SEMI E101-0600
PROVISIONAL GUIDE FOR EFEM FUNCTIONAL STRUCTURE MODEL

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1 Purpose

1.1 Productivity improvement is the task with the highest priority in semiconductor factories of the 300 mm generation, and computer-integrated manufacturing or factory automation (CIM/FA) technologies become more and more important to accomplish it. The standardization of these technologies is also necessary to provide the CIM/FA infrastructure in a short period of time at a low cost. Since the standards will have to cover a wide range of production equipment, communication hardware, and software tools, it is very important that the standards have a high degree of compatibility. In order to improve the compatibility, this guide provides a functional structure model of an Equipment Front End Module (EFEM) that handles carriers and substrates at the interface between the factory material handling system and the process equipment.

1.2 The major purposes of this guide are as follows:

1) provide a common understanding of functions of EFEM (Equipment Front End Module) and associated interfaces between functional elements (components with particular function roles),

2) provide a common understanding of the hierarchical structure of functions and their interfaces in an EFEM,

3) provide a common understanding of possible units used for maintenance, adjustment, and control, and

4) provide a map between EFEM functional elements and existing standards.

2 Scope

2.1 *Model Structure and Functions*

2.1.1 This document recognizes EFEM as a component of semiconductor manufacturing equipment. It creates an EFEM functional structure model to clearly describe EFEM, its functional elements, and the functions of each functional element. The functional structure model includes the following:

1) definition of functional elements that constitute EFEM,

2) definition of functions of functional elements, and

3) hierarchical description of functional elements.

2.1.2 For clarity, Fixed Buffer Type EFEM and Internal Buffer Type EFEM (see Terminology) are represented as independent functional structure models in this document.

2.2 *Preconditions for Modeling*

2.2.1 The models are created under the following conditions:

1) Modeling should be restricted to SEMI E15.1, Option 1, Options 2 and 3, and Option 3 types. (See SEMI E15.1, Figure 2 (Load Port Options)).

2) The model supports handling of open cassette (OC), and Front Opening Unified Pod (FOUP) (see Terminology).

3) The model is created for the maximum structure including options.

4) Functional elements that have interfaces with EFEM are also included in the model.

NOTE 1: Functional elements that don't belong to EFEM, but are important in defining interfaces among the functional elements, are represented in this model to clarify their functional positions and attributes in the entire equipment.

2.3 This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Referenced Standards

3.1 *SEMI Standards*

SEMI E1.9 — Provisional Mechanical Specification for Cassettes Used to Transport and Store 300 mm Wafers

SEMI E15 — Specification for Tool Load Port

SEMI E15.1 — Provisional Specification for 300 mm Tool Load Port

SEMI E19 — Standard Mechanical Interface (SMIF)

SEMI E23 — Specification for Cassette Transfer Parallel I/O Interface

SEMI E44 — Guide for Procurement and Acceptance of Minienvironments

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SEMI E47.1 — Provisional Mechanical Specification for Boxes and Pods Used to Transport and Store 300 mm Wafers

SEMI E57 — Provisional Mechanical Specification for Kinematic Couplings Used to Align and Support 300 mm Wafer Carriers

SEMI E64 — Provisional Specification for 300 mm Cart to SEMI E15.1 Docking Interface Port

SEMI E75 — Provisional Mechanical Specification for Box/Pod Compatible Cassette Used to Transport and Store 300 mm Wafers

SEMI E84 — Specification for Enhanced Carrier Handoff Parallel I/O Interface

NOTE 2: As listed or revised, all documents cited shall be the latest publications of adopted standards.

4 Terminology

4.1 *Abbreviations and Acronyms*

4.1.1 AGV — automatic guided vehicle (cart)

4.1.2 *OHT* — overhead transport system with hoist for lifting carriers between load port level and transport level.

4.1.3 *PGV* — person guided vehicle (cart).

4.1.4 *PI/O* — parallel input/output interface, for example, as specified in SEMI E23.

4.1.5 *RGV* — rail guided vehicle (moving on the floor).

4.2 *Definitions*

4.2.1 *BOLTS plane* — a plane parallel to the facial datum plane near the front of the tool where the box opener/loader is attached (as defined in SEMI E63).

4.2.2 *box* — a protective portable container for a cassette and/or substrate(s) (as defined in SEMI E44).

4.2.3 *box opener/loader* — the equipment component that opens wafer carriers (if needed) and presents the carriers to the equipment's Substrate Handler for unloading and loading wafers.

4.2.4 *carrier* — any cassette, box, or pod that are used to transport substrates (as defined in SEMI E15).

4.2.5 *cart* — a floor-based carrier transfer vehicle.

4.2.6 *cassette* — an open structure that holds one or more wafer substrates (as defined in SEMI E44).

4.2.7 *docking* — the act of locating a floor-based carrier transport vehicle for carrier transfer to/from equipment.

4.2.8 *equipment front end module (EFEM)* — it consists of the carrier handler that receives carriers from the factory material handling system on one or more load ports (as specified in SEMI E15.1), opens the carriers (if needed), and may include a Substrate Handler for unloading and loading wafers from the carrier to the process part of equipment.

4.2.9 *fixed buffer* — EFEM configuration with carrier places only on load port units arranged in a load port group.

4.2.10 *front opening unified pod (FOUP)* — front opening type box/pod with non-removable cassettes (as defined in SEMI E47.1).

4.2.11 *internal buffer* — EFEM configuration with carrier places different from load port units.

4.2.12 *kinematic coupling* — the physical alignment mechanism on the bottom of the wafer carrier that consists of features that mate with three vertical pins on the load port (as defined in SEMI E57).

4.2.13 *load port* — the interface location on a tool where carriers are placed to allow the tool to process wafers (as defined in SEMI E15).

4.2.14 *open cassette (OC)* — a cassette (as defined in SEMI E1.9) without a protective barrier around it.

4.2.15 *transfer* — to either load or unload (as defined in SEMI E15).

5 Modeling Methodology (General Rules)

5.1 *Notation*

5.1.1 A functional element to be defined is represented by a rectangle.

5.1.2 The name of a functional element is written in the rectangle representing the element.

5.1.3 Numbers preceding the functional element name indicate the number of elements.

[0, 1] indicates the element may exist or may not exist.

[1+] indicates the element may exist one or more times.

5.2 *Rules of Notation Usage*

5.2.1 A functional element that is written on the border between adjacent layers indicates the element may belong to either of two functional elements in the adjacent layers.

5.2.2 Functional elements whose position in the Functional Structure Model diagram are similar in the two models of Fixed Buffer Type EFEM and Internal Buffer Type EFEM have the same name.

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5.2.3 A functional element whose location is still undecided between two adjacent layers is located in between them.

5.2.4 The element of the outer rectangle represents the functions of all rectangles inside, and the numbers preceding the functional element name of the outer rectangle takes precedence over the numbers of each elements placed inside.

6 Definition of Functional Elements

6.1 *Overall Structure*

6.1.1 Figures 1a, 1b and Figures 2a, 2b show conceptual structures of two types of Fixed Buffer Type EFEM model and two types of Internal Buffer Type EFEM model in overall structure of equipment. Two types of EFEM exist, when Substrate Handler is installed outside the Process Part, and when the Substrate Handler is included inside the Process Part.

6.1.2 *EFEM [1]* — This is a major module whose functions are to transfer carriers to and from the factory material handling system, to provide all carrier handling and storage functions for production equipment, and to load and unload substrates from the carrier for processing. It consists of a Carrier Handler and may contain a Substrate Handler.

6.1.3 *Carrier Handler [1]* — A Carrier Handler receives and passes the carriers from and/or to the external system (such as the factory material handling system). A Carrier Handler of the Internal Buffer Type has the functions of handling and storing the carriers. A carrier handler for FOUPs has the opener(s) for opening and closing FOUPs.

6.1.4 *Substrate Handler [0,1]* — A Substrate Handler transfers substrates between the carriers and the process part of the equipment.

6.1.5 *Load Port Group [1+]* — The load port group is where carriers are received and passed from or to the external system (such as the factory material handling system). Each equipment has at least one load port group. A load port group consists of one or more load ports.

6.1.5 *Internal Buffer [1+]* — This is a buffer that stores carriers inside equipment. It moves carriers from Load Port Group to Buffer and moves carriers from Buffer to Internal Substrate Port. It consists of a Carrier Transfer Robot that transfers the carriers to or from a Carrier Storage and a Carrier Storage where carriers are stored.

6.1.6 *Internal Substrate Port [0,1+]* — This is where substrates are loaded and unloaded from a carrier, and it contains any functionality required to present the carrier for substrate access.

6.2 *Definition of Functional Elements for EFEM Models*

6.2.1 *Model of Fixed Buffer Type EFEM (see Figure 3)*

6.2.1.1 *Load Port [1+]* — A load port is where an individual carrier is held for pickup and delivery with the factory material handling system. It consists of a Load Port Unit and may contain PI/O for OHT/AGV/RGV, Cart-to-Tool Docking Port Interface, and a Load Port Door.

6.2.1.2 *Load Port Unit [1]* — This physically receives carriers from/to external systems. It consists of a Carrier Opener/Loader, and it may contain a Carrier Operation Panel, a Carrier ID Reader/Writer, and a Carrier Slot Mapper.

6.2.1.3 *PI/O for AGV/RGV/OHT [0,1]* — This is a means of low-level communications that synchronizes the hand-off between Automated Material Handling equipment (such as AGV, RGV, OHT) and production equipment. One Parallel I/O may exist for each stop position of the AGV, RGV, or OHT. It may be a part of a Load Port or a Load Port Group depending on the number of ports that can be accessed from a single stop position.

6.2.1.4 *Cart-to-Tool Docking Port Interface [0,1]* — This is the mechanical interface allocated for installing the module to be used as a docking means for a person-guided vehicle (PGV) at the Load Port Group. One Cart-to-Tool Docking Port Interface may exists per Load Port Group or per Load Port.

6.2.1.5 *Load Port Door [0,1]* — This is the door that may be used to separate the space on a load port from the external environment, or to prevent the operator from interfering with the load port mechanism or OHT. This may be a part of a Load Port or a Load Port Group depending on the number of ports that can be accessed through a single Port Door.

6.2.1.6 *Carrier Operation Panel [0,1]* — This is an operation panel that may be used when manually loading or unloading a carrier to or from a Load Port. One operation panel may exist for each of SEMI E15.1's Load Port Option 1 and Option 3 types. No operation panel may exist for a Load Port of SEMI E15.1, Option 2 type.

6.2.1.7 *Manual Switches [0,1]* — These are the switches that may be used by an operator when manually loading or unloading a carrier. They are located on the Carrier Operation Panel.

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