Big Data to Manufacturing Excellence

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Big Data to Manufacturing Excellence

• Lean Operation
• Precision Process Control
• Intelligent Fab Operation

Big Data • Machine Learning • Pattern Finding • Predictive Analytics • Self Diagnosis • Auto Control • Intelligent Fab
Big Data to Manufacture Excellence

Lean Operation

• Cycle Time Reduction
  – Wait Time Waste
  – Virtual Metrology

• Scheduling Modeling for Flexible Demand/Capacity/Pull-In
  – Lean WIP & Precision Integrated Scheduling
  – PHM (Prognostics and Health Management)
Big Data to Manufacture Excellence

Process Precision Control

• Fast Yield Learning
  • Thorough Database of Developing Phase
  • Yield Mining

• Stable Manufacturing
  • Tool/Chamber Matching
  • Intelligent APC & AEC
  • Precision Key FDC
Big Data to Manufacture Excellence

Intelligent Fab Operation

• Fully Automation
  • Equipment/Dispatch/Transportation/Materials Automation
  • Fully Equipment Remote Control System
  • Auto-Handling of Tuning/Abnormality

• Engineering Efficiency
  • Auto Image Pattern Recognition
  • Smart Diagnosis by Machine Learning
  • Smart App/Dashboard
Summary

• Key success factors to manufacturing excellence
  • Internal requirements
    • Align value & vision, do the right thing.
    • Top down & determination
    • Cross-division cooperation
  • External resources
    • Cross-field data scientists
    • Tool / Raw material suppliers software & hardware integration
    • Open source / data scientist society
    • University, consultants, software vendors, etc.
Thank You!
Wait Time Waste Basic Definition

Arrive → Prepare → Job in → Job out → Finish

Transportation→ Process Unit

Lot Level → Wafer Level

WTW

Lot Processing

Wait → Active

All Yellow segments are our Opportunities

For tool to tool delivery these time elements have 0 time

Existing

2013

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WTW Data Visualization

Leverage Productivity

WTW Dashboard

◆ Lemon tool “idle season trigger timing” is shorter than others.
WTW Data Visualization

Leverage Cycle Time

Transportation:
- Reduce variation of transportation time
- Improve AMHS

Theoretical Process Time:
- Multi-chamber processing
- Add extra load ports

Long distance transportation

• 1 chamber
• 2 chambers
• 3 chambers running in parallel
Integrate Demand & PM Schedule

- With demand forecast, we can
  - Integrate PHM prediction results to optimize PM schedule
  - Improve overall effective uptime

By Technology Node Daily Uptime Trend Chart

- High loading
- Low loading

Pull in PM to match demand (flow in prediction)
PHM Implementation Approach

Jay Lee & Edzel Lapira from IMS Univ. of Cincinnati, AMAT Nanochip Magazine, V6, issue 2, 2011
Yield Mining & Smart Diagnosis

1. **Bin group baseline monitor**
   - Long term baseline vs. short term difference test
   - High low / cluster analysis

2. **Wafer map analysis**
   - Pattern recognition
   - Auto clustering

3. **Inline Diagnosis**
   - Find data variation source

4. **EQ / FDC signal detection**
   - Find top N parameters

5. **Auto Notice Report:**
   - Bin Status Report
   - Bin/WAT/Inline Correlation Report
   - Inline Diagnosis Report
     - Top N EQ parameters

**Improve Engineering Efficiency**
Stable Manufacturing

- Feedback valuable experiences by models
- Current procedure
- Integrate information flow
  - CD, THK, WAT weak patterns, etc.
  - Weak patterns recognition

Vision cycle

- Data Analysis Teams
- Mask Engineering Service
- Production Team
- Lithography Engineering
- Auto recipes generation
  By ML models
- Auto recognize Metrology results
- Auto report generation
- Guide engineers setting recipes
- Auto data transform
- Manual recipes creation
- Auto report generation
- Passing data to systems
- Wafer map coordinates
- Manually handling

- Guide engineers setting recipes
RevSEM Productivity and Manpower Improvement

- RevSEM productivity >30%
- Reduce operation manpower >28%

Graph showing productivity and man-machine ratio over time with key elements indicated:
- Continuous run
- Auto transfer Inspector data to RevSEM
- Auto dispatch
- ADC (80%) for 2016 Q1
- ADC (95%) for 2018
Heterogeneous Image Pattern Recognition

- 100% sampling rate
- Real-time detection
- Support low yield case analysis
- Deep learning
- Structure learning

Virtual Image Derived from Tool Log

Real Wafer Image from Metrology Tool
Auto Measure Specific Pattern Size from SEM Images

- Image processing
- Machine learning

**Benefits:**
- Eliminate human measurement efforts
- Eliminate human errors
- Improve measurement speed:
  - Several hours → several minutes per wafer
- Reduce die-to-database tool requirements

*Auto repeat pattern measurement*