智慧製造業研討會
製造業獲利升級，關鍵就在現場
IBM Microelectronics Manufacturing: Analytics and Big Data

IBM Global Business Services - Andrew Vogel
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Agenda

1) IBM Microelectronics strategy and approach

2) The importance of Analytics, and where Big Data fits in

3) Big Data use cases at IBM’s factories

4) Connection to larger strategy for manufacturing analytics
IBM Microelectronics – 300mm Semiconductor Development and Manufacturing at Fishkill, New York

- **Mission:** World-class semiconductor manufacturing and development in support of the production of leading edge technologies for IBM and our OEM partners.

- **Wafer Size:** 300mm diameter

- **Capacity:** 400-500 Wafer Starts per Day

- **Technology Nodes:** 130nm, 90nm, 65nm, 45nm, 32nm, 22nm, 14nm…

- **Facility:** $6B
  - $2.6B+ corporate investment
  - “One Factory” - technology development and manufacturing
  - ~850 state-of-the-art manufacturing and development tools

**Built upon three themes: Controls, Integration, Analytics**
Leading Edge Technology Challenge

Continual focus on yield learning, equipment efficiency, cycle time reduction
The analytics techniques used in IBM Microelectronics combine the best practices from different industries with semiconductor specifics.

Combination of:

1) IBM’s Big Data platform and 2) custom applications largely developed, built and driven by IBM Research expertise

- Leverages all data available in fab: logistics, metrology, inspection, test, tool sensors

Equipment Sensor Data

- Digital valve position
- Pressure Readings
- Mass Flow Controller Readings
- Chuck Spin Speeds
- Chem/Mech Polish Table Data
- ElectrodynamicChuck Parameters
- Temperature Probes

~10 Billion data points per day

Yield analysis routines

Identifies variables and provides prediction
Big Data supports future needs for Yield and Asset Management

**Traditional Fab Infrastructure**

- MES
- Recipes
- Automation
- Data collect

**Messaging Bus**

- FDC
- Reports
- SPC
- APC
- YMS

MES - Manufacturing Execution System

FDC - Fault Detection & Classification

SPC - Statistical Process Control

APC - Adaptive Process Control

YMS - Yield Management System
Big Data supports future needs for Yield and Asset Management

Current Scope

Advanced Capabilities

Stop bad product or tool

Univariable to Multivariable

Wafer / Lot Analysis
Single parameter trends

Data Mining

Enhanced Data Mining
Predictive Modeling
Automated Models

Virtual Metrology

Predictive Maintenance

Tool Sensor Diagnostics

“Big Data”

Current Scope

Advanced Capabilities

Stop bad product or tool

Univariable to Multivariable

Wafer / Lot Analysis
Single parameter trends

Data Mining

Enhanced Data Mining
Predictive Modeling
Automated Models

Virtual Metrology

Predictive Maintenance

Tool Sensor Diagnostics

“Big Data”
What does “Big Data” mean for electronics manufacturing today?

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<th>Big Data Challenges for the Factory</th>
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<td>• incomplete integration of analysis tools</td>
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<td>• speed / performance issues - DB, or analytics layer, or both</td>
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<td>• shortage of advanced math skills</td>
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<td>• inability to understand complex variable interactions</td>
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<td>• insufficient resources to review output manually</td>
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<td>• incomplete organizational knowledge of data structures</td>
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<th>Big Data Solution Requirements</th>
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<tbody>
<tr>
<td>• automation</td>
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<tr>
<td>• integration</td>
</tr>
<tr>
<td>• diagnostic &amp; predictive results</td>
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<tr>
<td>• modeling, simulation, optimization</td>
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<td>• speed, near real-time</td>
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<th>Big Data Focal Areas</th>
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<tr>
<td>• Product test data</td>
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<td>• Equipment sensor data</td>
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<td>• Asset optimization</td>
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<th>Big Data Methods</th>
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<td>• Streaming analysis</td>
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<td>• Sensor data analytics</td>
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<td>• Multivariate methods</td>
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Example: Big Data approach to the problem of large dataset analysis

**Traditional**

- **Tester**
- **Data Warehouse**
- **Large dataset retrieval**
- **Large analysis routine**
- **Review reports**

**Challenge:** Existing analysis methods struggle with current data volumes
- pulling and manipulating data takes too long
- thousands of charts and graphs that require manual review
- analysis may not be complete before product is shipped

**New approach**

- **Tester**
- **InfoSphere Streams**
- **Near real-time analysis**
- **Interactive review**
- **Model results in-memory**

“In-flight Analytics”
Partial Least Squares (PLS) model compares actual yield to previous results - analysis output highlights what has changed

Automated Streams solution:

- compares yield by test pattern to historical data
- identifies unusual yield behavior, based on multivariate model
- larger bars indicate larger deviation from historical yield
- has been used to immediately identify problems on leading edge of new production wafers
- problem identified before the first wafer had completed testing
- new data added to existing model and kept in memory for fast and easy analysis
Use Case: Sensor data analytics in IBM fab for yield and equipment control

- **Challenge**: maximize usefulness of tool sensor data for process engineers
  - huge volume of data (billions of points per day) with many subtle interpretations
  - large engineering team, with varying skills in analysis, statistics, data mining

- **IBM’s solution**: Tracer Tool applications for sensor data analytics
  - enables quick review of massive amounts of sensor data, in a simple dashboard
  - identifies tool issues and parameters that influence critical product measurements
  - uses several scoring algorithms, including advanced info theory to highlight relationships
  - ease of use, guides analyst to significant findings
  - fully automated, with linked reports for full drill-down capability

- **Benefits**: Documented savings > $13M during first two years of use
  - drives actions for tool stability and control, process centering, yield learning, scrap avoidance
  - systematic implementation has continued throughout the fab
Sensor Analytics help engineers enhance tool stability and tool matching

- Drill-down reports with linked heat maps, to find and understand differences
Vision for an overall Big Data factory architecture

- **Streaming**
  - Real time metrics, alerts analysis and modeling
  - Spot new trends as they occur
  - Constantly updated dashboards

- **Discovery**
  - Perform analytics over large data sets
  - Discover new patterns
  - Develop new structured/unstructured models

- **Foundational**
  - Operations Management
  - Yield Improvement
  - Predictive Maintenance
  - Financial reporting
  - Call Center Analytics
  - Customer segmentation
  - Campaign management

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**Equipment Process Data**

**Test Instrument Data**

**Log Data**

**Web and Collaboration Data**

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**Real Time Scoring and Response**

**Streaming Feeds**

**Compressed/Summarized Feeds**

**InfoSphere Streams**

**Improved Analytics**

- Real time metrics, alerts analysis and modeling
- Spot new trends as they occur
- Constantly updated dashboards

**Structured Streaming**

**Structured Reporting and Analytics**

**Unstructured Feeds**

**Unstructured Reporting and Analytics**

**Queryable Archive**

**Queryable Discovery Zone**

**Mixed Mode Complex Data Analysis**

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**IBM BigInsights**

**BigSheets**

**IBM PureData**

**ERL**

**ETL**

**CIM**

**MES**

**ERP**

**Other**

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How to get started with a Big Data strategy in manufacturing?

1. **Assess your capabilities**
   - Understand your starting point
2. **Pick your spot**
   - Biggest and highest value opportunity
3. **Prove the value**
   - Start with questions
   - Embed insights
4. **Roll it out over time**
   - Add capabilities
   - Information agenda

IBM can help…

Big Data Business Value Accelerator

Big Data Pilot

Know the analytic capabilities you can leverage and extend through Enterprise wide Implementation

IBM BVA | Pilot | Roll out
Thank You