



Enterprise Yield Management



Semiconductor manufacturers are facing increasing device complexity with shrinking geometries, complex fabrication processes, higher mask set costs, sophisticated packaging, and advanced test requirements. Increasing competition continues to drive shorter product life cycles, making rapid progression through the design, characterization, and yield ramp phases even more critical. At the same time, manufacturers must collect an expanding amount of engineering data from a geographically distributed supply chain associated with taking a new product to market and supporting it after production release.

Yet most semiconductor companies continue to perform yield management the traditional way – collecting data from remote operations and assembling weekly or monthly yield reports. Engineers are only assigned to deal with problems as they become visible and spend more time looking for, assembling, and aggregating data than analyzing it. As a result, business response to critical yield issues is slowing, and engineering productivity is declining. Evidence of this can be seen in manufacturing production delays that impact time-to-market, customer satisfaction, and vendor reputation.

To respond to this challenge, semiconductor manufacturers need to implement a true enterprise yield management (EYM) system. An EYM system continuously monitors the entire global supply chain, automatically gathers information into a centralized repository, and makes analyzed data easily accessible throughout the enterprise. Users can automatically collect data and monitor yields through automated analysis flows based on industry best practices that allow them to focus on increasing yields. With daily on-demand yield reports, the critical information needed by engineering and operations executives, managers, and engineers to make decisions or determine root cause is immediately available.

By collecting and correlating data from diverse processes and facilities, and providing Web-based access to this data, EYM software helps companies monitor and enhance yield at each stage of the production process. EYM is a system-level solution that leads to increased profitability, improved business responsiveness, and greater engineering productivity.

Identifying Your Organization's Need for an EYM System

Symptoms that indicate the need for an EYM system appear as failure to meet time-to-market schedules, inability to maintain

or lower your cost structure, a decrease or lack of productivity, and unfavorable levels of customer satisfaction. These symptoms can result from problems encountered when an EYM system is not in place. They can be categorized into the following issues:

Yield Information – Lack of Uniformity and Timeliness

Organizing storage, retrieval, and analysis of large volumes of yield data is a complex problem. Without the ability to collect and correlate this data and provide relevant daily yield information, disagreements among engineering, operations, and finance can result. "Yield wars" result from the various reporting styles and systems across engineers and products, multiple sources of yield information, manual processing, and data cleansing approaches.

Organizational – Lack of Data Accessibility

The accessibility of information to various personnel within the enterprise and the time needed to determine the root cause of issues are growing challenges. Symptoms include slow response to product yield issues, with increases in the number of mask spins prior to product release. Because data is commonly located in disparate locations and in varying formats, obtaining the right data needed for further analysis is often a long and tedious process. By the time data is aggregated and analyzed, millions of dollars of material may already be scrapped and margins may be severely impacted.

Customer Satisfaction – Inconsistent Delivery

Semiconductor manufacturers with inaccurate and untimely yield information are plagued with delayed deliveries and a high number of customer returns. Because of this, they are unable to meet their customer commitments. There are delays between the time when lots are placed on hold and when the engineer responsible for the product is informed of the status of the lots. More time is spent tracking down the data related to the lots than intelligently dispositioning the material in question. Under time pressure, lots are dispositioned, but root cause problems are never determined, leading to subsequent returned material.

Financial – Low Profit Margins

Lack of access to accurate and timely yield information reduces revenues and increases costs. A clear sign of this problem is manifested in consistently lower profit margins than competitors. Shipments within the quarter are frequently missed, affecting revenue generation. Extra resources are often spent

on multiple retests, QA rescreening, multi-temperature process flows, and unnecessary maintenance and replacement of hardware.

Operational – Lack of Supply Chain Visibility

Today's geographically distributed supply chain commonly includes five foundries and four assembly/test houses with 20 different testers of varying types, each producing a different data format. Obtaining the engineering information necessary to run an engineering operation in this environment is an overwhelming challenge. Scarce resources are spent reacting to supply chain issues rather than on proactive activities. Fire fighting, tiger teams, and frequent trips to Asia or other manufacturing or sourcing locations are the norm rather than the exception.

Information Technology – Data Overload

Connecting to the distributed supply chain is producing a vast amount of data. Foundries are providing wafer acceptance test (WAT) and sort data, and test houses are now supplying full datalogs with every production lot (not just sampling or engineering lots). The amount of data is rising from 20 gigabytes per **year** to 20 gigabytes per **day** – more than a 350X increase. IT systems cannot load the amount of information being received within a single 24 hour period. Engineering is unable to sift through and analyze this data for important trends and root cause issues.

Yield Management for the Global Enterprise

Yield management's chief role is to maximize the number of good devices that can be shipped for those committed to

production. To achieve this, companies must have the ability to detect and respond to unexpected variations in the device fabrication and testing processes wherever and whenever they occur. For a company to respond quickly, it must have access to information across the supply chain, and engineering data must be available on demand in a manner that allows all stakeholders to rapidly identify and resolve problems.

With EYM, executives, managers, and engineers can gain visibility into the semiconductor manufacturing supply chain and work collaboratively (see Figure 1). By collecting and correlating data from diverse processes and facilities, an enterprise system helps companies monitor and enhance yield at each stage of the production process. Foundry, sort, assembly, and test data are collected and combined into a single data warehouse. Extensive raw data in a wide variety of formats is provided throughout the supply chain:

- ✓ Foundry – inline, equipment, defect, wafer acceptance test (also referred to as WAT, PCM, or Etest), lot comments, recipes, statistics summary.
- ✓ Sort – die pass/fail, parametric, die location, performance, datalogs, test pass/fail, functional test, bin summary, built-in self test (BiST), scan, boundary scan, statistics summary.
- ✓ Assembly – quantity in, quantity out, inspection summary, statistics summary.
- ✓ Final test – package pass/fail, parametric, performance, datalogs, equipment (tester, outboard, handler, site, contractor), scan, BiST, boundary scan, bin summary, statistics summary, test pass/fail, functional test.

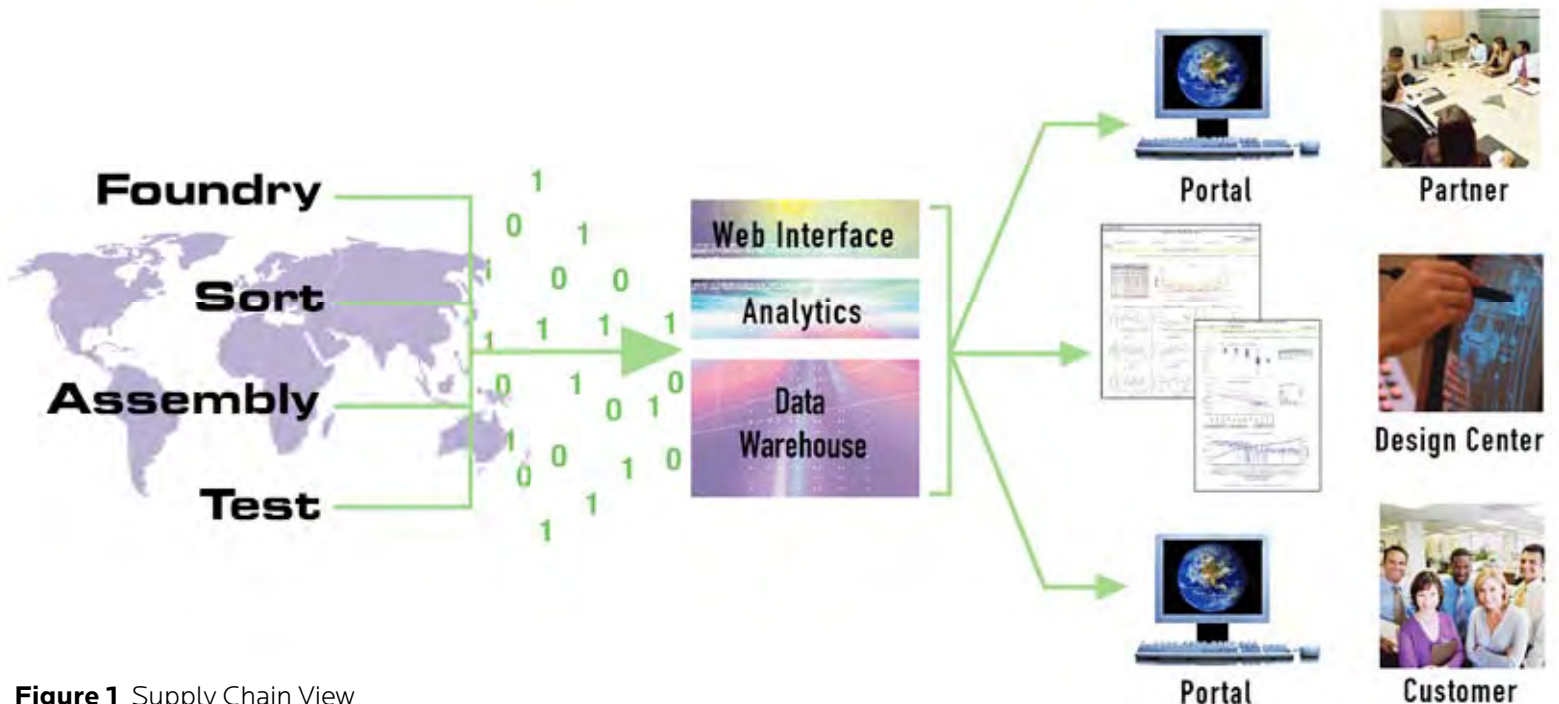


Figure 1 Supply Chain View

An EYM system automatically schedules regular delivery of this data to the warehouse. The transfer can be via bulk file transfer protocol (FTP) or RosettaNet interface. Once received, the raw data is automatically unpackaged, parsed, converted to a uniform format, and inserted into the warehouse. No valuable engineering time is spent searching for, assembling, or organizing the data. It is then automatically summarized by the EYM system and made available for management or engineering reports and analysis.

Scalability of the EYM system is critical, especially as data continues to grow from gigabytes to terabytes of data per year. The system must scale to accommodate growth at businesses of all sizes – from one user to hundreds of users. At a minimum, this means that an EYM system must have the ability to extract, transform, and load all the raw data received and summarize it within a one day period. However, to deal with the bursty nature of subcontractor FTPs and periodic system maintenance windows, extra insertion bandwidth needs to be available. A well-designed EYM system provides four times the average insertion rate load to accommodate these real-world vagaries.

An EYM system can also help communication across the geographically dispersed global enterprise as well as develop collaboration with corporate strategic partners and customers. Within the company, design and manufacturing centers are frequently in different physical locations and time zones. Detailed knowledge of the design may reside in the U.S., while wafer fabrication is done in Taiwan and assembly and test are performed in Singapore. Having a common data set centralized in a warehouse that is remotely accessible by all members of the team dramatically improves communication, collaboration productivity, and accelerates root cause analysis and problem resolution.

As chip designs become more complex and the necessary expertise more specialized, the need for semiconductor partnerships is expanding. Partnerships with design houses, system houses, universities, and customers are becoming commonplace. Since a company may have multiple partnerships underway at any point in time, the propriety and security of sensitive information are essential.

An EYM system that incorporates portal capability is an excellent approach to securely sharing sensitive data. From the time the first silicon arrives, the engineering data can be loaded into the warehouse, viewed, and/or uploaded for the partner or customer to view. Analytic tools and techniques can be shared, mask set iterations reduced, and the overall time-to-market accelerated. During the yield ramp phase and after production release, on-going engineering collaboration can continue via the portal to ensure that any latent design issues or manufacturing sensitivities are identified early and dealt with rapidly (see Figure 2).

Yield Management Within the Enterprise

Traditional yield management systems only address the needs of engineers and are difficult for executives to use. They involve complex and difficult-to-configure analysis tools that do not benefit mid-level and business management needs. It is therefore difficult for mid-level and business management to be fully engaged in all aspects of the product manufacturing process. For adoption and on-going utilization of an information system to be successful, data must be presented in a manner useful to the individual. Executives, managers, and engineers must each be able to draw the information they need from the common data warehouse.

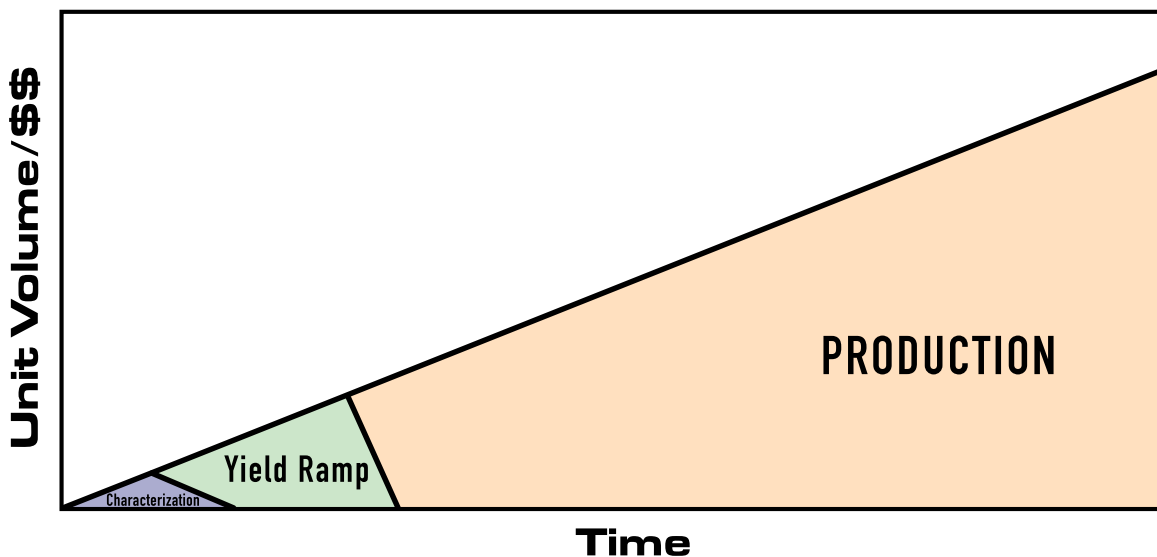


Figure 2 Yield Management Development Phases

Subcontractor supplied data that has been cleansed, merged, and compared with manufacturing move data can be made available for all levels of management and engineering, in a format that is relevant to their needs, as shown in Figure 3.

To be effective, an EYM system must allow data to be extracted and cleansed into a uniform format. Data is generally from multiple sources and operations, including foundry, sort, assembly, and test, and may be in inconsistent formats. Quick and efficient cleansing of this data into a standardized format is critical to subsequent analysis of the data. Once data has been cleansed, it is transformed based on business rules and loaded into the data warehouse.

Manufacturing execution system (MES) and manufacturing resource planning (MRP) data are also automatically loaded into the centralized data warehouse, bringing all data together into one repository to help bridge the gap between organizational levels and functions within the enterprise. Establishing a consistent genealogy between manufacturing and engineering flows, and simultaneously visualizing datalog data with MRP data, permits a broader perspective on the state of deliveries and immediate drill down into possible technical issues. Looking at the same data, a problem-solving atmosphere between engineering and operations groups is promoted, and overall operational responsiveness increases.

An EYM system makes daily, on-demand sort and final test yield reports by product available to all levels in the organization. Drill down capability from management level to engineering level data enables trends to be tracked and possible issues pin-pointed for further investigation and action. Cutting

across the organization silos, an EYM system empowers engineering groups throughout the organization, including design, product development, device engineering, process engineering, product engineering, and sustaining engineering, to verify and monitor all aspects of the data, from new process and product characterization through sustaining products in volume production.

As a yield management system grows, navigating the gigabytes or terabytes of data collected into the warehouse becomes an overwhelming challenge. An appropriately designed information model that allows the data and its attributes to be properly organized is fundamental to an EYM system. Effectively organized data establishes analysis flows specifically tailored to common use patterns of characterization, yield, product, and test engineers. These analysis flows dramatically simplify navigation of the variety of data types captured and logically and rapidly guide the engineer toward root cause problem identification.

Starting at the top level of WAT, sort, or final test, each EYM analysis flow provides a logical and easy-to-navigate flow from yield report cards to yield lot trends, lot level analysis, step-to-step yield correlation, integrated statistical analysis, and bin and parametric wafer visualization (see Figure 4). Automated analysis flows enable filtering of data to the material of interest, as shown in Figure 5. This is essential to quickly locating the prospective areas of root cause issues. At the same time, drill down to detailed engineering analysis on the same material is essential for continuity and productivity.

The EYM system allows engineers to identify problem areas in production-released product and easily navigate to flexible

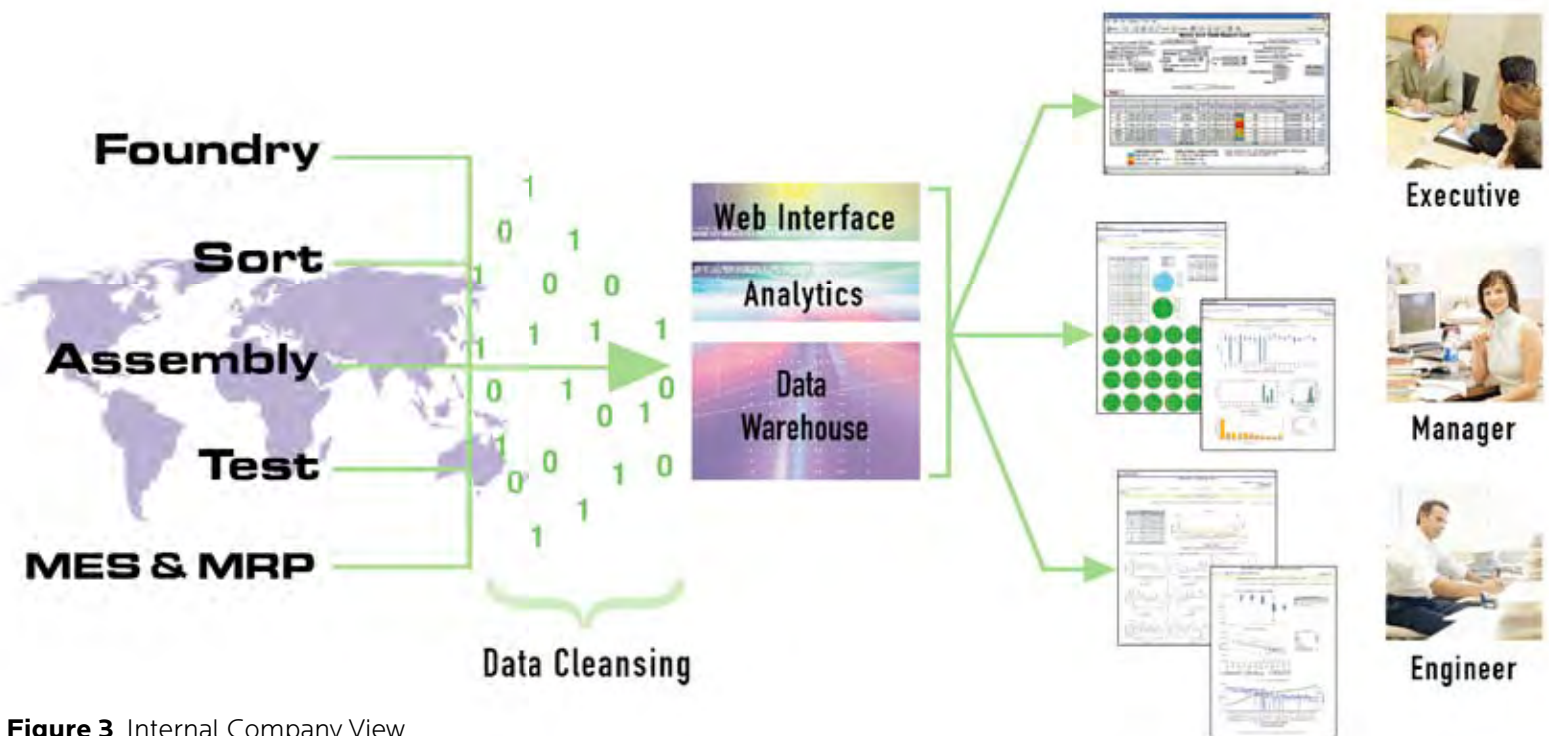


Figure 3 Internal Company View



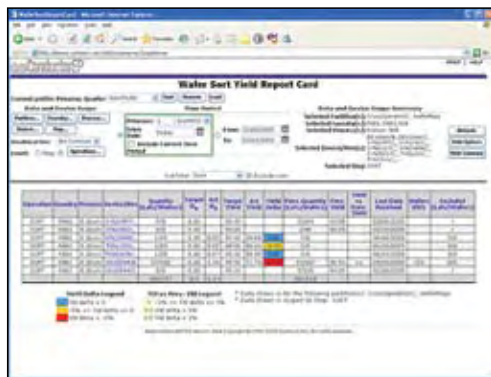
Figure 4 Automated Analysis Flow

engineering analysis tools for detailed root cause identification. All the ad hoc analysis tools available in traditional yield management systems continue to be available in an EYM system, including:

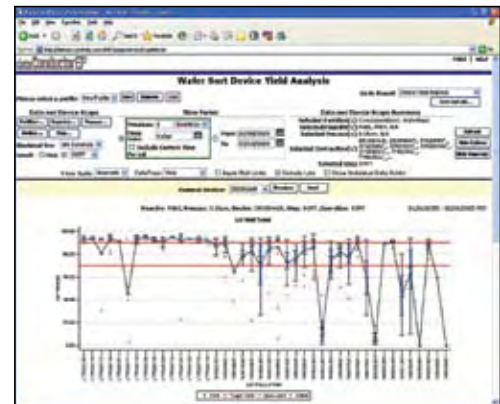
- ✓ Standard statistical and graphical analysis capabilities;
 - Distribution analysis - including histogram, frequency distribution, normal probability plot (NPP);
 - Distribution comparison analysis - including ANOVA, scatter plot, linear regressions, Student's t-Test;
 - Summary reports - including raw data, Process Capability Index (Cpk), parametric yield analysis,

chi-square distribution analysis, Shapiro-Wilkes Test, skew kurtosis analysis;

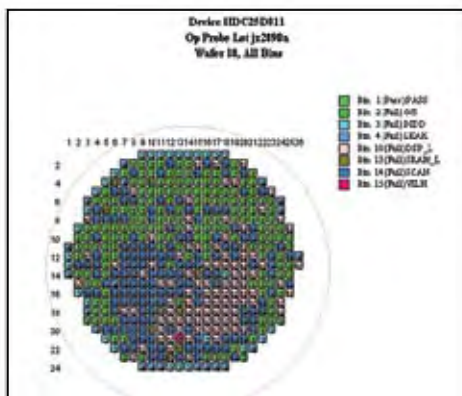
- Summary statistics analysis - graphical representation of summary statistics for all data, including Cpk, mean, median, range, standard deviation;
- EDA statistics - including pseudosigma, Trimean, Cpk, and median;
- ✓ Wafer maps - including zonal, bin distributions, parametric distributions, layer overlays, defect location;
- ✓ Correlation - including sort to WAT parameter, sort to inline parameter, sort to equipment type, and final test to WAT parameter.



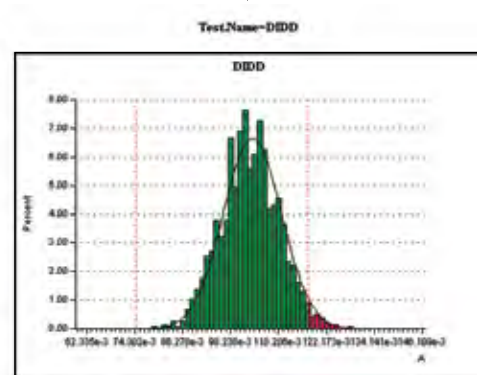
Yield Report Card



Yield Trend



Wafer Map



Statistical Distribution

Figure 5 Example of Report Card and Analysis Flow for Wafer Sort Operation

Using continuously updated and centralized wafer fab, die sort, assembly, and final test data and reports facilitates effective decision making by automating and simplifying sophisticated analysis and business practices. EYM helps promote executive to manager to engineer communication, enhanced business responsiveness, and increased profitability.

How Does Syntricity Support EYM?

Syntricity supports EYM through its dataConductorEP™ software solution with Power User analysis tools and Advanced Monitoring for Production (AMP™) application.

Syntricity understands that EYM must provide a reporting platform capable of supporting a large enterprise. Its dataConductorEP software is Web-native, designed and built for the Internet, making engineering data instantly accessible anywhere, anytime via a Web browser. With hundreds of parsers, automated data cleansing, and structured interface to

MES/MRP systems, dataConductorEP integrates with other software critical to the semiconductor manufacturing environment. This allows all members of the manufacturing supply chain, including executives, managers, engineers, and suppliers, to share data and work collaboratively.

By collecting and organizing wafer processing, sort, assembly, and final test engineering data, dataConductorEP's Power User analysis tools allow engineers to rapidly analyze and identify yield limiters associated with new products during the characterization and yield ramp phase. From the same data warehouse, using dataConductorEP's AMP application, executives, managers, engineers, and suppliers can access the data needed to monitor and improve yields on production released devices.

Widely deployed throughout the semiconductor industry, dataConductorEP is a proven solution for Enterprise Yield Management.

Syntricity Inc.

6020 Cornerstone Court West
San Diego, CA 92121

Tel. 858-552-4485 Fax 858-552-4493

www.syntricity.com



dataConductor, dataConductor.com, AMP and dataConductorEP are trademarks of Syntricity Inc.

Copyright © 2006, all rights reserved.