A Systematic Planning Approach for Continuous Flow Manufacturing in Semiconductor Production

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Agenda

- Initial Situation
- 3 Steps of Planning Method
- Conclusion & Outlook
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Initial Situation - Cycle Time Logic Product

CT: 88,29 days
Material Flow
72,16 days (82%)
Initial Situation – Value Adding Time

Percentage of value adding process time in semiconductor production not more than 2% [Töpfer 2008, S. 34].

The chosen manufacturing organisation has an impact on achieving manufacturing goals.

See Bibliographical Reference (1)
General Manufacturing Organisation

**Job Shop Manufacturing**
- tools are grouped according to their function
- in literature assigned to *small-series production*
- but: common business practice in gigantic mass production environment of commodity chip production

**Flow Production**
- mass production
  - **Spacial Flow Principle**
    - installation of machines follows product workflow
  - **Timed Flow Principle**
    - Capacity and Time Matching

**Fixed-Site Production**
- product is fixed at one place, that means not the product but the means for work were transported

**Group Technology**
- tools with different functions are grouped together to perform a set of operations
Job Shop and Material Flow with Stop & Go

Intrabay 1 - Furnace
Intrabay 2 - Cleaning
Intrabay 3 - Lithography
Intrabay 4 - Implantation
Intrabay 5 - Etching
Intrabay n

Intrabay - Cleaning
Intrabay - Etching
Intrabay - Implantation
Intrabay - Furnace
Intrabay - Lithography
Intrabay - Sputtering

S: Stocker
1. High Speed of Innovation and Short Product Life Cycles,
   - high frequency of technology and product flow changes
   - flexibility of job shop and support of learning process
   - lack of required unit process stability

2. Economical Conditions
   - high invest costs,
   - extremely complex equipment which is very difficult to maintain and sometimes still prone to unforeseeable very sophisticated failures
   - Simplification of utility distribution and chemical supply requirements, less footprint
   - in most cases manufacturing and R&D must coexist in the facility

3. Characteristics of Semiconductor Production
   - numerous extremely complex process steps and cyclical production with reentrant material flow
   - avoidance of repeated installation of same machines
   - huge variation in process times which makes synchronisation of processes difficult
Evolution in IC Manufacturing Practice

Development towards Cluster-Tools

Old Fabrication Facility (1980's) with 2µm node manufacturing

Modern Fabrication Facility (2008) with 0.048 µm (48nm) node manufacturing

Now isn't this anything else like applied flow process principles? This can be interpreted as an early preliminary stage of a kind of Flow Production since in a cluster tool several consecutive process steps are integrated in one tool.
Linear Linkable Tools
Blueshift

See Bibliographical Reference (2)
Main Features of Flow Production

**Spacial Flow Principle**
arrange tools according production flow

**Timed Flow Principle**
Capacity and Time Matching

usable for existing fabs

usable for new fabs

**Precondition for Using Flow Principle**
similarity of production flow of different products
Vision of Planning Method

Logical Overlay of Job Shop with „Virtual Flow Production“

Legende
FB = Fertigungsbereich
Planning Method

1. Building Flow Families (FF)
2. Analysing FF
3. Reengineering FF
Agenda

- Initial Situation
- 3 Steps of Planning Method
  - Building Flow Families
  - Analysing Flow Families
  - Reengineering Flow Families
- Conclusion & Outlook
Definition of a Flow Family

- origin of family building in parts production
- similarity criteria: *form und function* of parts
- translation to *production flow* necessary

A Flow Family is a united chain of consecutive single process steps which are similar within different product POR’s:

- sections of complete POR,
- same or replacing tool types and
- length and sequence are similar.

*POR: process of record*
Possible Solutions for Family Building

**50s-60s**
Descriptive Procedures
- e.g. „Eyball“ method, classification systems

**70s- Today**
Methods of Operation Research
- e. g. mathematical programming, graph partition methods,

**80s - Today**
Multivariate Analysing Methods
- e. g. Clustering

**90s – Today**
Other Methods
- e. g. neuronal network, fuzzy mathematics
Example for Clustering from Manufacturing of Parts

Clustering often on the basis of geometry

Goal of Clustering
- combining of elements to classes
- elements in one class are similar,
- elements of different classes are dissimilar

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Process of Building Flow Families with Clustering

1. Building Flow Families
   1.1 Preperation
   1.2 Clustering Procedure
   1.3 Evaluation

For details
See Bibliographical Reference (3)
Java based Software Tool for Finding Flow Families

ClusterTool-FH.jar

Setting of length of searched flow

Read in column of POR
Recommendation for Starting Point

1. Wafer Test
2. Copper or Alu Metallization
3. Implantation Layer
Different Viewing Points for Analysing Flow Families

**Hierarchical View**
Flow Family as part of whole

**Functional View**
Flow Family

- **Input**
- **Production Process**
  - Process steps, measurement steps, material- and information flow
  - Walk through

- **Support Functions**
  - Maintenance

- **Output**

**Structural View**
Relations between elements of flow family

**Bottom up**

**Top-down**

**Sphere**
External Customer

**Walk-through**

**Walk-around**
Process of Analysing

2 Analysing Flow Family

2.1 Illustration of Flow Family by Using Descriptive Model

2.2 Operational Structure
   - Space View
   - Time View

2.3 Organisational Structure
   - Tasks
   - Cross Functions

2.4 Consideration of Flow Family Regarding Key Performance Indicators

2.5 Variability Mode and Effect Analysis (VMEA)

2.6 Determining Design Opportunities
<table>
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<th>Information Flow</th>
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<td>Storage (VDI 3300)</td>
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<td>Handling (VDI 2860)</td>
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Space View - Visualisation of Flow Family in Fab Layout
Variability Mode and Effect Analysis

1. Illustration of Variability Level
   - Process
   - Material Flow
   - Information Flow
   - Support Process
   - Decisions

2. Variability Mode and Effect Analysis
   a) Decomposition
   b) Reasons (Ishikawa)
   c) Risks
   d) Opportunities for Mastering

   Check particle
   ...

3. Illustration of Variability Fields
3. Reengineering Flow Families

- 3.1 Design Arrangement of Process Steps
- 3.2 Operational Structure
  - Balancing & Customer Voice
  - Strategic WIP
- 3.3 Organisational Structure
  - Flow Work Organisation
- 3.4 Variability Mastery
Arrangement of Process Steps

Sequence Change

Parallelisation

Integration

Extension

Elimination
Space View - Remember

Fab-Modul
IB=Intrabay

Interbay

1
2
3
4
5
6
Reengineering

Adaptation of Product Flows to Existing Fab Layout

26% Cycle Time Saving
POR-Sequence of 6 steps

Sequence Change
Swap of Measurement Steps

Elimination

Fab-Modul
IB=Intrabay
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... it’s a long way to introduce Continuous Flow Manufacturing in Semiconductor Production, but it’s not impossible.
