

Web-Based Business Intelligence for Semiconductor Manufacturing

Leo Sennott, Jorge Willemsen

Skyworks Solutions, Inc
20 Sylvan Road, Woburn, MA, 01801, USA
Tel: (781) 376-3080 Email: Leo.Sennott@skyworksinc.com

Abstract

Business Intelligence (BI) is a relatively new concept that has received a tremendous amount of coverage in recent manufacturing publications. The use of an integrated knowledge base in establishing best business practices is not new, but the demands of very high volume wireless semiconductor manufacturing with high product and process yields, combined with thin profit margins, has intensified effort in this area. This paper includes the architecture of the business intelligence solutions used at Skyworks and details how this integrated system is being used to improve our competitiveness in a global marketplace.

INTRODUCTION:

Skyworks produces many types of products for the wireless industry including front end module (FEM) solutions. Our typical FEM may have as many as 10 unique die with many additional surface mount components assembled into this small package. The semiconductor devices are fabricated at a variety of qualified foundries, while assembly is performed at our facility in Mexicali, Mexico. The business intelligence system in use at Skyworks integrates data from these disparate sources and provides real-time web-based information and data in a variety of areas, including wafer and module yields, "Known Good Die" assembly methods, product genealogy, tool set-up, equipment utilization and information from engineering sample builds. This business intelligence system provides application-specific information that is used by management, product engineers, process engineers, and design engineers to improve the performance of our manufacturing operations.

This paper presents the business intelligence strategy designed at Skyworks. Elements of the strategy are discussed, including the design of the system, core data layers, databases, control agents and a series of web-based solutions developed for the seamless manufacturing of Skyworks products.

DISCUSSION:

SYSTEM ARCHITECTURE

The complexity of manufacturing solutions to supply semiconductors to the wireless industry requires a complex factory manufacturing integration strategy. This strategy

must provide a dynamic knowledge framework that allows for greater visibility into all manufacturing areas; wafer fabrication, assembly, design, prototype facilities, outside wafer foundries and assembly sub-contractors. The design of this factory integration system **must** provide seamless communication and production synergy. The components for this synergy are :

- Synchronize with core manufacturing enterprise systems (SAP / Promis)
- Acquire real-time production information used to provide precise manufacturing status.
- Maintain product records over full manufacturing life cycle.
- Design web-based tools and services that provide dynamic production management, life cycle history and genealogy information to users.

DATA LAYERS – OWNERS & RESPONSIBILITIES

Corporate Data Layer:

Owner – Skyworks Information Technology

- Support and sustain all manufacturing servers, data and licensing.
- Provide an enterprise system interface to extract product properties, manufacturing flows and schedules
- Provide daily feed of SAP delivery notes and genealogy feed for each completed work order.

Manufacturing Data Layer:

Owner – Skyworks Engineering

- Define system hardware and software requirements for all OEM capital purchases.
- Determine data server requirements for all manufacturing operations.
- Software design development
 - Server / Data Standards
 - Database design SQL server
 - Production Test
 - Manufacturing applications and interfaces
 - Integration strategies
 - Web / FTP applications
 - Windows services and data processing engines

**External Data Layer:
Owners – External Subcontractors, Skyworks
Engineering**

- External production test data
- Electronic wafer maps
- Production schedules

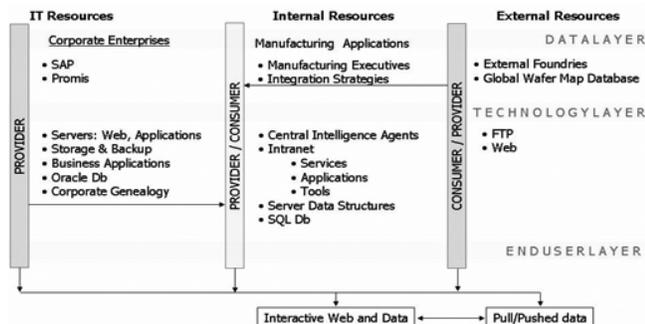


Figure 1: Data Layer Model

INTELLIGENT DATA STRUCTURE

In many manufacturing industries, computer servers, administration rights and data storage requirements are managed by the Information Technology department (IT).

There are a number of business drawbacks with this model. Integration is unlikely which can cause the servers to become data dumps with no rules. This model tends to provide limited information which is difficult for the users to locate, understand and utilize.

Supporting our worldwide wireless industry demands, a new model has been designed and is sustained by the Manufacturing and Engineering departments at Skyworks.

Servers, administration rights, data structures and services are designed specifically for our various manufacturing plant operations.

The primary goal of this design is to recognize, analyze and rectify problems in manufacturing fast. In order to achieve this, real-time data collections layered over our enterprise data is transformed from data to information, to knowledge, and eventually to intelligence.

Once the data is transformed, information becomes “hindsight”, knowledge becomes “insight” and intelligence provides “foresight”. (1)

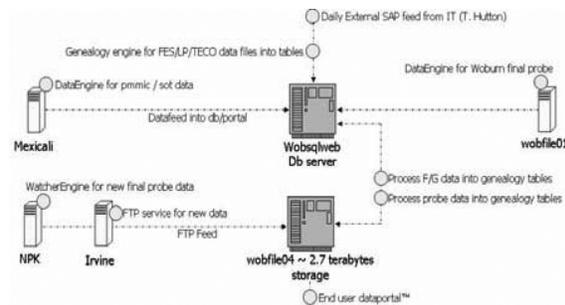


Figure 2: Production Servers

Manufacturing Databases: Push & Pull:

Push:

In parallel with our control documents, there are a number of internal databases and associated files to control the manufacturing logistics in any Skyworks facility dynamically.

Internal databases are used to control our Rapid Prototype Lines, KGD programs, RF Probe, AOI, Electronic maps, Inkless programs and Final production test.

Pull:

Databases are populated from various sources that include test data & status files from production areas, various window services used to process or convert manufacturing tool information and from enterprise system extracts.

These data sets are the foundation for an active knowledge framework that provides better visibility into the organization. This system produces precise manufacturing status while capturing key performance indicators in real time.

In the Test & Ink database shown in Figure 3, all control files, expected yields, historical modes of failure and the manufacturing rules are dynamically governed by individual wafer types.

The probe card database in Figure 4 was a quality and cost initiative to ensure that the proper card is used by test technicians. The database records all wafers tested, number of probe touchdowns remaining, card status and assembly drawings required for rework.

DUT	Mark	Pass %	Divisions	Bin Qty					
E397 a	RP0985	49	80	0					
Platform	Mode	Build	Map Output	Binning	Orientation	Measure	Ink(P)	Ink(Y)	Ink(Z)
ASL3K	Full	Production	Yes	No	South	Metric	No	No	No
Test Plan Path					Map Full Path				
[mantech01\onwafer\autotest\tp\6397g.tp1					[mantech01\onwafer\autotest\map\6397a.mp1				
Test Screen Path					Map Sample Path				
[mantech01\onwafer\autotest\ts\6397g.ts1					[mantech01\onwafer\autotest\map\6397a.ms1				
Test Engineer Path					Ink Map Path				
[mantech01\onwafer\autotest\tp\					[mantech01\onwafer\autotest\map\6397a.mp1				
Probe Alignment		DMR%	Hold%						
Fine		60	40						

Figure 3: RF Probe Database

TaskName	Remaining	Warning	Low	Discard	Target	Mask	Platform	Maker
1,000,000	600,561	300,000	300,000	130,000	72	RP1146	RF	Inventory

Usage History	LotId	FlatId	Test-Stand	Usage	Left
01/12/2009 06:29:45 PM	3682199-1	HD4853200	RF_AS3K_14	3,122	903,551
01/12/2009 08:25:45 PM	3685102-1	HD4853096	RF_AS3K_14	3,122	803,673
01/12/2009 01:52:46 PM	3682199-1	HD4853200	RF_AS3K_13	307	606,795
01/12/2009 08:04:45 AM	3685102-1	HD4853096	RF_AS3K_13	307	607,302
01/10/2009 03:28:43 PM	3682199-24	8635132715	RF_AS3K_13	3,122	607,409
01/10/2009 03:28:43 PM	3682199-23	8635132705	RF_AS3K_13	3,122	810,531
01/10/2009 03:27:43 PM	3682199-22	8635132695	RF_AS3K_13	3,122	813,653
01/10/2009 03:27:43 PM	3682199-21	8635132685	RF_AS3K_13	3,122	816,775

Log History	Action	By	Retired	Notes
01/05/2009 11:56:40 PM	Atch	mohammed	N	[Added] 192042.pdf
01/05/2009 11:56:22 PM	Inv	mohammed	N	Probe Card Introduced into System and Stocked as Inventory.

Figure 4: Probe Card database

DIE DEFINITION REQUIREMENTS:

The demands of the wireless industry continue to challenge all areas of Skyworks, from System On Chip (SOC) designs using multiple die, to assemblies with hundreds of wire bonds and stringent multimode RF test specifications.

Wireless product life cycles are short. This requires a new set of applications to be developed around our KGD programs and most importantly, serialized control builds needed for new product development.

This starts with precise die definition for each wafer mask design, as shown in Figure 5. Our die definition uses a primary set of Rows and Columns for each reticle, a secondary set for the die within the reticle and a single character supporting multiple circuit designs in an engineering pizza mask layout. These unique signatures are stored and travel with all test data, internal analysis applications, and upstream manufacturing files that provide a genealogy trace for serialized builds.

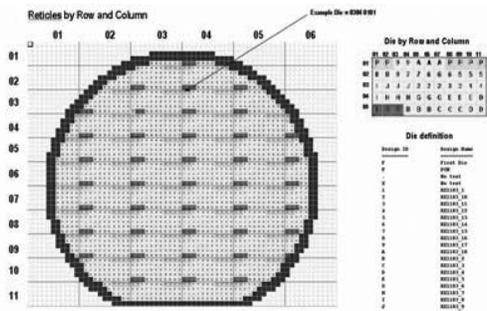


Figure 5: Die Definition

CIA: Central Intelligence Agents

At the center of Skyworks intelligence are PC's specifically designed to act as agents controlling our manufacturing processes, handlers, test equipment and various tools, as depicted in Figure 6.

Specific application software is developed by Computer & Test Engineering organizations providing integration to the enterprise, databases and test programs.

These agents are used to collect and capture real-time information in any plant and then supplied to users through various web dashboards and portals.

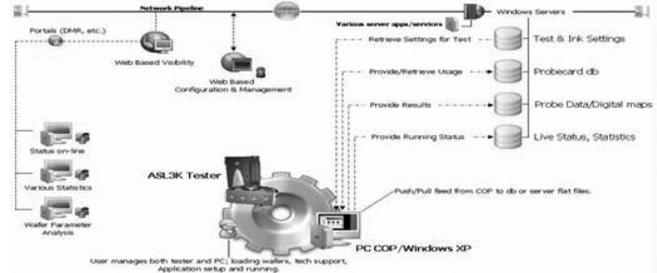


Figure 6: Central Intelligence Agent Model
BI Application 1: Desktop Status

The Skyworks RF test operation in Woburn has 35 probers running 24/7, which produce about 10 gigabytes of raw data each week. The agents provide status information every 2 minutes, which is captured in a SQL database. This web dashboard contains yields, lot completion times, equipment status and performance metrics, as shown in Figure 7.

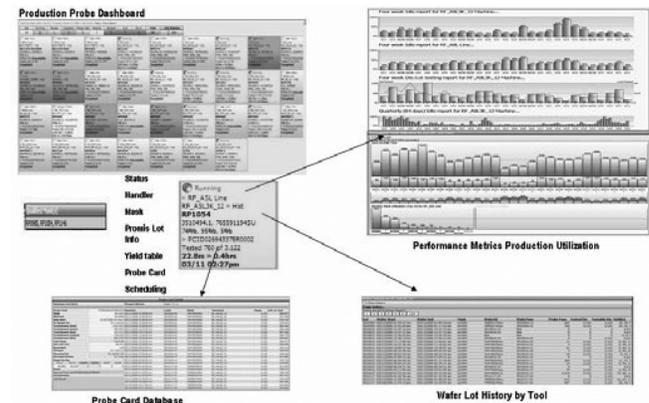


Figure 7: Probe production dashboard and metrics

BI Application 2: Parameter Viewer

The parameter viewer is designed as a web-based analysis tool used to provide fast analysis of test results, yield loss and process patterns by creating wafer map color images for any parameter tested in our probe operations. An example of the parameter viewer application is shown in Figure 8.

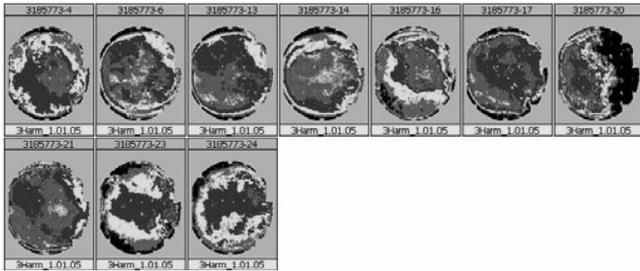


Figure 8: Parameter Viewer wafer images

BI Application 3: Skyworks Data Portal

The Skyworks Data Portal in Figure 9 collects test data for all products tested in our Mexicali manufacturing operation. This data, approximately 20 gigabytes per week, is also tied to genealogy feed from our SAP enterprise. This portal identifies all wafers and RF probe results used for each assembly work order build.

This tool is used by our Product and Test Engineering group to monitor yields and to assist in our continuous yield and product performance improvement activities.

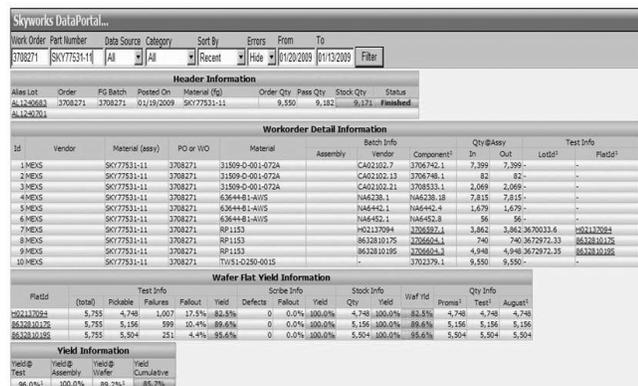


Figure 9: Skyworks Data Portal

BI Application 4: Rapid Prototype Line Portal

This year, we released a portal specifically designed for our rapid prototype lines located in Woburn MA and Irvine CA. This application allows designers to populate die attach maps, assembly drawings, bill of materials marking specifications and any other documentation needed for a prototype build used for new product developments.

The portal has self-contained communication loops that allow for an immediate change to a build, provide real-time build status, and contain embedded training videos, as well as a user forum.

The assemblies are paperless; technicians build directly from the portal using laptops, providing status, images and data of each build.

All information is recorded in the database, permanently establishing a knowledge base for future builds. A sample of this portal is shown in Figure 10

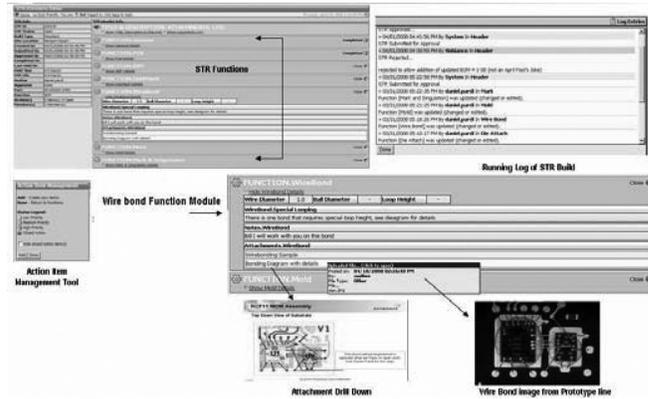


Figure 10: Image of prototype build

CONCLUSION:

This paper presented the successful business intelligence improvement strategy designed by Skyworks Solutions. This strategy employs an engineering team, our enterprise information systems and custom software providing real-time visibility into our various plant manufacturing operations. Elements of this approach were discussed, including data layers, network structures and databases. Several solutions were presented to illustrate the efforts and success of the Business Intelligence development team. These systems are utilized by a wide array of individuals ranging from production operators and operations management to design engineers. These systems provide the necessary real-time information and knowledge required to improve our competitiveness in a highly dynamic environment

ACKNOWLEDGEMENTS:

The authors would like to thank the following for their software and integration support: from Test Engineering - Mike Sirois, Tom Fenwick and Ed Aspell, and from IT - Tom Hutton.

REFERENCES:

- [1] Advice+Dissent:Managing Technology Data Dump – Karen D. Schwartz Government Executive

ACRONYMS:

- BI: Business Intelligence
- AOI: Automated Optical Inspection
- FEM: Front End module
- IT: Information Technology
- ATE: Automated Test Equipment
- KGD: Known Good Die
- CIA: Central Intelligence Agents
- OEM: Original Equipment Manufacturers
- SOC: System On Chip