Getting the Best 300mm Fab Using the Right Design and Build Process

Presented on SEMI ITRS
Agenda

- Introduction
- Objectives of Fab Design
- Design Process Overview
  - From process flow to toolset
  - Resource Modeling
  - Fab design guidelines
  - Design Stages
  - Project management (Construction, IQ)
  - Business process development & Unique 300mm Fab Issues
  - Information systems analysis (IS)
- Trends in 300mm Fabs
Introduction

- A working fab is more than a building, a toolset, systems, and humans, it’s the sum of all of the above working in sync.
- Fab design and build is one of the most important decision processes a company will encounter in its life cycle.
- Most companies do not build fabs on an annual basis.
Objectives

- To forecast as accurately as possible the future performance demands.
- To generate the best possible fab design meeting those demands within a budget boundary.
- Get from initial decision to capacity on line as fast as we can!
- Build, install and qualify all tools on time and on budget!
Design Process Overview

Process Flow Analysis
- Resource Modeling
- Design Guidelines

Conceptual Design
- Automation System
- Detailed Design
- Business Processes
- Information Systems

Detailed Design
- Construction Management
- Tool Install
- Tool and Process Qual
Design Processes Comparison

Typical Design - 12 months

- Conceptual
- Detailed + A&E
- CM Bids

Condensed Process - 6 months

- Conceptual
- Detailed + A&E
- CM Bids
Design Process Overview

Process Flow Analysis
From Process Flow to Toolset

- Any Fab design must start with a detailed process flow or flows.
- Fab layout should be based on the predominant flows, the composite flow should capture 80% of the products.
- The process flows dictates the tool list, the functional areas’ size, and relationships.
Design Process Overview

Resource Modeling
Clean room space is not the most expensive resource, and fab design is not just layout.

To truly understand fab operations all resources must be modeled:
- Tool capacity
- Product and material flow
- Operators staffing
- Maintenance and support labor requirements
Design Process Overview

Design Guidelines
**Fab Design Guidelines**

**Design to Operational Criteria:**
- Product / Material Flow
- Productivity / Staffing Impact
- Dispatch method (Pull, Push, etc)
- Layout flexibility and ramp impact on existing production
- Maintenance practices
- Ergonomics
- Automation
- Material handling
- Modularity to future expansion
- Install / Qual complexity

**Selection Criterion:**
**TCO - Total Cost of Operations**

**Design to Business Criteria:**
- Capacity
- Time to Capacity Online
- Cost / ROI (IRR)
- Quality / Yield
Performance Definition
CT Vs. TPT

WIP = CT x TPT

TPT = WIP / CT

1,000 = 8,000 / 8
1,000 = 4,000 / 4
Design Process Overview

Conceptual Design
Conceptual Stage

Optimize Flow!

- Floor Space Model
- Flow Model CAD Grid
- Block Layout
- Tool Layout
- Utilities Matrix
  Tool Coding System
  A&E Narratives
- Support Equip. Layout
- Capacity Requirements Analysis
Conceptual Layout Flow Analysis

Affinity Matrix:
(Both Inter-Bay & Intra-Bay by Tool and Area)

Block Diagram Methodology:

<table>
<thead>
<tr>
<th>Area</th>
<th>Sq Ft</th>
<th>Constrained Factor</th>
<th>Space Req.</th>
<th>Available Space</th>
</tr>
</thead>
</table>

![Diagram](image_url)
TCO Vs. Optimized Flow
Design Process Overview

Automation System
To start construction you need to know transportation volumes and times, the general type of automation system, as well as buffer and WIP stocker locations.

Since 300 mm does not allow manual transportation, the wafer handling system sets the pace of the fab.

Calculating WIP levels and buffers, is the first step to specifying the handling system.

The main challenge is to create and test a dispatching algorithm that will ensure delivery of the right lot to the right place at the right time.
Design Process Overview

Detailed Design
Detailed Layout Design

- Floor Space Model
- Flow Model
- WIP Model

- Finalize Tool & support Equip. Layout
- Finalize Automation & Material Handling
- Workstation Design
- Phasing Planning

Final Tool List
Phases and Ramp Plan

- Early Toolset (Capability)
  - Tool Qual
  - Process Qual
  - Short Loop
  - Full Loop

- Redundancy toolset

- Ramp Steps
  - 500 WSPW
  - 1000 WSPW
  - 1500 WSPW
  - 2000 WSPW
  - ……
Design Process Overview

- Conceptual Design
- Process Flow Analysis
- Design Guidelines
- Detailed Design
- Automation System
- Construction Management
- Tool Install
- Tool and Process Qual
The “critical chain” project management philosophy.
- Identify all activities
- Get real durations
- Reduce fudge factors
- Analyze Hidden Critical Paths

Step #1
Step #2
Step #3
Step #4

#1 #2 #3 #4

Project Buffer

#1 #2 #3 #4

Buffer

max

semiconductor Equipment and Materials International
Design Process Overview

Business Processes & Unique 300mm Issues
Business Process Development

- To finalize facility design all the internal business processes must be defined.
- Business Processes should be geared toward creating operational improvements.
- Typical major BP:
  - Shift management
  - Maintenance practices
  - Tool and recipe SOP
  - WIP Management
Buffer Strategy

- Identify buffer ‘location’ in the process flow following the bottleneck tools identified using advanced resource modeling that considers the following factors:
  - Tool dedication
  - Facility Lot Size
  - Batch policy
  - tools’ RR

- determine buffer size \( b \) [min levels] for tool Z in process step \( j \) using the following algorithm:

```
Control your buffer with Real Time Dispatching (RTD)
```
Global Release

- When releasing new lots to the line we will consider the following factors:
  - technology type
  - Customer commitment due date
  - MAX WIP level in the line (by technology) to support desired X factor
  - Fab due date - will include a standard time buffer (STB) from the customer committed due date
  - On time delivery goal - will set the goal CT confidence level, thus setting the STB
  - Quantity and frequency of actual starts will follow this concept:
    - lot out triggers lot start - continuous starting
    - last lot in order i starts at the beginning of the X factor determined by technology
Real Time Dispatching

- Real time dispatching is really event triggered. There are two types of events that could trigger a dispatch:
  - tool X calls for a new lot
  - Buffer B calls for a lot

- the dispatching algorithm should follow a combination of routines to determine the right lot to dispatch:
  - M ratio(lot i) = CR(lot i) X % of remaining Work
    CR - Critical Ratio of lot i
    % remaining work = process steps to finish / total # of steps in process

- Dispatch triggered by tool - run the lot with the min M ratio
- Dispatch triggered by buffer - Fastest Lot to Buffer
- Critical factoring of changeover need for the lot time to arrival to the trigger
Fab Optimization Routines

- Tool changeover rules
- Batch policies
- Lot size optimization
- Tool speed optimization (cluster tool modeling)
- Service tools optimization using queuing theory
- X factor modeling
- Bottleneck’s buffering
- Test and dummy wafers quantity and usage optimization
- PM planning and execution
Recovery Procedures

- Tool recovery - fix following BNI
- Notification procedures
- Escalation procedures
- Interactive repair (MES - CMMS - Technician - Vendor)
Basic Fab Run Rules

- Operator, Tech Engineer and Mgr. Roles and Responsibilities in a fully automated fab
- Shift management procedures
- PM / Repair procedures
- fab performance measurements
- fab mgmt business processes
- quality/yield mgmt process
Design Process Overview

Information Systems
Information Systems (IS)

- Manufacturing Execution System
- Computerized Maintenance Management System
- Enterprise Resource Planning
- Facilities Control System
- Visual Management - clean room personnel and management update.
Trends in 300mm Fabs

- Most Fabs started as R&D or captive fabs
- Commercial demands hopefully will drive higher volumes manufacturing
- Management Processes need to become more mature
- Product mix will be higher than 200mm level
- Yields and Cycle time will be the focus
Conclusion

- Following the right fab design and project management process reduces overall time to capacity.

- The difference between a good and an average layout can cost 10 to 20% in operating costs and can impact cycle times by as much as 30%.

- Detailed resource understanding is the base for any improvements.

- Mature business processes is a must for capitalizing on all the resources involved in daily activities.