Welcome to the ISMI Predictive and Preventative Maintenance Supplier Introduction Forum!

INTERNATIONAL SEMATECH
ISMI
MANUFACTURING INITIATIVE

2007 ISMI

Predictive and Preventative Maintenance

Supplier Introduction Forum

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ISMI Meeting Antitrust Statement

- **ISMI, as a consortium, is cognizant of potential antitrust issues surrounding our interactions with Members.**
- **We represent a large percentage of the industry market share and as such activities of our membership are subject to heightened scrutiny**
  - **ISMI, SEMATECH and members are NOT exempt from antitrust laws**
    - **Limited protection under *National Cooperative Research and Production Act of 1983* (e.g., single, not treble, damages)**
  - **"Horizontal" activities between competitors receive more scrutiny than "vertical" activities between buyer & seller**
- **Our focus is on pre-competitive technologies, not competitive matters, and not business operations which helps keep us compliant with the law, but we need to continuously monitor that line**
- **Please do not disclose proprietary or confidential information!**

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Administrative

- The restrooms are outside in the common area, please use them as needed
- In the case of a fire alarm or evacuation, please follow the posted signs and procedures
- Parking validation is available from Carolon at the registration desk
- Presentation materials from this General Session will be posted to the ISMI Public web site following the meeting
- The lunch buffet will be available immediately outside following the General Session

This is intended to be an informal and interactive meeting – so please participate!

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Purpose

To introduce and discuss the *"ISMI Consensus Preventive and Predictive Maintenance Vision Guideline: Version 1.0"*

To engage the Supplier community in collaboration for the development, implementation, and deployment of Predictive and Preventative Maintenance capabilities for the tactical and strategic future

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Agenda

- **Wednesday, Mar 21, 2007**
  - **Morning - Public Session**
    - **09:00-09:15 Introduction - Steve Fulton / ISMI**
    - **09:15-10:15 PPM Guideline Presentation - Steve Fulton / ISMI**
    - **10:15-10:30 Break**

    ISMI Member Company PPM Presentations
    - **10:30-10:45 Martin Sinzinger - TI**
    - **10:45-11:00 Les Marshall - AMD**
    - **11:00-12:00 Open Discussion**
  - **12:00-13:30 Lunch**
  - **Afternoon - Suppliers 1:1s with ISMI Member Company Quorum**
    - **13:30-16:45 Suppliers Presentation/Discussion**
    - **16:45-17:15 MC wrap-up**

- **Thursday, Mar 22, 2007**
  - **Suppliers 1:1s with ISMI Member Company Quorum - continued**
    - **09:00-15:00 Suppliers Presentation/Discussion**
    - **15:00-15:30 MC wrap-up**

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Predictive and Preventative Maintenance Vision

Steve Fulton
Project Manager
International SEMATECH
Manufacturing Initiative
Austin, Texas

ISMI Consensus Vision

This Guideline documents the consensus PPM vision of the participating ISMI member companies

- AMD
- IBM
- Intel
- NXP
- Qimonda
- Renesas
- Samsung
- Spansion
- TI
- ISMI

The Guideline presents common pre-competitive needs

It provides forward looking direction, based upon our current understanding, requirements, and best engineering judgment

Predictive maintenance is emerging in other industries as a compelling value – with direct application benefit

The Guideline represents a starting place for IC maker and Supplier collaboration

Agenda

INTRODUCTION:
- Background
- Purpose
- Definitions

FUNDAMENTAL PPM EXPECTATIONS:
- Improving Productivity
- Factory Systems
- Equipment Systems
- Data

PHASING STRATEGY:
- Vision Challenges
- Implementation Challenges
- Phased Approach

GENERAL GUIDELINES:
- PPM Data Sharing
- Determination of PPM Data
  - Preventative (PM)
  - Condition-Based Preventative (CPM)
  - Predictive (PdM)

★ **ISMI Project Overview**

INTERNATIONAL SEMATECH ISMI MANUFACTURING INITIATIVE

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Background

- Equipment productivity is one of the key factors in competitive high volume production
  - Effects factory capacity (availability)
  - Drives manufacturing cost
  - Impacts production schedules (predictability)
- Typical Overall Equipment Effectiveness (OEE) estimates; 40% – 60% range representing a huge potential opportunity
- Equipment productivity improvement is required by Moores Law and the ITRS
  - Availability
  - Predictability
  - Cost contribution
  - Asset management

- Current practices are generally rudimentary if they exist at all
  - Equipment does not incorporate advanced predictive and preventative maintenance capabilities
  - Factory systems are not well developed or implemented

Conclusion

Because of the need, many ad hoc efforts under way to change traditional maintenance

- **By IC makers**
- **By Suppliers**
- **Working together**
- **e-Diagnostics**
- **Equipment Engineering Capabilities (including TDI an EEQA)**

There is little coordination or common direction in these ad hoc efforts, little analysis and virtually no standardization. This is a recipe for high cost with low return.

We need a new paradigm, a fresh look at what we want to accomplish and the tools and methods for achieving it

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Purpose

- **Communicate:**

  The consensus ISMI member company vision, concepts and values for use by suppliers and others in the industry to understand the direction and requirements for planning and action

- **Open discussions:**
  - **On PPM systems that will support improved stable equipment availability, productivity, and OEE**
  - **Establish equipment behavior and data requirements for PPM that will improve equipment productivity metrics**
- **Establish collaboration:**
  - **With all stakeholders throughout the supply chain participating in the definition and development of PPM capabilities**
  - **Actively contributing to investigation, research, concept & feasibility and prototype, and implementation for robust manufacturing worthy systems on the equipment and host sides**

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Terminology

- **Traditionally equipment downtime breaks down into two general categories**
  - **Planned:** dealing primarily with consumables and periodic adjustments and calibrations
  - **Unplanned:** unidentified wear out, breakdown, random failures
- **The PPM vision proposes that this outlook is too simplistic. It does not adequately consider use conditions, effectiveness of PMs, or the impact of unplanned failures on the overall manufacturing operation.**
- **Analysis suggests another breakdown:**
  - **Preventative Maintenance**
  - **Condition based Preventative Maintenance**
  - **Predictive maintenance**
  - **Remedial repair (random catastrophic failures)**

Preventative Maintenance

- **Preventive Maintenance –** A schedule of planned maintenance actions aimed at preventing unscheduled equipment down time. It is traditionally based on elapsed calendar time or fixed unit count usage.
  - Predominantly time and usage based
  - Daily, weekly, monthly
  - Wafer count- or RF count-driven

Condition-based Preventative Maintenance

- **Condition-based Preventive Maintenance** – An enhanced method that applies advanced analysis techniques to data from equipment components, modules, or other sources to identify performance indicators, such as thresholds, control limits, voltage, etc., requiring preventive maintenance. Condition-based PMs are intended to maximize the availability and productivity of the equipment while optimizing maintenance costs.
  - Optimizes the availability of the equipment
  - Includes conditional and time-based preventive maintenance
    - Uses real data to determine when PMs should be done
    - Uses data from all possible data sources that can be obtained as input (equipment data, maintenance data, warning frequency and etc.)
  - Applies advanced analysis and scheduling techniques
  - Aims to reduce scheduled downtime, usage of consumables/parts, and optimization
  - of maintenance effort and costs
  - Acknowledges that “optimum” may vary among users or equipment type and related costs for implementation, as may the important input parameters to analytical algorithms

Predictive Maintenance

- **Predictive Maintenance** – A maintenance technique that uses data from equipment and other relevant sources (i.e., FDC, APC, Yield learning, PM history, etc.). These data allow events and trends in performance and equipment settings to be monitored through advanced analysis techniques and failure behavior profile matching. Analysis of component performance data and other indicators enable the identification, give warning, and prioritize impending or imminent unscheduled failures in advance. Predictive maintenance is complementary to condition-based preventive maintenance.
  - Predictive maintenance is supported by high performance equipment data availability and well developed factory systems

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- **Equipment Systems**
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Fundamental expectations

- **Improve equipment productivity**
  - **Improve Uptime and Availability -** by reducing or eliminating unplanned failures
  - **Reduce Operational Cost** – using data analysis to gain insight into consumable lifetimes and enhance the efficiency of service personnel
  - **Improve Product Quality** – by eliminating degraded operation and tightening process windows
- **Factory Systems**
  - **Decision making based on all data available (equipment data, SPC, in-line monitors, etc)**
  - **Product and process factors should be included as inputs**
- **Equipment Systems**
  - **Provide the first line of defense reacting to changes in tool performance**
  - **Auxiliary equipment data (pumps, RF generators, etc) should be integrated to the equipment for PPM**
  - **Data availability and poling rates are important – they cannot adversely impact tool performance**

Fundamental Data Expectations

Access to extensive high fidelity data is a requirement for predictive and preventative maintenance

- **Predictive maintenance solutions should use data obtained from all available sources**
- **New data sources may require development**
- **Equipment data should be provided through standard interfaces (SECS/GEM, EDA or Interface C)**
- **Collection and storage of data *must not* impact tool performance , in quality or rate of production**
- **Equipment predictive maintenance applications should allow remote access and portability**
- **Advanced analysis techniques for factory and equipment should include parameter and prediction models**
- **Data sampling rates and storage requirements should be defined by the end user to meet fab needs**

INTERNATIONAL SEMATECH ISMI MANUFACTURING INITIATIVE

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- **Vision Challenges**
- **Implementation Challenges**

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Phasing strategy

- **PPM implementation will not happen immediately or as a single event**

- **Implementation is expected to be a smooth transition over time, following a logical progression**
  - **Improving current Preventative Maintenance practices**
  - **Concurrently developing new data sources and handling**
  - **Condition-based Preventative Maintenance implementation**
  - **Predictive Maintenance implementation**

- **Developing and implementing PPM capabilities will enable the future integration of WIP levels, dispatch priority, spare part management, and other operational factors to be incorporated**

Vision Challenges

- **Data Quality and Availability**
  - Accurate and complete data is needed
  - Proper sensors to collect equipment and product status
    - Equipment state sensors: Monitor equipment parameters
    - Process state sensors: Monitor process condition
    - Product state sensors: Monitor product status
- **Condition Monitoring, Health Assessment, & Prognostics**
  - Stable baseline performance is needed
  - "Condition monitoring algorithms" should be developed
  - A standard health assessment metric at the module level would be useful, available through the EDA interface
- **Data Integration and Automation Architectures**
  - Fragmentation and organization of data in high volume fabs
  - Integration of data from multiple sources and formats/structures
  - The sheer volume of data in a production fab operation
- **PPM capabilities are needed regardless of wafer size, technology node, or operational product mix**

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Implementation Challenges

- **Predictive and Preventative Maintenance requires development and implementation of capabilities on the equipment and the factory systems**
  - **Advanced PPM capabilities should be “designed in” to the equipment**
  - **Robust factory PPM solutions need to be developed**
- **Near real time monitoring and notification is needed for effectiveness**
- **Predictive notification early enough to allow scheduling that avoids manufacturing interruption**
- **Product and device considerations should provide input to the PPM solution**

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★ ISMI Project Overview

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General Guidelines

- **PPM Data Sharing**
  - Describes possible sources and types of data in the factory environment

- **Determination of PPM data**
  - Discusses the role of each type of maintenance activity
  - Looks at the data needed for each type of maintenance activity
  - Outlines examples of the analysis methods that can be applied in the PPM environment
  - Typical outputs and expected results are briefly discussed

Acknowledgement

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INTRODUCTION:

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- Purpose
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ISMI PPM Project Overview

- **ISMI has started a new project and focus in e-Manufacturing on Predictive and Preventative Maintenance. The purpose of this project is:**
  - ***"Establish requirements, guidelines, and feasibility for the use of data and factory systems to enable improved equipment availability and productivity thru the use of Predictive Maintenance and Condition Based Preventative Maintenance capabilities"***
- **Developing new predictive and preventative maintenance capabilities will require:**
  - **Additional equipment capabilities at the local level**
  - **Broader low level data availability from the equipment and factory environment**
  - **New factory level applications and possibly architecture**
  - **Enhanced factory level data exchange and handling**
- **The project objectives include:**
  - **Establish a collaborative environment, promoting cooperation and synergy between the IC maker end users, the equipment supplier community, and the 3rd party solution providers**
  - **Promote and champion the Predictive and Preventative Maintenance Initiative**
  - **Conduct technology investigation, research, and where appropriate perform concept and feasibility studies or prototyping**
  - **At the appropriate time, encourage the commercialization and availability of PPM solutions**
- **Are you interested in working with ISMI and/or the member companies to develop Predictive and Preventative Maintenance capabilities?**

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Q & A

Predictive Maintenance

prepared by Martin Sinzinger

Texas Instruments Quality Policy

We will achieve business excellence by:

- Encouraging and expecting the creative involvement of every TIer.
- Listening to our customers and meeting their needs.
- Continuously improving our processes, products and services.

Richard K. Templeton
President and Chief Executive Officer

TEXAS INSTRUMENTS

Why do we want to have Predictive Maintenance?

Why Predictive Maintenance?

- **Quality**
  Reliable products come from reliable processes on reliable equipment
- **Cost**
  Cost in all aspects is a critical factor
  Year-on-year cost reduction are an expectation
- **Cycletime**
  On-time delivery is a need for any customer
- **Flexibility**
  Adaption to fast changing business cycles

Why Predictive Maintenance?

TECHNICAL SPECIFICATION

ISO/TS 16949

Second edition
2002-03-01

Quality management systems —

Particular requirements for the application of ISO 9001:2000 for automotive production and relevant service part organizations

Systèmes de management de la qualité —

Exigences particulières pour l'application de l'ISO 9001:2000 pour la production de série et de pièces de rechange dans l'industrie automobile

Why Predictive Maintenance?

ISO/TS 16949:2002(E)

Work instructions shall be available for set-up personnel. The organization shall use statistical methods of verification where applicable.

NOTE Last-off-part comparisons are recommended.

7.5.1.4 Preventive and predictive maintenance

The organization shall identify key process equipment and provide resources for machine/equipment maintenance and develop an effective planned total preventive maintenance system. As a minimum, this system shall include the following:

— planned maintenance activities;
— packaging and preservation of equipment, tooling and gauging;
— availability of replacement parts for key manufacturing equipment;
— documenting, evaluating and improving maintenance objectives.

The organization shall utilize predictive maintenance methods to continually improve the effectiveness and the efficiency of production equipment.

What do we expect from Predictive Maintenance?

What do we expect from Predictive Maintenance?

- Reduce effort for doing maintenance
  - as often as necessary but not more
- Increase availability for operation
- make maximum use of consumables and spareparts

=> drive costs down

What do we expect from Predictive Maintenance?

- Deeper visibility of equipment and its behavior helps to keep process on baseline
- Indication for future failure will help avoid scrap or yield loss
  => no “Excursions”

=> Quality

What do we expect from Predictive Maintenance?

- Indicate need for maintenance in advance
  => still room for production planning and maintenance technician planning
- less material impacted by spontaneous failure of equipment
  => no “Excursions”

=> cycle time

What do we expect from Predictive Maintenance?

- Production capacity needs to be adjusted to loading => idling tools
- Varying levels of utilization have impact on need for maintenance for a specific tool
- Base maintenance decisions on data takes this into calculation

=> Flexibility

What’s already being done?

What's already being done?

- Specific maintenance activities are based on SPC charts
- Data being gathered though basic machine checks and analyzed with EXCEL worksheet
- Sensor value being fed into an analysis tool
- ...

=> in most cases based on only one kind of data input

What are the opportunities?

Opportunities?

- There's surely lots of data generated within a production equipment which might give valuable information which is not accessible yet

  => equipment OEM

- Analysis tools for various data sources

  => 3rd party development

Requirements

Requirements

- Intuitive user interface
- payback for an investment in short period of time (one year)
- flexible / adaptable
- modular => expandable
  “smaller portions of investment”

=> in the end it MUST give a cost reduction to the user

AMD
Smarter Choice

Predictive and Preventative Maintenance (PPM)

Elfido Coss, Thomas Altnickel,
Stephan Gramlich, Les Marshall

March 21, 2007

Why is this important?

- Demand-driven supply chains require the principles of Lean Manufacturing to be applied
  - Unnecessary maintenance is a non-value-add activity that consumes processing resources and introduces scheduling uncertainty
- Address all uncertainties
  - Need reliable equipment and early warning indicators for potential issues
  - Avoid all unscheduled events
  - All PM and CM work should be scheduled in advance and aligned with WIP management requirements
- A proactive approach is required to detect any potential issues
  - Equipment must present all relevant data and recommendations to the host
  - Equipment-centric fault prediction algorithms that provide metrics that can be used for PM and CM scheduling as well as supply chain management of consumables and parts
  - Avoid equipment surprises

Goal

Gaining real-time, actionable insight into

Equipment

health

and

performance