# Introducing TIBC Spotfire

## Semiconductor Use cases

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### **Advanced Process Control**

Enterprise Tier: Visualize & Manage - Business Apps *TIBCO Spotfire, Data Virtualization* 

#### Reports & Dashboards



Data Science Tier: *TIBCO Data Science, Data Lake* Models: Build, Evaluate & Push to Production

Platform Tier: Real-time Decisions *TIBCO Streambase* Fault Detection, Virtual Metrology Run-to-Run control





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## Virtual Metrology

### Virtual Metrology (VM): A Promising Solution to enhance APC with Real-Time Feedback Data



When deployed in production, the VM predictive model facilitates:

improved process feedback control with real-time VM estimates

- elimination of multi-wafer scraps with timely monitoring capability
- reduced measurement frequency to save production time and cost



### Wafermap Feature Engineering



### **Anomaly Detection & Correction**



# Define problem, cluster similar defects together

• Define:

• Field Return, Life test, Defect Inspection, Functional or Performance test

#### Classify:

- Symptom and Cause codes,
- Defect class, Failing test,
- Cluster similar items together
- Characterize by Production factors:
  - What model or sub-assembly
  - When and where produced
  - Visualize spatial distributions of problem

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- Characterize by Usage factors:
  - When and where used and failed
  - Visualize geographical distributions
  - Where on the product
  - What mileage

#### Unsupervised Machine Learning Algorithm

- Zonal / Bin Aggregation: 25 zones x 10 bins = 250 features / wafer
- Variable reduction: Autoencoder to reduce from  $250 \rightarrow 20$  features
- K-means clustering to group wafers with similar spatial bin patterns

### Pattern Analysis on WaferMap Spatial Signatures





Data Preparation

Wide Data Analysis



Bessel function components



#### **Spatial Signatures for Wafermap Classification**

- Create a spatial signature exploration dashboard based on wafer test data, using pass/fail flags, bin components, and other (numeric) test parameters. The case has about 1500 parameters that they analyze currently.
- To do a form of spatial signature analysis that takes into • account all 1500 parameters, not just one parameter at a time.
- Users can subscribe to features of a dashboard (e.g. ٠ frequency of a particular wafer pattern) and be alerted when those features pass a threshold.

### Wafermap Pattern Classification At Scale

#### What

- Automatically clusters wafers with similar spatial patterns
- Engineer refines AI-recommendations to create ML models
- Classify new wafers against a library of pattern-detecting models

#### Innovation

- Human-driven artificial intelligence
- Accurate models
- Ease of use and interpretability
- Fast results for large numbers of wafers









### **Univariate Statistical Process Control**

#### Process Capability Summary with drill-down

Automated Alerting: Periodic or Real-time

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### **Multivariate Statistical Process Control**

#### The Power of Multivariate Control Charts

- Suppose we measured 2 parameters y1 and y2 (e.g., person's height & 1/weight)
- Univariate charts would not detect some obvious outliers
- This happens in many real applications







LIRC 🔊

### **Real-time Performance/Status Monitoring**

#### **Problem**

Reduce manufacturing line stoppages

#### **Solution**

- Predict equipment failure and product quality ٠
- Factory equipment sensor + line stoppage + product defect data
- In-Hadoop big data modeling **Results**
- Predict future line stoppages ٠

emperature

Anufacture

Last Reading

Reading Quality

- 50% reduction in defects .
- More predictable demand for supplies ٠
- Empowered analysts to focus on problem-solving •



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QA 08:09:42

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## Intelligent Equipment Real-Time FDC Dashboard

To Monitor the all sensers on each chamber of wafer equipment , and display real-time statistical values and charts



### Digital Twin for Yield Prediction

•Digital Twins for Semiconductor Manufacturing Yield: Wide-and-Big Data Analysis •Build Models to relate Product Yield Failure Modes ( $Y_i$ ) with Process Parameters ( $P_i$ )



### **Conceptial Solution Picture**







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### 通過機器學習建立模型預測故障指標

可預測項目 (Predictive Targets)
機器發生故障 (Machine outage)
產品質量下降 (Defective product)

需要收集的數據 (Predictors)
物聯網機器感測器 (Machine sensor data)
物聯網環境感測器 (Environmental data)
製程控制狀態與指標 (Process measurement)





Receiver Operating Characteristic Curve (ROC)

02 03 04 05 06 07 08 09

### 物聯網數據收集與分析提高維護預測準確性

企業在物聯網感測器收集的使用資料中尋找新的模式 以此延長機械、發動機、運輸和倉庫裝置等供應鏈重 要資產的生命週期。 哪些因素對機器效能的影響最大? 哪些因素會導致品質下降? 毀損機率上升的可能性? 多長時間是最佳的維護週期?

#### Digital sensors collect data on

- vibration (震動)
- Iubrication (摩擦力)
- bearing temperatures (內外溫度)
- noise (噪音)
- pressure (內外壓力)
- ...and a host of other variables

All information that can be used to predict when components will fail or need repair or replacement

Analysis of sensors data allows users to <u>schedule</u> <u>maintenance at an optimal time</u>, cutting costly unscheduled maintenance or breakdown



# 預防性保養 (Preventive Maintenance)



Real-time dashboard showing predicted pump fails

## **Overlay/Yield Analysis**



### LIS (LithoInsights) OEM of Spotfire

- \$100M Business in 3 years (from \$0)
  - 76 Spotfire Templates Overlay, Yield Analysis
  - LIS Development Issues
  - Version Control exploring EPAM solution, developing certification process
  - GUI customization JS library management, assembly, reuse // MODS
  - Automated Testing issue re unique ID on visuals. Need ASML to agree to POC
  - On-hold; ASML exploring internal ASML-built app

### Internal Deployment of Spotfire

930 analysts

- 20K users, all departments
- 8K templates in library
- MSFT PBI threat





## **Analytics Dashboards**

**Company:** Largest semiconductor manufacturing equipment vendor, \$10B annually

**Opportunity** - Embed TIBCO in

**Use Cases** - Analytics dashboards with Layer-tolayer overlay, Defect and Parametric contour wafermaps to display data collected on their equipment

#### **Engagements to-date:**

Demos, PoC & Customer evaluation completed successfully for individual product groups in Israel







