Computer Integrated Manufacturing in smaller GaAs Fabs

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ABSTRACT

GaAs semiconductor manufacturing Fabs historically don't have the automation budget of larger Silicon Semiconductor companies to buy the latest software or tools to build their wafers. So, how does a smaller, budget constrained, Fab improve productivity and yields? They use CIM (Computer Integrated Manufacturing)!

INTRODUCTION

This paper outlines the approach TriQuint Texas used to improve wafer yield through fewer operator mistakes and more consistent tool function. By hiring a small staff and directing them to work on the issues highlighted in this paper, we were able to achieve a consistent reduction in operator caused errors resulting in millions of dollars saved every year. We were able to create all these systems with a small internal team and at a fraction of what larger semiconductor companies spend.

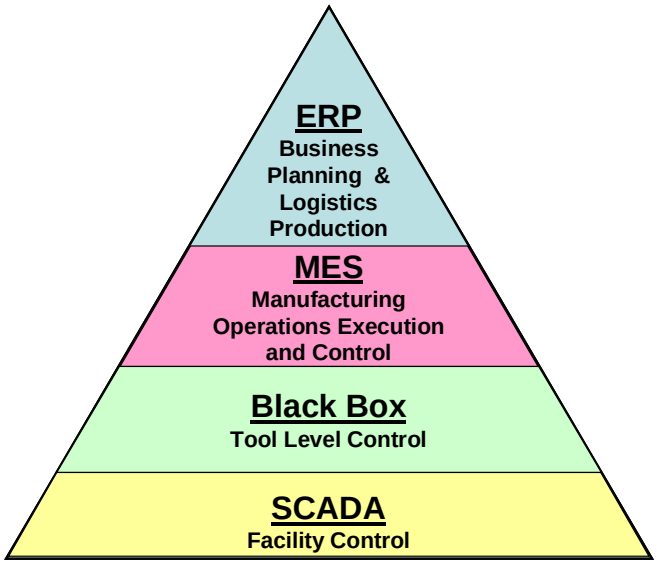


Figure 1: Business Automation Software

The typical manufacturing software environment is noted in Figure 1.

ERP

ERP is the main business software for Accounts Payable, Accounts Receivables, Inventory, MRP, Sales Order Management and Sales forecasting. Most Semiconductors companies invest heavily in automating their business systems.

MES

Many GaAs Fabs use antiquated software to support the Shop Floor Control and don't integrate these functions.

A Typical MES consists of Lot Scheduling, WIP Tracking, Resource Allocation, Performance Analysis, Labor Management, Tool Management, Quality Management, Data Collection, Dispatching, Process Management, and Documentation Control. Our older VAX based version of Workstream was supposed to support some of these functions but using them proved to be very cumbersome. Integrating all of these functions into one all encompassing off the shelf MES software never works well. Most of the older software is not flexible to adapt to the ever changing needs of today's business environment. Today's MES vendors have many new features that try to integrate these mentioned features, but not one of them will meet all the needs without extensive customization.

Instead of spending millions for a new off the shelf MES, we created our own stand alone WEB based applications supporting all of the above items. All MES functions have been integrated into a GUI based operator interface that performs many verifications that used to be determined by the operator. The GUI executes Workstream

commands in conjunction with these other verifications upon every Lot Move In or Move Out.

Figure 2: GUI Interface with Lot Flow Chart

This new GUI, Figure 2, is WEB Based and accessed by operators with wireless PDA's or Fab PC's. They scan their Badge ID, Lot Number, and Tool number. The computer then performs the following verifications.

Chemical Loading – The operator scans their badge ID, barcode on chemical bottle, and the specific barcode on the tank of the tool needing chemical. The code verifies that the correct chemical is being added to the proper place, the operator is certified on the tool, and checks to make sure the chemical has not expired.

Correct Tool – Verifies that the operator is using the correct tool at the called for step in the process.

Certified Operator – Verifies that the operator is certified to run wafer per the tool specification. All operator certifications are linked to the ECN process not allowing them to process lots on recently changed procedures unless they acknowledge the change. The GUI also verifies that the operator has moved material under that specification within the recent past. If the operator has not worked on that tool in X number of months, they become decertified.

Tool Status – Verifies that the tool's status is up and all PM's and periodic QUAL's are current. If any PM or QUAL goes past due, the tool automatically goes down. The GUI prevents them from moving tool into an operation on a down tool.

Calibrated Equipment – Verifies calibration of all tools are current.

SPC – All operations that require specific SPC data entry are automatically required to input the required data. If the data violates specific SPC rules, the lot goes on hold requiring disposition preventing further processing.

ETS – All operations that require putting the lot on hold are done so through the "Electronic Trouble Sheet". This tracks the status of the lot allowing for specific notes to be added along the way if any operator/tech notices something abnormal during processing. Holds require engineering to disposition the lot releasing it for continued processing. If the lot is on hold, the operator will not be allowed to move the material.

Recipe Down Loading – Tools capable of SECS/GEM interfacing have the recipe automatically downloaded upon the move in of the lot with the GUI. Older tools retrofitted with a Black Box can also be configured to support recipe downloading. The "Black Box" description is explained later. Recipe downloading does require specific software knowledge pertaining to the Semi Std.

For non-SEC's compliant tools were there is no opportunity to place a Black Box, like manual dip sinks, the recipe downloading takes the form of an informational download to the PDA or PC Screen. This gives the operator specific recipe information

right at their fingertips instead of having them look to a run sheet or try to recall from memory.

Dispatch – Web based dispatch monitors located at all WIP shelves allow for Factory management to control the work center prioritization without having to send production control type personnel into the Fab to help direct work flow. The dispatch rules can be easily modified to meet the Fab's particular interests like: Hot Lots, New Product Development, FIFO, Critical Ratio, Holds, and Down Stream Scheduling.

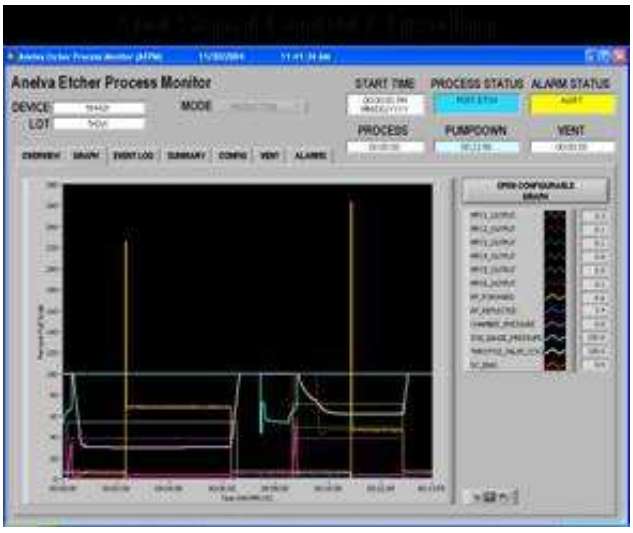
Planning / Lot Starts – A good MES will cross the imaginary border with the ERP system the company uses. Planning tools were created from SFC (Shop Floor Control) data to organize starts as not to overload particular bottlenecks in the Fab that might be mix related. By keeping a good flow through the factory, we are able to prevent WIP bubbles from piling up in capacity constrained work centers because these constraints are planning into the starts model.

Special Work Instructions Requests – All Fabs have some new product or process being developed or just working the bugs out of existing ones. Test lot turns through the factory are impetrative to continuous improvement and company life. Minimizing mistakes with operators running these special requests on hand written notes can be frustrating. Integrating them within the MES can be difficult because of their one off nature and overhead needed to set up routes in the MES. We created a custom interface that Engineering can use to create whatever flow they can dream up and still have the operator run the material except at those critical steps where the engineering tech needs to process the wafers. We have dramatically improved the turn time for these experimental lots and reduced the number of mistakes by keeping in automated.

BLACK BOX

Another missing piece of the business automation software tree is tool level control. Most tool level control assumes the use of the existing tool Operating System to keep track of the tool's performance. Process Engineers then use post processing metrology to monitor the tools' performance and typically react to trends in the data allowing for large scrap costs associated with a poor performing tool. Large Semiconductor companies have entire automation departments to implement SECS/GEM compatible AEC (Automated Equipment Control) and FDC (Fault Detect and Classification). This is great if you have billions and completely compliant tools. We implemented tool level control and monitoring on a modest budget even on non-SECS compliant tools.

By using Labview programming on PLC's with I/O connected to critical tool parameters like MFC set points, Pressure, Temp, RF power, Bias, Throttle Valve Angle, etc. we were able to trend and monitor the tool's performance and have historical tool conditions by lot number to track yield issues back to potential tool problems. Once critical tool parameters limits have been established, the software then tracks each run and alarms for abnormal conditions. Having specific tool histories by part number allows for quick yield issue analysis. Process Engineering can determine if a suspected tool is the cause of the yield loss with relative ease. See figure 3 for an example of historical tool parameter signal trends.



Fiqure 3: Black Box Lot History

SCADA

Represented by the bottom of the Business Automation Software is the basic control structure for the facility functions. All Environmental and Life Safety systems are managed by an automated data monitoring system automatically adjusting for external changes, see Figure 4.

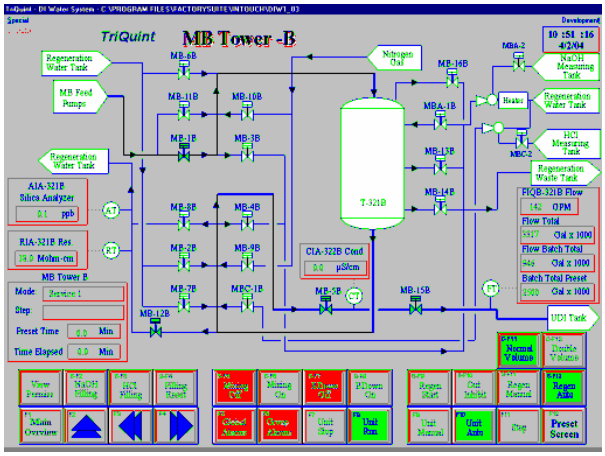


Figure 4: SCADA Facility Control

Integrating these into the MES allows for further scrap reduction opportunities. When temperature or humidity changes cause the fab to go out of spec, all lot movement is halted via the operator interface GUI upon the next lot move. Tools are automatically taken to the down condition when any gas alarms are detected by the SCADA system. When SCADA shuts down the gas supply, the operator GUI does not allow the operator to move material on a down tool preventing possible scrap.

CONCLUSIONS

Automating the most basic of operator functions allows them to focus on handling, loading, and unloading wafers from the tools. Keeping them from making mistakes is the primary goal for most Fab automation. CIM that involves all these functions needs to include a comprehensive operator training program along with highly qualified employees. When you include all three of these aspects, bottom line improvements have been demonstrated at the TriQuint Fab here in Texas.

Eliminating these mistake opportunities has allowed us to dramatically reduce operator scrap over the past 5 years, see Figure 5.

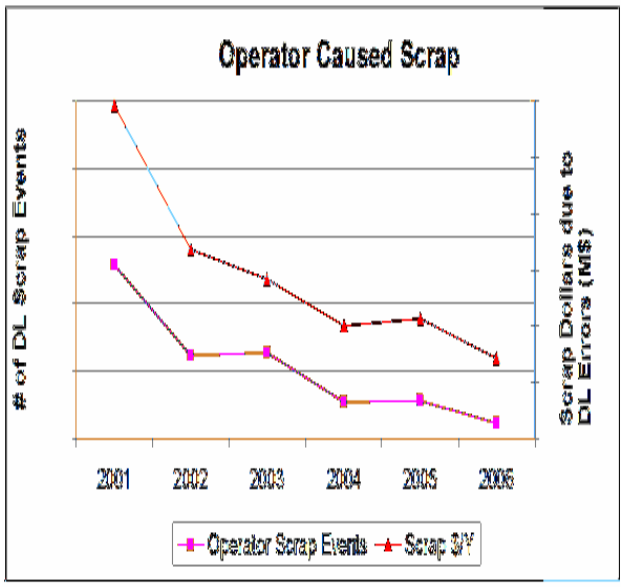


Figure 5: Scrap Events per Year

Not only will wafer scraps decline, time spent chasing yield issues by engineering can be reduced considerably. Engineers can pull data electronically when suspected low yielding wafers are examined. The exact tool conditions when a low yielding lot was processed through critical tools can be recalled instantly to validate tool or operator recipe errors. This diagnostic work can be reduced due to better Fab yields and faster problem lot diagnostics.

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