to be processed are transported in product containers, and wherein product processing data of product processing steps are stored with reference to product positions in the product containers and to product identification codes.

Such a method is common use in semiconductor industry. Often hundreds of processing steps are performed to manufacture integrated circuits. Integrated circuits are arranged on a semiconductor wafer which has a unique wafer identification code (ID).

A great number of processing tools is required for execution of deposition steps, patterning steps, doping steps or etching steps on respective tools, for instance. The equipment and the operating personnel controlling the equipment are working in cleanroom environment to avoid particle contamination of the semiconductor products.

Within the cleanroom, the semiconductor products are manually or automatically transported to the respective processing tools. As in most cases groups of several wafers are transported together in a container, e.g. a SMIF pod or a FOUP (Front Opening Unified Pod), usually a multitude of wafers is subjected to the respective processing step. In order to evaluate the results of the processing steps, processing data are stored together with the information indicating the posi-

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tion and identification code (ID) of each wafer in a container. Due to the great number of hundreds of processing steps performed in sequence, it is very important to store all position data identifying all wafer positions in the containers from the beginning to the end of wafer processing. The main benefit of this storage is the possibility of retrieving the information of wafer location and identification when improper processing performance has occurred. Systems for automatic transport of semiconductor products are disclosed in DE 19962703 A1 and in "Sorting and Transfer Drive Mechanism" IBM Technical Disclosure Bulletin, US, IBM Corp. New York, Vol. 33, no. 6A.

Due to complex processing procedures, very often handling steps for changing the number of the position of the wafers in the containers are required. For instance, a certain number of wafers in a container has to be separated from the others by reasons of processing plans or other circumstances. As the processing tools are not able to change the number or the position of the wafers in the containers, handling devices like mappers are provided in the cleanroom. Whenever a mapping step is required, the respective container is transported to one of the mappers, the mapping step is executed and the container is transported to the next processing tool. According to prior art, the transport to and from the mapping devices is performed manually by the operating personnel.

Whenever a mapping step is performed according to the processing plan, the wafer positions in a container have been altered, and the processing data no more correspond to the former arrangement of wafers. However, as the process plan is created in advance, such handling steps are foreseeable, and proper processing data rearrangement can be programmed in advance. Thus, any handling step foreseeable from the beginning of the process plan does not seriously affect the possibilities of processing data retrieval.

Apart from regular handling steps, at any time an unplanned handling step may become necessary by reasons of improper processing performance, for instance. Due to the complexity of modern semiconductor manufacture, the necessity of per-

forming an additional handling operation arises with increasing probability. The handling operation as such may be performed in the same manner as the regular handling steps at any stage of the process plan. However, as the need and the moment of this unplanned handling step within the whole process flow cannot be foreseen, any further processing data are attributed to incorrect wafer positions within a carrier. As a consequence, processing data as well as wafer position data must be rearranged afterwards for proper wafer history information retrieval. The present invention relates to these irregularly performed handling steps.

Hence, it is a first object of the present invention to obviate the need for such subsequent data rearrangement necessary according to prior art when unplanned handling steps are required.

Furthermore, with increasing demands on cleanroom quality, any atmospheric contact of semiconductor products and operating personnel – even when working under cleanroom conditions – have to be avoided. To this end, a mini-environment of very high cleanroom quality is provided within a cleanroom of minor quality. The operation personnel is working within the latter one, whereas the processing tools and the transport machinery to and from the processing tools are allocated within the high quality mini-environment. As a consequence of the mini-environmental cleanroom demands, manual handling of the wafers is no longer executable. Mapping devices have to be used. Hence, it is a second object of the present invention to avoid any contact between equipment in mini-environment and operation personnel out of mini-environment in the case that an unplanned handling step must be executed.

These objects are achieved by defining, upon irregular processing requiring a product handling step of changing the number and/or the position of semiconductor products in one or more product containers, a product handling order and integrating it in

the predefined sequence of orders, thereby resulting in an extended sequence of orders, by executing the product processing steps and the product handling step in compliance with the extended sequence of orders, and by storing product position chance data when the integrated product handling step is executed.

In contrast to prior art, processing methods requiring final data rearrangement for proper wafer history retrieval, it is the general idea of the present invention to influence the underlying process plan itself, whenever an unplanned handling step is required. Instead of executing the additional handling step separately, that is without any correspondence in the process plan, it is proposed to redefine the original process plan resulting in a new lot specific instance of the process plan now containing orders for the additional handling step, too.

Specifically, one expression of the invention is as defined in claim 1.

Referring to the features of claim 1, a sequence of orders is predefined before executing product processing, and as long as the semiconductor products are processed regularly, the processing steps are executed in compliance with this predefined sequence of orders. When irregular processing requires an additional product handling step, this sequence is redefined. In a simple case, this redefinition is performed by defining a product handling order and integrating it into the predefined sequence of orders, thereby resulting in an extended sequence of orders. All subsequent processing steps as well as the additional product handling step are executed in compliance with the extended sequence of orders, which may result from the original sequence of orders by varying the chronological succession of processing steps, splitting single processing steps, inserting additional steps or more complex product treatment procedures, nesting template nodes and so on. In any case, the additional handling step is performed in accordance with the product handling order integrated in the amended process plan, and product position change data corre-

sponding to this handling step are stored. As a consequence, the system now is able to record all wafer position rearrangements, because each unplanned handling step is included in the final sequence of orders. It is now possible to assign the exact final processing data to each single wafer.

Furthermore, so manual interference of operating personnel is required for performing unplanned handling steps, because - as the operating personnel merely has to redefine the sequence of orders - the mapping device can be joined with the processing tools and an existing transport system, that is with the complete equipment, which is provided within the mini-environmental cleanroom atmosphere, and which automatically executes any sequence of orders one programmed.

The present invention allows flexible reaction on any process complication requiring other order sequences than initially predefined. Upon irregular processing, the amended order sequence can be extended in turn. In any case, the resulting actual product flow is in conformity with the product flow resulting from the order sequence.

As at least the defined product handling order is integrated in the existing sequence of orders, two preferred embodiments concern the way of its integration.

First, the product handling order can be inserted between two product processing orders of the predefined sequence. That is, it is inserted like an additional product processing order. This embodiment is preferred especially when no urgent actions are required upon irregular wafer processing.

Second, the product handling order can be inserted after partial execution of a product processing step being interrupted, thereby creating an order for residual execution of the interrupted product processing order. According to this embodiment, the order for the unplanned handling step is

nested in two parts of the single product processing order, which is recommendable when immediate action is required to save wafers not yet processed from disadvantageous process operation.

Whereas in simplest case of redefinition of the predefined sequence of orders according to the invention, a single handling step, that is the step performed by a device not actually processing the products, is inserted in the process plan of product processing orders, according to preferred embodiments further product processing orders are defined and integrated in addition. These further product processing orders may be template process nodes instanciable at any time when required by reasons of irregular process execution. According to a preferred embodiment, the further product processing orders are reprocessing orders serving to restore a processing stage before disadvantageous processing, for instance to remove, in semiconductor industry, a distortedly patterned lithographic structure of a deposited layer.

According to a further embodiment, the orders are executed by a multitude of product processing tools, and handling orders are defined in such a way that they are executable by anyone of the handling devices. According to another preferred embodiment, at each process tool operating personnel is capable of defining and integrating the handling order executable by any handling device.

These embodiments allow for remote definition and execution of handling steps within current complex large-scale manufacturing. Especially there is no need that an operator defining handling orders must also - in cases still required - accompany the handling step at the respective handling device.

According to further embodiments related to semiconductor industry, the semiconductor products are semiconductor products arranged in respective slots of the containers. The handling step is per-

formed by a mapper of a sorter, capable of performing splitting, merging, sorting or transferring operations, for instance. The products to be handled may preferably be semiconductor wafers.

Due to the benefit of the invention of consistent data collection with regard to position data and wafer ID preferably processing data and position data are stored for each single semiconductor product in a semiconductor history data file.

Herein below, the invention is discussed with respect to the accompanying figure. The figure schematically illustrates a sequence of processing steps PS representing a process plan rather complex in reality. The sequence of orders contains a first processing step interrupted upon irregular processing, as well as process steps PS + 1, PS + n - 1 and PS + n. To excerpts of the sequence of orders denoted as case I and case II illustrate two preferred embodiments of the invention. They refer to two different ways of integrating unplanned optional mapping steps OMS. According to case I, the first part POn of a processing step is interrupted upon irregular processing execution, and a mapping order MO is defined and inserted, thereby creating an order POff for residual execution of the interrupted product processing order to be executed after the mapping order. After residual execution of the interrupted by performed processing step (POn, POff), the next process step PS + 1 is executed. At each processing tool, a dispatch list with orders to be executed is stored, and semiconductor products corresponding to data in the dispatch list are transported to the respective processing tool by a transport system. The semiconductor products are transported in groups of one or several lots in containers like front opening unified pots, for instance, with several slots, each slot receiving a single semiconductor wafer. Every processing and mapping order is initiated and concluded by respective move-in and move-out sub-orders MVIN and MVOU.

According to case II, a mapping order is integrated in the sequence of orders by insertion between two processing orders PS + n - 1 and PS + n.

By integrating mapping orders and, if required, further processing orders, into the order sequence before executing subsequent orders, in any case the slot related wafer position data are retrievable. In order to use the benefit of the present invention, for every process step and mapping step, a job report JR is created and filed in a database containing history data of every single wafer. The history data contain all relevant processing data as well as the position data of the wafer, that is number of the slot of the front opening unified pod and the identification of the unified pod.

The history data contain all information required for gapless slot and wafer ID related wafer tracking from the beginning to the end of the processing root. According to prior art, the history data did not correspond to the actual wafer positions after diverse handling steps manually performed upon irregular processing, and hence had to be rearranged.

Claims

1. A method for processing semiconductor products by:
   - predefining a sequence of orders (PS) and
   - executing product processing steps (POn, POff) by product processing tools,
   - during regular processing the product processing steps being executed in compliance with the predefined sequence of orders,
   - wherein multitudes of semiconductor products to be processed are transported in product containers and
   - product processing data of product processing steps are stored with reference to product position data identifying product positions in the product containers and to product identification codes,

   c h a r a c t e r i z e d i n

   that upon improper processing performance requiring an unforeseeable product handling step of changing the number and/or the position of semiconductor products in one or more product containers
   - a product handling order (MO) is defined and integrated in the predefined sequence of orders (PS) thereby resulting in an extended sequence of orders,
   - the product processing steps (POn, POff) and the product handling step are executed in compliance with the extended sequence of orders and
   - product position change data corresponding to the integrated product handling step are stored.

2. Method according to claim 1,

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   that the product handling order (PS) is inserted between two product processing orders (POn, POff) of the predefined sequence.

3. Method according to claim 1,

   c h a r a c t e r i z e d i n

that the product handling order (PS) is inserted after partial execution of a product processing step being interrupted, thereby creating an order for residual execution of the interrupted product processing order.

4. Method according to one of claims 1 to 3, characterized in that further product processing orders are defined and integrated in the order list together with the product handling order.

5. Method according to claim 4, characterized in that the further product processing orders are product reprocessing orders.

6. Method according to one of claims 1 to 5, characterized in that the orders are executed by a multitude of product processing tools and handling devices, and that handling orders are defined in such a way that they are executable by anyone of the handling devices.

7. Method according to claim 6, characterized by remote definition and execution of handling steps such that at each processing tool an operator is capable of defining and integrating the handling order executable by any handling device.

8. Method according to one of claims 1 to 7, characterized in that the semiconductor products are semiconductor wafers arranged in respective slots of the containers.

9. Method according to one of claims 1 to 8, characterized in

that the handling step is performed by a mapper or a sorter.

10. Method according to claim 9,
characterized in
that the handling step is at least one of a splitting, a merging, a sorting or a transferring operation.

11. Method according to one of claims 1 to 10,
characterized in
that for each semiconductor product processing data and position data are stored in a semiconductor product history data file.