Leveraging Equipment Productivity

Symphony's Equipment Productivity Manager

Abstract

The Symphony Equipment Productivity Manager (EPM) is a suite of applications that interacts directly with semiconductor manufacturing equipment to provide the information and analysis tools that equipment engineers, process engineers, and managers need to improve equipment productivity.

The information collected and analyzed using the EPM suite can help optimize maintenance schedules, refine processes, repair equipment before it fails, reduce scrap, save time and increase yield.

An open and extensible platform is the foundation that enables a suite of software tools to provide a critical competitive edge. Our experience shows that a set of general-purpose applications plus several focused tools can provide both fabs and OEM's with the solutions to their unique challenges.

The main focus of the EPM is equipment: manufacturing tools, sensors, and other subsystems. In addition the EPM provides and infrastructure for Advanced Process Control (APC), focusing on wafer quality. In this arena, the EPM suite provides a data collection and tool connectivity platform for fab-specific solutions.

Improving tool throughput enables fabs to delay new tool capital investment. With typical tool operation costs running *2 – 4% of the purchase price per month*, postponing the installation of a new $2 million tool by 3 months saves a fab well over $100,000 in operating costs. A downturn is a particularly good time to commence equipment productivity initiatives. This solution is less costly, gives faster results, and better prepares a fab for the next upturn with tuned and maintained tools and processes.

Overview

Chip manufacturers have a common goal: to manufacture the maximum number of chips at a minimum cost. There are a number of ways to achieve this goal: larger wafer size, yield improvement, shrinking feature size, and increasing tool productivity among others. Reducing the manufacturing cost of a wafer by increasing wafer size requires a significant investment of both capital and time. Adding new advanced tools is another expensive effort. **Improving the productivity** of equipment has been identified by an International SEMATECH study as a key factor for staying on the historical trend of lowering the costs for producing semiconductors by 25% - 30% per year.

Comparing statistical data on the annual percentage of reduction in cost/function provided by International Sematech (April 2000) shows that increasing wafer size provides much less opportunity than it did in the 1990s. Today, improving equipment **productivity** is expected to contribute as much to reducing semiconductor manufacturing costs as shrinking feature size.

The following scenario shows how the EPM was used to improve a tool's productivity and the immediate savings that were realized with this simple-to-install, easy-to-use solution.

Annual % Reduction in Cost / Function[i]			
Factor	**1980**	**1995**	**Future**
Shrinking feature size	12%	12-14%	12-14%
Productivity	3%	7-10%	>9-15%
Larger wafer size	8%	4%	<2%
Yield improvements	5%	2%	<1%

Scenario 1: Troubleshooting a throughput problem

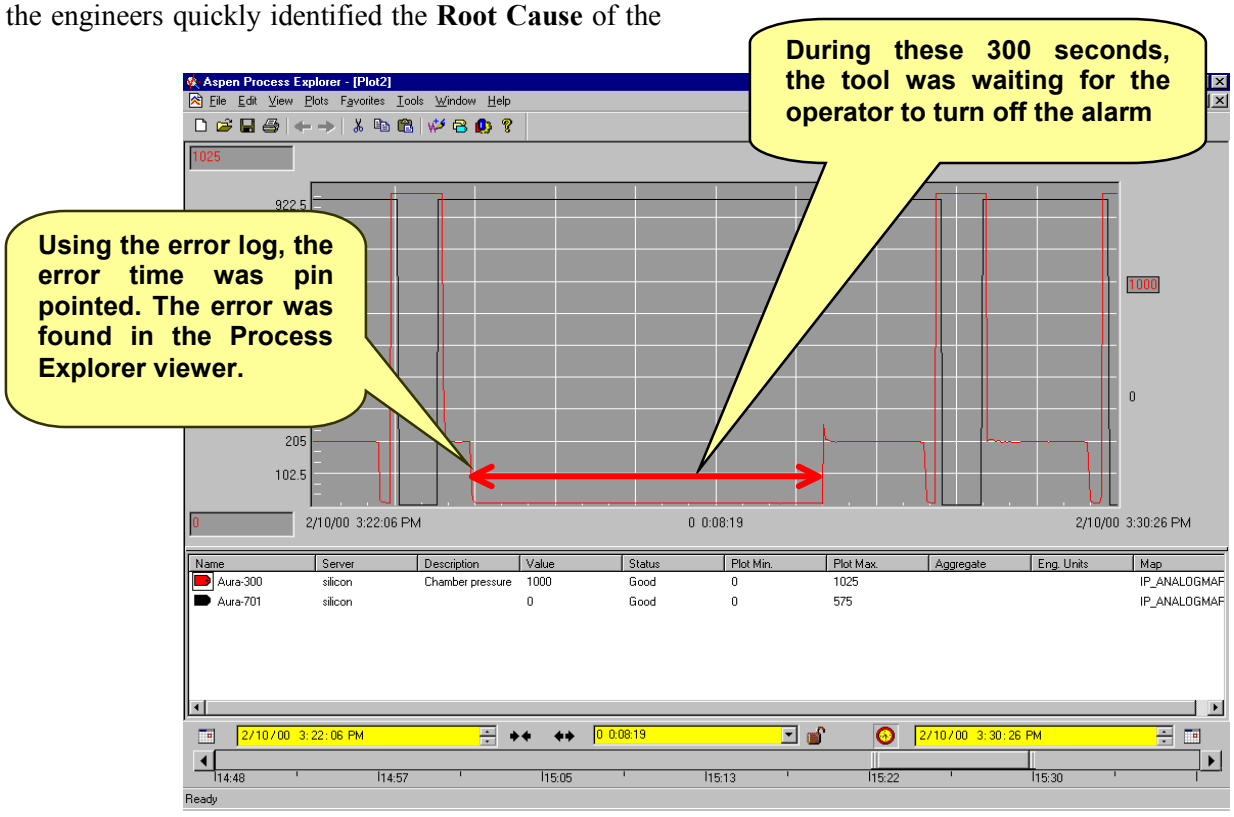
The problem of maintaining and improving throughput is always an issue in the fab. In this example, process engineers noticed that the throughput levels on a particular tool dropped to an unacceptable level, while maintenance logs reported a consistently high level of tool uptime. Was there a problem with the tool, with the process, or in the operation? How could a tool have consistent uptime, but inconsistent productivity? What was the most efficient way to find the problem and return the tool's throughput to the expected level? How could the process be optimized while maintaining product quality and yield to a minimum cost?

The fab's process engineering department chose the EPM suite for solving the problem. The EPM was installed on the troublesome equipment.The EPM alarms and event histories showed that certain alarms repeated regularly. Review of the data at the time of a specific alarm indicated that pressure stabilization time was too long because the pump throttle valve was 100% open while the pump attempted to stabilize pressure under process flow conditions.

The throughput issues were due to long periods of inactivity while operators cleared the alarm (but did not solve the problem). These periods of inactivity were still considered uptime for that tool. Using the EPM, the engineers quickly identified the **Root Cause** of the problem: the pump package was operating at the edge of its performance capability. The solution was implemented quickly. Once the pump package was serviced, pressure stabilization was re-established on a consistent basis.

Potential for Savings

- Decreased time for failure analysis from 24 to 12 hours
- Decreased qualification time from 15 to 12 hours
- Eliminated idle tool time (300 seconds in a 100 second process) waiting for operators to clear alarms and increased uptime by 23% (assuming that the alarm condition occurred on 10% of the wafers)
- Saved $40,000 (80%) of maintenance costs by replacing only the worn-out pump ($10,000) instead of multiple components ($50,000). This was possible only because the EPM suite identified the malfunctioning pump as the root cause of the problem.
- Saved continued engineering labor during failure analysis and re-qualification of the tool
- Eliminated a large potential source of scrap



Scenario 2: Troubleshooting an etch problem

Graphical analysis of the etch process with the EPM suite showed that the etch time could be safely reduced from 55 seconds to 40 seconds on each of the 24 wafers in a cassette without affecting wafer quality. Such an analysis would not be possible without using EPM suite.

Using EPM suite for fine-tuning the recipe, engineers reduced the processing time by 27%, thus increasing the throughput of the tool. This finding effectively means that three tools could do the work currently performed by four tools. Decreasing number of tools required to produce the same number of wafers provides fab with immediate savings:

- Reduced maintenance and consumable costs
- Reduced depreciation expense
- Reduced test wafer costs

Savings per tool for every fourth tool	
Depreciation	$350k per year
Maintenance and consumable expenses	$10Kper month = 120 K per year
Test wafers	$100 per day = 36 K per year
Total per year	Over $500 K per year

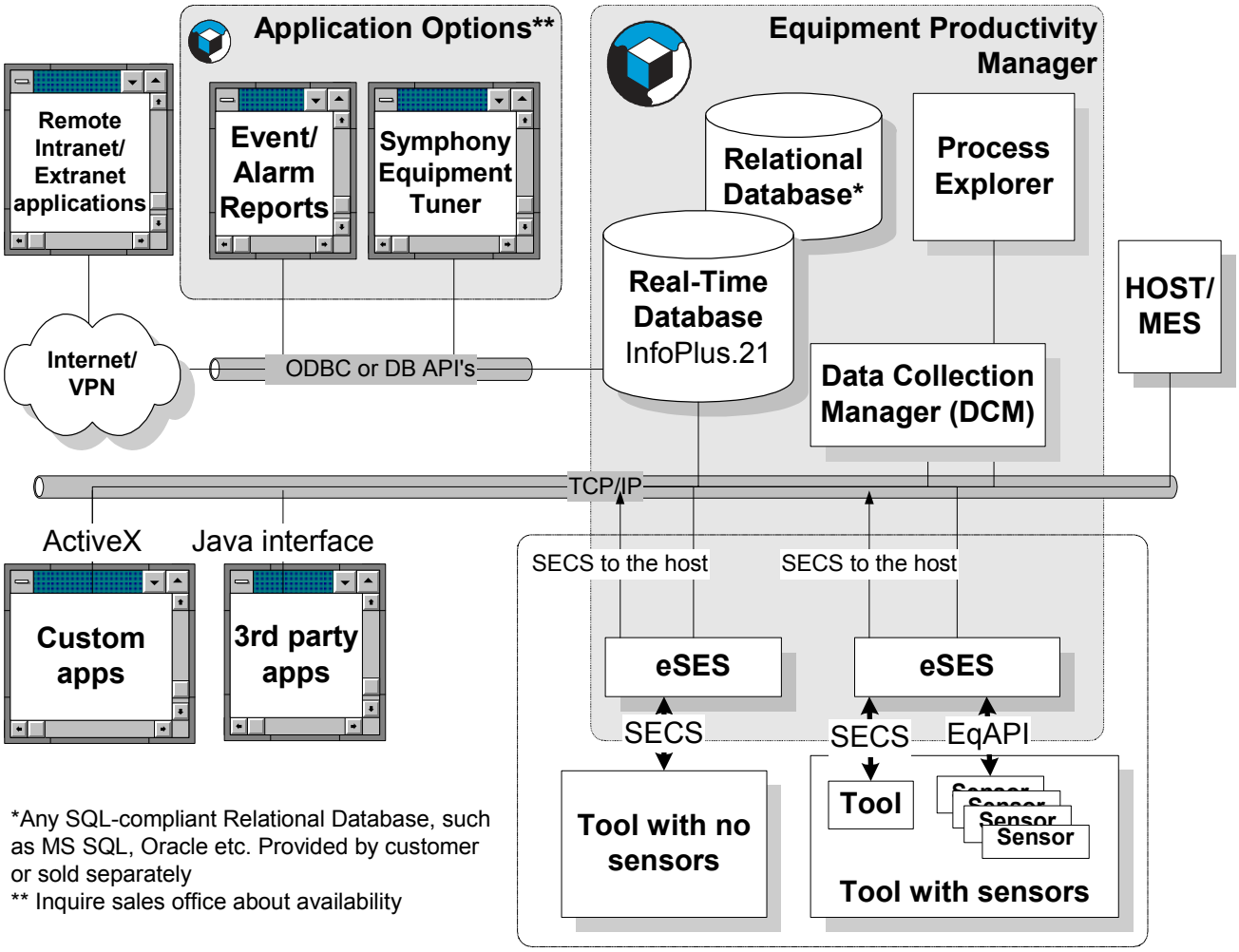
For a medium sized fab with 120 – 160 tools, fine-tuning the recipes can turn into 15 million dollars in annual savings.

Leveraging the downturn

- A downturn in business is a great opportunity to develop and deploy EPM in the fab. Process improvement projects with EPM started during a downturn will be ready in time to deliver significant increases in capacity and yield at the beginning of the next upturn.
- Risk is small relative to compared potential return and customary investments for evaluating new process technologies.

Improving equipment productivity across a fab should be viewed as a continuous improvement process: problems with tools are analyzed and solved and each tool's performance is incrementally improved. Improving the productivity of existing fabs and equipment permits fabs to delay their investment in new equipment, perhaps by several months. Considering that a new fab can easily cost over $1 billion and that equipment depreciation and maintenance costs are typically $30 million per month, even a delay of a couple of months provides economic benefits in the tens or hundreds of millions of dollars.

EPM Architecture and Components



The EPM suite creates a platform for standard and fab-customized applications by providing connectivity (eSES) to manufacturing equipment, sensors and subsystems, and a high-performance real-time database, InfoPlus.21™, for storing and archiving time-series parametric data. The EPM provides fabs with an integrated suite of applications for equipment productivity management and improvement — much like Microsoft Office™ replaced various office machines (such as typewriters and calculators) with one computer containing a suite of powerful applications.

EPM™ Equipment Productivity Manager provides:

- Network connectivity for manufacturing equipment and sensors (eSES™ External Symphony Equipment Server)
- Sophisticated automated data collection capabilities (Data Collection Manager (DCM™)
- High-performance, real-time InfoPlus.21™ database
- Graphical viewing tools for data presentation and analysis (Process Explorer™)
- Tools for analysis and management of data, events, and alarms (see datasheets for additional applications)
- A hardware platform (Symphony's NetGateway™ and PC server hardware)

Symphony Equipment Server™ (SES)

The hallmark of the SES is equipment connectivity. Its open architecture makes deployment, modification, and expansion of a network extremely easy. SES software works for your tool like a network driver works for a printer, making a peripheral accessible by variety of applications. SES transforms your tool and connected subsystems into network resources that can be shared with anyone connected to the network simultaneously from anywhere in the world. The SES enables equipment to become shared resources on the network, allowing multiple applications to concurrently access the tool in real time, much like accessing a network drive. The SES enables connectivity over any TCP/IP network: an internal LAN, an intranet, or the Internet.

The SES network is installed overlaid with existing MES systems and can be deployed without any interruption of the current fab operation, or as a free-standing system.

The SES network provides a platform that supports SEMATECH's e-diagnostic and JEITA's Equipment Engineering System initiatives as well as APC functionality. Users can rapidly build their own applications for their own e-Diagnostic and APC solutions.

See the SES White paper[ii] for more details on the SES.

Real Time Database (InfoPlus.21)

InfoPlus.21™ (IP.21) is an information management system used for real-time manufacturing processes. IP.21 stores large volumes of process data and makes the data available for analysis and reporting to client users, business systems, and production applications. Users apply this information to improve productivity, increase profits, and enhance business flexibility.

The InfoPlus.21 real time database integrates real-time and historical information generated by fab systems to present a unified view of the operation of the plant. The advanced database technology of InfoPlus.21 helps users faster find process information across multiple fab databases and platforms, analyze it, and present the data in a meaningful way.

InfoPlus.21 allows direct queries into the real-time and historical database using a standard ODBC connection. APIs are also available to build advanced analysis tools.

InfoPlus.21 is used in manufacturing and process environments[iii] for:

- Storing and indexing parametric tool, subsystem, and sensor data.
- Monitoring manufacturing processes
- Collecting historical process data
- Monitoring event and alarm notices

InfoPlus.21 Architecture

Several InfoPlus.21 systems located in various factory or tool areas can be configured so they can share information. In addition, desktop users can access information from any InfoPlus.21 connected to the network.

The configuration can be set up to have multiple tools feed a single database, or (depending on data rates) there may be a single database per tool. Some process tools could include an IP.21 database resident on the tool controller for archiving tool-specific data, as well as having that tool populate a database on the fab network. Many configuration and network topology options can be supported.

Data Collection Manager (DCM)

The Symphony Data Collection Manager (DCM) is a data acquisition engine. It collects data from the tools, using the SES for communication with the tool over the network, and automatically stores the data in the real time InfoPlus.21 database

The DCM user interface runs in a browser. You can easily configure and initiate data collection from any client workstation on the network through drop-down menus and dialog boxes, and can start and stop data collection without having to go to equipment inside the clean room.

The DCM offers the following benefits:

- Easily set/change data collection patterns through user interface – no coding involved!
- Immediately view variable values over the network
- Configure data collection from tools and sensors from one interface

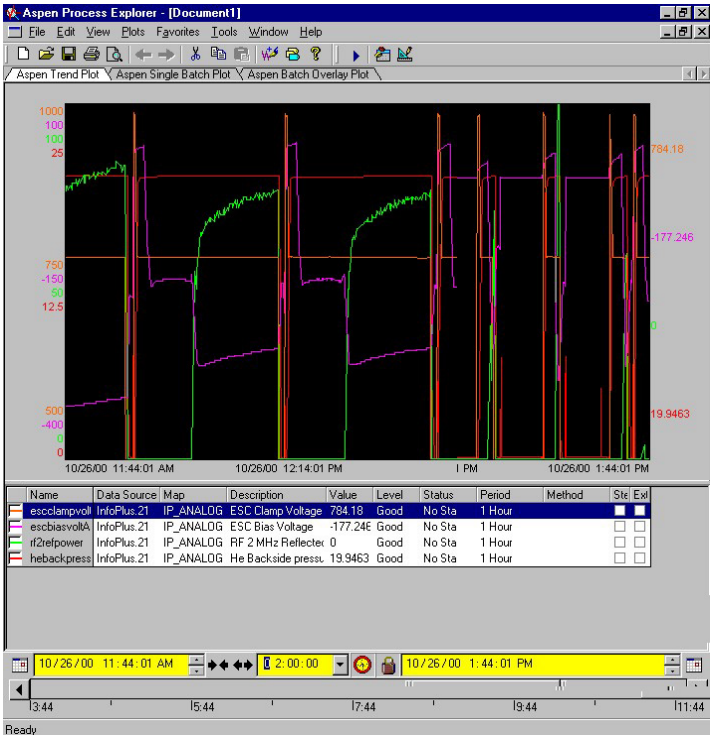
- Stores data from multiple tools in a single data repository
- Automatic database configuration eliminates the need for complex database management
- Designed for rapid factory–wide deployment
- Optimize data collection performance based on your factory configuration and requirements

Process Explorer™

Process Explorer is the window into the InfoPlus.21 database. It is used to view real-time and/or historical data from any tool connected through a Symphony Equipment Server/DCM to any InfoPlus.21 database present on the network.

Process Explorer organizes and presents information about a process or tool in a meaningful and usable form. Process Explorer data display features enable engineers and managers to view data in a variety of meaningful formats. This information facilitates quick and accurate decisions allowing engineers to improve the process performance.

Process Explorer runs on client workstations in the office providing simultaneous access to data from multiple tools and sensors stored in one or more databases. Advanced visual tools expedite chamber-to-chamber process matching, qualification, and process transfers.



The EPM suite is an evolving product

In addition to the current capabilities of the EPM, Symphony Systems, our application partners, and others are developing new applications. The EPM suite provides a common platform that permits integration of customized software, currently available database and analysis reporting tools, and an easy upgrade path to future generations of Advanced Process control and Overall Equipment Effectiveness applications without replacing network infrastructure, hardware or drivers. New advanced applications from variety of vendors can run on the EPM platform the same way that graphic design, accounting or other applications run on the Windows platform.

Symphony's Equipment Productivity Manager provides fab engineers and managers tools for rapidly improving the productivity of existing and new fabs. Symphony's EPM was conceived with flexibility, extensibility and rapid deployment in mind so that fabs and equipment manufacturers can rapidly respond to changing needs and to incorporate new knowledge into their operations. Fixed equipment depreciation and maintenance costs are a major element of the semiconductor manufacturing costs – using the EPM enables fabs to obtain more productivity from their existing fabs and to reduce operating costs.

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i http://www.sematech.org/public/resources/ediag/workshops/02232001/docs/2Wohlwend.pdf

ii SES White Paper http://www.symphony-systems.com/products/ses/Symphony_White_Paper_eSES.pdf

iii Aspen IP.21 White Paper - Analysis of Data Storage Technologies for the Management of Real-Time Process Manufacturing Data