FUJIMI CORPORATION



The Future of Materials Quality 'Big Data'

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What is Big Data?

In 2001, Doug Laney summarized the challenges of Big Data management as having three distinct dimensions, introducing the 3V's of Big Data

- Big Data is high-<u>Volume</u>, high-<u>Velocity</u> and/or high-<u>Variety</u> information assets that demand cost effective, innovative forms of information processing that enable enhanced insight, decision making and process automation.
- <u>Veracity</u>, integrity or "truth" of the data or analysis
- <u>Value</u>, big data or its analysis used as an asset



3V's

Volume

- Internal
 - Manufacturing in process
- External (private)
 - Raw Material
 - Customer
 performance
 feedback
 - Local Warehouse
- External (public)
 - Weather
 - Water Quality

Variety

- Structured
 - Product Analysis
- Semi-Structured
 - Raw Material Lots
 - Customer Qualitative Feedback – Lists of Good/Bad
- Unstructured
 - Photos, pictures, sensory characterization
 - Operator observations, batch notes

Velocity

- Very fast
 - in process censors
- Fast
 - Wafer/customer functional performance
- Slow
 - Batch Card entries
- Very slow
 - Per manufacturing run

CMP Manufacturing Big Data: High-Variety at a range of volume and velocity



Unstructured Data



Particle Size (nM)



Qualitative Particle Characteristics are Unstructured Data



Innovative Forms of Information Processing





Cell Plot using OOC Characteristics





Innovative Form of Processing



Response screening is way to look for relationships and avoid p-hacking – identifying false relationships by chance – through FDR p value – False Discovery Rate p-value

Response Screening to Avoid p-Hacking



Continuous Improvement

PCS - Continuous Improvement through Variation Reduction

- DOE's to identify critical to control parameters
- Metrology variation reduction and improved precision
- Trend Reviews and Investigation

Big Data – Continuous Improvement through Collaboration

- High Variety Process Settings, Product Monitors, Product Performance
- High Volume Internal and External sources, Supplier through Customer
- Innovative Forms of Information Processing

Share Big Data to Drive Continuous Improvement



Monitor Gamma



PCS Program Implementation and Continuous Improvement Successful



Monitor Alpha



Continuous Improvement Not Successful



Focus on Veracity

Prepare data for Sharing

- Standardizing data $(X-X_{min})/(X_{max}-X_{min})$ or Normalize data $(X-\mu)/\sigma$
- Summarize Data by Lot
- Characterize unstructured data

Remove Noise

- Understand sources of variation such as metrology, applications, environmental conditions
- Identify gaps in data, missing data
- Identify covariates
- Identify inputs versus output

Statistical Techniques

- Scatter Plot Matrix
- Response Screening for False Discovery Rate

Validate Models

- Apply expertise and experience
- · Validate causation versus correlation

"The signal is the truth. The noise is what distracts us from the truth" – Nate Silver



Scatter Plot Matrix

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Customer Response Including;  $C_{\alpha}$ ,  $C_{\beta}$ 

Product Monitors Including;  $M_{\alpha}$ ,  $M_{\beta}$ ,  $M_{\gamma}$ ,  $M_{\beta}$ 

Supplier Settings and Monitors Including;  $S_{\alpha}$ ,  $S_{\beta}$ ,  $S_{\gamma}$ ,  $S_{\delta}$  FUJIMI CORPORATION

# **Veracity Check**





 0
 Stage 1
 Stage 2
 Stage 3
 Stage 4
 Stage 5
 Stage 6

 Customer Beta
 Customer Beta
 Stage 5
 Stage 6
 Stage 6



# Value – Enhanced Insight





# Value - Decision Making



Restricting range of Setting Gamma, reduces variation of Monitor Alpha



# Is Big Data the Future of Quality

- High-Variety of data
- Innovative forms of information processing
- Expertise to prepare data and develop models for testing
- Collaboration with Supplier, Manufacturing and Customer



# **Big Data Vision**



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