2002 Semiconductor Manufacturing Technology Workshop

Sorter Automatic Operations in A 300mm Fab

Yu-Chih Wang, Dan Ho, Chung-Sheng Wu, Larry Jann
Ycwangk@tsmc.com.tw
Taiwan Semiconductor Manufacturing Co., Ltd
No. 6, Li-Hsin Rd, Science-Based Industrial Park, Hsin-Chu, Taiwan 300, R. O. C.
Phone: +886-3-5636688-6039 Fax: +886-3-5775686

Primary Area of Interest — 300mm Manufacturing

Abstract

This paper demonstrates the approach of sorter automatic operations, which is integrated with an all-new mechanism, called "Dynamic Sub-route" in a 300mm fab. Basing on the advanced 300mm fab operation features of allowing multiple lots in one carrier and multiple recipes within a carrier [1], this approach facilitates the automation of wafer split/ merge and carriers exchange operations in fab daily activities. An automated sorter operation system that implements the approach is being developed in a local 300mm mass production fab as a key component and driver toward the labor saving, miss operation reduction, and fully automated semiconductor manufacturing.

I. Introduction

With advanced CIM (Computer Integrated Manufacturing) system, lots will be split and merged very frequently basing on the ability of wafer level tractability in a 300mm fab. Therefore, sort and merge operations plays a very important role in 300mm fab. According to the study, in average 20%~30% of labor resources per day will be trapped to do sort and merge operations [2][3]. Absolutely, more manual operations will cause more MES in-consistent problem, which will seriously impact the execution of production line. Furthermore, there are some serious problem from ergonomic and safety issue. If sort and merge operations cannot be replaced by automation, operators will suffer occupational injury by moving heavy 300mm carriers (9.5 KG with 25pcs wafer inside) to do wafer sort and merge. Based on these considerations, we develop an effective sorter automatic operation system to integrate 300mm MES and AMHS. However, sort and merge operations are hard to predicate, therefore, it cannot be clearly defined in route information to indicate when and where to do this exchange operation. In this paper, we will introduce a new mechanism, called "Dynamic Sub-Route" to solve this uncertainty. With dynamic sub-route, the user or system can assign the specified lots to do sort and merge automatically.

The mainly functions of sorter automatic operations integrated with dynamic sub-route can be divided into three groups —

(1) Slot verification --- Wafers could be verified with MES by sorter automation. This function could be treated as the watchdog to filter out the problem wafers, which are not consistent with the MES database.

(2) Carrier exchange --- Lots could be transferred to another carrier. Such as carriers over clean due or process contamination issue could be solved.

(3) Dynamic route for lot split/ merge. --- Specific wafers could be split/ merged and be transferred to another carrier automatically to follow and complete unanticipated rework process and engineering experiment.

The remainder of this paper describes the approach for sorter automatic operations in details. Section II reviews the requirements of sorter operations in semiconductor manufacturing. Section III highlights the new features arise in 300mm fab operations, which motivate us the ideas to automate sorter operations. Section IV describes the solutions to cope with all the complicated sorter operation requirements. An automatic sorter operation system which implements the approach is demonstrated in Section V. Finally, Section VI concludes with some future research direction.

II. Background

Compared with a full size 200mm carrier weighting 4.9kg, a full size 300mm carrier weights about 9.5kg. Therefore, too many manual transportation and load/ unload operation will cause serious occupational injury. For this issue, unmanned fab will become the future goal in large size foundries. Causing of unpredictable character of sorter operation, however, sorter automation system never be discussed and thought in past. Therefore, how to setup a sorter automation system so that become the key point of future fab. Especially, there are too many fab activities are associated with sorter operations which are estimated about 45%~50%. And

0-7803-7604-8/02/$17.00 ©2002 IEEE

some of them are inevitable, such as follow wafer rework process, wafer broken handling process, or split partition wafers for abnormal handle and etc. Another important issue is that no matter how careful operators were, the result always came out that the actual slot position or total pieces are not consistent with the MES Data Base. Many wafers were processed at wrong tool with wrong recipes thus happened. Even, this kind mistake might cause thousands of wafers to scrap causing of tool corrosion issue.

III. New Features in 300mm Fab Operations

In order to maintain semiconductor industry profitability and growth, new solutions for cost-effective manufacturing have been proposed and defined for the past few years [1]. Some of the advanced proposals to 300mm fab operations motivate us the ideas to automate sorter operations.

A. Wafer Level Tractability

In 300mm operations, both material tracking and data collection in wafer-level basis are essential and necessary to MES functions. This feature enables wafer-level tractability in sorter operations, which is difficult to achieve in existing 200mm operation MES functions. This transparent function to wafer-level details not only enables the best utilization management of each carrier, but also enlarge the requirement of sorter operation.

B. Tools Capability of Multiple Lots One Carrier

In 300mm fab operations, a single carrier may contain several lots with different processing condition requirements. This feature is based on the new equipment capability of being able to set a recipe or parameter on the wafer level and on the new MES functions that manage the relation between lots and carriers. It is the other feature that establishes our solution to sorter automation for better tool utilization.

IV. Sorter Automation Approach

Based on the above powerful features introduced into 300mm fab operations, an effective approach for sorter operation automation is proposed as an integrated part in 300mm CIM systems. And how to automatically execute carrier exchange therefore becomes the core operation. To implement on SiView system, MMS(Material Management System), OMI(Operation Management Interface), TCS(Tool Control System) and TAP(Tool Application Program) realize Sorter Automation. Fig. 1 can illustrates the architecture of sorter automation system.

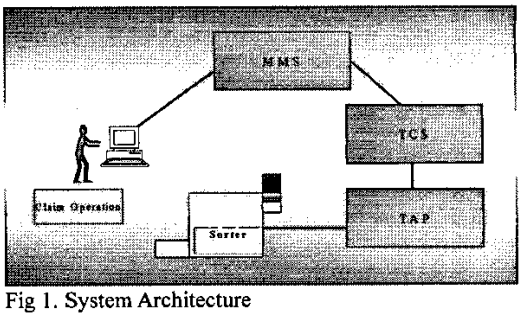


Fig 1. System Architecture

When carriers arrive Sorter, TCS gets actual slot map information from MMS to ask Sorter to execute wafer transfer. After complete transfer, TCS/OMI automatically update MMS the slot map. MMS provides "Dynamic Sub-Route" function. That means there are some unique pre-defined sub-route. This sub-route will be dynamically added to any main route when user or system claims a sorter operation. OMI provides users the interface to claim relative operation. After operation claimed, MM move the lots to WIP of sorter by suited dynamic sub-route. For carrier exchange, user can specify a carrier by carrier ID or just tell system by carrier clean state. TCS execute the operation and send command to Sorter via TAP by control sequence table. During the load/unload cycle, TCS need to send request to MM to delivery carrier. After operation complete, TCS claim carrier-exchange and do lot merge (if necessary) then update information the carrier ID system. Because most of algorithms are implemented in MM and TCS, TAP just send recipe to equipment and report some events to TCS to go through the sequence.

Basing on the system architecture, three functions are then developed to tackle the three classes of daily sorter operation activities described in detail as below.

IV.1 Slot verification

Due to the advanced 300mm MES and CIM system, multiple lots in one carrier become a most basic phenomenon in a 300mm fab. For that, we need an automatic mechanism to filter out the unmatched wafer any time so that we can ensure all the wafers are processed in right time and at right tools with right recipes. Therefore, we establish an automatic system for sorter to compare wafer with the MES DB, which is the only one function that does not associate with carrier exchange. Therefore, if there are any unmatched wafers to be detected, then this lot could be held for further check to avoid unnecessary scrap or tools corrosion. This function is built when operator or TCS trigger the sub-route for T-7 code comparison, sorter will read the T-7 code from wafer, and download the MES DB to compare the T-7 code reading result. If there is any in-consist, the unmatched wafer will be hi-lighted with different

color in OMI system, and this lot will be held by TCS. Fig 2 illustrates the mechanism of slot verification.

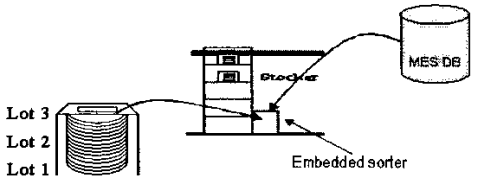
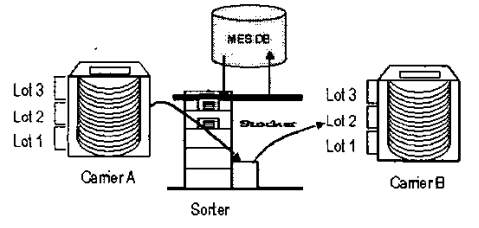


Fig 2. Slot verification function

IV.2 Carrier Exchange

In too many situations, carrier exchange are required, especially when manufacturing cost becomes higher and higher, customers required CTPL gets shorter and shorter, and AMHS (Automatic Material Handling System) loading effects the fab performance more and more directly. Based on these considerations, carrier utilization must be improved. For that, we develop an automatic carrier exchange function by sorter operation. When operators or TCS trigger the pre-defined sub-route to do carrier exchange, a requested type carrier will be transferred. After wafer transferring are done, a lot could be transferred into another carrier automatically, and the MES DB will be updated automatically. Fig 3



shows the mechanism of carrier exchange.

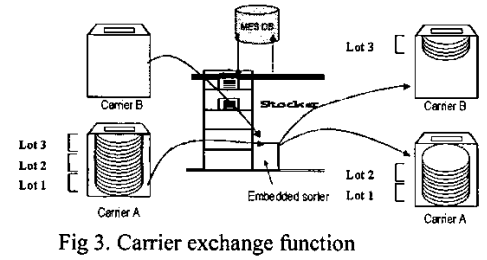


Fig 3. Carrier exchange function

IV.3 Dynamic Route for Split/ Merge

Because of unanticipated partition wafers need to be rework, or even for better tools efficiency. Sometimes it is necessary to split some partition wafers to transfer another carriers, such as some batch run tools. Due to this kind requirement, we develop dynamic sub-route for split/ merge function. And the split lot will start to follow the dynamic sub-route to transfer to another carrier to complete the split or merge operation automatically. With these dynamic sub-routes for split and merge, the maximum carrier utilization, and shortest CTPL could be achieved. Fig 4 illustrates the sorter operation for lots split and merge.

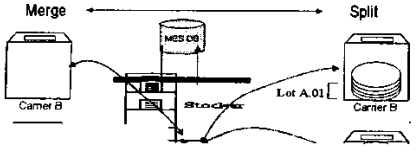


Fig 4. Dynamic route for Split and Merge function

V. Sorter Operation Automation System (SOAS)

Basing on the above sorter automatic system architecture, we can develop a complete scope for SOAS, and it can be illustrated by Fig.5. As a key element in the whole computer-integration manufacturing systems, SOAS realizes the automation of fab sorter operations and integrates MES of the advanced 300mm functions, new interbay and intrabay material handling and transport, real-time job dispatching, and embedded sorters.

SOAS is composed of two major building subsystems – (1) Dynamic route generator, and (2) Dynamic route execution criteria database. The dynamic route generator is the engine for sorter operations, including the clean carrier preparation for carrier exchange requirement, and slot verification function execution for wafers check. Tasks of dynamic route generator can be initiated either by the system or by the operator for event-triggered split/ merge requirements.

In addition to the two major subsystems as its core building blocks, there are several interface functions in SOAS to integrate with other CIM systems. The interface to MES provides the channel to utilize all the process and wafer information defined in MES. Real-time information like fab and equipment status can be also referred from this interfacing. The interfaces between SOAS and AMHS provide the path where the coordination is well managed among sorter operations, wafer handling and transport, as well as equipment automation. Moreover, SOAS interfaces with the real-time job dispatching system for the preparation of the monitor wafers to meet the requirements of dispatched product wafers.

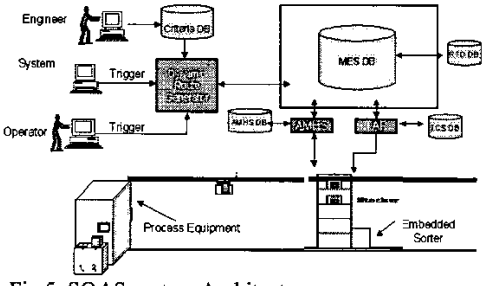


Fig 5. SOAS system Architecture

VI. Conclusion

We have proposed an effective approach for sorter operations automation in a 300mm semiconductor fabrication. According to the study, about 40%~50% fab activities are linked to sort and merge operations. With these functions of sorter automation are implemented in a local 300mm mass production fab, estimated 20%~30% labor resource saving and in average 10%~15% tool efficiencies could be improved. Table I summarizes the benefits from full sorter automation in detail. However, there are some difficulties and open issues to be resolved, such as how to successfully handle abnormal hold lot by automatic sorter operations or how to achieve the best carrier utilization and tools efficiency without impacting fab performance. However, it is very certainly that sorter automation is the major item to get unmanned fab. Through these kinds of operations, thus labor consuming could be saved effectively, manual miss operation could be thoroughly eliminated and the best efficiencies of tools could be gained.

Table 1. Benefit of Sorter Automation

No	Function	Status Analysis	Estimated Contribution
1	Contamination Carrier Exchange	5% of WIP daily	1% labor saving
2	Clean Due Carrier exchange	1.1% of Carriers daily	0.5% labor saving
3	Slot Verification	5%~10% of carriers	3% labor saving
4	Multi-lots One Carrier	Average Lot size=16	1. Average 15% tool efficiency improve 2. 3% labor saving
5	Special partial split	10% of WIP	3% labor saving
6	Control wafer preparation	20% fab activities	10% labor saving
7	Partial Rework process	6.7% of WIP	1% labor saving
Summary		40%~50% of fab activies are linked to Sort & Merge	1.20%~30% labor saving 2.15% tool efficiency improve 3.Miss Operation reduction to 0

References

[1] I300I Factory Guideline: Version 4.2, International SEMATECH, 1999.

[2] *Comparison of daily operator activities between 200mm and 300mm fabs*, tsmc Technical Report, September 2000.

[3] Automatic Monitor Operations in A 300mm Fab, SEMICON Taiwan 2001