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THE EXPERIENCE OF ADOPTING MES BY TAIWAN IC FOUNDRY OPERATORS

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ABSTRACT

MES (Manufacturing Execution System) is a computer application system that integrates all relevant real-time information along every step in a manufacturing process. MES functions include data collection, WIP (Work in Process) tracking, material management, inventory management, exception management, and quality management etc.

IC manufacturing has over 300 fabrication processes, prohibitively expensive equipment, a large variety of products, and short product life cycle. MES, therefore, is essential for IC foundry manufacturers for gathering real-time production line information, supporting manufacturing decision making, and increasing manufacturing efficiency.

Taiwan IC manufacturers have invested in MES over the past few years. For this study we interviewed managers from Taiwan's leading IC manufacturers responsible for implementing MES systems. Their MES adoption experiences and suggestions could benefit other IC manufacturers as well as manufacturers of other industry sectors.

Keyword: MES, MESA, IC Foundry

1. INTRODUCTION

Rapid progress in information and communications technologies made global connection via the Internet possible. Transportation capabilities have enabled goods to be shipped worldwide and communication capabilities have allowed information exchange. Enterprises throughout the world now face global competition. To compete manufacturers will have to produce the best quality, at the lowest cost, and become responsive to customers' needs. The Manufacturing Execution System (MES) is a platform of computer system designed to help manufacturers reach these objectives.

MESA (Manufacturing Execution System Association) is a non-profit professional organization composed of MES software development companies. The charter of MESA includes providing a forum for MES developers and users to exchange ideas, joining efforts to promote industry awareness of MES, and defining standard interfaces between MES functions and between MES and other enterprise information systems.

According to MESA [2][3][4][5][6], the definition of MES is as follows: MES collects real-time status and performance data about products-in-process and equipment in the production line. MES processes such data, transforms it into useful information, and disseminates it to all production related organizations. The information is then used as input to re-optimize manufacturing resources allocation and scheduling.

Taiwan has become the base of world's largest IC foundry. Because IC fabrication involves over three to four hundred processes, and the cost of equipment for these processes may be as high as several million US dollars, from the supply-side perspective of saving manufacturing resources, the IC industry should be an early adopter of MES.

Due to the dynamic and competitive nature of the IC market, IC products' market windows and life cycles are getting shorter. The customers of foundry operators request the latter to be responsive and flexible enough to accommodate their changing needs. From the demand-side perspective of increasing flexibility and efficiency, the IC industry should also be an early adopter of MES. In fact, most all of Taiwan IC foundries have adopted MES. The top three MES products used is PROMIS, Workstream, and POSEIDON.

Taiwan IC foundries were the first to adopt MES. There have been some success stories and some painful experiences, which can be valuable references for other plants planning to implement MES. For this paper, we interviewed several Taiwan IC foundry personnel involved in implementing MES. Their experiences and suggestions are summarized for the benefit of future MES adopters.

2. LITERATURE RESEARCH

The purpose of this research is to summarize the experiences of Taiwan IC foundry operators in their adoption of MES. The following literature summarizes other scholars' observations of important factors for making adopting of a new system successful.

Kostoff and Geisler (1999)[1] studied the strategic management and implementation issues of adopting textual data mining systems in government organization. Their research found three major reasons which can cause the adoption of a new system to fail: 1.) The new system was treated as subordinate; 2.) The new system was treated as independent to the existing system; and 3.) There exists big difference in understanding between the new system

developer and the users. These two scholars then suggest the following twelve prerequisites for the successful adoption of a new system.

1. Commitment of senior management
2. Motivation of the evaluation managers
3. A clear statement of objectives
4. Competency of technical evaluators
5. Relevance of evaluation criteria to future action
6. Selection of evaluation criteria
7. Reliability of evaluation
8. Evaluation integration
9. Normalization across technical disciplines
10. Awareness of available information
11. Cost of S&T evaluation
12. Ethics of personnel

Sultan and Chan (2000)[7] studied the adoption of object-oriented computing in software companies. They classified the important factors that will affect the adoption of a new system into four categories, namely, the personal factors, the team factors, the organizational factors, and the technological factors.

Personal factors include the level of experience of personnel involved in the adoption project and the motivation to make the project succeed. Team factors include the team spirit, leadership, communication among team members, and responsiveness to solve problems. Organizational factors include organization culture, organization structure, technology policy, competitive strategy, risk management, and the support from senior management. Technological factors include the relative advantages of the new technology to the existing technology, the compatibility between the new technology and the existing technology, and the complexity of the new technology.

3. THE BENEFITS OF MES TO IC FOUNDRIES

1. A MES system has control over all processes of an entire production line. It's online monitoring and guiding capabilities assure smooth flow of manufacturing activities, which, in turn, increases the equipment utilization rate and product yield rate. MES has become indispensable in any IC fabrication plant.
2. The cost of some IC fabrication equipment may be as high as several million US dollars per unit. It makes economic sense to have the most intelligent software to orchestrate the orderly operation of all of the equipment in the IC foundry.
3. Although the cost of implementing a MES system is quite significant, the savings generated from more efficient operation of the fabrication process and better quality products make this investment very worthwhile.
4. Without MES, all in-process batch jobs are monitored by "run cards". But the tracking capabilities of run cards are not only very primitive, but also limited. A MES system can track the real time status of every batch job in the fabrication processes.
5. A MES system can generate real time status reports of the performance of equipment and the quality of in-process products. Any malfunction of equipment or defect in product quality can be detected right after it occurs, and correction actions can take place immediately. The efficiency of IC fabrication equipment is thus increased, while the human resources required to achieve this level of performance is less than without MES.
6. MES has become the core of a Computer Instructed Manufacturing (CIM) system and the foundation of operation of IC foundries. It provides management with critical information to make business decisions.
7. MES can simplify and systemize the information required for manufacturing control, and increase the usefulness of it. MES also provides a foundation for the innovation and exchange of information and knowledge.
8. Besides fabrication technology, five other key success factors for an IC foundry are: cost, yield, quality, customer service, and cycle time. A MES system is targeted to excel on each of these manufacturing performance benchmarks, therefore, MES is critical to the competitiveness of IC foundries.
9. MES generates an abundance of useful information, which translates into commercial value in IC fabrication, a typical knowledge management example in an era of knowledge economy.
10. MES controls the core of a manufacturing-oriented enterprise. Without precision and responsiveness in the core activity, the benefits of Supply Chain Management (SCM) and Enterprise Resource management (ERP) cannot materialize.
11. MES makes use of information technology that emphasizes information collection, distribution, and eventually turns the information into useful knowledge to support decision-making. It has become the "brain" of IC fabrication.
12. IC foundry has gone through business cycles every several years. At the peak of a cycle, the demand is high, and the efficiency of IC fabrication is critical in order to produce more output. At the bottom of a cycle, cost containment becomes the critical survival factor. MES can accomplish both goals of expanding throughput and lowering costs.
13. Taiwan IC foundry companies expect to become the "virtual fab" for other IC companies. To do so will require MES to provide to customers detailed real-time status information about their orders at every stage of the fabrication process. Only by sharing information so openly, directly and instantaneously with customers will they feel comfortable and confident about the quality

and services provided by a virtual IC foundry.

14. MES can be integrated with other enterprise information systems to provide customers with one-stop shopping service. Two-way communication via the Internet, information such as orders, technical specifications, service menus, in-process status reports, performance statistics reports, delivery schedule confirmation, and all kinds of inquiries can be exchanged promptly. Benefits to customers include saving human resources and time, as well as providing critical information to help customers make right business decisions in time.

15. IC foundry with MES capabilities can provide customers with real-time information. It increases customer satisfaction and establishes an enterprise image of being technologically advanced and assurance of customer-oriented service quality.

16. The life cycles of IC products may be as short as several months in a highly dynamic and competitive market. Both customers and providers of IC foundry services must exercise extreme flexibility with respect to order/production adjustments. Customers may want to increase or decrease the size of an order, or push forward or delay the schedule of another order in response to the latest market information. The foundry provider must be able to rely on MES to re-optimize the production scheduling of all orders to adapt to customers' requests for changes.

4. THE DIFFICULTIES IN ADOPTING MES

1. Decision makers do not easily appreciate the benefits of MES to IC foundry, as the cost of acquiring MES is over several millions of US dollars. This is why there is always debate over whether to implement MES sooner or later.

2. In evaluating alternative MES vendors and selecting the right MES product most appropriate for the existing operation of an IC foundry are the critical decisions to make in the preparation stage.

3. Adopting MES means changes to existing procedures, which inevitably lead to re-organization. There will be resistance from the personnel because they will have to abandon past experiences and routines, learn new skills, and will be under the tight scrutiny of computers. Top management's persistence in pursuing MES as well as support for middle management are essential to the success of adopting MES.

4. Unrealistic anticipation that adoption of MES will be quick may cause chaos in the operation and lead to abandoning of MES. Transition to MES should start with a few simple functions run parallel with old procedures and tests of its validity, then gradually phasing out old procedures and implementing additional new MES functions. It is estimated that at least one year to 1.5 years is required to bring in MES and have the new system operate smoothly in an IC foundry.

5. Before implementing the MES, verbal descriptions of process related situations were written on "run cards" by operators to pass down to the next shift operators or their supervisors. One of the most tedious tasks in converting to MES is to generalize the situations into specific states, which are prioritized according to their relative importance and frequency of occurrence, and code them with computer language into the MES database. This process converts operators' observations and judgments based on their past experiences into discrete states that the computer can distinguish. This is also to convert operators' personal experiences into managed knowledge in the MES so that some of the operators' tasks can be performed by the MES computer system. The human brain of an experienced operator can respond to very complex situations, expecting computers to possess the same capability requires a lot of effort. Making a routine check up, for example, may involve hundreds of possible situations, which need to be coded into the MES database to prepare for any possible outcome.

6. MES engineers need to convert the standard operations procedures of every piece of equipment involved in the IC fabrication process into the MES database. The purpose is to make MES knowledgeable enough to control the fabrication equipment under any circumstances. However, there are many "exceptions" of the "standard" operation procedures. It took MES engineers over one year to take care all exceptions before the MES could perform its functions smoothly.

7. Much of the required data for the MES is entered into the computer by operators who need to be trained so that the precision of the data they code in will have significant impact on the performance of the MES as well as other business decisions.

8. In IC foundry, about 20%-30% of capacity is used to fabricate pilot lots, which share use of equipment with other lots. Because the quantity of pilot lots is small and the processes are still experimental, it generates lots of unstable situations, which need to be reported by operators into the MES. This is one of the areas operators complain about a lot. Because a computer system works reliably in repetitive conditions, but unintelligently when confronted with new conditions, much effort is required from operators to input into the MES information about the pilot lots.

9. The processes of IC assembly and testing vary for different products. Hence, the flexibility of the MES to adapt to various requirements is important.

10. All personnel working in the MES environment should be able to respond quickly to unexpected conditions and make adjustments to change of requirements.

11. IC fabrication involves several hundred complex processes. However, customers continue to expect

shorter cycle time. MES engineers have to respond quickly to customers' requests so that changes can be made before the delivery date is reached.

12. IC foundry always faces a dilemma before adopting a MES system: whether to purchase the source code of a MES product or pay only royalty to lease a MES product. The advantage of purchasing is the ability to modify the source codes to fit the user' s needs. Some concerns include whether heavy cash outflow to pay for the purchase price is worthwhile and whether there is enough in-house talent to enhance and maintain the purchased version. The advantage of leasing is that the IC foundry can rely on the MES vendor to upgrade and maintain the system, but the risk is that the vendor would not make the necessary modifications required by user.

13. MES needs to be integrated with a Computer Integrated Manufacturing (CIM) system and a Manufacturing Resources Planning (MRP) system. However, incompatibility problems may exist between the data formats and structures used by different systems. Interfaces will have to be defined in order to do data trans-coding or conversion before information can be exchanged between systems.

14. MES engineers' main responsibilities include developing or activating new MES functions. However, in order for MES to be user-friendly to production line operators, MES engineers should also devote time to improve the user interface to the MES.

15. The selection of MES product must be very cautiously evaluated not only because the capital investment is huge but also due to the fact that the implementation of MES takes a long time and tremendous human resources.

5. SUGGESTIONS FOR ADOPTING MES

1. A MES can only be built based on the foundation of a computerized plant information system. Therefore, top management has to realize this fact and be prepared to invest in computerizing the plant management information system.

2. The head of the MIS department has to become a firm believer in MES who understands the strategic position and importance of a MES in the entire enterprise information system. This champion must develop a thorough implementation plan and explain the benefits of MES to top management.

3. The determination and commitment of top management to implement MES is essential for the success of MES.

4. A "MES Steering Committee" composed of leaders from all departments should have the authorization and full support from top management to implement MES because implementing a MES is not the responsibility of the manufacturing department only. Implementing MES will revolutionize the entire operation of an enterprise.

5. To implement a MES depends on the scale of business, the availability of investment capital, and the complexity of the manufacturing processes to decide the right set of MES functional modules which should be implemented in several phases with consideration of the overall operations strategy.

6. Different industries require different MESs. Even companies in the same industry may need different MES functionalities. Therefore, thorough investigation of the characteristics and needs of a company is important to select the most appropriate MES product.

7. Implementing a MES is an important business decision. It will result in big benefits if successful but it might cause serious damage to a company if it fails. Therefore, the conservative "risk aversion" strategy is recommended. In other words, every effort should be made to avoid the risk of failure.

8. For plants with unique manufacturing processes, purchasing a MES product with just the fundamental MES functional modules and developing other needed functional modules either in-house or through an outside software house is recommended. This is because no MES product can satisfy all of its customers' needs.

9. For plants with standard manufacturing processes, selecting a MES product that has been used, tested, and proved by other plants within the same industry will be a safe strategy.

10. The success of implementing MES requires the full cooperation of all personnel. The first-line operators are responsible for the accuracy of the data they enter. Proper training in technicality and mentality with respect to MES is essential.

6. CONCLUSIONS AND RECOMMENDATIONS

IC fabrication involves three to four hundred processes. Each requires equipment that is complex, precise, and highly automated by computer control. There may be hundreds of products in production simultaneously. Because different products require different processes, the status monitoring capability of MES becomes indispensable for an IC foundry.

This research emphasized the importance of implementing MES in IC foundry, summarized the implementation experience of those who have adopted MES, and highlighted some suggestions to those who plan to adopt MES.

MES is the core of Computer Integration Manufacturing (CIM) and should be integrated with Enterprise Resource Planning (ERP) and Supply Chain Management (SCM). ERP facilitates communication between departments within an enterprise. SCM facilitates communication with partners outside of the enterprise. Without real-time and accurate information provided from MES, there is really nothing useful to share either within or outside of the enterprise. Consequently, MES is the most important capability that a

manufacturing facility must develop. It is also the foundation for ERP and SCM.

MES is a dynamic system that should evolve and be upgraded constantly. For example, the tracking capability of an MES for IC foundry can only manage the unit of each order lot in the past, the direction of future improvement is to be able to track the unit of each single wafer. Another area that deserves further development is the optimization capability to re-schedule orders and the re-assignment of equipment at times of order priority change, machine breakdown, or other unexpected disturbances to the existing production plan.

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