Compound Semiconductors Industry Benchmark Study

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Keywords: Industry Benchmark, Cycle Time, Resource Utilization, Operational Controls

Abstract

The purpose of benchmarking is to measure ourselves against our peers or competitors and to learn from the different ways other organizations are approaching similar and sometime identical problems.

The article will give an overview of the benchmark study finding, providing a high level summary of some key indicators, this can serve as the template for fabs that want to improve their performance to check their current parameters against.

INTRODUCTION

The semiconductors industry is a very cyclical environment, and the last five years have thrown the compound semiconductors segment into a cyclical whirlwind. While every company is working to find an edge on the technology side, it is important for the industry as a whole to improve operation levels to be able to compete with Silicon companies. Operational excellence, which is the key to success, is always achieved by learning from other people successes and failures. The best way to learn is to benchmark yourself to others in the industry. MAX I.E.G. conducted a benchmark study that includes five different companies in the compound semiconductors arena.

We will highlight only a handful of high level indices in this article and although we plan to share many more in the presentation, only the study participants will receive a full analysis of all indicators based on the results and compared to their position in the industry.

OVERVIEW OF INDICATORS

We sent the participants a detailed questioner that served as a base for calculating eighty four different parameters in the following categories:

- Capacity
- Cost
- Yield
- Cycle Time
- Productivity
- Maintenance
- Systems

To validate the data we conducted site visits in each participant's fab and went on an extensive fab tour to authenticate the data on the floor. Following is the List of parameters we looked at.

CAPACITY

- WSPM vs. Fab Layout type
- Bottleneck Max Demonstrated Utilization
- Bottleneck Max Demonstrated OEE
- WSPM per gross sq. ft.
- Test wafers to Product Wafers Ratio
- Current run rate vs. maximum run rate
- Production wafers to R&D wafers ratio
- Wafer edge exclusion by wafer size and technology
- Processing tool to test/measurement tools ratio
- # of tools per sq. ft
- # of tool types per sq. ft
- # of functional tests per typical product
- # of functional tests to test/measurement tools ratio
- Tools to tool type ratio
- Front side processing to backside processing sq. ft. ratio
- WSPM vs. clean room area usage efficiency
- WSPM per net bay sq. ft.
- Max Layers/Alignments per week

COST

- Cost per wafer by technology type and wafer size
- Wafer Cost per sq. ft.
- Cost per photo layer
- Revenue per employee
- Training $ per Operator
- Cost Fraction due to labor
- Cost Fraction due to material
- Cost Fraction due to equipment support
- Cost Fraction due to depreciation
- Cost Fraction due to facilities
- Cost Fraction due to other charges

- ☐ Maintenance Cost of Total Operational Cost
- ☐ Process Eng. Cost of Total Operational Cost

YIELD

- ☐ Average Line Yield per layer
- ☐ End to End Fab Yield
- ☐ Average # of Inspection steps to average total steps by technology ratio
- ☐ Average Scrap per 1000 wafer start
- ☐ Wafer Breakage to wafer starts ratio
- ☐ Wafer breakage per mask layer
- ☐ Defect Density
- ☐ Electrical Test Yield
- ☐ Final Visual Inspection Yield
- ☐ Scratches per sq.in or sq. cm
- ☐ Scratches per Wafer Start
- ☐ Mechanical yield loss events per week
- ☐ Mechanical yield loss events per layer
- ☐ Scrap per 1000 Alignments/Layers

CYCLE TIME

- ☐ Average CT per mask layer
- ☐ X Factor by technology
- ☐ Fraction of cycle time that is hold time
- ☐ WIP that proceeds through line with no holds
- ☐ WIP that requires no special processing
- ☐ Cycle time per mask layer vs. fab Layout type
- ☐ Goal CT to mean CT ratio
- ☐ Average % to mix (monthly based on the last 6 months)
- ☐ Average % to volume (monthly based on the last 6 months)
- ☐ Finished wafers to WIP ratio
- ☐ Average wafers on hold

PRODUCTIVITY

- ☐ Moves per DL Hour
- ☐ Operator to Supervisor Ratio
- ☐ DL to Tool Ratio
- ☐ Maintenance Tech to tool Ratio
- ☐ New Operator Training period
- ☐ Employee Attrition Rate
- ☐ Shift Structure
- ☐ WSPM / DL ratio
- ☐ WSPM / Process Engineers ratio
- ☐ WSPM / Equipment Engineers ratio
- ☐ WSPM / Maintenance Technicians ratio
- ☐ WSPM / Process Technicians ratio
- ☐ WSPM / IT employees ratio
- ☐ WSPM / IE employees ratio
- ☐ WSPM / Managers ratio
- ☐ WSPM / Facilities employees ratio
- ☐ WSPM / PC employees ratio
- ☐ Mask Layers / DL / Day
- ☐ WSPM per total work force
- ☐ Net production time per shift
- ☐ Available production time per week
- ☐ DL / IDL ratio
- ☐ Engineers / Tool type ratio
- ☐ DL headcount vs. layout type

MAINTENANCE

- ☐ Average Bottleneck Utilization
- ☐ Max Bottleneck Utilization
- ☐ Min Bottleneck Utilization
- ☐ PM compliance
- ☐ Dedicated Maintenance Management System (CMMS or through MES)

SYSTEMS

- ☐ Fab MES System
  - Dispatch Rules used
  - paperless
  - MES modules used
- ☐ Fab automation Level
- ☐ Formal Continuous Improvement program

OVERVIEW OF KEY RESULTS

For each parameter or indicator we calculated the study Best Worst and Average, and added an average number from a group of similar equipped fab in the Si world among our clients.

PHOTO MAX DEMONSTRATED OEE

Definition: OEE - Overall Equipment Effectiveness = % of time a tool is busy producing sellable goods at the max theoretical run rate (OEE = Availability X Operational Efficiency X Rate of Quality)

Best	**Average**	**Worst**	**Si**
80.0%	69.0%	64.0%	**85%**

WSPM PER GROSS 1000SQ.FT (4" EQUIV)

Definition: Total wafer start per month divided by Gross space including bay, chase and all other support areas

Best	**Average**	**Worst**	**Si**
754	265	5	**810**

FAB LOT SIZE

Definition: Average Fab lot size

Best	Average	Worst	Si
20	14	6	**24**

AVERAGE CT PER MASK LAYER

Definition: Average cycle time (days) per technology divided by the average number of layers across all running technologies (mix weighted)

Best	Average	Worst	Si
1.74	4.37	11.23	**1.30**

X FACTOR BY TECHNOLOGY

Definition: X times the theoretical CT weighted by technology

Best	Average	Worst	Si
2.2	6.3	12.5	**2.5**

END-TO-END FAB YIELD

Definition: Average number of wafers that complete final die visual inspection divided by the average wafer starts per period

Best	Average	Worst	Si
89.6%	69.4%	30.4%	**90%**

REWORK RATE

Definition: Ratio of rework moves to total fab volume

Best	Average	Worst	Si
1.30%	3.69%	5.00%	**0.50%**

AVERAGE # OF INSPECTION STEPS TO AVERAGE TOTAL STEPS

Definition: Average number of visual inspections divided by the average number of steps weighted by technology

Best	Average	Worst	Si
10.30%	24.45%	40.00%	**10.00%**

MOVES PER DL HOUR

Definition: the Average number of fab moves performed per operator/direct labor employee hour

Best	Average	Worst	Si
26.27	17.53	5.23	**30.00**

OPERATORS TO SUPERVISOR RATIOS

Definition: The average number of operators per supervisor (include shift mgrs) across all shifts

Best	Average	Worst	Si
6.0	11.0	14.5	**15.0**

CONCLUSIONS

While the companies participating are of different sizes and cultures they are a good representation of the III-V industry. We learned that in many cases the difference in operating maintenance, engineering, and fab management is due more to the nature of the organization and not necessarily to technology. If any we learned that improving any parameter across the board will be best correlated to the cumulative motivation of the organization to improve, rather then to technology size budget or any physical obstacle. We clearly see that some fabs meet the Si average and our conclusion is that as an industry we can improve to operate on the Si efficiency levels and to remain competitive we clearly should.

ACKNOWLEDGEMENTS

The authors would like to thank the representatives from all the participants for all their hard work and support.