Manufacturing Excellence, Still Achievable in the US

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Abstract

While GaAs manufacturing is still strongly represented by US based wafer fabs, if it follows in the footsteps of silicon, it will only be a matter of time before it is dominated by offshore foundries. GaAs will never reach the volumes or revenue of silicon and therefore does not have the same level of attraction for venture capital but unless US based factories are competitive in productivity, cost, yields and quality they will eventually be shutdown in favor of the lower labor cost Asia sites. How can a US based GaAs factory remain viable in one of the most competitive industries, semiconductor manufacturing?

Introduction

These are some metrics that can lead to the long term viability of U.S.-based GaAs fabs:

- 9 quarters of 100% OTD to assembly demand
- 90% end to end yields (die started to module package shipped)
- Average cycle time of less then 1 day per mask layer
- Critical lot cycle time of less than one week
- Customer reliability metrics below 100PPM
- Manufacturing productivity metrics improved by more than 2X in 3 years
- Voluntary personnel turn over less than 1% per month
- A business unit that considers the factory as a critical asset to their success

Business Success

Any high technology business needs excellence in:

- Technology
- Design
- Marketing
- Sales
- Customer intimacy
- Quality

However, whether product production is in house or at a foundry, excellence in manufacturing can make or break a business.

At many companies management focuses much of their attention on technology which gives the organization performance bragging rights or on product designs that are critical to sustaining and growing revenue. Manufacturing is often viewed from a cost and risk perspective and achievement of world class manufacturing standards is not typically an organizational objective. Yields are discussed when they are not 100%, execution is mentioned when it is not meeting customer requirements (regardless of forecast accuracy), quality is talked about when customers raise issues and manufacturing cost is always too high. This can result in a lack of focus on best manufacturing practices and eventually at least the consideration of moving out of the wafer fab manufacturing business. With this atmosphere why would anyone want to work in manufacturing in the U.S.? Well, it's a dirty job but someone has to do it!

There is no exact formula for achieving manufacturing excellence, however there are methods and approaches that work and others that clearly do not. Be suspicious of any one that claims overnight success in manufacturing. Like weight loss (an area I have not excelled in) any success which is too quick will not be sustained and is most likely unhealthy.

So what are the key points of success to manufacturing excellence? Let me start with something I heard from a previous manager. He told me "You will never make a good manager until you realize that you cannot care about people, if you care about people you will make the wrong decisions". I learned a lot from this manager, mostly what not to do.

Manufacturing excellence starts with realizing that you should not strive to be a good manager, you must be a good leader. This has been said many times by many people but it is not often practiced, particularly when times are difficult. However, these are

the times that need leadership (not management) the most. Leading an organization is achieved by the combined wisdom of the staff with which you surround yourself and by example, how they build their staff. The characteristics of these people are what make the key difference.

Everyone has strengths and weaknesses; the trick is not to let the weakness of any one individual create a weakness for the organization. Each staff member must be willing to recognize any area of weakness and "plug the hole" for any other member of the staff, even when this hole is not their responsibility. Another often quoted analogy "because the leak is not in your end of the boat does not mean that your feet will stay dry". You need to have a team of people that are focused on the success of the factory, not their own individual success and can feel others successes as their own. All areas must move forward at the same pace for maximum performance. Any area falling behind must be supported, mentored or, if necessary, realigned. In simple terms the manufacturing staff must function as a true team – achieving greater things than they could as a group of individuals.

I came to the Newbury factory when it was Rockwell, then became Conexant and is now Skyworks. Most of the staff I started with is still in place and a few have been added. The success was not achieved by replacing a lot of people but by giving those in place an opportunity to develop and excel.

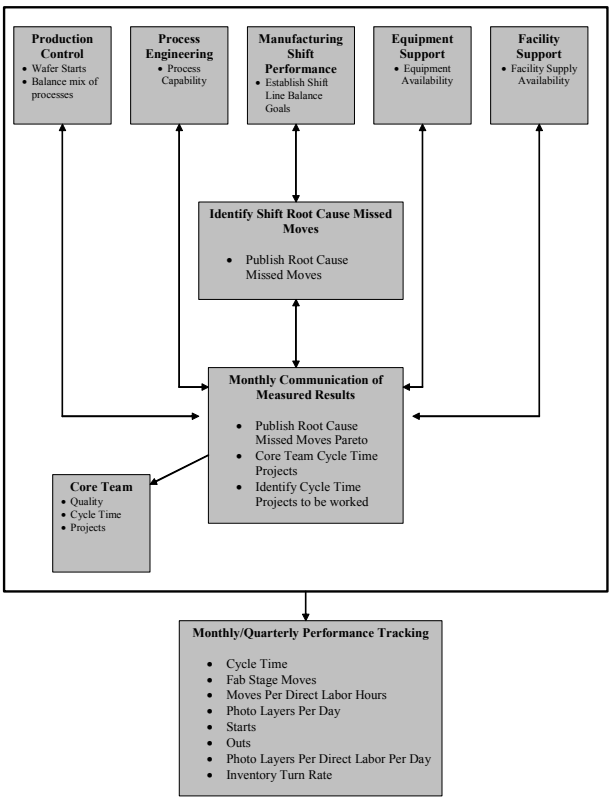
The key factors in this approach are:

1. Don't take personal credit for any success of the factory, point to the team or individual that drove the accomplishment.
2. Don't assume that the approach which has been successful for you in the past is by definition the best way to achieve a goal.
3. Don't make up your mind on a topic without discussing it with your staff and in particular with the people that will be most affected by a decision.
4. Allow and even encourage dissenting opinions to be expressed and be willing to change your mind when sufficient new information is presented but do not "flip flop".
5. Expect your staff to support the management team's decisions completely.
6. Recognize that your goal is not factory metrics; it is making the business successful. Your real boss is the business leadership, not the manufacturing chain of command. You want the business leaders to consider the factory as one of their most critical asset in their success.
7. Maintain complete integrity in your metrics. This is the key to your personal and organizational credibility.
8. Don't compromise quality for speed, volume or yields. Consider the long term impact of any quality-related decision.
9. Have in place and use a disciplined approach to making changes, bringing up new tools and implementing new process. (MPCpS)
10. Work with your hands-on team members as partners and not just direct labor.
11. When dealing with differences of opinion, remember, the goal is to win the war. You may lose a few battles but stand strong on the important ones. It is not important that you are always right but it is it is critical the decisions made by the team are.
12. Understand what motivates your key contributors and leaders and keep them challenged.
13. Always reward and recognize your team's accomplishments.
14. Stay current with your customers' expectations.
15. Don't be afraid to hire people with skills and abilities that exceed your own.

Let's pick a few of these topics and talk about them in more detail:

2. Don't assume that the approach which as been successful for you in the past is by definition the best way to achieve a goal.

In 1994 I presented an invited paper on how to achieve world class cycle time. The approach used was to put SPC charts on the cycle time of each module and react to the out of control data points as you would any process. This was successful but when I presented this idea to the manufacturing manager at the Newbury Park fab he had a difficult time relating to the approach. He came up with his own approach. He collects what he calls "missed moves" for each month. His supervisors keep track of any missed moves in the factory which could have been made but were missed due to a long list of reasons. A Pareto is developed, costs are calculated and actions are put in place for the highest Pareto items. On a weekly basis stage cycle times are extracted and the highest are addressed with the appropriate group with action put in place to make improvements.



Pareto of Root Cause Missed Moves

Quarter 3 Root Caused Missed Moves			
Category	Equipment/Issue	Missed Moves	OH Abs. Loss
Process	Holds	18473	$148,892
Facility	Exhaust Removal	7516	$ 60,579
Facility	Power Bump	6395	$ 51,544
Equipment	LAMs	6077	$ 48,981
Manufacturing	Manning	3946	$ 31,805
Process	Disposition	3279	$ 26,429
ESR	Evap 08, 09	3039	$ 24,494
Facility	Power Outage	2527	$ 20,368
Equipment	NOVs	1904	$ 15,346
Equipment	Canons	1720	$ 15,460
ALL	SVGC	1620	$ 13,057
Equipment	EAT02	1551	$ 12,501
Equipment	PLSH03,05	1450	$ 11,687
Equipment	Evaporators	1390	$ 11,203
Manufacturing	Execution	1246	$ 10,043
Process	EVAP 6,7,8,9,10	1000	$ 8,060
Equipment	Poly 01, 02	994	$ 8,092

List of missed moves for the quarter by cause with the loss of absorption in dollars.

Another critical requirement in reducing cycle time is a strong Industrial Engineering organization. This team created a factory floor where all tool installations took into consideration the product work flow. When tool moves were required to meet this goal they were supported and implemented. Moving forward, the IE team heads up "Core Team" efforts to drive OEE, cycle time and yield improvements. Core teams are typically but not always headed by an IE and are made up of key cross functional members including process and equipment engineering and manufacturing in the specific discipline such as photo and etch. The teams meet regularly (weekly or biweekly) and drive continuous improvement projects. Significant performance improvements have been realized through these teams.

An example of the direction taken by the IE team:

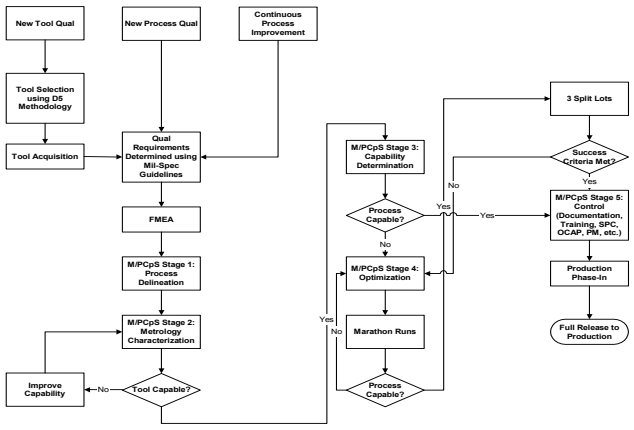
Cycle time improvements included understanding the process flow and identifying opportunities for creating work cells to minimize lot travel time. Tool layouts were developed to optimize the location of each work cell and understand how it would work on the factory floor. In addition, cost versus cycle time analysis were completed to understand the trade-offs of relocating tools to create an optimized factory layout. Once the tools were installed according to the new layout, tool dedication plans were developed for high volume toolsets. The objective of the tool dedication plan was to ensure lot travel time was always minimized between process steps, balance the workload across a major toolset and maximize tool utilization. The tool dedication plans were documented using a standard format and posted at each tool set so that operators had a consistent plan to follow.

These approaches, along with others, have allowed us to achieve what I believe are world class cycle times hitting below 1 day per layer for normal production and even shorter for priority lots.

8. Don't compromise quality for speed, volume or yields. Consider the long term impact of any quality related decision.
There is always pressure to pass product when it is not clear that it is bad or there is at least hope that it could be good. There is a tendency to try to find ways to salvage product by rework so that the yield loss does not have to be taken. This approach will not only result in performance or reliability issues with your customer but will consume engineering time trying to find a way to salvage. In most cases you need to accept the loss and spend the effort on corrective action. It is very hard to do but in the long run will provide a more robust process and better product for your customer.

9. Have in place and use a disciplined approach to making changes, bringing up new tools and implementing new processes. (MPCpS)
There will always be pressure to implement changes, introduce new tools or bring in new chemicals or materials. It is very difficult to determine the affect of these changes without hard data, particularly for RF products. Establish a process for making changes and do not compromise for the sake of speed of execution. "Do it right the first time". There are many approaches and most will work if they are properly and consistently implemented. Skyworks uses what is called Manufacturing Process Capability Study or MPCpS.

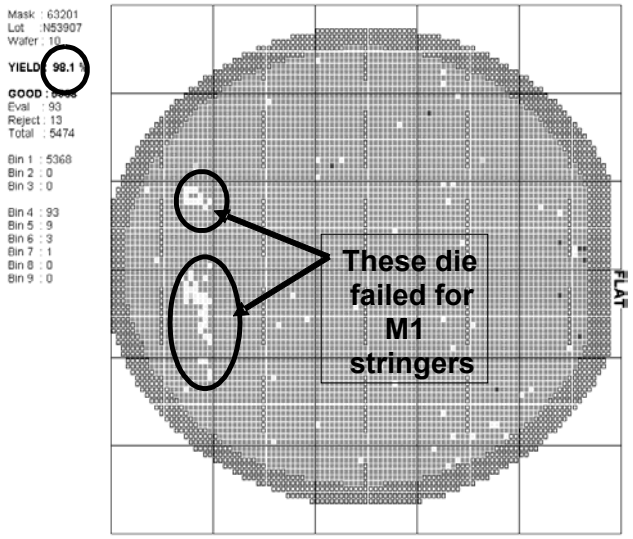
Manufacturing Process Capability Study



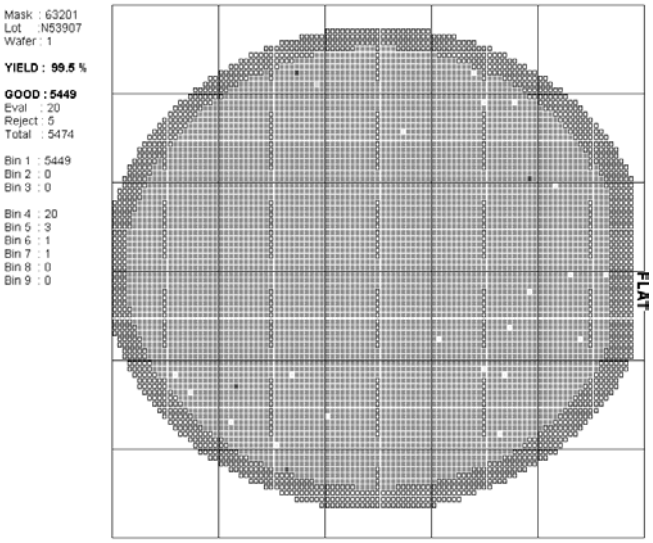
With this approach we successfully ramped the factory 5X in 12 months with no mistakes made in bringing up the large number of new tools required. We have continued to implement an average of 10 fully qualified process improvements per month since the ramp which was completed in 2000.

In addition to the disciplined approach to making improvements and introducing new tools we have a strong yield organization that continually looks at yield loss, identifies issues and works with the appropriate people to resolve any problems. The yield issues we are addressing today would have been completely missed a few years ago. An example of what we look for is as follows:

A wafer with a recognized yield problem



After minor changes in M1 layout to improve the manufacturability of the part without affecting device performance



We have moved from dealing with customer problems to finding and correcting problems before they get to the customer. This was accomplished by creating a close relationship between the reliability, failure analysis, quality and the factory engineering team. Once we got past the defensive posturing which is a natural response to an "outside" organization finding problems and created a close coupling within these organizations, great strides were made in early detection of problems and corrective actions. This relies on the point made earlier that the goal is to make the factory successful, not the individual. Develop a culture where accepting a problem which could make the owner appear less than perfect is considered a strength not a weakness.

There is considerably more detail that could be discussed about each of the 15 items listed above and all of the programs, projects and approaches that have made the Newbury Park factory successful. Each area could be a paper in itself. However, the key points I would like to make are that manufacturing excellence is a key (if sometimes under appreciated) requirement for a businesses success. It can still be accomplished in a US based factory. In addition, never underestimate what a dedicated team can achieve in one of the most competitive areas in the world today, semiconductor manufacturing.

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