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Dynamic Automation System for Semiconductor Manufacturing

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Abstract:
From a point of view of systems-level, semiconductor manufacturing crisscrosses with design outline, fabrication, integration, assembly and reliability. The elementary purpose of manufacturing are to tie all of these technologies together to achieve finished outcome with low cost, high quality and high reliability. Cost is most instantly influenced by yield and throughput. Quality is attained from a stable and well-composed manufacturing process while reliability results from curtailing the manufacturing faults.

Keywords: *System structure, Bay Automation system, working span method*

1. Introduction

A new semiconductor manufacturing line was framed and eventually expanded to meet flourishing demand. The high yields and short turn-around time required by the most recent technology entails current process equipment to function at the limit of its capacity. Present day factory automation systems must repeatedly progress to meet these new requirements. Photolithography and ion implantation are amongst the several bays in the semiconductor manufacturing line. [1] Big companies have developed an advanced, versatile automation system that can be applied to constructing at the bay level. This structure has two aims to reduce operators' working hours by fully automating fabrication and semi-automating the inspection of wafers and equipment, and to elevateworking span between required appliance maintenance. The automation system is accomplished using in-situ monitoring.

2. Fundamentals of Automation

Line operations are divided into three groups according to the relationship between working interval and workinghours as shown in Fig.1. Our newlydeveloped system adopts a different method of automation for each group in order to reduce operators' working hours. The first group includes fully-automated operations concerned with fabrication, such as loading, recipe indication, process data, acquisition unloading, and cassette exchange. The working hours and intervals of this system are relatively short. The second group includes operations that concern fabricating and inspecting the product, as well as pilot and dummy wafers, Semi-automation is the most cost-effective method for realizing these operations. Inspection data must be evaluated in-process by operators. The third group includes operations concerned with maintenance, such as the cleaning of process equipment, and the replacement and repair of parts. The working hours and intervals associated with these operations are long. The system indicates maintenance schedules for the convenience of the operators. Because inspection and maintenance at regular intervals may be inadequate, the system evaluates the status of the process equipment, adjusts parameters accordingly, and indicates the need for inspection or maintenance ifequipment performance becomes substandard.

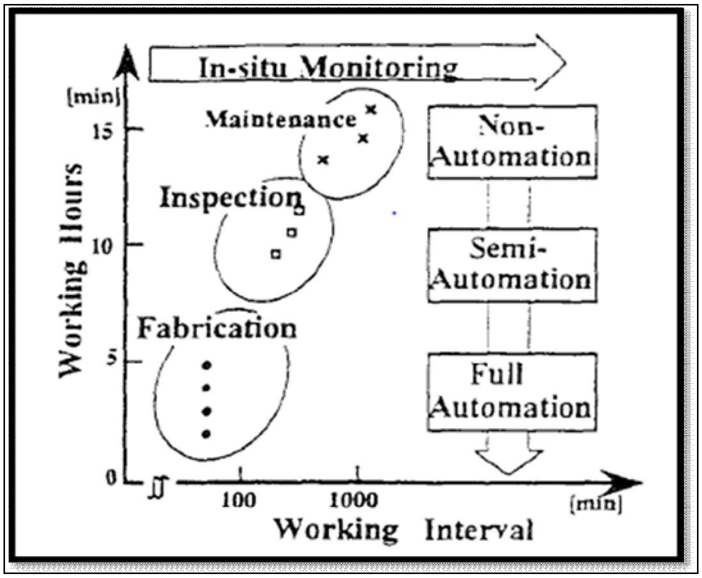

Fig. 1: Fundamentals of Automation

3. System Structure

Fig 2 below shows the structure of the newly-developed system. The automation system for a continually-evolvingline is designed takinginto consideration the number of process steps. First control systems such as theproduction management system and quality management system are constructed. The next step is to placestockers in each bay; all lots are transferred from one stocker to another via an inter-bay transport system.Finally, each bay automation systemis constructed independently, along with its related process equipment.The concept of flexibility permits easy modification in an environment where products, processes, and equipmentare continually evolving. Data stored in the management system database can be accessed via the network by thebay controller.

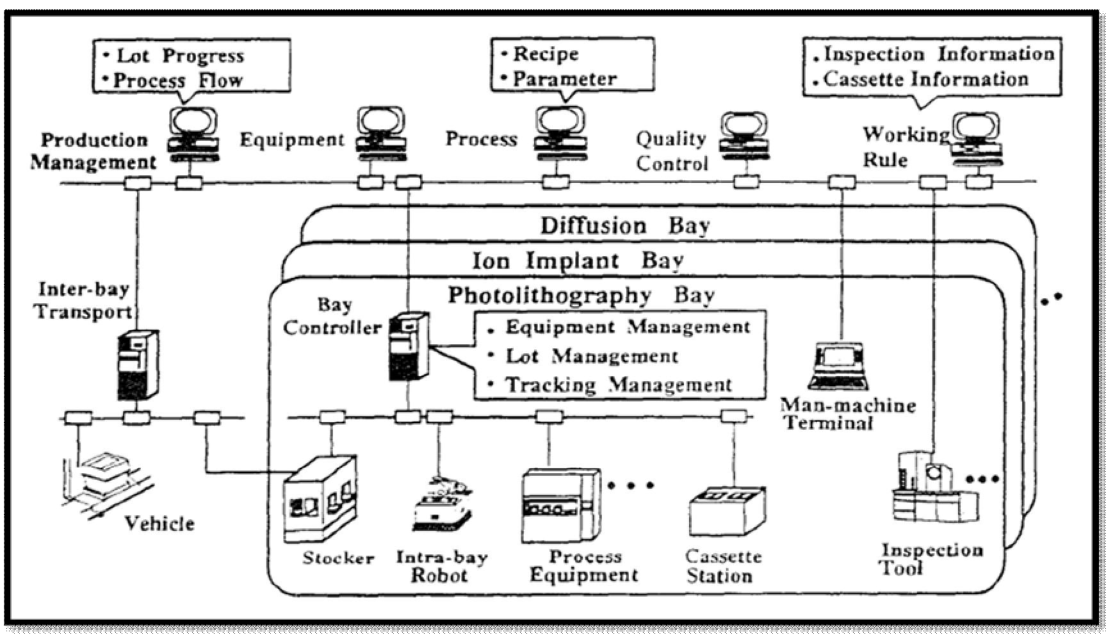

Figure 2: System Structure

4. Bay Automation System

4.1. Semi-Automation

In order to facilitate operation of the automation system, each bay is divided into an automated system area andanoperator area. Fig. 3 shows an example of semi-automation. Acassette station is located between the automation system and operator areas. First, the bay controller obtains inspection information from the working rule management system. When alot is stored in the stocker, the bay controller receives real-time information about the lot such as theprocess flow in the bay, equipment needed for each process step, as well as and the recipe from the management system.

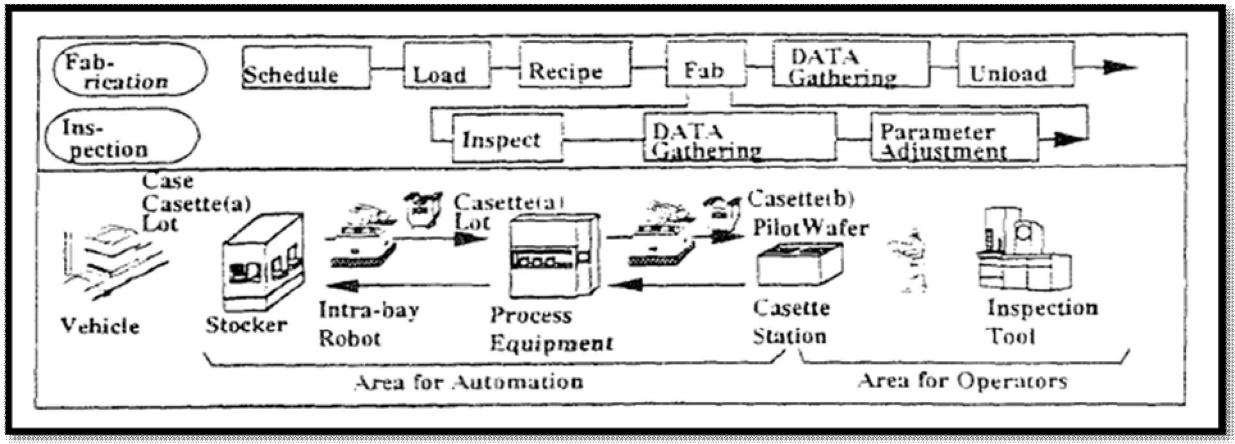

Figure 3: An example of semi-automation

The bay controller creates a schedule for each lot in the bay by referring to this real-time information. Next, the intra-bay robot transfers the lot from one piece of equipment to another while the bay controller communicates appropriate recipes for the lot and pilot fabrication. Afterfabrication, the intra-bay robot transfers the pilot wafer from the process equipment to the cassette station, and provides information about the pilot wafer. If the operator is dissatisfied with the quality of the pilot wafer, he adjusts the parameters of the process equipment from a man-machine terminal. The pilot wafer is returned to the process equipment by the intra-bay robot. After the lot is fabricated, the bay controller againobtains process data, and the intra-bay robot transfers the lot to other equipment.

4.2. Standardization of the Bay Automation System

A virtual manufacturing device standardizesequipment sourced from various manufacturers for thebay automation system. [2] Process equipment is classified into three categories:single wafer, lot divisionand batch processing equipment.For loading and unloading, process equipment isclassified as types A, B, or C (Fig 4). TypeA loaders andunloaders are combined and each wafer is separated fromthe cassette on the loader/unloader. After the wafers areprocessed they are returned to the same cassette on theloader. Type B and C equipment loaders are separate fromthe unloaders. In a type B loader, wafers are separatedfrom the cassette. Processed wafers are combined withthe cassette on the unloader. In type C loaders, both thewafer and the cassette are transferred from the loader tothe process unit.The primary function of the bay controller is to thecoordinate the flow of information and the movement ofthe lot. However, it should be noted that some genericequipment cannot manage this function adequately. Fig4 below shows the lot and equipment management.

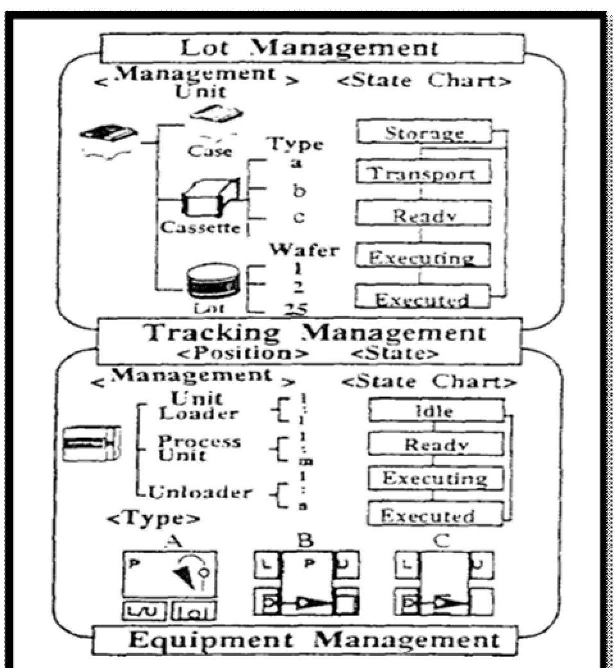

Figure 4: Detail tracking Management in the Bay Controller

For lot management, the system manages theposition and the status of lot cases, cassettes, and wafers,and also manages cassette exchange.For equipment management, the status of eachcomponent, such as the loader, process unit and unloader,are managed in response to data obtained from theequipment.When the bay controller receives data from the process equipment, it identifies the similarities and differences between each lot case, cassette and wafers based on the particular characteristics of the equipment.

4.3. Expanding Working Span Method

First, the automation system gathers in-situ monitoring data such as wafer temperature, QMASS, and particle contamination data from the process equipment. After the wafers are processed inspection data such as reflectance, sheet resistance, and particle counts are gathered from the inspection tool. Next, the system analyzes the relationship between in-situ monitoring data and inspection data. Finally, upper and lower limits of in-situ monitoring data are computed. At the same time, the automation system obtains monitoring data from the process equipment. The system notifies the operator of the need for inspection and maintenance only when the equipment performance is substandard. All this can be seen in Fig. 5 below.

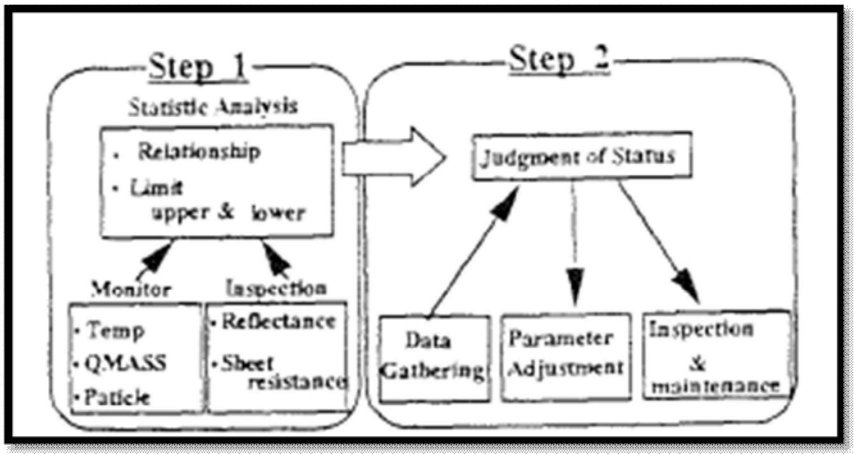

Figure 5: Method of expanding working span

5. Conclusion

Semiconductor technology will continue to evolve. 12 inch wafers, for example, will soon become an industry standard. Automated systems must continually evolve with process technology. Automation systems, which have until now been concerned mainly with reducing the working hours, must now become more flexible, more integrated with operators, and more intelligent in order to drive current equipment to the limit of its performance.

6. References

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2. Gary S. May, Costas J. Spanos,“Fundamentals of Semiconductor Manufacturing and Process Control”