

# ISMI Industry Briefing

## Next Generation Factory

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December 6, 2007

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# Agenda

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## Fab Transition Strategy

December 6, 2007, 3:30 – 5:30pm

- Introduction and Overview
- Next Generation Factory Vision
- ISMI/JEITA J300P Joint Directions
- 300mm Factory Simulation update
- 300mm Projects
  - Overview of 300mm projects supporting Next Generation Factory Vision
- 450mm Transition Program
  - 450mm Transition Strategy Program
  - 450mm Silicon Readiness
  - 450mm Interoperability Test Bed
  - 450mm Guidelines and Standards
- Questions & Answers

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# Introduction and Overview

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# Opening Comments

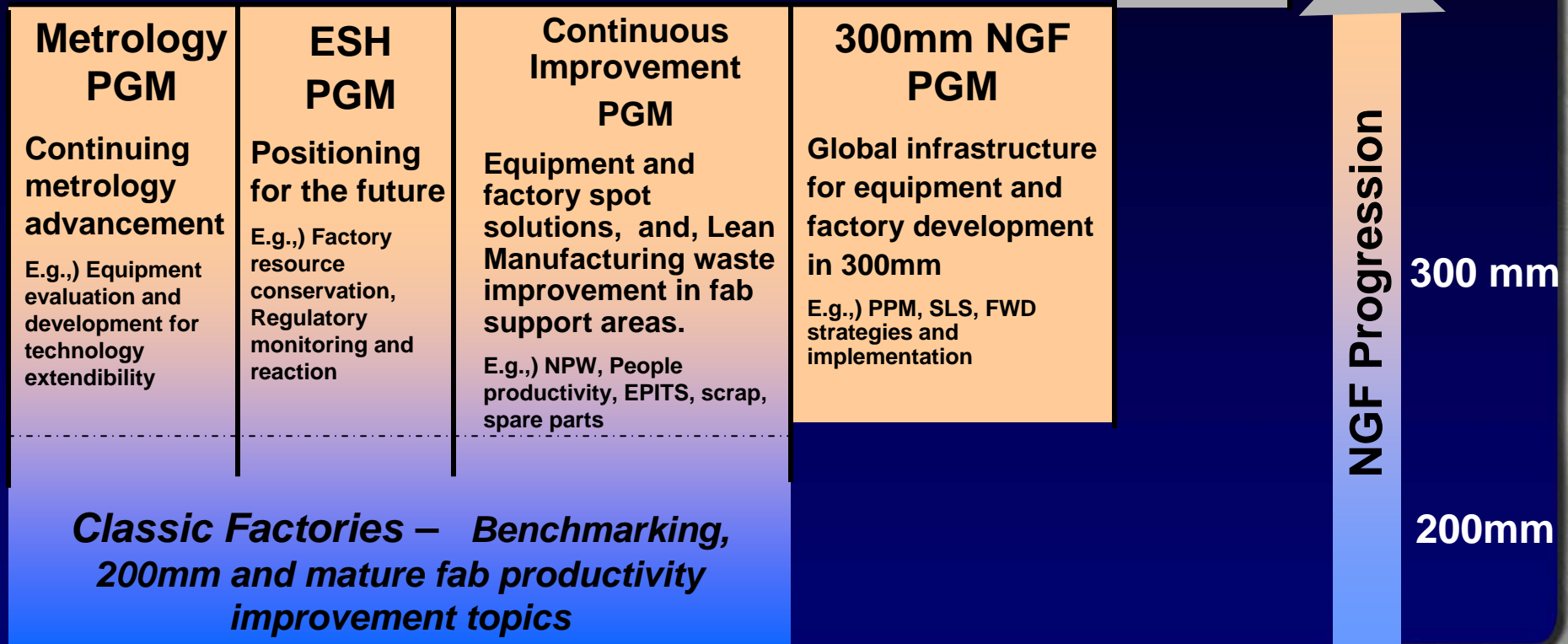
- ISMI member companies concur that major improvements in productivity are needed to sustain industry growth
  - 300mm fab productivity improvement is as important as the eventual transition to 450mm manufacturing
  - 300mm NGF improvement is a critical enabler to the 450mm transition
- Significant changes in business conditions and business needs have revealed limitations in existing 300mm designs
- ISMI is investigating various paths to achieve significantly higher manufacturing productivity in the near- and far-future

# Perspective on ISMI Direction

- ISMI has developed a comprehensive strategy for near- and long-term productivity improvements
  - Next Generation Factory Vision and Guidelines covers the continuum of existing and future fabs from 300mm to 450mm
- An analysis of potential 300mm improvements shows 300mm Prime has cycle time opportunity but falls short of the traditional cost reduction required to stay on Moore's Law.
  - Metric goal: 30% cost reduction and 50% cycle time improvement
  - The financial benefit of cycle time reduction is difficult to quantify for different business models
    - Faster new product introduction, time to money, faster product delivery to customers
- ISMI has developed a complementary forward-compatible approach of 300mm Prime to 450mm
  - Addresses the needs of our various member constituencies
  - Attempts to minimize the R&D expenditure by the industry
    - **Efficient use of industry resources is key**

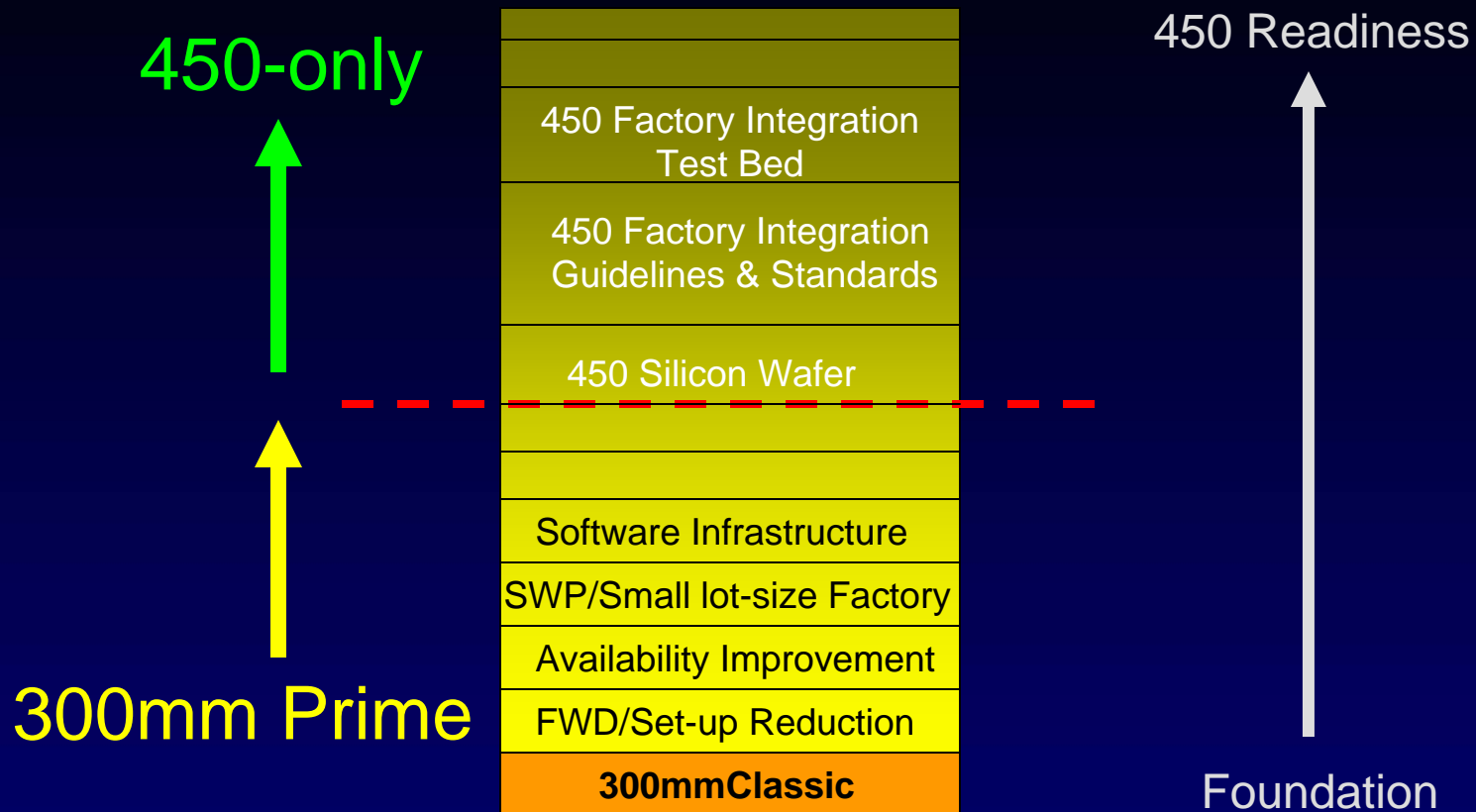
# NGF Fab Development and Improvement Activity at ISMI

## ISMI Programs



PGM = Program

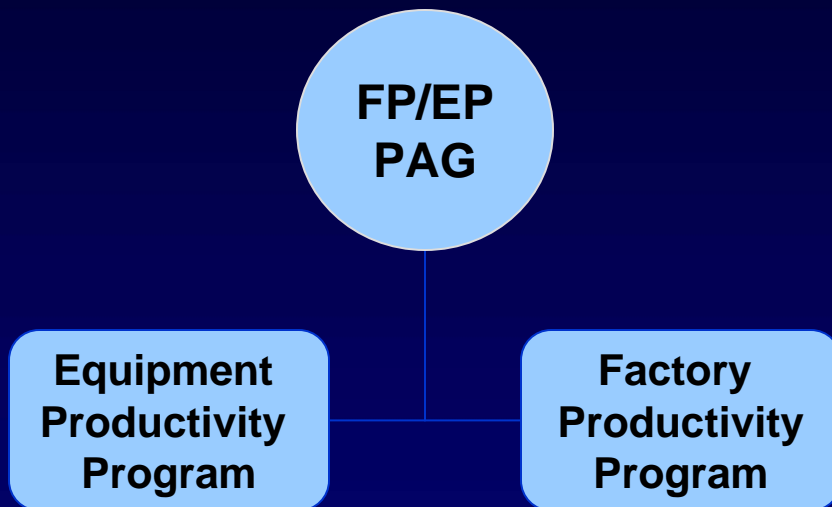
# Next Generation Factory Vision Realization



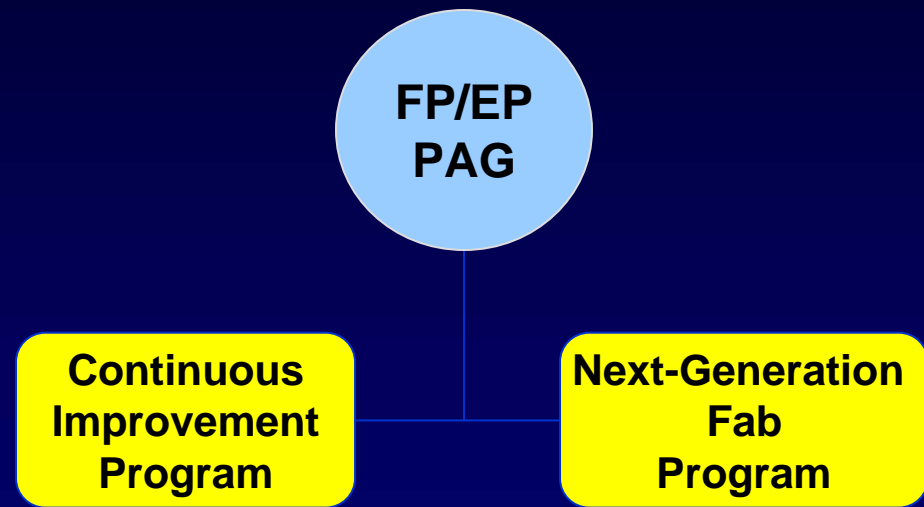
- ISMI is moving forward with complementary forward-compatible paths for 300mm Prime and 450mm
  - Realization of 450mm is built upon coordinated improvements from 300mmPrime and 450-only activities to efficiently utilize industry resources
- Collaboration is a critical success factor: Inside and Outside ISMI

# ISMI Program Structure Change

Old Structure  
2007



New Structure  
2008-



# ISMI Perspective on 300mm Prime

- In 2008, ISMI plans to have a dedicated Program to pursue 300mm improvements that offer near-term productivity benefits in cycle time and cost reduction.
  - Initial focus areas include:
    - Next Generation Factory Realization Project
    - First Wafer Delay/Set-up Reduction
    - Predictive Preventative Maintenance
    - Equipment Data Quality
    - Factory for Small Lot Size
  - Production equipment reliability is a key opportunity for continuous improvement

# ISMI Perspective on 450mm

- In 2008, ISMI will have a 450mm Program dedicated to moving ahead with 450mm industry capability.
  - New mission
  - New structure
- ISMI plans to pursue in 2008:
  - Availability of 450mm silicon wafers
  - 450mm Factory Integration Guidelines & Standards
  - Creation of a 450mm Factory Integration Test Bed
    - Interoperability testing of prototype automation and equipment interfaces

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# Next Generation Factory Vision

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# Next Generation ISMI Factory Vision Themes

## - Categories and boundaries for guidelines and standards

- 1. Process equipment shall be designed with an emphasis on elimination of all equipment-driven processing delays and per-lot overhead (including multi-lot batching)**
  - Enables rapid lot-to-lot setup/changeover at a competitive Cost of Ownership that is independent of lot size, with no negative impact to reliability
- 2. Process equipment and their supporting systems shall be designed to enable the realization of near-zero variability maintenance**
- 3. Next-generation equipment shall realize a significant reduction in the time required to install and qualify new toolsets, and shall be designed to reduce utilities and non-product wafer consumption.**
- 4. Process equipment shall have the ability to maintain continuous, real-time communication with host systems**
  - *Includes all tool-generated messaging (down to wafer level data), via standardized messaging formats and open architecture protocols.*
- 5. Flexible physical interfaces and wafer carriers, and high-speed, low variability AMHS that can cost-effectively support multiple operational models (including the potential for small-lot manufacturing)**
  - *Required to enable best-achievable equipment utilizations and yield*

 Process Equipment Themes

 Communication/Controls Themes

 Carriers/AMHS Themes

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# **“19 Point” Guidelines to enable Next Generation Factory Vision**

1. **Maximum 450mm carrier capacity and specification for early prototypes**
2. **Front Opening 450mm wafer carriers**
3. **Carriers Designed for efficient Purging with standardized purge locations**
4. **MHS Design to assume infrequent, anomaly manual handling only**
5. **Design allowing Automated reticle transport**
6. **Standardized interfaces - equipment mainframe:process chambers**
7. **Standardized locations for low-cost buffers on tools (beyond loadports)**
8. **Equipment to be Predictive Maintenance friendly**
9. **Equipment maintenance and operation in parallel**
10. **“Smart Idle” mode for equipment**
11. **Facility adaptor plates**
12. **Equipment First wafer delay reduction**
13. **Single Wafer or Mini-batch (vs. Batch) processing tools**
14. **Equipment design for flexible capacity increments**
15. **Enable Continuous processing of material**
16. **Wafer-level instruction at any time before processing**
17. **Single Point of Control for factory system command/control**
18. **Equipment to provide data to enable external monitoring**
19. **Carrier:Slot integrity flexibility**

**Carriers  
and AMHS**

**Equipment  
Design**

**Equipment  
Controls**

# ISMI Guideline Development Priorities

## 300mm

- Elimination of First Wafer Delay (#12) is the top priority guideline for 300mm NGF
- Predictive Maintenance (#8), Ability to perform Maintenance and Operations Simultaneously (#9), Continuous Operation (#15), and Equipment Engineering Data for Monitoring (#18) are important and with high benefit.

## 450mm

- Front-opening, 25 wafer, purge-able carriers (#'s1-3) are top priority for 450mm
- Elimination of First Wafer Delay (#12) is important and with high benefit
- 300mm equipment improvements and learnings expected to be applicable to 450mm

# Summary

- ISMI member companies concur that major improvements in productivity are needed to sustain industry growth
  - 300mm fab productivity improvement is as important as the eventual transition to 450mm manufacturing
  - 300mm NGF improvement is a critical enabler to the 450mm transition
- 300mm Prime has cycle time opportunities but does not sufficiently address cost reduction needs to replace 450mm transition
- ISMI has developed a complementary forward-compatible approach of 300mm to 450mm
  - Addresses the needs of our various member constituencies
  - Attempts to minimize the R&D expenditure by the industry
    - Efficient use of industry resources is key
- ISMI has developed common 300mmPrime / 450mm guidelines for productivity and cycle time improvement
- In 2008, ISMI will establish dedicated Programs with 300mm NGF productivity improvement and early 450mm infrastructure development

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**ISMI and JEITA  
J300P Joint  
Statement of  
Issues and  
Directions**

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# Joint Statement by ISMI and JEITA J300P for Current and Next Generation Manufacturing

J300P and ISMI have explored areas of mutual concern with existing 300mm Classic manufacturing and discussed issues expected with Next Generation Manufacturing. A number of high-level common issues and directions were shared by ISMI and J300P. This joint statement is intended to assist and guide the industry in understanding our initial common issues to be solved.

**Productivity increases in our current and future factories are expected to result from the reduction of wasted time that slows production. One example of time-waste is First Wafer Delay (FWD) consisting of the non-optimized overhead experienced by wafers between arrival and start of first processing. Set-up durations can also be time-waste with non-optimized preparation for process quality. More areas of waste (“Dandori”) are expected to be identified including logistical delays in lot movement within the factory. It is expected that suppliers will measure, reduce and design-out time-waste.**

**Predictable equipment availability is critical** for high-productivity factories. Preventive and predictive maintenance is a common goal that requires the development of a tool data, analysis and control infrastructure. **Equipment must be able to measure parameters and communicate them before analysis and action** can be taken. This infrastructure enables multiple tool improvement activities such as continuous improvement, reduction of required maintenance, predictive maintenance and waste reduction.

**ISMI and J300P will continue to discuss and exchange further areas of mutual concern to improve productivity in current and future factories.**

# Initial Joint Common Issues and Directions from ISMI and J300P

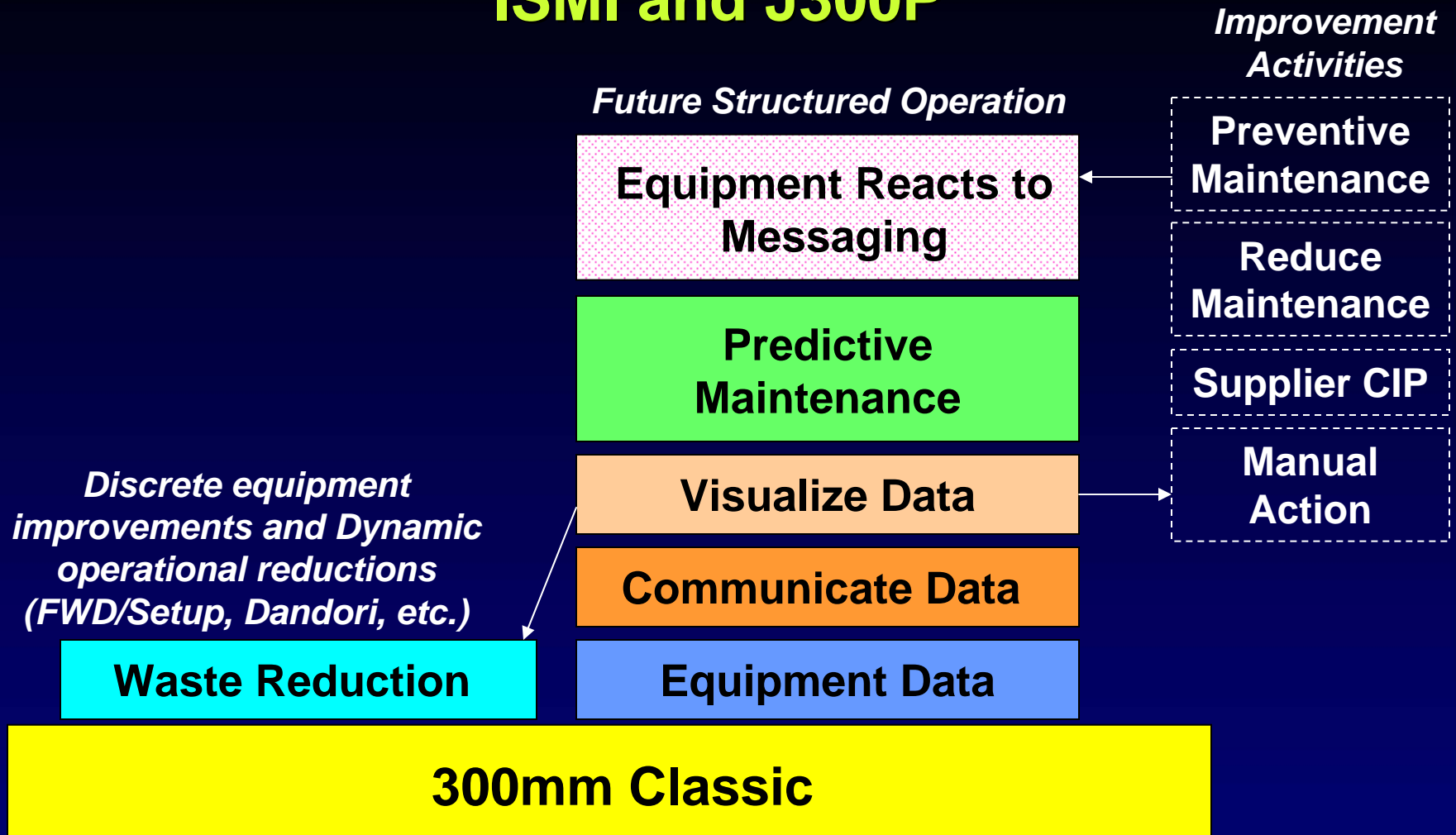
## 1. Reduce Time-Waste

- Measure, reduce and design-out unnecessary time-waste delays such as FWD, Set-up & other *Dandori* waste

## 2. Predictive and Preventive Maintenance

- **Equipment Data Contents**
  - Ability of equipment to accurately monitor/measure internal performance
- **Communicate Data**
  - Ability of equipment to provide a performance data stream (i.e. via Interface A) separate from tool control commands
- **Visualize Data**
  - Performance data must be processed or analyzed for interpretation
- **Predictive Maintenance**
  - Avoid unexpected equipment downtime by proactive action to failure prediction
- **Reduce Maintenance**
  - Data enables continuous improvement of maintenance durations, frequency
  - Eliminate root cause of failures
- **Equipment Reacts to Messaging**
  - Messages sent from factory control system allow wafer-level equipment operation and control

# Initial Joint Common Issues and Directions by ISMI and J300P



- Common directions built on 300mm Classic framework preparing for Next Generation Manufacturing

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# 300mm Factory Simulation Update

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Associate Director - ISMI

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# Outline

- **Background**
- **Hi-Mix Assumptions, Results and Observations (1H 07)**
- **Enhanced Hi-Mix Assumptions, Results, and Observations (2H 07)**
- **Summary**

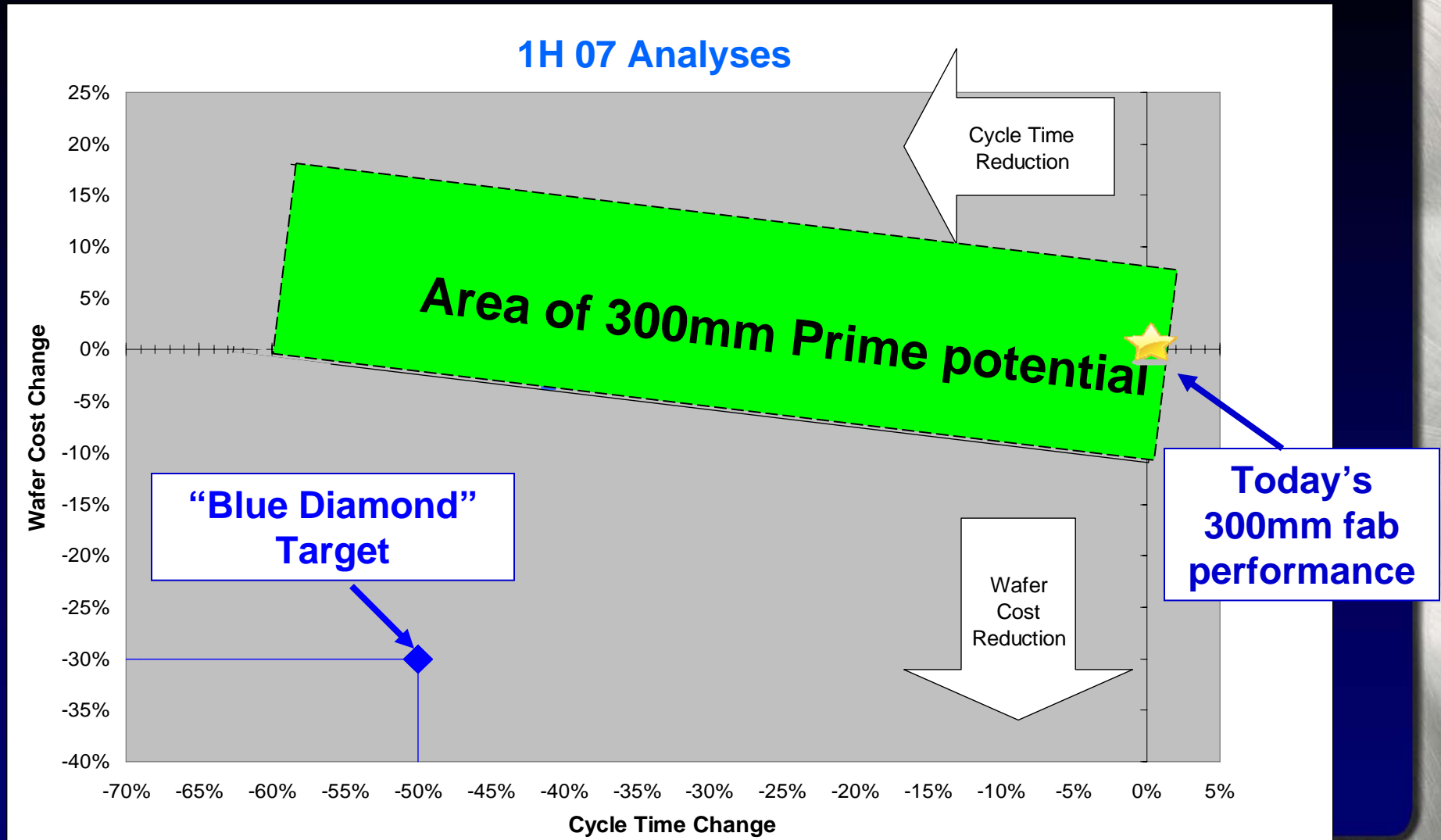
# “Blue Diamond” Background – 1H 07

- 30% reduction in cost per area and 50% reduction in cycle time were set as the targets for 300mm Prime
- Determine whether 300mm Prime can be expected to deliver 30% cost reduction and 50% cycle time (Blue Diamond Analysis)
  - 450mm could move out to an intermediate timeframe based on expected benefit of 300mm Prime
  - OR
  - Accelerate 450mm planning and development
- 300mm Prime analyses performed
  - >130 full factory simulations analysis
    - Over 10,000 hours computing time
  - Static factory and economic modeling

# Simulation Variables

1. Lot size
2. Cascading
  - Cascading reduces the frequency of setups and FWDs
  - A trade-off of cascade size and frequency of setup and FWD can be exploited
3. Equipment Availability is key to reducing cycle time
  - Equipment Availability has a larger effect on cycle time than other equipment improvements modeled
4. Single Wafer Processing (SWP)
  - SWP can improve cycle time by eliminating the need to wait to form a batch
  - Economies of batching are traded for cycle time reduction (Cost of SWP equipment must be considered)
5. Product Mix
  - Increased product mix drives an increase in setup and first wafer delays
6. Reducing First Wafer Delay (FWD) and Setup
  - Reductions in FWD and setups drive reductions in the need for cascading as the non-productive time and cycle time are reduced
7. Additional Equipment

# 300mm Prime - Cycle Time vs. Wafer Cost View



- Best-case 300mm Prime wafer cost savings modeled are <10%
- Cycle time reductions >50% modeled but may drive higher wafer cost

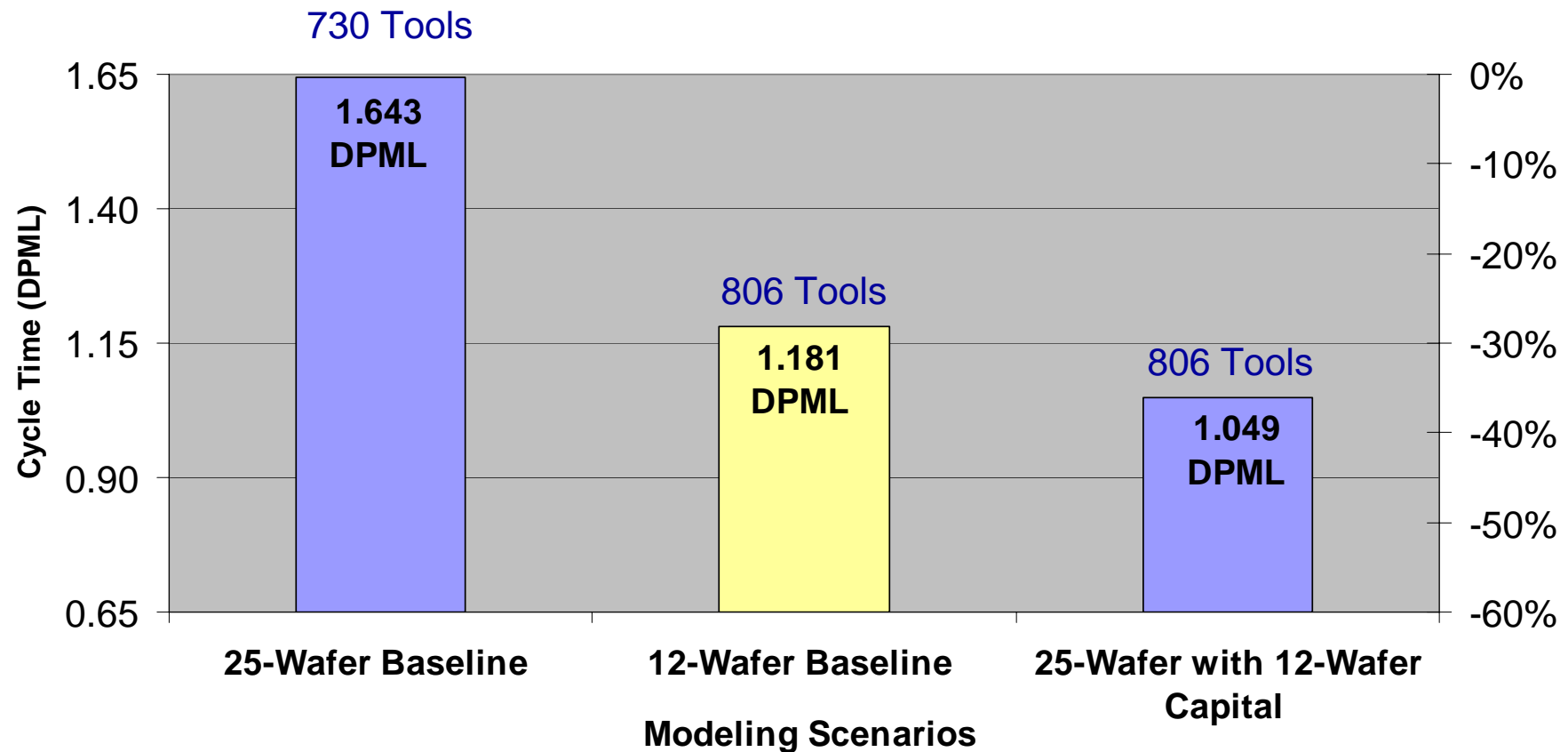
# Blue Diamond Analysis Note:

- **Factory Simulations shown earlier were based on 25-wafer carrier/lot size**
  - **Early 12-wafer simulations indicated dependence on equipment improvements to maintain equal factory capacity**

# 1H07 High-Mix 25 and 12-Wafer Comparison Results

## 1H 07 Analyses

### High-Mix 25 to 12-Wafer Comparison Scenarios Cycle Time Impact Summary



More equipment capital \$ required for the 12-wafer model which provided 28% improvement in cycle time. Using equivalent capital in the 25-wafer model provided a 36% cycle time improvement

# High-Mix Observation

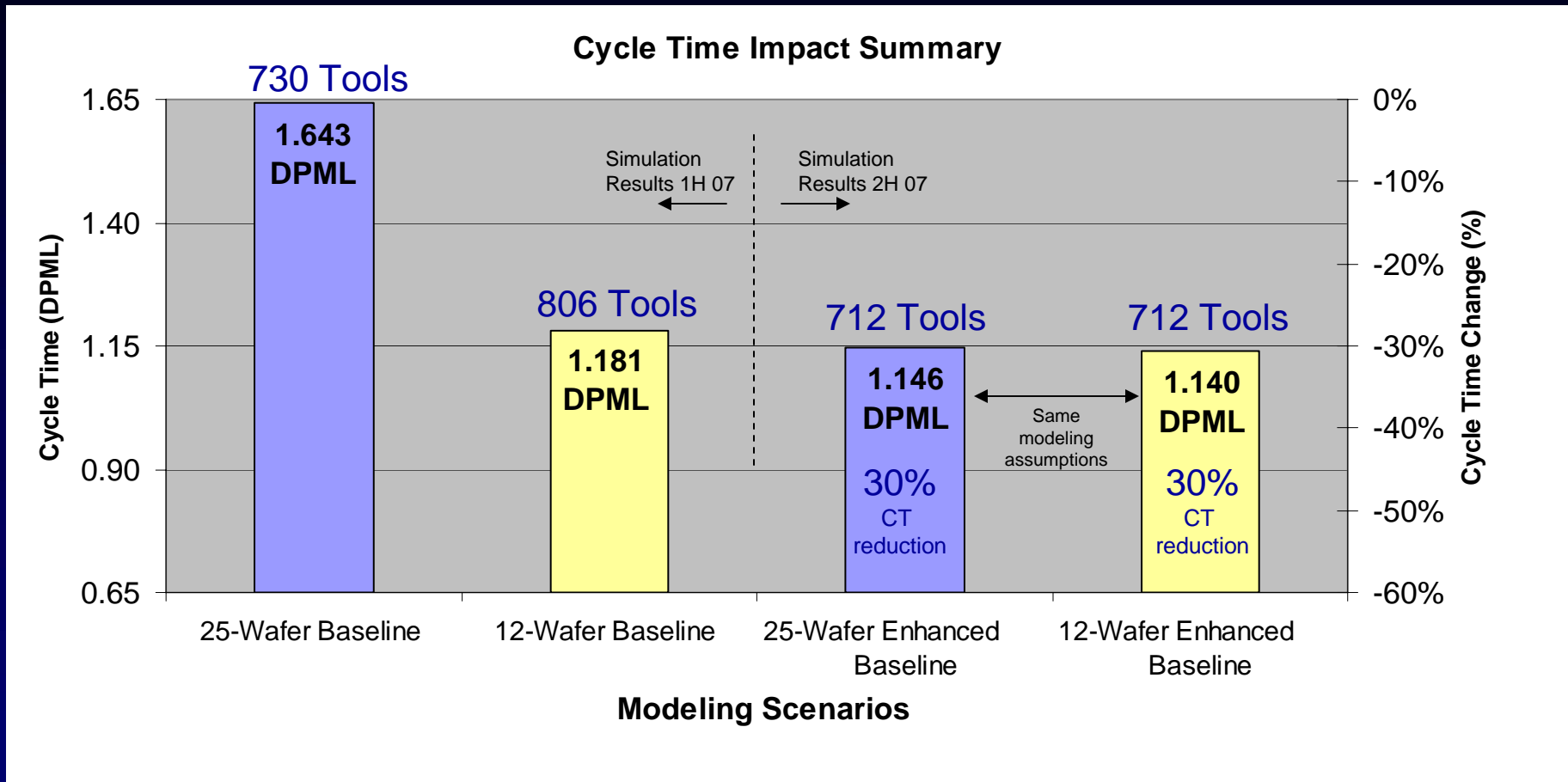
- Without equipment improvements 12-wafer lot size factories required more equipment to produce the same output due to the increased frequency of setups and First Wafer Delay's

The following slides show additional analyses  
(2H07)

# Enhanced Hi-Mix Scenarios - 2H07

- Enhanced Baseline Assumptions
  - Dynamic cascading rules depending on product volume
  - Equipment improvements
    - 5% equipment availability improvement
    - 25% FWD and setup improvement
- Enhanced Hi-Mix Scenario Results
  - Constant tool count for 25 and 12-wafer models
  - Improved cycle time

# 2H07 Enhanced High-Mix 25 and 12-Wafer Comparison Results



DPML: Days per Mask Layer



# Enhanced Hi-Mix Observations

- Ways to achieve cycle time reduction
  - Increased capital expenditure (tools, upgrades)
  - Changing operating variables
    - Equipment Utilization
    - Buffering / Cascading / Batching
    - Equipment Availability, Reduction in FWD/Setup

Productivity improvements can result in comparable cycle time for both 25 and 12 wafer lot sizes

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# 300mm Projects for Next Generation Factories

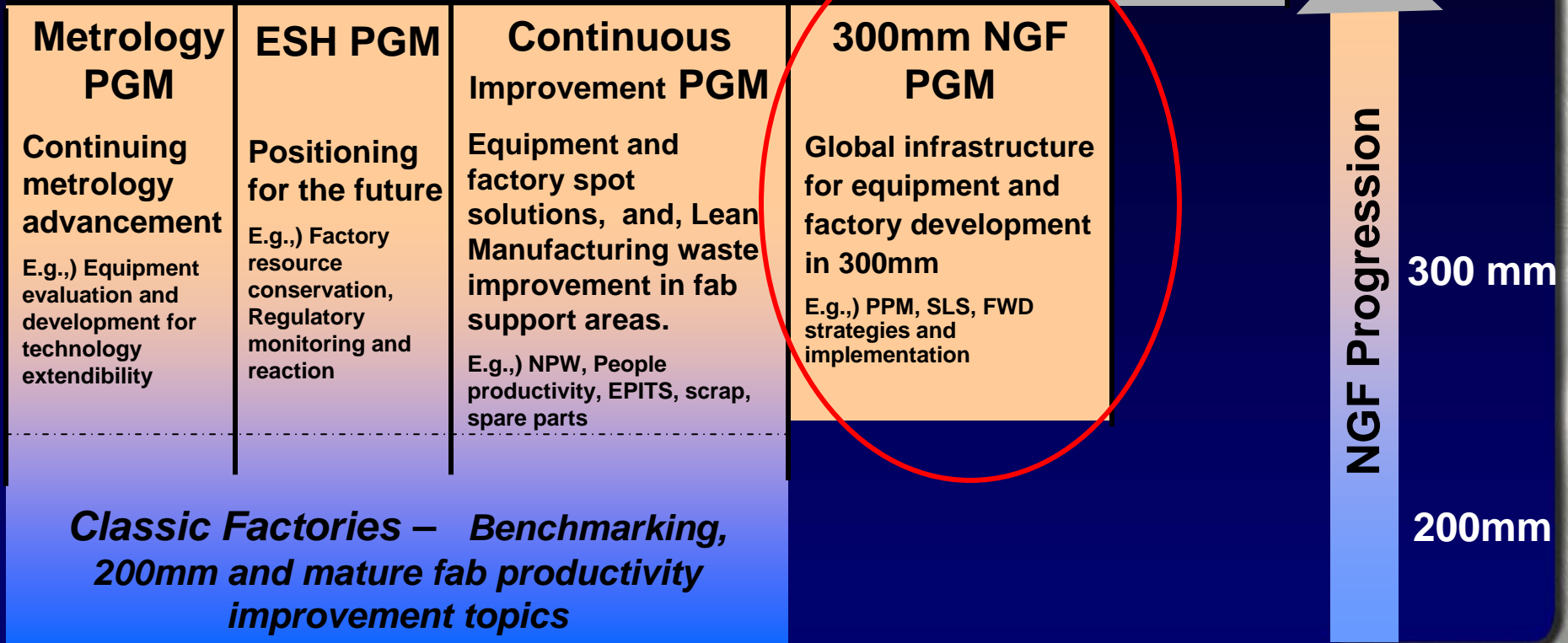
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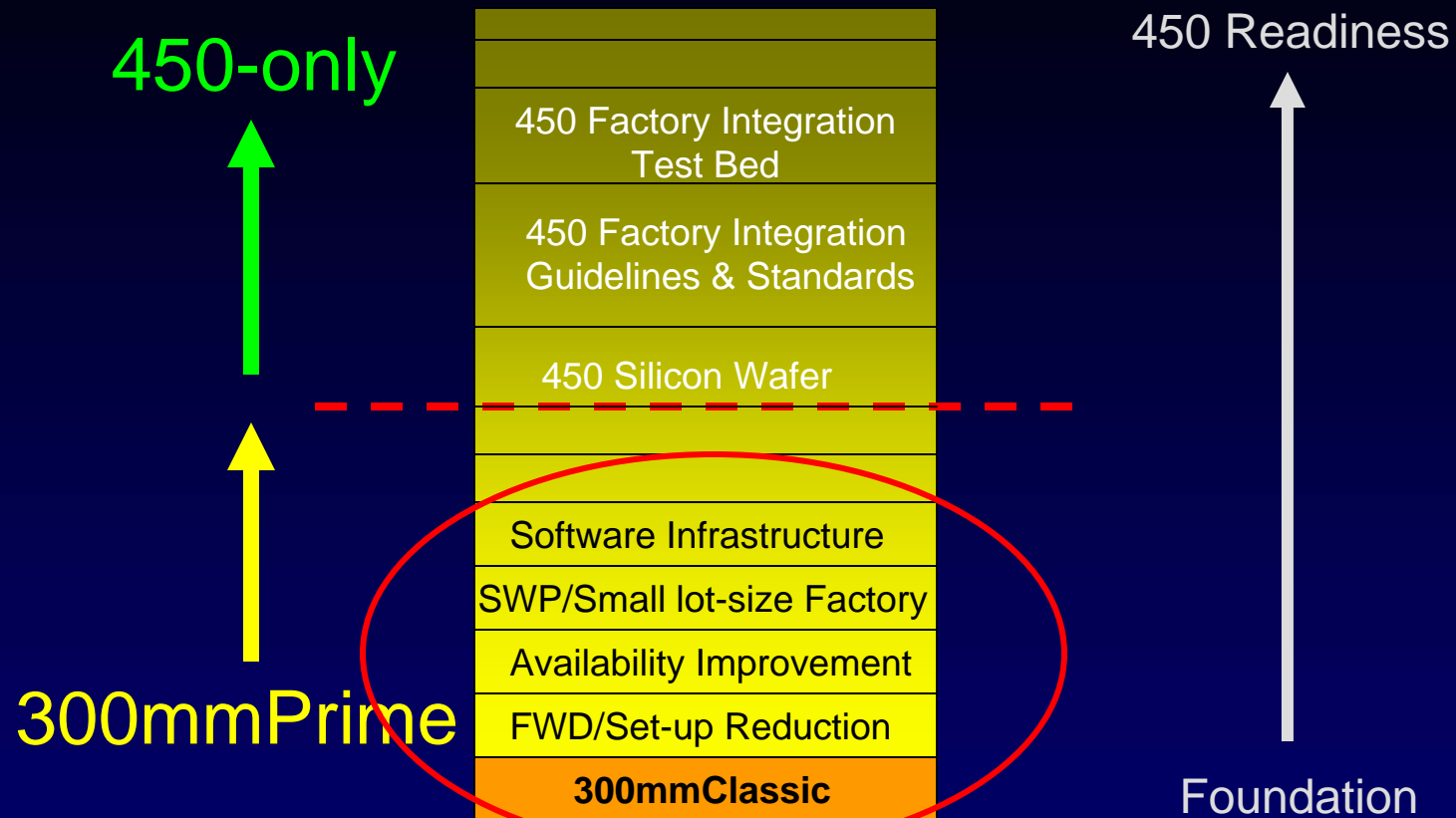
# NGF Fab Development and Improvement Activity at ISMI

## ISMI Programs



PGM = Program

# Next Generation Factory Vision Realization



- ISMI is moving forward with both complementary forward-compatible paths for 300mmPrime as well as 300mm continuous improvement projects
- **Collaboration is a critical success factor: Inside and Outside ISMI**

# ISMI Approach on 300mm Prime

- ISMI plans to pursue 300mm improvements that offer near-term productivity benefits in cycle time and cost reduction.
    - Aimed at realization of Common Guidelines
    - Prioritize implement able designs to existing factories.
  - Initial focus areas include:
    - First Wafer Delay/Set-up Reduction
    - Predictive Preventative Maintenance
    - Equipment Data Quality
    - Factory for Small Lot Size
- Production equipment reliability is a key opportunity for continuous improvement

# ISMI 300mm Projects

## - First Wafer Delay (FWD)/Setup Reduction

***Objective*** : Reduction in the time between the delivery of a lot to a process tool and the time the first wafer begins processing

- Member company consensus of the tools that offer the greatest potential improvement
- Pareto tools with longest FWD and Setup Delays
- Supplier engagement to identify root causes and development of improvement plans
- Target solutions that are economically viable

# ISMI 300mm Projects

## - Predictive, Preventative Maintenance (PPM)

***Objective : Establish member company requirements, guidelines, and feasibility for the use of data to improve equipment availability and productivity through PPM***

- Define member company requirements for both on-board and off-tool equipment PPM capabilities
- Define factory and equipment data required for PPM
- Engage equipment and software suppliers to implement and demonstrate selected PPM capabilities
- Champion and promote the adoption and implementation of PPM methods for the industry

# ISMI 300mm Projects

## - Equipment Data Quality

**Objective : Establish member company requirements, guidelines, and best practices for availability/delivery of high quality data. Identify, select, and address top issues**

- Define member company consensus requirements, scenarios, methods, and best practices
- Champion a data quality SEMI standard
- Develop data quality evaluation method
- Demonstrate selected supplier data quality improvements
- Demonstrate benefits of fab-wide time synchronization
- Educate industry to accelerate the adoption of data quality / time synchronization requirements

# ISMI 300mm Projects

## - Factory for Small Lot Size

**Objective : Define the equipment and manufacturing systems impacts, capabilities, user requirements, member company consensus guidelines, standards, usage scenarios and test criteria required to enable small lot size for hi-mix or accelerated Cycle Time factories**

- Establish consensus vision/requirements for small lot size factory: equipment, transport, factory systems, operations
- Create fab behavior models to identify and prioritize system wide impacts and opportunities
- Engage in feasibility studies, prototypes, and pilots for the challenge points including the creation of a test bed virtual fab
- SEMI standards development as required

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# **ISMI 450mm Program Update**

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# ISMI Perspective on 450mm

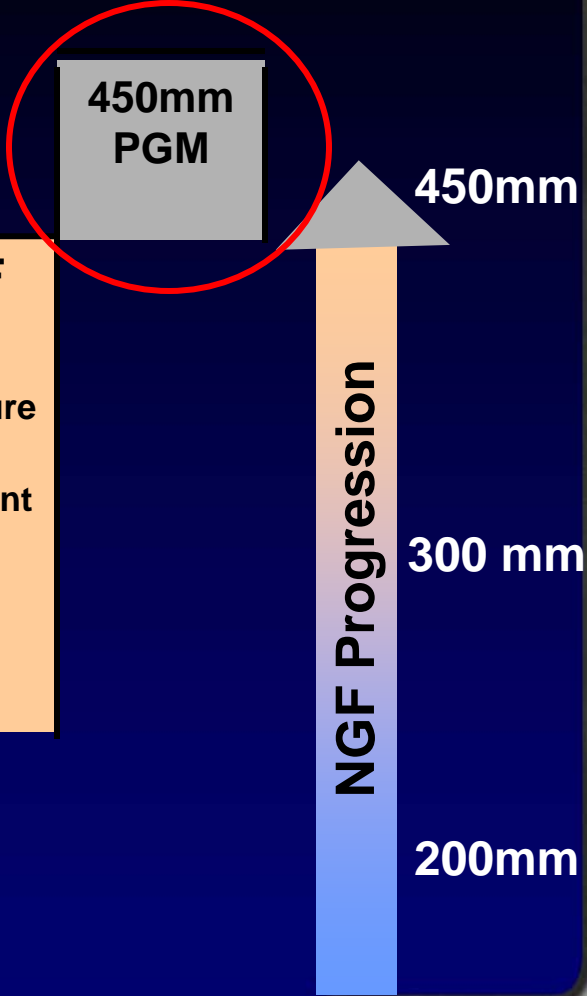
- ISMI will initiate a 450mm Program dedicated to moving ahead with 450mm industry capability.
  - New mission
  - New structure
- ISMI plans to pursue in 2008:
  - Availability of 450mm silicon wafers
  - 450mm Factory Integration Guidelines & Standards
  - Creation of a 450mm Factory Integration Test Bed
    - Interoperability testing of prototype automation and equipment interfaces

# NGF Fab Development and Improvement Activity at ISMI

## ISMI Programs

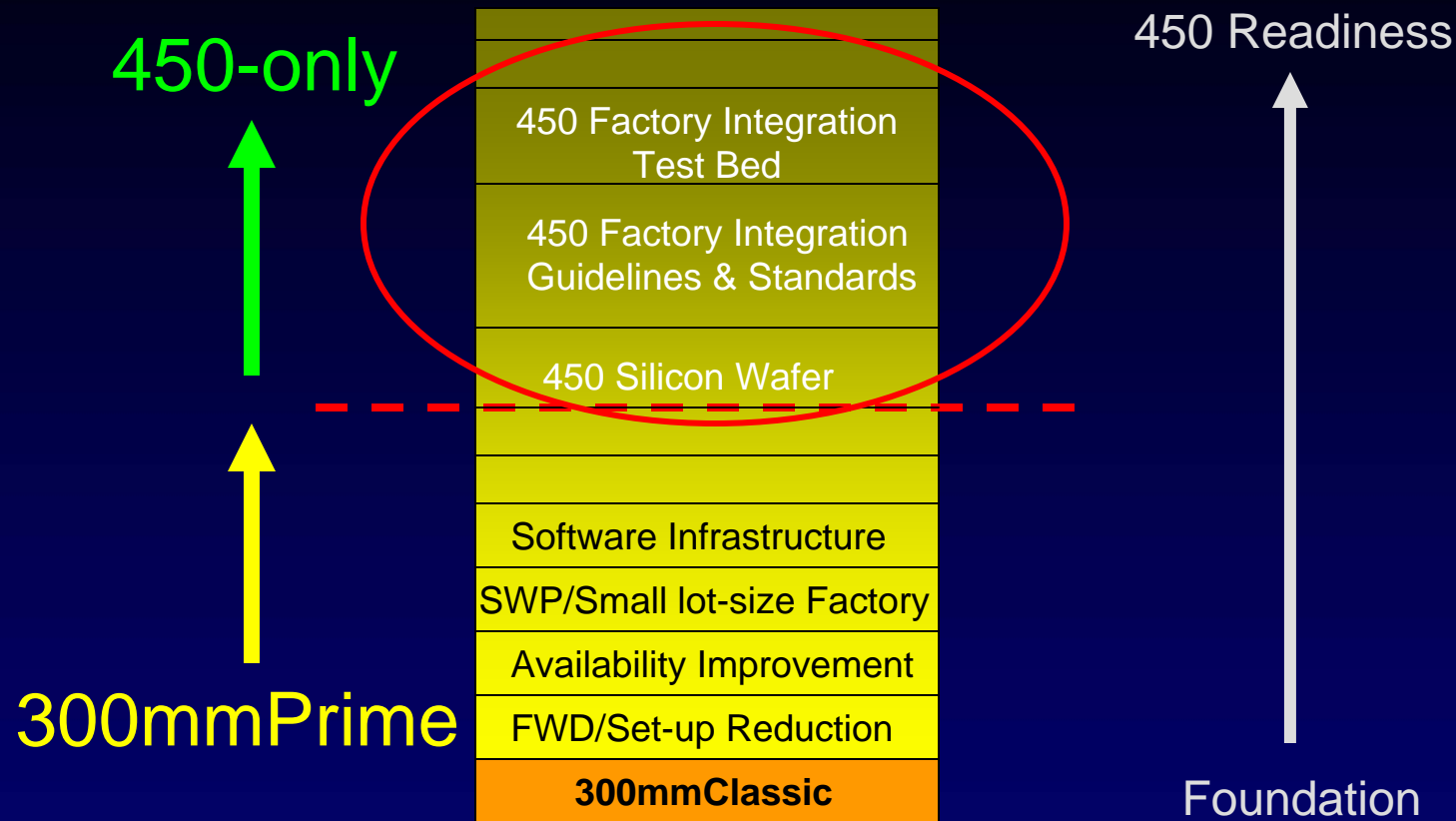
<p><b>Metrology PGM</b></p> <p>Continuing metrology advancement</p> <p>E.g.,) Equipment evaluation and development for technology extendibility</p>	<p><b>ESH PGM</b></p> <p>Positioning for the future</p> <p>E.g.,) Factory resource conservation, Regulatory monitoring and reaction</p>	<p><b>Continuous Improvement PGM</b></p> <p>Equipment and factory spot solutions, and, Lean Manufacturing waste improvement in fab support areas.</p> <p>E.g.,) NPW, People productivity, EPITS, scrap, spare parts</p>	<p><b>300mm NGF PGM</b></p> <p>Global infrastructure for equipment and factory development in 300mm</p> <p>E.g.,) PPM, SLS, FWD strategies and implementation</p>
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*Classic Factories – Benchmarking, 200mm and mature fab productivity improvement topics*



**PGM = Program**

# Next Generation Factory Vision Realization



- ISMI is moving forward with both complementary forward-compatible paths for 300mmPrime as well as 300mm continuous improvement projects
- Collaboration is a critical success factor: Inside and Outside ISMI

# 450mm Program Structure for 2008

## 450mm Transition Program (Exclusive 450mm Focus)

Si Wafer Readiness

Factory Integration Guidelines and Standards

Factory Integration Interoperability Test Bed

# 450mm Transition Program

**2008 Objective:** *Coordination and support of 450mm transition projects and strategic industry activities*

## Goals

- Timely and open communication with suppliers and at industry forums
- Active supplier engagement with ISMI (Test Bed, silicon readiness, guidelines)
- Coordinated industry standards activities (SEMI MTF, PEA, standards, ESG, etc.)
- Ongoing economic monitoring responsive to changing industry dynamics for 450mm
- Clear understanding of 450mm ESH challenges

# 450 mm Silicon Wafer Readiness Project

**2008 Objective:** *450mm wafer availability to enable 450mm development*

## Goals

- Validation of 450mm handling wafer & process test grade wafer assumptions
- SEMI 450mm silicon handling wafer & process test grade wafer standards
- Assessment of technical feasibility, supplier commitment, and implementation plans for silicon, inspection and silicon manufacturing infrastructure
- A supply of functional 450mm silicon handling test wafers

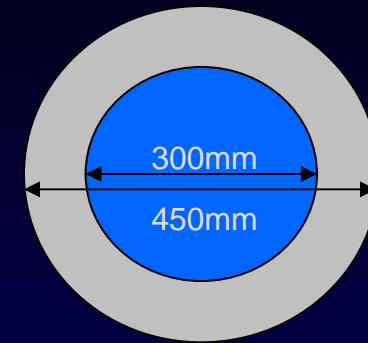
# 450 mm Handling Wafer Standardization

- Goal is to limit changes from 300mm wafer as much as possible
  - ❖ Thickness is a critical decision
  - ❖ Notch is likely for 450mm wafer
  - ❖ Wafer diameter tolerance may reduce
- 450mm wafer assumptions require validation and feasibility studies by silicon suppliers
- Edge profile may need to be standardized for 450mm
- Shippers/Carriers for 450mm wafers need to be standardized in the near term

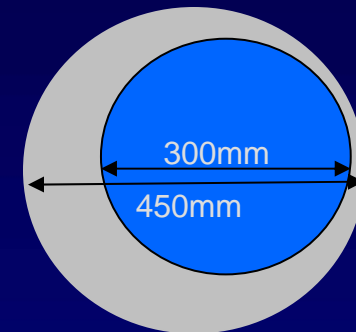
# Sintered Wafer Strategy

- Sintered silicon ingots and wafers have been developed to jump start the 450mm manufacturing activities
  - Can reduce the silicon manufacturing learning curve
  - Can provide wafers with the mechanical and optical characteristics for wafer carrier, automation and OEM development work
- Hybrid test wafers will supply material for characterization equipment development and provide OEMs with preliminary wafers for process development
- Sintered and hybrid silicon wafers are not replacement of single crystal silicon wafers required in IC manufacturing.

## Hybrid test wafers



concentric



eccentric

# Wafer and Manufacturing Equipment Infrastructure Status

- The silicon suppliers infrastructure (pullers, crucibles, DSP polishers..) is moving toward 450mm support. The characterization equipment is still lagging behind.
- Mechanical test wafers (sintered) have been manufactured starting H2/06 and CZ single crystal pulling feasibility studies were completed.



# 450mm Factory Integration Guidelines and Standards

**2008  
Objective:**

*Timely creation of testable Next Generation Factory Architecture guidelines and standards to accelerate 450mm*

## Goals

- “Rev. 2” level detail of the Unified Guidelines which comprehend and identify needed 450mm FI standards
  - e.g., Carriers, Shipping Boxes, Load Ports, Equipment Platforms, AMHS, etc.
- Defined tests and evaluation of early prototypes in support of ISMI 450mm Test Bed for interoperability and standards development
- Factory integration standards coordinated in timeframe required for 450mm early adopters

# Guideline Development Approach

## Motivation:

The current version of the 19 point guidelines have varying degrees of maturity/detail. Assessing current level of detail is a critical next step to enable suppliers to begin development and implementation of solutions

## Approach:

1. Establish the current level of maturity/detail for each guideline
2. Define the required end-state level of detail for each guideline.
3. Prioritize guidelines via survey inputs to understand where to focus work
4. Qualitatively estimate scope/content for top priority guidelines

# ISMI 450mm Guideline Development Priorities

- **Front-opening, 25 wafer, purge-able carriers (#'s1-3) are top priority for 450mm**
- **Elimination of First Wafer Delay (#12) is important and with high benefit**
- **300mm equipment improvements and learnings expected to be applicable to 450mm**

# 450 mm Factory Integration Test Bed Project

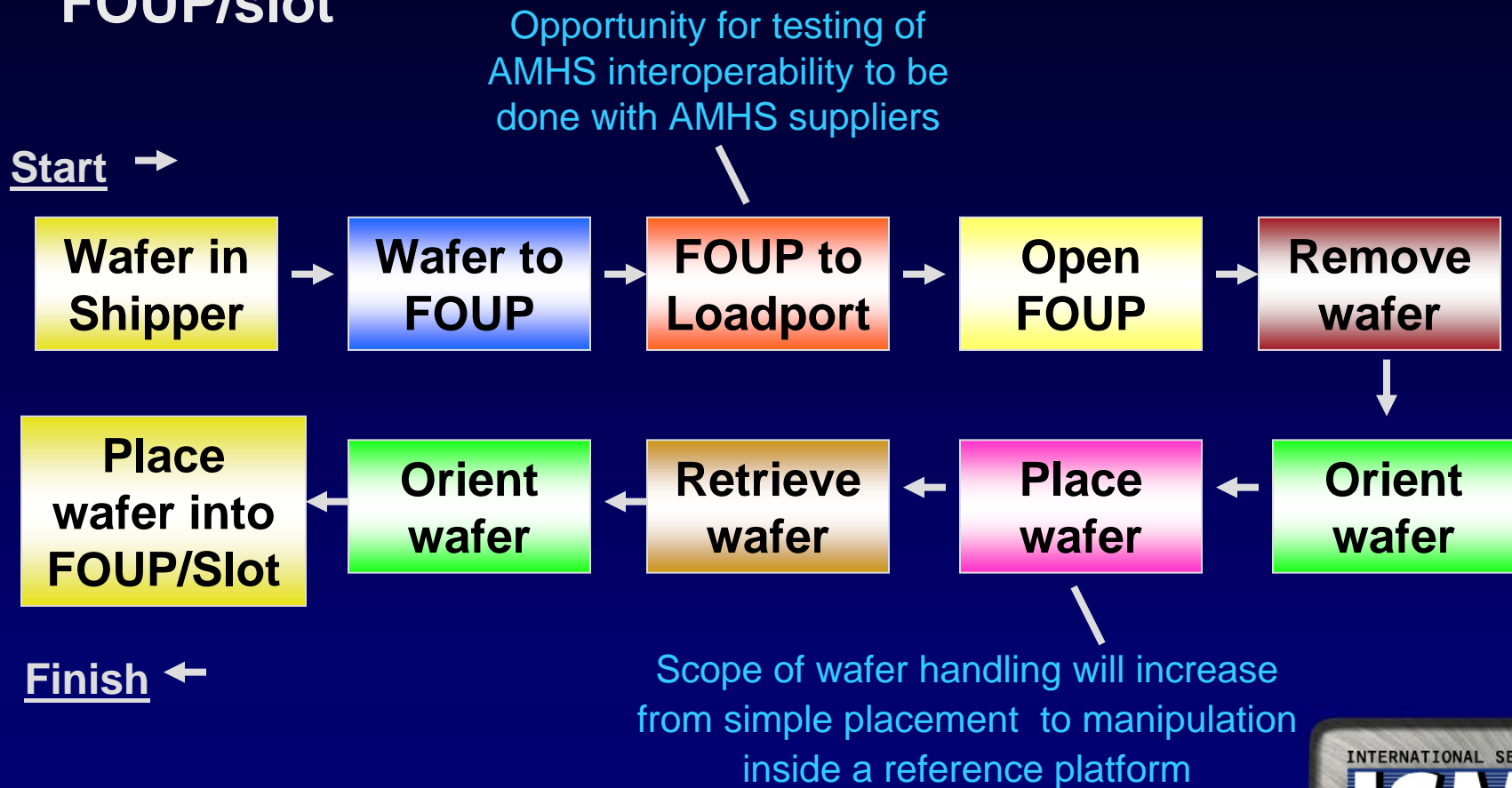
**2008**  
**Objective:** *Prototype Testing of 450mm Factory Integration Interoperability Challenges*

## Goals

- Prototype 450mm equipment developed for testing by Carrier, Loadport/EFEM, Equipment Mainframe, and AMHS suppliers
  - Equipment integrated and demonstrated/tested at ISMI facility
- Test plans defined, planned, and executed for key 450mm technical challenges
- Defined 450mm factory integration requirements supported by structured testing and evaluation
  - E.g., Carrier wafer support, wafer pitch, wafer handling, purging/sealing, reference platform interface standardization,, etc.
- Standards activities enabled by published low-level testing results and learnings

# 450mm FI Test Bed Approach

- Demonstrate and identify challenges moving silicon from shippers through an EFEM returning to a desired FOUP/slot



Suppliers are encouraged to participate in Test Bed activities

# Next Steps for ISMI

- Meet with interested suppliers to discuss 300mm and 450mm implications & opportunities
- Continue development of Next Generation Factory Guidelines for more detailed level guidance & global perspective

*Proceed consistent with the principle that 300mm Prime is a productivity continuum to 450mm*

# In Conclusion

- **ISMI member companies concur that major improvements in productivity are needed to sustain industry growth**
  - 300mm fab productivity improvement is as important as the eventual transition to 450mm manufacturing
  - 300mm NGF improvement is a critical enabler to the 450mm transition
- **300mm Prime has cycle time opportunities but does not sufficiently address cost reduction needs to replace 450mm transition**
- **ISMI has developed a complementary forward-compatible approach of 300mm to 450mm**
  - Addresses the needs of our various member constituencies
  - Attempts to minimize the R&D expenditure by the industry
    - Efficient use of industry resources is key
- **ISMI has developed common 300mmPrime / 450mm guidelines for productivity and cycle time improvement**
- **In 2008, ISMI will establish dedicated Programs with 300mm NGF productivity improvement and early 450mm infrastructure development**

Questions ?

# For more Information...

This presentation material will be made available for download at the SEMATECH public website:  
[www.ismi.sematech.org](http://www.ismi.sematech.org)

To initiate individual discussions with the ISMI Team, please contact:

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