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Usage of Generic Equipment Model (E30 Standard) for Semiconductor Equipment and Materials International (SEMI) robotization instrument

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Abstract

The Semi Equipment Communication standard (SECS) defines a communication interface suitable for the exchange of messages between semiconductor processing equipment intended for wafer manufacturing, wafer processing and a host. This standard provides a means to communicate between different equipment without knowledge of their protocols. SECS is a layered protocol, which helps to understand meaning of messages between semiconductor processing element and host. Implementation of SECS standard will provide solution for making changes in automation software for complete process. This paper proposes a scientific and systematic approach to the design and development of a universal equipment interface by taking enterprise integration and cutting-edge technology requirements into consideration. In this paper, implementation of Alarm Management standard (E-30) under GEM (Generic Equipment Model for communication and control) layer is discussed. It is one of the layers of SECS Standard. GEM defines equipment behaviors and methods to communicate and control. GEM features in the equipment conforming to SEMI E30 standard.

Keywords: Semi Equipment Communication standard (SECS), Generic Equipment Model (GEM), Semiconductor Equipment Materials International (SEMI).

INTRODUCTION

Chip manufacturing is an important process in semi-conductor industry and today's growing electronic equipment consumption has lead to the need of its establishment in a developing country like India where IT boom is spreading like wild fire. Also India is developing as one of the largest markets for electronic equipment fuelling semiconductor demand. It has been predicted that India will account for 6.5% of global semiconductor revenues, which by no means is a small market. This is a nice concept and its domain needs to explore. This was the major motivating point, which made us choose this field.

Chip manufacturing process comprises of:

1. Design of chip
2. Wafer Fabrication Units (FAB)
3. Equipment control systems

The equipments used in FAB phase must be compliant to some specific standard so that every manufacturing company produces equipment, which are compatible to each other. SEMI standards provide a solution to the arisen conflicts by providing a standard mechanism and set of rules, which have to be followed by any equipment manufacturer so that they can be accepted worldwide.

SECS standard

The SEMI Equipment Communication Standard (SECS) protocol, originally introduced by SEMI in 1980, was developed to provide a standard equipment communication

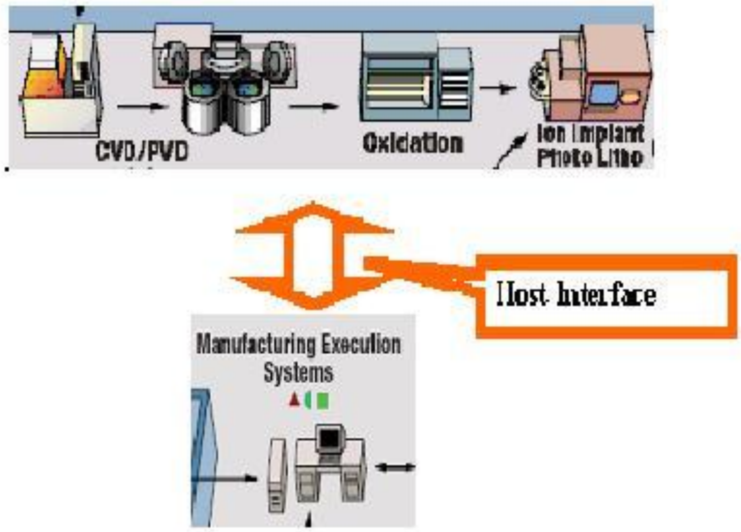

Figure 1. FAB layout

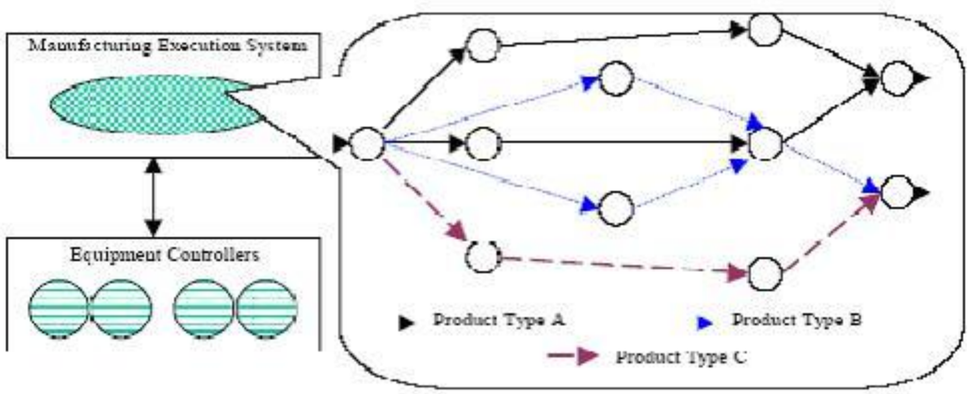

Figure 2. MES Model

protocol for both semiconductor equipment manufacturers and host developers (or end-users on the other side of the interface) (Tang et al., 2003). It became the widely accepted standard for equipment communications in the semi-conductor industry; SECS-compliant capability is typically a requirement in equipment purchase orders.

MES (Manufacturing and Execution Systems)

Figure 1 shows fabrication layout in semiconductor industry. From the production control perspective, chips advancing through a manufacturing system can be described by a chip production flow diagram showing the sequence of chip processing states on the shop floor. Materials are released at the first processing step. The materials are processed as they progress through each successive processing machine by following designated process routes. As the materials exit from the last processing step they are finished products ready for shipping out. MES has been developed based on the chip production flow diagram by tracking all the chip states and resources. As seen in Figure 2, the diagram can be represented as a finite state machine, which can be used to describe the behavior of a manufacturing system.

E30 STANDARD (GEM)

What is GEM?

GEM, the Generic Equipment Model, is an industry standard specifying the format and usage of SECS messages between a host computer and a piece of process equipment. The standard has been approved by SEMI, the Semiconductor Equipment Manufacturing Institute, and it builds on the definitions contained in the SECS-I and SECS-II standards. GEM defines three broad areas of operation of the SECS interface and equipment interaction. These include:

(1) Specification of what messages to use to fulfill a particular GEM requirement and how to use them.
(2) Description of the internal states and modalities of the equipment and interactions between the SECS interface and those states.
(3) Definitions of variables important to the host.

Related to the specification of messages, GEM sets forth message scenarios. Message scenarios are sample exchanges of messages between the equipment and the host for the purpose of having a particular effect on the equipment. Scenarios specify precisely the order of messages between the host and equipment.

A good example of a message scenario would be one in which the equipment queries the host for the date and time, and upon receiving this data correctly, the equipment sets its time accordingly. The second area specified by GEM is in the area of machine states (or modes). The GEM specification talks about what categories of states the equipment can fall into and it specify what states may exist within those categories.

At present, these state models include following categories:

(1) Communications State Model
(2) Control State Model
(3) Spooling State Model

There may be other state models forthcoming, such as models dealing with material movement, and these will be added to GEM (and GEMLib) as they mature and receive SEMI approval. It's just as important that GEM define how equipment can transition from one state to another as the fact that it defines what states can exist. By doing so, a host can unambiguously follow the state of the equipment.

Communication state

The GEM standard defines how an equipment and host initially establish communication. It also defines how communication is re-established when communication is broken. An on-line identification method verifies the equipment's hardware and software identity. Terminal service features allow the host operator and equipment operator to exchange text manually typed at a console.

Control state

The GEM standard outlines a control state model to define the level of cooperation between the host and equipment. GEM equipment provides three basic levels of host control which determine the host's ability to control and monitor the equipment. Remote control capabilities permit the host to send GEM-defined commands like "START", "STOP", "PAUSE", "RESUME", and "ABORT" to control the equipment's processing. The equipment may support custom commands. GEM requires a small set of equipment constants to configure the GEM state machines. A machine may define additional equipment constants to provide refined control of the equipment's behavior.

Spooling

Spooling capabilities provide the means for the equipment to queue information intended for the host during communication failure. When communication is restored, the host may purge or request the queued data. The host may configure which information is queued, how a full queue is handled, the queue size, and how queued information is recovered. The host may also switch spooling features on. All GEM compliant manufacturing equipment share a consistent interface and certain consistent behavior. All may communicate with a GEM capable host using either TCP/IP (using the HSMS standard, SEMI E37) or RS-232 based protocol (using the SECS-I standard, SEMI E4). Often both protocols are supported. Each piece of equipment may be monitored and controlled using a common set of line management tools defined by GEM. When an equipment has GEM interface, it takes just minutes (or even seconds) for factory GEM host software to establish communication and begin monitoring the machine's activity on/off.

Operation Notification

Collection events and alarms allow the host to keep track of equipment’s operations. Equipment collection events notify the host of significant normal and abnormal activity. Equipment alarms notify the host when potentially dangerous activity is detected and cleared. The host determines which collection events and alarms is setup for notification to minimize and control communication traffic.

Data Gathering

GEM defines five methods of gathering data. The host may gather data from the equipment, but not vice-versa.

1. A set of status variable values may be requested at any time.
2. A set of equipment constant values may be requested at any time.
A report containing status variable, data variable, and equipment constant values may be requested at any time.
3. Reports may be attached to a collection event so that

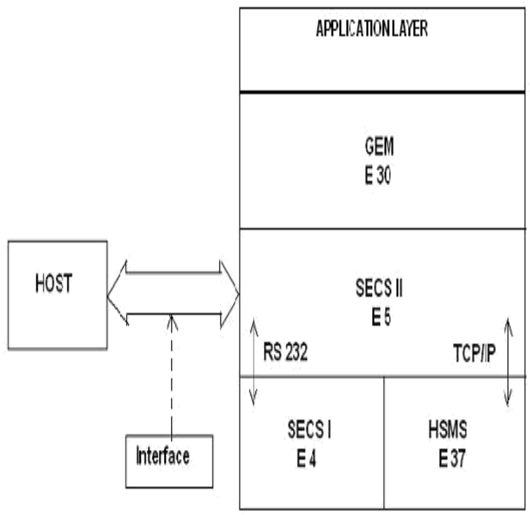

Figure 3. Layered architecture

the report information is transmitted along with the collection event automatically. This feature enables data to be sent to the host as the values become available thereby reducing or possibly eliminating the host's obligation to poll information.

4. The host may define traces so that the equipment automatically transmits the specified status variable values every specified time period. This feature facilitates time-based data collection.

5. The host may configure limits monitoring so that the equipment notifies the host whenever a specified variable value transitions across a host-defined limit boundary. This feature eliminates the need for the host to poll critical values is situations where the host is only con-cerned when the value becomes too high or low. Multiple limit boundaries may be defined.

Equipment status tracking

The third major area, which GEM defines, concerns variables. Variables allow the host to track many of the activities and progress of the equipment.

GEM ARCHITECTURE

As shown in Figure 3, typical GEM implementations incorporate an architecture where a single host computer acts a line management system for one or multiple manufacturing equipment. The host communicates directly with each equipment using either the SECS-I standard (RS-232 based serial communication) or HSMS-SS standard (TCP/IP based network communication). Once low level communication is established, then the host and equipment may exchange SECS-II messages.

Typical GEM implementations incorporate an architecture where a single host computer acts a line management system for one or multiple manufacturing equipment (www.semi.org). The host communicates directly with each e-quipment using either the SECS-I standard (RS-232 based serial communication) or HSMS-SS standard (TCP/IP based network communication). Once low level communication is established, then the host and equipment may exchange SECS-II messages.

SECS-II (SEMI Equipment Communications Standard Part 2) defines the method of conveying information between equipment and host in the form of messages.

These messages are organized into categories of activities, called streams, which contain specific messages, called functions. A request for information and the corresponding data transmission is an example of such an activity.

The messages defined to such a level of detail that some consistent host software may be constructed with only SECS-II message is identified by a stream number (0-255) and a function number (0-255). An odd-numbered function is a primary SECS-II message. A consecutive, even-numbered function is a secondary message - the reply to the corresponding primary message. Unless the reply bit is clear, a primary message should always be responded to with a secondary message minimal knowledge of individual equipment. For example, if the host sends an S1,F1 (stream 1, function 1) message to request 'Are you there?', then equipment will send a reply S2,F2 message to indicate 'I am here'. The GEM stan-dard defines a number of SECS-II messages scenarios; an ordered sequence of SECS-II messages. The SECS-II message scenarios establish an implementation guide-line so that the equipment manufacturer can anticipate how the host might use the GEM standard.

REQUIREMENTS

1. A set of alarms relating to physical safety limits of operator, equipment or material must be defined for equipment-by-equipment manufacturer.
2. The equipment must maintain all enable/disable states and report definitions in non-volatile memory.
3. Each alarm defined must have brief description of meaning, an associated unique identifier, alarm text, alarm status and two-collection event identifier.
4. Enabled alarm reports must be sent prior to corresponding enabled event reports.

Tools and technology

1. C# .Net
2. CCS Envoy: Used for host simulation
3. Visual Source Safe: Visual SourceSafe (VSS) is a client/server application, which acts as a storage system for files. Developers can safely and easily manage source code, Web content, and any other type of file.
4. Doxygen: A documentation system for C++, C, C#.

PRODUCT SCOPE

As the testing tool is compatible to SEMI standards, there is no overhead of changes in the host software. Testing tool checks the compatibility between the host and equipment. FAB's (Fabrication Automation – an important phase in Chip Manufacturing process) require equipment to follow common communication standards. These standards are voluntary technical agreements between suppliers and customers aimed at improving product quality and reliability at reasonable prices and steady supply.

The tool will provide benefits, which will enhance SEMI standards acceptance on the international level. It can address the communication needs of semiconductor equipment and other factory objects and will provide a general-purpose set of alarm management services.

CONCLUSION

For a semiconductor equipment manufacturer to compete in an international market, it is mandatory to design and build machines that conform to international, vendor - independent standards. The Semi Equipment Communication standard defines a communication interface suitable for the exchange of messages between semiconductor processing equipment and a host.

Implementation of SECS standard provides a means to communicate between different equipment without knowledge of their protocols. Compliance is defined with respect to individual standard capabilities to indicate adherence to that standard for specific capability.

Compliance testing based on an agreed implementation approach that provided by the International SEMATECH Manufacturing Initiative (ISMI) can eliminate the industry problem

This project is basically intended to implement Alarm management functionality of the Generic Model for Communications and Control of Manufacturing Equipment, that is, over the existing HSMS (High-speed SECS Message Services), the E-37 standard. The test application that will be developed intends to validate the equipment, check their compatibility against all or specific standards, make them universally acceptable. Communication between remote host and different equipment is also possible.

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