

SEMI E101-1104 (Reapproved 0710)

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 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 Standard 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 are represented as independent functional structure models in this Standard.

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 (refer to SEMI E15.1, Figure 2 [Load Port Options]).
2. The model supports handling of open cassette (OC), and Front Opening Unified Pod (FOUP) (refer to 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.

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3 Referenced Standards and Documents

3.1 SEMI Standards and Safety Guidelines

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

SEMI E15 — Specification for Tool Load Port

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

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

4 Terminology

4.1 Abbreviations and Acronyms

4.1.1 *AGV* — automatic guided vehicle

4.1.2 *OHT* — overhead transport system

4.1.3 *PGV* — person guided vehicle

4.1.4 *PI/O* — parallel input/output interface

4.1.5 *RGV* — rail guided vehicle

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.

4.2.2 *box* — a protective portable container for a cassette and/or substrate(s).

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.

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

4.2.6 *cassette* — an open structure that holds one or more wafer substrates.

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.

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.

4.2.13 *load port* — the interface location on a tool where wafer carriers are delivered. It is possible that wafers are not removed from, or inserted into, the carrier at this location. [SEMI E15]

4.2.14 *open cassette (OC)* — a cassette without a protective barrier around it.

4.2.15 *transfer* — to either load or unload.

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.

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

6 Definition of Functional Elements

6.1 Overall Structure

6.1.1 Figures 1 and 2; and Figures 3 and 4 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.

6.1.6 *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.

6.1.7 *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 (refer to Figure 5)

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 exist 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.

6.2.1.8 *Carrier Indicators [0,1]* — These consist of a Carrier Presence Indicator (that indicates the presence of a carrier) and a Carrier Placement Indicator (that indicates whether the carrier is correctly seated). One set of Carrier Indicators may exist for each Load Port Unit. They are located on the Carrier Operation Panel.

6.2.1.9 *Carrier Opener/Loader [1]* — This is the unit that prepares a carrier for access for loading and unloading substrates and includes all mechanisms required for docking and undocking, purging, opening and closing FOUPs. In the case of an OC, it consists only of the Load Plate.

6.2.1.10 *Dock Plate [0,1]* — This is a mechanism that advances a FOUP up to the door opening/closing mechanism. It contains a Load Plate that a carrier is placed on, and it may contain the Dock/Undock mechanism that advances the carrier into the equipment, and/or a Carrier Purge Interface.

6.2.1.11 *Load Plate [1]* — This is the base plate on which carriers are placed. It consists of a Kinematic Coupling and may contain Carrier Sensors and/or Info Pad Sensors.

6.2.1.12 *Carrier Sensors [0,1]* — These are sensors to detect whether a carrier is present and/or a carrier is correctly placed.

6.2.1.13 *Info Pad Sensors [0,1]* — These are sensors to detect Info Pads as defined in SEMI E1.9.

6.2.1.14 *Carrier Purge Interface [0,1]* — This is a mechanical interface for injecting and withdrawing gasses.

6.2.1.15 *Dock/Undock Mechanism [0,1]* — This is the mechanism that advances a carrier to the FOUP opener and locks the carrier, or releases it from its locked state. In the OC (as defined in SEMI E1.9) case, this mechanism only moves carriers.

6.2.1.16 *FOUP Opener [0,1]* — This is the mechanism that opens and closes the FOUP door.

6.2.1.17 *Carrier Opener/Loader Maintenance Panel [0,1]* — This is a user interface for maintenance of the Carrier Opener/Loader.

6.2.1.18 *Carrier Slot Mapper [0,1]* — This is the mechanism that detects the presence or the absence of substrates and their positions in a carrier. It may be installed on the FOUP Opener, the Carrier Opener/Loader, the Load Port Unit, or the Substrate Handler.

6.2.1.19 *Carrier ID Reader/Writer [0,1]* — This is the unit that reads and/or writes to an ID tag attached to a carrier. At most, one Carrier ID Reader/Writer exists for each Load Port Unit.

6.2.1.20 *Status Indicator [0,1]* — This is a set of indicators which shows operating status of the Load Port Unit.

6.2.1.21 *Substrate ID Reader [0,1]* — This is the unit which reads the Identification Label on the Substrate.

6.2.1.22 *Aligner [0,1]* — This is the unit which aligns the angular orientation of substrates and may center the substrate.

6.2.1.23 *Substrate Transfer Robot [0,1+]* — This is the unit which transfers substrates between Carrier Handler, automation components (Aligner, Substrate ID Reader, etc.) and Process Part.

6.2.2 *Model of Internal Buffer Type EFEM (refer to Figure 6)*

6.2.2.1 This section defines functional elements that exist only in an Internal Buffer Type EFEM.

6.2.2.2 *Internal Buffer [1+]* — This is where an individual carrier is stored in an EFEM. It consists of a Carrier Transfer Robot that transfers carriers and a Carrier Storage where carriers are stored.

6.2.2.3 *Carrier Transfer Robot [1]* — This is a robot that handles carriers in Carrier Storage.

6.2.2.4 *Carrier Storage [1+]* — This is where an individual carrier is stored.

7 Related Documents

7.1 *SEMI Standards and Safety Guidelines*

SEMI E19 — Standard Mechanical Interface (SMIF)

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

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

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

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

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