

e-Business and e-Manufacturing in the Semiconductor Market

A White Paper

Executive Summary

In the drive to advance technology, our society has become increasingly dependent on semiconductors to power our cellular phones, our computers, our home entertainment equipment, our cars and even our toys. In 1999, General Motors shipped more microprocessors than Intel did.

As the global demand for semiconductors grows at an increasing pace, existing resources are strained, and operations and support staff are forced to perform at a much higher level than ever before in order to maintain the availability of the tools on the fab floor.

At the same time, through the growth and acceptance of the internet in business, a new channel has become available for the delivery of rich content, and in fact a new capability to collaborate between the OEM and the service provider. The availability of complex semiconductor fab equipment is critical, and as complexity increases, that availability can only be achieved through more efficient communication between the supplier and the semiconductor manufacturer.

E-commerce and e-business systems that can deliver the necessary product support content and aid the operator in improving the availability are vital to the effective operation of today's semiconductor fabrication facilities.

Availability is Critical

Demand for semiconductors is increasing, with no signs of stopping. Semiconductor manufacturers are building new fabs to meet this growing demand at a rapid pace. The cost to equip a semiconductor fab completely is approximately \$2 billion, with over half of that amount going to buy capital equipment that will be effectively obsolete in about 2 years. This amount is expected to grow by a factor of 5 to \$10 billion in 2005. The steep cost is a result of not only the relatively high cost of the equipment, but also the requirement for substantial tool redundancy to ensure high availability. According to figures from the semiconductor industry, on average a semiconductor tool is unavailable for 3% of each day as a result of planned downtime (i.e. maintenance), and for 15% of each day as a result of unplanned downtime (i.e. repair). The cost of downtime in a semiconductor fab can be higher than \$1 million *per day*.

In order to increase availability, maintenance staff must be able to quickly troubleshoot problems, procure spare parts and make the necessary repairs. Efficient troubleshooting of complex systems requires access to all of the required and relevant information, so that the correct decisions can be made. Once a decision has been made, it must be easy to procure the required spare parts so that the machine can be repaired. In order to maintain high availability, manufacturers also stock a large inventory of spares. The excess inventory is estimated to be approximately \$3 billion on an annual basis. This is stunningly high in an industry where new equipment sales are only about \$25 billion per year. More effective maintenance predictability could help to reduce this inventory.

With a potential loss of \$150,000 per day on average as a result of a machine down, there can be no delay in getting failed systems back online and operational. Furthermore, as the typical semiconductor manufacturing process takes about 30 days, a down machine can result in a substantial decrease in chip yield in the manufacturing process.

“e” Building Blocks

In attempting to move to an e-Business and e-Manufacturing architecture, semiconductor manufacturers and suppliers have identified several key building blocks. These are e-Collaboration, e-Commerce, e-Documentation, e-Knowledge Management and e-Diagnostics. The primary goal is to increase the availability of the tools on the fab floor. A major semiconductor manufacturer has initiated a plan to achieve complete “e” status by the end of 2001. Their goal is a 66% reduction in equipment support dollars. Approximately \$40 billion is spent annually for the maintenance of semiconductor tooling equipment across the industry. A 66% reduction would translate to a savings of over \$26 billion across the industry. These building blocks are the foundation of a total electronic solution for the semiconductor industry. The Semiconductor Industry Suppliers

Association (SISA – www.sisa.org) has a committee composed of both suppliers and manufacturers studying the e-business/e-manufacturing issue.

In addition to the “e” building blocks, e-manufacturing allows suppliers to have a view into the operation of their machines so that they can remotely diagnose and troubleshoot their machines. The purpose of this e-manufacturing view is achieve 100% availability with minimum impact on the semiconductor manufacturer.

e-Collaboration

E-Collaboration is the controlled exchange of information such as specifications, meeting minutes, drawings and other information. It is more than just email and may also of information shared in the form of Post-It Note-style annotation as well as more complex collaboration.

e-Commerce

E-Commerce is the controlled exchange of information such as purchase orders, invoices and procurement. This also encompasses the consumables and materials used in the semiconductor manufacturing process, as well as the aftermarket spare parts required to keep the fab equipment operational.

e-Documentation

E-Documentation is the controlled collaboration and exchange of documents such as product support content, configuration specifications and training manuals.

e-Knowledge Management

E-Knowledge Management is the controlled exchange and management of information between semiconductor tool manufacturers and semiconductor manufacturers. This may consist of web-based access to procedures, realtime and historical equipment performance data as well as the field service knowledge management database.

Effective knowledge management can allow support staff to anticipate problems before they occur, as well as achieve faster response times in problem situations and therefore increased productivity.

e-Diagnostics

E-Diagnostics consists of diagnostic tools such as remote sensing, remote monitoring, remote diagnostics, remote debugging and model tool behavior. Monitoring the behavior of semiconductor fab equipment can potentially aid maintenance engineers in anticipating problems and significantly reducing repair time.

Delivering Complex Information

Current systems are designed to allow the semiconductor manufacturer to manage the operations, troubleshooting and maintenance processes. However, they do not aid in the troubleshooting process, which has become extremely involved due to the increased complexity of the fab infrastructure. Troubleshooting a problem with semiconductor equipment can be a complicated procedure. The cost of floor space in a fab is prohibitively high, so the paper documentation will not be available in the fab. The required product support content must be current, available electronically and accessible by engineers in the fab. This information is most likely paper-based, and probably several releases out of date. The engineer must then attempt to find the information required to resolve the problem. Furthermore, once the problem is resolved, the engineer must go to a different system to order the spare parts required to perform the necessary repairs.

Effective problem resolution requires access to the most complete and up-to-date information, especially where complex infrastructures and rapid system changes are involved. Finding the information required to troubleshoot and solve a problem is also much easier using product support content in electronic form rather than paper. However, the information must be structured effectively, or it may be no more useful than the old paper-based documentation. In a fab environment one may also find that there is no available paper documentation.

A recent study of search times for information by the telecommunications standards group Telcordia showed that given content presented in an HTML web-based format, users could find information in about 60% of the time it took to find the same information in a paper-based catalog. However, given content presented in Adobe PDF format, users took the same or longer times as finding information in the paper-based catalog. Content delivered in a structured format in HTML (and XML) is almost twice as effective as either PDF or paper-based information. Since maintenance staff typically spend up to 10-20% of their time searching information, effective structured information can save them almost half of that time. By improving access to information, maintenance productivity can be increased substantially.

Training

With constant growth in semiconductor demand training delivery to the customer support and field service departments is a major problem. Corporate training departments typically re-purpose the equipment manufacturer's manuals and documentation, as well as add their own content, to train their staff. This is a time intensive procedure requiring re-keying of information found in paper or possibly Adobe PDF documents.

This process may yield excellent training information, but the support staff will be faced with the original documentation in the field. Training would be much more effective if the original documentation was usable as training material, so that staff would be able to directly re-use what they had learned in training. By directly incorporating the OEM documentation along with their own best practices into one information delivery system and then structuring their training procedures to match the actual on the job use, one high technology company was able to substantially increase the effectiveness of their staff training. At a hiring rate of approximately 700 support employees per year, they were able to reduce their training time by approximately 45%. In fact, when they surveyed their staff they found that 89% of the employees regularly used the skills they had learned in training. They also discovered that 79% of their employees felt that they were able to work more independently, and 25% felt more confident in their jobs.

Semiconductor manufacturing staff may spend over 30 days per year in both initial and in-service training. Combined with the exceeding short cycles before new technology is obsolete, sometimes as short as two years, staff must be constantly learning in order to keep fabs operating at peak efficiency and therefore attaining the best possible semiconductor yields. Effectively delivery and re-use of training information can also help to reduce the cost of fab operation.

Finding and keeping skilled network maintenance staff is becoming increasingly difficult. In fact a 1999 study of field service and maintenance showed that 58% of respondents felt that recruiting and retaining talented staff was their greatest challenge. When staff are changing rapidly, training becomes extremely important in ensuring that employees are effectively prepared to perform the tasks assigned to them.

Aftermarket Support

Aftermarket support comprises all of the aspects of service and support after the initial sale of the equipment. This also includes all of the spare parts required to maintain the equipment and operate it efficiently. Manufacturers provide extensive support offerings for their customers. Typically customers such as semiconductor manufacturer must provide their own support initially. Access to the most current information can aid customers in problem resolution as well as remove some of the support burden from the manufacturers.

Manufacturers are increasingly turning to using the internet as a channel to provide the most current product support content to their customers. This allows them to deliver documentation updates and product support updates to their customers immediately as soon as they are available. A major equipment manufacturer estimates that delivering support information via the web to enable customer self-support can cut down on their support calls by as much as 50%.

At the same time, manufacturers are moving downstream in the supply chain by providing services that are much closer to the customer than merely the sale of the equipment. For example, Applied Materials has two support offerings; Total Parts Management and Total Support Package. With Total Parts Management, Applied will manage all of the customer's spare parts and consumables with

inventory at the fab site. With Total Support Package, Applied will manage all support and maintenance required for equipment in the fab. Applied Materials guarantees and improvement in productivity and a decrease in operating costs. Their customers have said that they typically see a 20% improvement in productivity and a 30% decrease in operating costs.

Applied Materials can achieve this because they know their machines better than anyone else. They have the most complete collection of content required for the operation and repair of the semiconductor fab equipment that they manufacture. Other manufacturers can achieve these results by delivering their content in a navigable way on the web. By delivering product support content as well as spare parts information and pricing they enable their customers to find information more quickly. Those customers can take advantage of that delivered content to more effectively troubleshoot and resolve problems.

This can also act as a channel for cross-selling and up-selling of tooling equipment to existing customers. Manufacturers can offer all of the content required to make purchasing decisions. Such a collection of information is referred to as *transactive content*. Customers who need equipment and spare parts can use the support content as well as product and pricing information to make a purchasing decision.

Aftermarket support is also more effective when there is the potential for collaboration between the semiconductor manufacturer and the fab equipment manufacturer. The use of the web as a channel allows for different forms of collaboration, from simple Post-It style notations, to far more complex customer originated changes. The customer can use this feature to communicate their issues back to the manufacturer, and the manufacturer can use the customer feedback to help to improve their products. The customer can also incorporate their own best practices into their documentation.

Keys to Customer Satisfaction

The keys to satisfying the customer in terms of availability, training and aftermarket support are effective content management and delivery, simplified purchasing decisions and procurement, and collaboration between the manufacturer and the customer. Or to put it more simply, the most important elements are *Content*, *Commerce* and *Collaboration*.

Content

An effective solution for semiconductor manufacturers must be able to deliver a large volume of content electronically. The high cost of fab floor space will not allow the storage of paper in the fab. It must also make that volume of information navigable and searchable. When information is delivered in this fashion, especially in a structured form using HTML or XML, versus a format such as Adobe PDF, the time required to find information is substantially decreased and employees are correspondingly more productive.

Commerce

Commerce, and more recently e-commerce refers to providing all of the information required to drive a purchasing electronically. Equipment manufacturers can sell spare parts via the web, by providing the information that their customers need to make procurement decisions. These web-based systems can also integrate with enterprise resource planning (ERP) and order management (OM) systems on the sides of both the manufacturer and the operator of the equipment, allowing a complete “e” solution.

Collaboration

Effective problem resolution is a product of ongoing collaboration between the customer and the product manufacturer, as well as collaboration among the customer’s support staff. The incorporation of best practices within the product support content can also improve the ability of the customer to maintain and grow their infrastructure with greater reliability.

Integration with the Back Office

Semiconductor manufacturers have a number of back office systems to deal with. The systems generally center on the manufacturing and materials management processes. Solutions for the maintenance of fab equipment should be able to integrate with those systems, as well as with automated diagnostic systems in order to enable employees to more effectively diagnose and resolve problems,

In addition to this, where manufacturers offer the potential for e-commerce, the solutions should be able to integrate with the customer’s procurement and order management and inventory systems, allowing the efficient procurement of spare parts. This type of integration can allow the service provider to manage their inventory with greater predictability, and therefore reduce their excess inventory, while still maintaining a level of comfort regarding the ability to have equipment available where necessary.

Conclusions

Consider some of the following decision points and questions about your customers, your organization, its business goals, and its technical infrastructure and approach.

Identify the Requirements of Your Customers

- ◆ Is technical support a major cost or issue for your dealers?
- ◆ Would better information make your customers more productive?

Identify Where Your Organization is Regarding e-Content

- ◆ Do you author your content in a structured format?
- ◆ Do you deliver thousands of pages of technical and catalog content to the operators of your equipment?
- ◆ Do you have a solution in place to deliver your product support content?
- ◆ Is it easy to find information when required?

Identify Where Your Organization is Regarding e-Commerce

- ◆ Are you evaluating or rolling-out content management or catalog management software? Or do you have such technology in place already?
- ◆ Do you require your content to be integrated with technical data, e-commerce information, or other back office information?
- ◆ Would you like to deliver integrated content and technical information to customers and channel partners?
- ◆ Do your content systems on both the sell-side and buy-side need to be integrated with transaction systems?

Identify Where Your Organization is Regarding e-Collaboration

- ◆ Do you provide web-based customer support and/or selling? Have your customers ever asked to be able to do this?
- ◆ Could you benefit from knowing more about how your customers use your products?

Assemble the Right Technologies and Solutions

- ◆ Concentrate on assembling best-of-breed technologies for content management, e-commerce, applications serving, and applications integration.

Decide on the Business Objectives of the Implementation

- ◆ Clearly, you will be looking for improved reliability and maintenance productivity. You will want to evaluate certain customer support metrics to look for an increase in self-service customer support among operators, as well as increased customer satisfaction.

Implement, Measure for Success, and then Build on that Initial Success

This early success will convince management, employees, and partners of the viability of the new content-commerce-collaboration business models. Other parts of the organization, and other partners, will be ready to participate as you expand these solutions across your enterprise.