Applied Materials
Advanced Manufacturing Solutions for Pharma

— From the Semiconductor Fab to the Pharma Plant

IFPAC PR 2016
Amos Dor
Automation Products Group

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Imagine a toolbox that can help achieve the following:

- 50% Less Inventory
- Lower capital cost 60%
- Process Cost Savings $13M
- Yield Increase 30%
- Process Capability 40% Up
- Unscheduled Down Time Reduction 25 hrs
- False Alarm Reduction 90%
- 60% Less manpower
- Less waste 90%
- Rework Rate Reduction (From 3% to 0.8%)
- 25 hrs

What toolbox is this?
Agenda

- Who We Are?
- Why go from Semiconductor to Pharma?
- What we can offer to Pharma?
- How Pharma will benefit from our solutions?

From the Semiconductor Fab to the Biopharmaceutical Plant
Who We Are
Applied Materials - Applied Global Services - Automation Products Group

The main provider of automation software to the semiconductor industry

Successful in ensuring quality attributes, improving manufacturing efficiency and reducing cost

Leverage semiconductor automation best practices to help transform pharma
Comprehensive Factory Automation Capabilities

Factory Execution
*Work in process, workflow, experiments, recipe*

Factory Productivity
*Dispatching, scheduling, reporting, SenseDecideRespond™, prediction*

Material Controls
*Automated Material handling (intra factory & cross factory)*

Equipment Controls
*Preventative maintenance, equipment automation*

Planning and Simulation
*Capacity, material starts, layouts, multi-plant*

Process Understanding & Control
*Data collection, big data, statistical process control, advanced process control*
Automation Products Group (APG a group under AGS)

Profile
- Result of 2 Acquisitions
  - Consilium 1998
  - Brooks Software 2007
- 400+ Employees Worldwide
- Organized into Service and Engineering Centers
Semiconductor Wafer Processing

Manufacturing Automation Software

- Epitaxy
- Ion Implantation
- Deposition
- CMP
- Mask Etch
- Mask Defect Detection
- Lithography Technologies
- CD SEM Metrology
- Defect Inspection & Review
- Wafer Cleaning
- Etching

Manufacture Wafer

Assembly, Test

Fab & Equipment Services

Process M&I
Applied Materials Display Products

CURRENT PRODUCT PORTFOLIO

PECVD

Applications
Array (a-Si, LTPS, MOx)
Thin-film encapsulation

PVD

Applications
Array (a-Si, LTPS, MOx)
Color Filter
Touch

EBT

Applications
Array Test

Roll-to-Roll Coating

Applications
Film Touch
Packaging
Currency
Barriers

NEW PRODUCT RELEASE

OCTOBER 2015
PECVHD for Thin Film Encapsulation

AKT 20K TFE PECVD
AND
AKT 40K TFE PECVD
Why Go from Semiconductor to Pharma?

What pressure/goals do both industries have in common?

- Meet quality requirements
- Improve manufacturing efficiency
- Reduce costs...

<table>
<thead>
<tr>
<th>Measure</th>
<th>Semiconductor</th>
<th>Pharma</th>
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<tbody>
<tr>
<td>Overall Equipment Effectiveness</td>
<td>High (80-90%)</td>
<td>Low (10-60%)</td>
</tr>
<tr>
<td>First pass yield- zero defects /process capability</td>
<td>High (6σ to 5σ)</td>
<td>Low (2σ to 3σ)</td>
</tr>
<tr>
<td>Production lead time (days)</td>
<td>Less (5-10?)</td>
<td>More (120-180)</td>
</tr>
<tr>
<td>FG Inventory (days)</td>
<td>Less (5-50)</td>
<td>More (60-90)</td>
</tr>
<tr>
<td>Direct/indirect labor ratio</td>
<td>Low</td>
<td>High</td>
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✓ Enabler: - A high degree of automation, advanced control and optimization in semiconductor!
Pharmaceutical OPEX and Quality Initiatives

Costs

Efficiency & Effectiveness

Quality & Compliance

6 Sigma

Lean Mfg

RFT

QbD/PAT

Continued process verification

Continuous mfg

Improve capability, reduce defects…

Reduce waste, lower inventory, increase equipment utilization…

Assure quality …

Improve mfg efficiency…
What We Can Offer to Pharma
Integrated solutions to support cost reduction, efficiency and quality assurance in pharma

Desired Quality & Compliance, Efficiency and Cost

Support 6 Sigma, Lean, QbD, PAT, RTRt, CPV/CQV and smart manufacturing

E3 Pharma
Advanced Platform for real-time process analytics and control
- Equipment Performance Tracking (EPT)
- Fault Detection and Classification (FDS)
- Run-to-run control (R2R)
- Statistical Process Control (SPC)

APF Pharma
Suite for real-time production planning, scheduling and dispatching
- Activity Manager
- Real-time Dispatcher/Reporter
- Fusion
- AutoSched
- SmartSched

Xsite Pharma
System for real-time equipment maintenance management
- CMMS
- Preventive and predictive equipment maintenance
- Audit and Compliance

Seamless integration with process control system, data historian, MES and ERP, 30 years of experience
E3 (Enterprise, Equipment & Engineering) Pharma

- **E3 Pharma™**—Integrated automation modules *(Real Time)* to maintain BioPharma operations in a state of control (Continued Process Verification)

- **E3 Pharma™** enables plant-wide process data collection for real-time process monitoring, control and quality assurance

- **E3 Pharma™** is designed to enable advanced control strategy without coding

- E3 ™ modules currently operate in 70% of the semiconductor factories world wide
Xsite Pharma - A Complete CMMS Solution

CMMS is part of the pharma plant heartbeat

Use equipment-centric data to develop optimum maintenance schedules → Improve asset availability and performance
The APF suite provides integrated modules to improve plant productivity

- Implementing continuous productivity improvements
- Analyzing, testing, and executing dispatching and scheduling policies
- Automating and optimizing complex scheduling
- Reclaiming hidden capacity within plants
- Debottlenecking
E3™ GUI Based Strategy Engine

- Event-Condition-Action is simply the execution of a linear series of items
  - Data into Action

✓ Completely defined through GUI configuration without coding or scripting, allows process engineers to easily customize and modify models
Lactate Accumulation Control Strategy - Glucose Control in E3™

Easily Configured Feedback Control “drag and drop”
Increasing Product Yield & Quality

- Data Collection
  - SPC
- Advanced Process Control
- Recipe Mgmt
- Fault Detection
- High Speed Data
- Trend Discovery
- Big Data
- Integrated Data & Rules
- Prediction
- Chamber Matching

Data Growth & Integration
Increasing Output / Reducing Cycle Time

Data Growth & Integration

- WIP Tracking
- Capacity Planning
- Data Collection
- Reporting
- Layout Planning
- Material Controls
- Dispatching
- Automated Resolution
- Master Planning
- Prediction
- Expert Analysis
- Short Interval Scheduling
- Optimization
- Data / Rule Orchestration

DPS Poly scrap wafer trend

GOAL < 10 wafers / Month

8/4/2005 eDSA start
8/25/2005 EPD optimize
11/3/2005 add Stab Step
11/16/2005 Preset optimize

In the middle of December

(BM: 74.3 wafers / Month - 05Q1)

*Target:< 10 wafers / Month*
Solutions

- Work flows
- Unit monitoring - SPC, UVA, MVA
- Close Loop Control - APC, R2R
- Virtual metrology
- Soft sensors
- Real time Scheduling
- Planning
- Maintenance management
- Predictive maintenance
Glossary of Terms

- **E3** – Enterprise Equipment Engineering
- **PAT** – Process Analytical Technology
- **QbD** – Quality by Design
- **CPV** – Continued Process Validation
- **PLC** – Programmable Logic Controller
- **SCADA** – Supervisory Control And Data Acquisition
- **MVA** – Multivariate Analysis
- **SPC** – Statistical Process Control
- **APC** – Advanced Process Control
- **Suite** - Collection of E3 Applications
- **Core** – Common infrastructure for data access, logging, security, message routing, load balancing etc.
- **EPT** – PCS Compliant Equipment Performance Tracking Engine
- **Controller** – Handles start up/shut down and system diagnostics
- **Studio** – All E3 user interface applications
- **Designer Studio** – E3 strategy editor
- **Dashboard** – User configurable data viewer
- **Collector** – Equipment integration software drivers
- **Adapter** – Application integration component
- **R2R** – PCS Compliant Run 2 Run Engine
- **FD** – PCS Compliant Fault Detection Engine
- **E3 SPC** – E3 SPC module including SAWS and statistical engine