PRODUCTION FACILITY FOR INTEGRATED CIRCUITS

The invention relates to a production facility for integrated circuits, comprising at least one cleanroom, in which processing means for processing raw materials like wafers into integrated circuits have been located, and associated equipment for said cleanroom and the processing means located therein.

Such production facilities are generally known.

Those prior art production facilities generally comprise an integrated construction shell, in which all technical provisions, like the processing means and utility systems, are located. Under processing means inter alia equipment is understood.

The set-up of such a prior art facility usually employs generalised construction choices, a single main cleanroom and a centralized supply of air.

The lay-out of such a prior art production facility is complicated leading to high costs, a substantial probability for errors and to long periods for construction and implementation.

The aim of the present invention is to provide such a production facility, in which the draw-backs mentioned above are avoided.

This aim is reached in:

- that the production facility is divided into mutually separated process cells, separated by walls;
- that each process cell comprises a cleanroom;
- that each cleanroom is equipped with processing means for executing processes requiring substantially similar conditions;
- that each process cell comprises associated equipment for said cleanroom in the same process cell; and

- that the associated equipment in said process cell is dedicated for maintaining the conditions required for the process equipment in said cleanroom.

The features of the invention lead to a facility, in which the local processing and environmental conditions are optimised to local needs. In addition the realisation period of the production facility is significantly reduced.

The aim of the invention is also reached by a

- production facility for integrated circuits, comprising:

- at least one cleanroom, in which processing means for processing raw materials like wafers into integrated circuits have been located; and

- associated equipment for said cleanroom, characterized in:

- that the production facility is divided into mutually separated process cells, separated by walls;

- that each process cell comprises a cleanroom;

- that each cleanroom is equipped with processing means for processing substantially similar product type;

- that each process cell comprises associated equipment for said cleanroom in the same process cell; and

- that the supporting equipment in said process cell is dedicated for maintaining the conditions required for the process equipment in said cleanroom.

This embodiment is especially applicable to situations wherein speciality products are produced. It leads to substantial simplification of the lay-out of such a production facility and thus to simpler routing of supplies, materials and staff and to a shorter construction period.

Although in both of the above cases the invention is applicable to production facilities of any size and capacity, the advantages of the invention are especially apparent in large scale production facilities.

According to a first embodiment each process cell is equipped substantially only with connections to those utility supply systems which are required for the process means in said cell.

These features lead to a simple logistic structure for the utility supply systems.

According to a second preferred embodiment each of the process cells comprises substantially only process equipment for executing similar type of processes.

This feature leads to a further simplification of the lay-out, so that each process cell is arranged to cater for process means requiring similar set ups and similar types and qualities of utility and air supply. This also leads to a further reduction and simplification of the utility distribution arrangement.

According to third preferred embodiment the cells are arranged around a central cell, the central cell being arranged for providing access for staff and materials to at least cleanrooms and for gowning and decontamination.

This lay-out leads to an excellent and well controlled access to all cleanrooms through only a single provision for gowning and decontamination in the central cell. Under materials inter alia process equipment, installing tools, and raw materials are understood. Further central access to the parts of the process cells not being cleanrooms is obtained.

According to fourth preferred embodiment the central cell comprises a clean compartment and a non-clean compartment, said compartments being separated by at least one station for gowning and decontamination, the cleanrooms of the process cells being accessable only through the clean compartment of the central cell.

This embodiment further enhances the advantages of the preceding embodiment.

According to a fifth embodiment the central cell is arranged for transport and materials and staff between cleanrooms of different process cells.

This feature has logistic advantages in terms of shorter and simpler paths, without passing gowning or decontamination stations.

According to a sixth embodiment the clean compartment of the central cell is adjacent to the clean-rooms belonging to different process cells.

This further enhances the advantages of the preceding embodiment.

According to a seventh embodiment intermediate stores have been provided in some of the cells including the process cells and the central cell for the intermediate storage of wafers, and transport means are arranged for executing transport of wafers between cells through the intermediate stores.

This leads to an improvement of the simplicity of the design of the material handling systems as the wafer transport between the process cells and in the central cell is separated. It will be clear that this simplifies the set-up of the control system and leads to a cost reduction due to efficient transport routing.

According to another embodiment in the process cells and in the central cells separate means have been provided for automated transport of wafers between the process means.

Together with the features of the preceding embodiment the separation leads to a substantial simplification of the control of the automated transport.

According to yet another embodiment the central cell is arranged for suppy of utilities to and withdrawal of exhaust from the process cells.

This leads to a clear and simple structure of those systems and to a considerable shortening of the distances over which those utilities and exhausts have to be transported, and thus to less material consumption and a shorter construction period.

According to another embodiment the process cells have rectangular plan.

This feature leads to a simple construction for which pre-fab buiding and cleanroom materials and proven construction methods can be used. Further, it leads to an optimal utilisation of the floor plan of each of the cells.

According to another preferred embodiment the process cells have a hexagonal plan.

This feature leads to a very good use of the available surface, but possibly to less optimal utilisation of the available structural cleanroom components, such as ceiling grids, walls and raised floor components, as most of these usually employ a rectangular base shape.

In principle the process cells can have any arbitrary shape or combination of shapes, even mutually different shapes.

In case the capacity of the production facility according to the claims mentioned above is not sufficient, it is possible to use a cluster of at least two production facilities according to one of the preceding claims.

This feature can, however, also be used in cases wherein integrated circuits of different types are produced requiring different processes or different sequences of processes.

The production facility, as known from the prior art, has a substantial time lag from the initial go ahead to the start of the pilot run. In view of the fact that integrated circuits have a relatively short life cycle it is of utmost importance to have the production facilities ready at a time, when there is substantial demand for the products of said facility. Thus timing is of utmost importance. It will be clear that shortening of the preparation time will allow a better timing of the investment.

Therefore the present invention also aims for a shorter preparation time.

This aim is reached in that each of the process cells is arranged to be erected and installed as a separate entity.

Therefore the activities required for the realisation of a cell in terms of the erection of the building structure, installation of the cleanroom utility and other technical provisions and finally hook-up of process equipment can take place in parallel for each of the cells or can be arranged such, that similar realisation stages are applied in short sequence to individual cells providing a significant reduction of the overall realisation period of the facility.

According to another embodiment the type, quantity and quality of the utilities to which a process cell is connected differs between cells.

Thus only connections neseccary for the process cell concerned have to be made leading to simplification of the topology of the supply systems.

According to yet another embodiment provisions for building rigidity, for protection against vibration, EMC and hazards are different between cells.

As such a building design of a cell is tuned to meet the required process environment, the provision of unnecessary provisions is avoided.

According to yet another embodiment the number and the constructive properties of the building layer below and above the main production floor of a process cell is adapted to the process means in said cell.

This allows floors to be arranged for purposes which are cell-specific, such as the allocation of different numbers and types of remote process equipment or the accomodation of utility installations.

The invention also relates to a method for building a production facility of the type mentioned above wherein the individual process cells are erected independently.

This method leads to the advantages of a still faster construction.

These advantages are emphasised, when the subsequent realisation stages of a cell are at least partly executed in parallel to another cell.

Subsequently, the present invention will be elucidated with the help of the accompanying drawings, depicting embodiments of the invention by way of example, and in which:

figure 1 is a plan view of a production facility according to the present invention;

figure 2 is a plan view of another production facility according to the present invention;

figure 3 is a plan view of the production facility shown in figure 1, in which the paths of the wafers are shown;

figure 4 is an exploded plan view of the production facility shown in figure 1, in which the paths of electrical power, other utilities and the exhaust are shown;

figure 5 is a view similar to figure 4, in which typical paths for staff and materials are shown;

figure 6 is a vertical, cross-sectional view through a production facility according to the invention; and

figures 7 A-E show plan vieuws of different configurations of clusters of production facilities according to the invention.

In figure 1 a production facility denoted in his entirety with 1 is shown in plan view. As appears from the drawing, the production facility comprises a central cell 2 and six process cells 3,4,5,6,7, respectively 8.

In the present example there is question of a process cell 3, equipped for support functions, a process cell 4, equipped for CMP/implant functions, a process cell 5, equipped for thin film processing, a process cell 6, equipped for lithografical processes, a process cell 7, equipped for etching processes, and a process cell 8, equipped for diffusion processes.

As depicted in figure 6 the process cells 3,4 and 5 comprise three floors, 100, 200 and 300 above each-other.

The main process equipment for processing of the wafers are located in the cleanroom on floor 200.

On the upper floor 100 the air handling equipment is located, while on the lower floor 300 remote equipment is located which is connected with the processing equipment on floor 200. Further, the piping for the distribution of the utilities needed for the process equipment, like ultra pure water or chemicals is located on the lower floor 100.

In the central cell 2 facilities are arranged for access of staff to the process cells 3-8. As most of the second floors 200 of the process cells 3-8 will have the status of cleanrooms, it is important that access of staff and materials to those process cell floors is controlled. Therefore the central cell 2 comprises on its second floor a corridor 50 which is adjacent to all process cell floors having the status of cleanroom. The corridor 50 is connected to a gowning and decontamination station 51, which in term is connected to the central part 52, not having the status of cleanroom, in which stair cases, people and goods elevators, and personel facilities, etcetera are located.

When the equipment located on the lower floor 300 also requires access through a gowning station, a similar set-up is envisaged.

Figure 1 shows an embodiment in which there is question of six process cells; it is, of course, also possible to use other numbers of process cells, for instance eight process cells. Further, in this figure there is question of process cells, having the same rectangular, and in particular quadratic shape; it is, of course, possible to use other shapes, even shapes which are mutually different.

Figure 2 shows a similar embodiment, in which both the central cell and the process cell have hexagonal shapes, however other shapes are possible.

Figure 3 shows a view similar to figure 1, in which the paths for the transport of wafers in process are shown. It is apparent from this drawing that in the central cell 2 there is question of a circular path 9 and that in each of said process cells a separate path 10 has been established.

Each of the paths 10 is connected by the central path 9 by means of paths 11. The paths 9,10 are separated by stores not depicted in the drawings. These stores can be located in the central cell but also in the process cells. The approach by which the transport between cells and within a cell follows simple circular routes and are mutually decoupled, simplifies the logistic concept and the control thereof to a large extent.

Figure 4 shows a perspective, diagrammatical view of the embodiment depicted in figure 1, in which the paths of the electric power 12 and other utilities 13 like pure water are shown. These utilities enter the production facility by means of a set of conduits 12,13 extending through the lower level 300 of in this embodiment the process cell 4 and enter the central cell 2. On said lower level 300 the utility conduits are branched to the lower levels of all process cells to supply the equipment located there with said utlities. Further, the conduits extend upward in the central cell 2, and that at the floor 200 of the production facilities they are branched and connected to the process cells which need a connection thereto. A similar arrangement is present in the upper floor 100 for the air handling equipment usually located there.

A similar conduit arrangement 14 is present for the exhaust. The equipment in the processing cells of the lowest floor produces fumes and exhaust, which, afther appropriate processing, are delivered to the environment. Transport takes place through a conduit system 14, ex-

tending upward in the central cell and being branched on the appropriate floors.

It is stated that, although one conduit is drawn, it is of course possible to use several conduits, as there are several different type of exhaust classes needing separate treatments. The same count for the utility conduits 12,13.

It will be clear that similar functions and conduit systems exist for other utilities, like drains.

The function of the central cell comprises also the distribution of materials, like raw materials, small quantities of materials needed in the production, equipment and tools to the process cells, and the removal of equipment and finished products, as indicated by path 16 in figure 5. Further, as stated before, staff can reach process cells through the central cell, as indicated by the path 15.

Figure 6 shows a vertical, sectional view of the production facility shown in figure 1. Again it shows the three levels 100, 200 and 300, which together constitute the process cell. In the current example the cleanroom is located on level 200. It also shows the location of the central cell 2, and the process cell 3 and 5. Process cell 5 is provided of denser piling 18 than the piling 19 of the process cell 3 and 17 of the central cell 2. The process floor of process cell 5 is thus more rigid than the working floor of process cell 3. Put it otherwise, the equipment located on the process floor 5 is thus less prone to mechanical vibrations, making is better suited for equipment being sensible to vibrations, like lithography equipment. Further, contrary to cell 2 and 3, which employ a solid slab 20 and 22, the actual floor construction of the process cell 5 comprises a so called perforated slab 22, leading to a rigid construction, but allowing substantial freedom for conduits, cables etc. extending through said floor, and of course the removal of air from said floor. It is noted that the upper layer of the actual floor construction is a so

called "raised floor", allowing room for housing cables and conduits, and vertical transport of air to the plenum underneath.

Several of the production facilities according to the invention can be clustered, if the need arises. The lay-out of such a cluster can vary according to needs. Several of those combinations are indicated in figures 7A-7E.

These combinations are, however, not to be considered as limiting; other possibilities can be conceived.

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CLAIMS

1. Production facility for integrated circuits, comprising:

- at least one cleanroom, in which processing means for processing raw materials like wafers into integrated circuits have been located; and
- associated equipment for said cleanroom and the processing means located therein;

characterized in:

- that the production facility is divided into mutually separated process cells, separated by walls;
- that each process cell comprises a cleanroom;
- that each cleanroom is equipped with processing means for executing processes requiring substantially similar conditions;
- that each process cell comprises associated equipment for said cleanroom in the same process cell; and
- that the associated equipment in said process cell is dedicated for maintaining the conditions required for the process equipment in said cleanroom.

2. Production facility for integrated circuits, comprising:

- at least one cleanroom, in which processing means for processing raw materials like wafers into integrated circuits have been located; and
- associated equipment for said cleanroom and the processing means located therein;

characterized in:

- that the production facility is divided into mutually separated process cells, separated by walls;
- that each process cell comprises a cleanroom;
- that each cleanroom is equipped with processing means for processing substantially similar product type;



- that each process cell comprises associated equipment for said cleanroom in the same process cell; and

- that the associated equipment in said process cell is dedicated for maintaining the conditions required for the process equipment in said cleanroom.

3. Production facility according to claim 1 or 2, **characterized in that** each process cell is equipped substantially only with connections to those utility supply systems which are required for the process means in said cell.

4. Production facility according to claim 1, 2 or 3, **characterized in that** each of the process cells comprises only processing equipment for executing substantially similar type of processes.

5. Production facility according to claim 1, 2, 3 or 4, **characterized** in that the cells are arranged around a central cell, the central cell being arranged for providing access for staff and materials to at least the cleanrooms and for gowning and decontamination.

6. Production facility according to claim 5, **characterized** in that the central cell comprises a clean compartment and a non-clean compartment, said compartments being separated by the facilities for gowning and decontamination, the cleanrooms being accessible only through the clean compartment of the central cell.

7. Production facility according to claim 5 or 6, **characterized** in that the central cell is arranged for transport of materials and staff between cleanrooms of different process cells under contamination controlled conditions.

8. Production facility according to claim 6 or 7, **characterized in that** the clean compartment of the central cell is adjacent to the clean rooms belonging to the different process cells.

9. Production facility according to claim 7 or 8, **characterized in that** in at least some of the cells including the process cells and the central cell inter-

mediate stores have been arranged for the intermediate storage of wafers, and that transport means are arranged for executing transport of wafers between cells through the intermediate stores.

10. Production facility according to claim 8, **characterized** in that in the central cell and in the separate process cells means have been provided for potentially automated transport of wafers between the process means.

11. Production facility according to one of the preceding claims, **characterized** in that the central cell is arranged for central supply of utilities to the process cells and for central withdrawal of exhaust from the process cells.

12. Production facility according to one of the preceding claims, **characterized in that** the the process cells have a rectangular plan.

13. Production facility according to one of the claims 1-11, **characterized** in that the process cells have a hexagonal plan.

14. Production facility, **characterized** by a cluster of at least two production facilities according to one of the preceding claims.

15. Production facility according to one of the preceding claims, **characterized** in that each of the process cells is arranged to be erected and installed as a separate entity.

16. Production facility according to one of the preceding claims, **characterized** in that the type, quality and quantity of the utilities, to which a process cell is connected, differs between process cells.

17. Production facility according to one of the preceding claims, **characterized in that** the provisions for building rigidity, for protection against vibration, EMC, and hazards differ between cells.

18. Production facility according to one of the preceding claims, **characterized in that** the number and the constructive properties of the building layer below

and above the main production floor of a process cell is adapted to the process means in said cell.

19. Method for building a production facility according to one of the preceding claims, **characterized** in that the individual process cells are erected independently.

20. Method according to claim 19, **characterized** in that at least one of the the subsequent realisation stages of a cell is at least partially executed subsequent to the same realisation stage of another cell.



