Smart Manufacturing – The Digital Transformation Journey

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Smart Manufacturing - Drivers for a Digital Thread

- Build-to-demand beats build-to-inventory. Increasingly, consumers demand personalization, matching shoes and clothing to exact body type and size, and near-instant access to all goods and services.

- Product lifecycles are collapsing thanks to same-day delivery business models, rapidly advancing manufacturing processes, social-media sharing, and intense global competition.

- The size and cost of electronic components continue to lessen. Computer and conductivity technologies are integrated into everything, as smaller, lighter, and more powerful chips do more with less energy.
Electronics Industry Dynamics:
Leveraging Standards Across Electronics Industry Segments

Converging Technologies Create Competition for Value Added:
Silicon, Package, Board

- Foundry (Fab)
- 3D/WLP
- OSAT (Pkg/Test)
- SiP/MCP
- EMS (System)

Timeframe
2-5 Years

Opportunity
$4B+

Chip Stack, WL-CSP
Package Stack, MCP/POP

World Lead Packaging Concepts
Electronics Industry Dynamics

New “backend” technologies driving change

- FO-WLP development and adoption
- Blurring of segment lines Semiconductor Front End, Back End and PCBA/SMT
- Consolidation of SEMI and SMT equipment suppliers i.e., K&S-Assembléon, ASM-Siemens, etc.
- Wafers as carriers driving SMT type equipment in the Semiconductor Back End
- OSATs versus Foundries

Common Connectivity across industry segments is an ideal strategy

- Reduces engineering costs for all equipment suppliers
- Simplifies host systems – Enables the Digital Thread, Digital Twin
- Allows advancement towards Plug-N-Play & Smart Manufacturing
- Reduces the industry cost of ownership
Smart Manufacturing - Promises from the Digital Twin

- The benefits of the smart factory include faster, real-time decisions, with more flexible and efficient business processes. The impact will extend globally, in economic value from waste reduction and increase (U.S.) gross domestic product.

- Customers benefit through reduced time-to-market and lower costs from more-efficient capital investments and optimized inventories. There is less waste, and a significantly-smaller carbon footprint.

- Customers will have better access to goods and services than ever before. They depend on new solutions to bring more of their products safely to market faster than ever before, at lower costs, and, of course, with superior quality.
Smart Manufacturing / Industry 4.0 – Digital Thread

Design → Manufacturing → Reliability

Multi Direction Data Communications – Digital Thread
Smart Manufacturing / Industry 4.0 – Digital Thread

- Product Company
  - Product Lifecycle
  - Logistics
  - Product Design Data
  - Traceability

- Manufacturer
  - (EMS, IDM, Foundry, OSAT, etc.)
  - Process Control
  - Shorter Downtime
  - Configuration Flexibility
  - Traceability

- Supplier
  - Remote Diagnostics & Maintenance
  - Yield Improvement
  - Adaptability

Host System

Multi Direction Data Communications – Digital Thread

SEMICON EUROP A
14-17 NOV 2017
MUNICH
GERMANY
Smart Manufacturing – Journey in EMS

- A typical SMT line for proof of concept
  - Demonstrator of smart manufacturing principles, M2M, iFactory
Production Control Center

Site (or enterprise level) data is frequently updated to provide input for aggregate metrics. Real-time data is used to exercise Production Control and provide key metrics. Analytics to extract ‘meaningful information’ from data (lakes and/or ocean).
Manufacturing Equipment Data - Smart Manufacturing

**Event Notification**
- Collection Events
  - Notify the host of processing events, errors
- Alarms
  - Notify the host of dangerous states

**Data Gathering**
- Host Polling
  - Host may request data as desired
- Machine Polling (Traces)
  - Host configures the equipment to send data periodically
- Event Reports
  - Host configures data to be reported with a collection event
- Limits Monitoring
  - Host defines limit boundaries for a status variable
  - Equipment notifies host when a boundary is crossed
Manufacturing Equipment Data - Smart Manufacturing

**Equipment Control & Configuration**
- Change equipment constant settings
  - Change modes & configure behavior
  - Modify elements of process program
- Remote control
  - START, STOP, PAUSE, RESUME, ABORT
  - Machine specific commands

**Recipe Management**
- Transfer process program files to and from the equipment
- Select a process program remotely
- Query the current process program and list of available programs
- Delete process program files on the equipment
- Notify the host when the equipment operator makes any process program file changes
Manufacturing Equipment Data - Smart Manufacturing

Terminal Services

- Equipment and host operator exchange messages
- Acknowledge for operator

Fundamental State Machines

- Equipment behaves in a predictable, consistent way
- Communication State Machine
- Well defined means to establish communication
- Control State Machine
  - Equipment determines the level of host control
  - Remote, Local, or Off-line
- Spooling State Machine
  - Equipment may persist valuable messages when communication is lost. Restore the messages when re-established.
- Processing State Machine
  - UML/Harel Notation
  - Machine-defined
  - States and State transitions
The Quest for Meaningful Information

The Different Types of Analytics

- **Information**
  - What’s happened? Descriptive Analytics
  - Why has it happened? Diagnostic Analytics

- **Optimization**
  - What may happen? Predictive Analytics
  - How to prevent bad things from happening and to potentialize the good ones? Prescriptive Analytics

- Value vs. Difficulty
  - Hindsight
  - Insight
  - Foresight
Digital Twin: Machine to Machine Communications