Mask Automation: Lessons Learned from the Wafer Fab Perspective
Presentation Overview

• Problem statement
• Lessons Learned in Equipment Automation
• Lessons Learned in SMIF & MENV
• Automation Vision for the Mask Industry
Problem Statement

• Mask manufacturing is about 10-15 years behind wafer manufacturing in automation terms, resulting in:
  – Poor yield
  – Poor cycle time
  – High costs

• Mask business is much smaller than semiconductor device business
  – Cost to implement change will be a challenge
Wafer Fab Perspective: The Evolution of Process Control

Data visibility is a key enabler
Wafer Fab Perspective: The Evolution of Process Control

• Data visibility
  – Need visibility of what is happening at every process step
  – Post process Metrology only reveals part of the picture

• Process Control
  – Needs to specify equipment data collection requirements
  – Needs to control processing conditions
  – Needs real time data collection for SPC
  – Needs context information to correlate data for yield analysis

• Yield Analysis
  – Identifies specific process steps with poor yield
Mask manufacturing: Current automation scenario

Factory Network

Very few mask tools are connected to the Factory Network

MES   SPC

Mask production line

Poor data visibility
Mask manufacturing: Vision of the future

Every mask tool connected to the Factory Network

Factory Network

Mask production line

Good data visibility
Establishing Process Control
First steps: Basic Communications & Control

• Need a host <-> equipment communications standard
  - Hardware interconnect
  - Software protocol

• Need a simple process control framework
  - Equipment data collection setup
  - Basic processing control
  - Equipment based alarm monitoring

E37 HSMS, E5 SECS & E30 GEM are simple to implement
E37, E5 & E30: High Level View

• E37 HSMS & E5 SECS are a hardware interface and a software communications protocol

• E30 embodies functionality required for equipment automation, but only need limited subset for first implementations

Scope of E30:

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Recipes and Process Programs

- E30 has requirements for Recipe Upload (tool to host), Recipe Download and Process Program Select (PP-SELECT)
- Users can live with PP-SELECT for early implementations
  - i.e. select a Process Program that exists on tool
- Host needs to know if operator has changed a recipe
  - PP-CHANGE event
- Recipe structures need to be made public
- Recipe parameters need to be externalized and adjustable

Enables host control
E30 Integration: Leverage available tools and expertise

- Several third party SECS communications drivers available on the market
  - Asyst (GW GEM)
  - Cimetrix
  - Wonderware
  - SDI
  - etc.

- Use of equipment software integrators recommended

- Test implementations against industry standard test plans

- Leverage ISMI Test Service Provider initiative to control quality of test

Goal is common equipment communications behavior
Wafer Fab Perspective: Lessons Learned

• Wafer manufacturing didn’t move from “no communication” to “e-Manufacturing” over night
  – Needed to establish a solid foundation and a roadmap to ensure progress in the right areas for the right reasons
  – Needed to prioritize which areas to address first

• Data visibility is a key enabler

• Systematic data collection into an engineering data warehouse enables effective yield analysis and data mining applications

• Ensure implementation consistency across whole tool set
  – Avoids having to develop custom Equipment Interface per tool
  – Use proven third party SECS communications software
  – Use experienced third party integrators
  – Use ISMI licensed Test Service Providers to validate tool software
Lessons Learned in SMIF & MENV

AMD Fab30 Factory Automation
Newsflash!
Equipment contamination causes defects!

- Particle control more important with reducing line geometries
- Other MENV design characteristics also contribute to contamination
- AMD strongly believes that there is a need for proactive contamination control
- Cannot delegate responsibility to equipment suppliers
  - They don’t understand the problem
  - Need to “set the standard” & check that it has been met
  - Leverage qualified third party expertise
  - Push the cost of compliance onto equipment suppliers (where it belongs)
Holistic Approach Needed

- Everyone associates contamination with particles
- For minienvironments, contamination control needs to be “holistic” – this means that we need to consider the WHOLE manufacturing environment, not just particles
  - Differential Air Pressure ➜ Positive air pressure inside MENV
  - Filter Leakage ➜ No leaks through filter or frame
  - Induction Leakage ➜ Exterior particle challenge
  - Airflow Velocity ➜ Keeping particles away from WIP zone
  - Airborne Particulation ➜ Keeping particles away from WIP zone
  - Surface Particulation ➜ Static and dynamic particle testing
  - Electrostatic Charge ➜ Controlling ESD
  - Temperature & Relative Humidity ➜ Controlling other “variables”
  - Recovery Time ➜ Equipment uptime after PM
  - SMIF Pods ➜ WIP transport environment
Particles are a big problem, but not the only problem...

Dynamic particle problems accounted for 66% of MENV problems on tools tested during equipment acceptance -> 34% from other causes.
Mechanical design of equipment is critical for effective contamination control

- Particle problems on a 150mm tool
  - Problem not detectable when tool was new
  - Wafer handler in close proximity to drive belt
  - Particles generated by drive belt wear
  - Internal cooling fans distributed particles within tool
The same 150mm tool

Problem was so acute that particles were visible to the naked eye
The same supplier’s 200mm tool

- 150mm design problem transferred to 200mm tool

Wafer handler

Cooling fan

Drive belt
AMD Fab 30:
“Single Wire SMIF” requirements were ENFORCED

Equipment Supplier responsible for Tool, SMIF, AutoID

GEM Link covers
• Equipment
• SMIF
• AutoID

AutoID Link

Type 1

Equipment Supplier responsible for Tool & SMIF, only partly for AutoID Integration

GEM Link covers
• Equipment
• SMIF

AutoID Link

Type 2

Equipment Supplier responsible for Tool only

SMIF Link

GEM Link covers
• Equipment

Type 3
AutoID: An **essential** piece of the puzzle

**Typical scenario used in wafer manufacturing**
- Carrier delivered to process or metrology equipment
- Equipment reads CarrierID and sends to host
- Host verifies CarrierID and identifies job to perform on material and data collection plan
- Host sets up data collection event reports on equipment
- Host selects recipe on equipment
- Host initiates processing
- Equipment processes material and sends collection events to host, including context information
- Equipment completes processing
- Carrier removed from equipment

**AutoID helps prevent misprocessing**
AMD Fab 30
General SMIF/MENV Experiences

• Fab 30 SMIF/MENV systems had the best yield ramp AMD has ever seen due to excellent MENV functionality, cleanliness and reliability
• Didn’t happen by accident - SMIF/MENV procurement and qualification was planned, monitored and controlled (i.e. “managed”)
• Industry knowledge of SMIF/MENV has increased but there are still problems - equipment suppliers need to be educated
• Equipment suppliers were made responsible for MENV design and load port integration
• Equipment suppliers should contract SMIF/MENV specialists for design and validation
• Non-SMIF tools are a contamination risk
Third Party MENV Integration

- Equipment suppliers have limited MENV design experience
- Recommend third party MENV design specialists to suppliers
- Test early to allow time for corrective action & retest
  - Cheaper to correct design issues before tool shipment!

Avoid the pitfalls of learning from first principles

Leverage wafer manufacturing lessons learned
Third Party Certification

- Use qualified independent contractors for MENV certification
- Source inspection (MENV design qualification)
- On-site acceptance test
- Contractors must have experienced personnel and sufficient test equipment
- Need comprehensive test methodology
- Require a detailed test report (makes redesign and further issue investigation very easy)

Avoid the pitfalls of learning from first principles

Leverage wafer manufacturing lessons learned
SMIF & MENV Lessons Learned

• MENV procurement must be planned, monitored and controlled (i.e. “managed”)

• Industry knowledge of MENV control is increasing but there are still problems – equipment suppliers need to be educated

• Equipment suppliers should be responsible for overall MENV design & reticle load port and AutoID integration

• Equipment suppliers should contract MENV specialists for design and validation

• Third party certification required – MENV design qual and final acceptance
Automation Vision for the Mask Industry: Step-by-Step Approach Required

Automation Software

Step 1
Contract SECS/GEM Specialists

Step 2
SECS/GEM & PP-SELECT

Step 3
3rd Party Test

Step 4
3rd Party MENV Design Qual

Step 5
Add Recipe up/download
Add Recipe parameter control

Goals are Data Visibility and Control

SMIF & MENV

Step 1
Contract MENV specialists

Goal is Contamination Free Manufacturing

Add sensor alarms
(Could include in earlier step)

In-fab MENV Test

Add Recipe up/download

3rd Party Test

(must be of high quality)

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