SEMI E130-0618 (Reapproved 0723)
SPECIFICATION FOR PROBER SPECIFIC EQUIPMENT MODEL FOR 300 mm ENVIRONMENT (PSEM300)

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NOTICE: The section symbol (§) is used to reference a numbered section, paragraph, or header and all subordinate paragraphs, headers, and embedded material (i.e., EXCEPTIONs, lists) therein. The paragraph symbol (¶) is used to reference a particular numbered paragraph and embedded material therein. When duplicated (i.e., §§ and ¶¶) the symbols are used to reference more than one section or paragraph, respectively.

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1 Purpose

1.1 This Standard establishes a Prober Specific Equipment Model for prober equipment deployed in a factory adhering to the Global Joint Guidance for 300 mm Standards (PSEM300). The PSEM300 consists of equipment characteristics and behaviors that apply to this class of equipment and are required to be implemented. The intent of this Standard is to facilitate the integration of prober equipment into an automated semiconductor factory. This Standard accomplishes this by defining an operational model for prober equipment as viewed by a host. This definition provides a standard host interface and equipment operational behavior.

2 Scope

2.1 The PSEM300 extends the generic Process State Model of SEMI E30 (GEM) with a Specific Process State model for prober equipment. This Standard attempts to be protocol independent. There is no attempt to replace the protocol dependent aspects of SEMI E30 (GEM). Instead, this Standard assumes that certain equipment features not covered within the concepts and behaviors of the related 300 mm Standards will be supported using the concepts and behaviors defined within SEMI E30. Refer to § 9 for a description of the SEMI E30 provisions.

2.2 This Standard does not attempt to define the full set of equipment capabilities. It is understood that additional value-added features will be provided in addition to the requirements set forth in this Standard.

2.3 This Standard intends host-instructed indexing of sites within a substrate and the loading/unloading of the substrates. Automated self-indexing with such communications as GPIB or RS-232C between tester and prober equipment is outside the scope of this Specification but is not precluded. Refer to Related Information 2 for reference.

2.4 This Standard does not describe much about recovery of exception or manual operation to recover from alarm/potential-alarm (warning) situations. Such conditions are usually configuration specific.

2.5 This Standard presents a solution from the concepts and behavior down to the messaging services. It does not define the messaging protocol.

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3 Limitations

3.1 This Standard does not define the format of each data item specified in the equipment recipe.

3.2 This Standard does not define a communications protocol. In order to implement this Specification, it requires a standard communications protocol and data format specification.

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4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI E30 — Specification for the Generic Model for Communications and Control of Manufacturing Equipment (GEM)

SEMI E40 — Specification for Processing Management

SEMI E42 — Recipe Management Standard: Concepts, Behavior, and Message Services

SEMI E87 — Specification for Carrier Management (CMS)

SEMI E90 — Specification for Substrate Tracking

SEMI E94 — Specification for Control Job Management

SEMI G81 — Specification for Map Data Items

SEMI G85 — Specification for Map Data Format

4.2 *IEEE® Standards*[1]

IEEE 754-1985 — IEEE Standard for Binary Floating-Point Arithmetic

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

5 Terminology

5.1 *Definitions*

5.1.1 *alignment* — a procedure in which a coordinate system is established on a substrate.

5.1.2 *cassette* — a physical object containing one or more substrate locations. [SEMI E87]

5.1.3 *chuck* — the primary stage for processing a substrate.

5.1.4 *column* — synonymous with the term 'X-coordinate'. Columns increase along the X axis.

5.1.5 *die* — (1) a field sub-unit. (2) An area of substrate that contains the device being manufactured.

5.1.6 *fiducial* — flat or notch in the physical substrate used to identify the substrate orientation.

5.1.7 *inker* — a resource of the prober. The electromechanical units to put ink mark on die.

5.1.8 *load* — (1) move a substrate onto a substrate location. (2) Move a carrier onto the equipment.

5.1.9 *marking* — the process of the prober that deposits an ink mark on a die using the inker.

5.1.10 *pipelin*e — an equipment configuration consisting of multiple stages through which the equipment sequences material in succession.

5.1.11 *pre-align* — set up a substrate to be processed on the chuck. The equipment may have a separate stage for performing the pre-align function.

5.1.12 *probe card* — the electromechanical interface necessary to enable temporary electrical contact between the substrate to be tested and the tester resource. May consist of multiple components.

5.1.13 *row* — synonymous with the term 'Y-coordinate'. Rows increase along the Y axis.

5.1.14 *stage* — a general term for a substrate location that serves a specific function such as pre-align or chuck.

5.1.15 *state* — (1) a static set of conditions. If the conditions are met, the state is current. [SEMI E30] (2) A state reacts predictably to specific stimuli.

5.1.16 *substrate* — the basic unit of material, processed by PSEM300 equipment such as wafers.

[1] Institute of Electrical and Electronics Engineers, 3 Park Avenue, 17th Floor, New York, NY 10016-5997, USA; Telephone: +1.212.419.7900, Fax: +1.212.752.4929, http://www.ieee.org. IEEE trademark is owned by The Institute of Electrical and Electronics Engineers, Inc.

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5.1.17 *unload* — (1) remove a substrate from a substrate location. (2) Remove a carrier from the equipment.

5.1.18 *X axis* — the *X* axis is the horizontal axis from left to right when the substrate is rotated according to Orientation.

5.1.19 *Y axis* — the *Y* axis is the vertical axis from bottom to top when the substrate is rotated according to Orientation.

6 Conventions

6.1 *Remote Command Parameter Table Definitions*

6.1.1 The table below provides an example of the tables used to list and describe arguments for services or remote commands defined in this Specification.

Parameter	*Req/Ind*	*Rsp/Cnf*	*Form*	*Comment*
	(Refer to ¶ 6.1.3)	(Refer to ¶ 6.1.4)		

6.1.2 *Parameter* — Specifies the name of the parameter.

6.1.3 *Req/Ind* — Specifies relationship of the parameter for the command request or indication message. Refer to table below for codes used.

6.1.4 *Rsp/Cnf* — Specifies relationship of the parameter for the command response or confirmation message. Refer to table below for codes used.

6.1.5 *Form* — Specifies the data type of the parameter. Data types are as defined in the SEMI Standards Compilation of Terms or are included in this Specification. Specific representation of the data types will depend on and be defined by the communications protocol and data format adjunct specification.

6.1.6 The following codes appear in the Req/Ind and Rsp/Cnf columns to define how each parameter is used in each direction:

M	Mandatory Parameter – Must be given a valid value.
C	Conditional Parameter – May be defined in some circumstances and undefined in others. Whether a value is given may be completely optional or may depend on the value of the other parameter.
U	User-Defined Parameter
-	The parameter is not used.
=	(for response only) Indicates that the value of this parameter in the response must match that in the primary (if defined).

7 Requirements

7.1 Following sections in this Standard, except such supplementary descriptions as Related Information, are requirements of this Specification.

8 State Model

8.1 The purpose is to define the equipment-specific processing state model to portray the expected operational states of the equipment to enable host tracking and control in place of a local operator. The Process Job Management Standard (SEMI E40) is part of the required behavior of this Standard as described in § 9. For additional description of this behavior refer to § 10 or SEMI E40.

8.1.1 The Process State model tracks the state of the equipment with regard to its ability to perform processing on a substrate. The Process State model is used to inform the host when a substrate is loaded on the main chuck and has been properly setup for processing.

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8.1.2 It is expected that the prober will be preparing a substrate to be loaded on the main chuck while the host is processing an existing substrate on the main chuck. This concurrent activity does not impact the host's ability to process the existing substrate and therefore does not cause a change in the Process State model. The Standard for Substrate Tracking (SEMI E90) is used for tracking substrates between individual substrate locations.

8.1.3 The processing state model in this Standard is required for implementing a PSEM300-compliant prober, in addition to the required state models in the related standards. A state model consists of a state model diagram, state definitions, and a state transition table. A state model represents the host's view of the prober, but not necessarily the actual prober operations. All PSEM300 state model transitions shall be mapped sequentially into the actual equipment events that satisfy the requirements of those transitions. In certain implementations, the prober may enter a state and has already satisfied all of the conditions required by the PSEM300 state model for transition to another state. In this situation, the prober makes the required transition without any additional actions.

8.1.4 Some equipment may need to include additional states. However, any additional states must not change the PSEM300-defined state transitions. All expected transitions between PSEM300 states must occur.

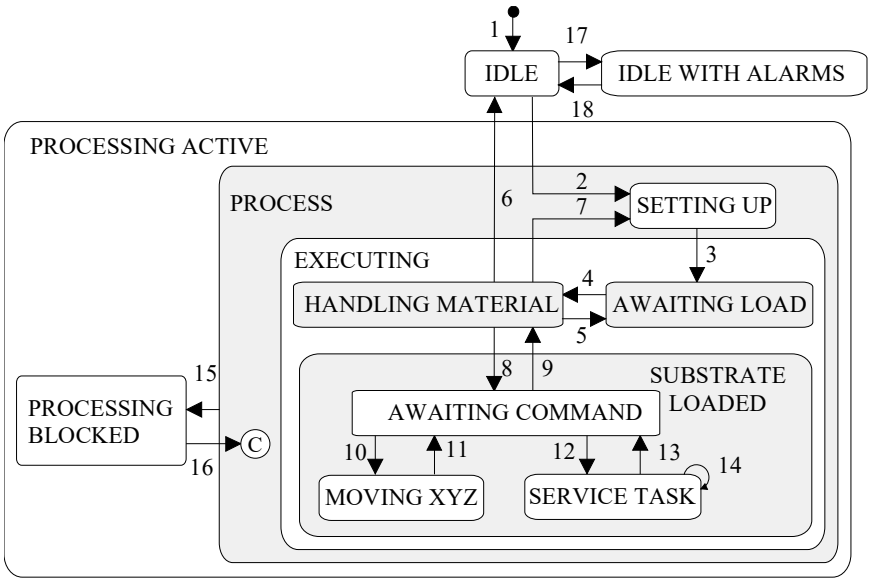

Figure 1
PSEM Process State Model Diagram

8.1.5 *Description of Prober Processing States*

8.1.5.1 *AWAITING COMMAND (SUBSTRATE LOADED Substate)* — A substrate on the main chuck is ready for processing. The prober is ready to receive an instruction from the host.

8.1.5.2 *AWAITING LOAD (EXECUTING Substate)* — At least one Process Job is in the PROCESSING state. No substrate is loaded on the main chuck. The prober is waiting for a host command to load a substrate.

8.1.5.3 *EXECUTING (PROCESS Substate)* — One of the following conditions exists: (A) At least one Process Job is in the PROCESSING state and the prober is processing material as directed by the host. (B) A single Process Job is active in either the STOPPING or ABORTING state and the prober is removing material.

8.1.5.4 *IDLE* — No Process Jobs are in the ACTIVE state and the processing resource is available without alarms.

8.1.5.5 *HANDLING MATERIAL (EXECUTING Substate)* — The prober is loading a substrate, unloading a substrate, or a combined action of loading and unloading substrates on the main chuck. When loading a substrate onto the main chuck, the HANDLING MATERIAL state is maintained until all preconditioning tasks (i.e., aligning, profiling, etc.) are completed and the substrate is ready for processing. If a condition arises where the substrate on a chuck must be re-aligned, the HANDLING MATERIAL state is active until the alignment task has completed.

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8.1.5.6 *MOVING XYZ (SUBSTRATE LOADED Substate)* — The prober is executing a move command. This state is maintained until the move is complete. This includes motion in the *z*-axis. When this state is exited, the target unit(s) on the substrate is in position to be processed.

8.1.5.7 *PROCESS (PROCESSING ACTIVE Substate)* — This state is the parent of those substates that refer to the preparation and execution of a process job.

8.1.5.8 *PROCESSING ACTIVE* — The state in which at least one Process Job is active.

8.1.5.9 *PROCESSING BLOCKED* — The processing resource is not available for processing.

8.1.5.10 *SETTING UP (PROCESS Substate)* — A single ACTIVE Process Job is in the SETTING UP state.

8.1.5.11 *SERVICE TASK (SUBSTRATE LOADED Substate)* — A service task such as inking, cleaning, or inspection is being performed by the prober.

8.1.6 *PSEM Processing State Transition Table*

Table 1 PSEM Processing State Transition Table

#	*Current State*	*Trigger*	*New State*	*Action*	*Comment*
1	No state	The processing resource has become available for processing.	IDLE		There are no active process jobs at this time.
2	IDLE	A process job has been dispatched into the SETTING UP state.	SETTING UP	Actions taken correspond to preconditioning activities within the SEMI E40 Process Job.	
3	SETTING UP	A single Process Job is active and has transitioned from the SETTING UP state to the PROCESSING state.	AWAITING LOAD		The prober is awaiting instructions from the host to load a substrate on to the main chuck. The Process Job PRMtlNameList contains the list of substrates to be processed.
4	AWAITING LOAD	Prober has received a command from the host to load a substrate on to the main chuck.	HANDLING MATERIAL	The equipment is loading a substrate on the main chuck.	None.
5	HANDLING MATERIAL	The material handling task completes leaving the main chuck unoccupied. A Process Job is in the PROCESSING state.	AWAITING LOAD		Refer to § 17 for a description of the prober behavior related to material handling.
6	HANDLING MATERIAL	The material handling task completes leaving the main chuck unoccupied. There are no active Process Jobs.	IDLE		
7	HANDLING MATERIAL	The material handling task completes leaving the main chuck unoccupied. There are no Process Jobs in the PROCESSING state. A Process Job is in the SETTING UP state.	SETTING UP		

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#	*Current State*	*Trigger*	*New State*	*Action*	*Comment*
8	HANDLING MATERIAL	The material handling task completes. A substrate located on the main chuck has been fully setup and is ready to receive processing as directed by the host.	AWAITING COMMAND		All pre-processing steps including profiling, aligning, temperature soak, etc. have completed. Refer to § 22.4 for the list of remote commands the host can issue while the prober is in the AWAITING COMMAND state.
9	AWAITING COMMAND	The host issued a material handling related remote command.	HANDLING MATERIAL	The prober performs the task as commanded by the host.	Refer to § 17 for a description of the commands the host may issue relating to material handling.
10	AWAITING COMMAND	The prober receives a motion related remote command.	MOVING XYZ	The prober moves the main chuck to the specified location on the substrate.	Refer to § 17 for a description of the motion related commands the host can issue to trigger this transition. Refer to § 19.2 for the list of required data items associated with this transition.
11	MOVING XYZ	The prober has completed the motion related task and waits for further instructions from the host.	AWAITING COMMAND		Prober waits for further instructions from the host.
12	AWAITING COMMAND	The prober received a remote command specifying a service task.	SERVICE TASK	Refer to § 16 for a description of the prober actions related to performing a service task.	
13	SERVICE TASK	The prober has completed a service task.	AWAITING COMMAND		Prober waits for further instructions from the host.
14	SERVICE TASK	The prober is configured to perform a subsequent service task upon completing a current service task.	SERVICE TASK	Refer to § 16 for a description of the prober actions related to performing a service task.	Example: The recipe may call for a probe card inspection to automatically follow a probe clean service task.
15	PROCESS	The processing resource has become unavailable.	PROCESSING BLOCKED	No further processing is possible.	The cause of this trigger can be an internal interrupt or an external command from the operator or host.
16	PROCESSING BLOCKED	The processing resource has become available or the prober is handling material in the process of terminating a job.	PROCESS Substate	Refer to ¶ 8.1.7 for the conditional return state.	If the job(s) have been terminated, the HANDLING MATERIAL state will be occupied while the material is being removed from the prober.
17	IDLE	An alarm state is entered that causes the processing resource to be unavailable for processing.	IDLE WITH ALARMS		
18	IDLE WITH ALARMS	The alarm condition has been cleared.	IDLE		

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8.1.7 *Process Model Conditional Table*

Table 2 Process Model Conditional Table

Conditions	*Next State*
The current Process Job is terminating	HANDLING MATERIAL
The processing resource has become available and the current Process Job remains active	Previous EXECUTING state

9 Related Standards Hierarchy

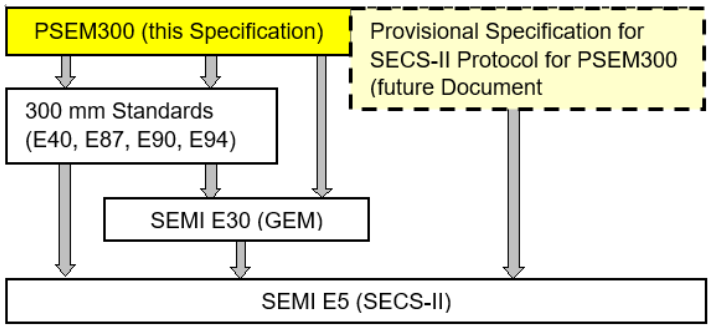

Figure 2
Related Standards Hierarchy

9.1 *SEMI E30 Relationship* — This Standard does not attempt to redefine the concepts and behaviors of SEMI E30 (GEM). Instead, this Standard takes a hierarchical approach to identifying the methods for achieving a given task as shown in Figure 2.

9.1.1 *SEMI E30 Inclusions* — All of the SEMI E30 state models are required with exception of the processing state diagram. This diagram is replaced with the one defined in this Standard.

9.1.2 *SEMI E30 Exclusions* — Data Type restrictions may conflict with the newer 300 mm Standards and therefore, the constraints found within the newer standards shall take precedence over the restrictions found in SEMI E30.

10 Process Jobs

NOTE 1: SEMI E40 is required for PSEM300 compliance.

10.1 A PSEM300 prober is not able to operate as an independent processing agent. It requires a host to coordinate interaction with the tester. This Standard defines a suitable GEM interface consisting of the Process State Model and associated remote commands to allow the host to act as the processing agent on behalf of the prober to complete the execution of the process job.

10.2 This Standard assumes that if the equipment has a pipeline (e.g., pre-align stage and main chuck), the equipment will support concurrent process jobs such that when the last substrate of an active process job leaves the first pipeline stage, the equipment will launch another process job thus maintaining continuous material flow.

10.3 *Process Job Preconditioning* — This Standard does not attempt to define the set of recipe attributes that, when different from the current equipment configuration, will require a transition to the Process Job SETTING UP state (preconditioning required). The recipe attributes that do impact the Process Job transition to SETTING UP will be user defined and documented as such.

10.4 A PM compliance checklist must be filled out to indicate the level of compliance to both the Fundamental and Additional PM capabilities.

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11 Control Job

NOTE 2: SEMI E94 is required for PSEM300 compliance.

11.1 Refer to SEMI E94 for details of Control Job management.

11.2 A substrate's destination substrate location is specified in the Control Job's MtrlOutSpec attribute. If the MtrlOutSpec attribute is not set, the destination substrate location defaults to the source substrate location.

11.3 A CJM compliance checklist must be filled out to indicate the level of compliance to Fundamental CJM capabilities (no Additional capabilities are defined at this time).

12 Carrier Management

NOTE 3: SEMI E87 is required for PSEM300 compliance.

12.1 *CarrierReCreate* — After processing material for a given carrier, the host must be able to define a new CJ/PJ for the same carrier without having to remove the carrier from the tool. For this, the equipment must support the CarrierReCreate service.

12.2 A CMS compliance checklist must be filled out to indicate the level of support for CMS for a given equipment configuration.

13 Substrate Tracking

NOTE 4: SEMI E90 is required for PSEM300 compliance.

13.1 Substrate Tracking must be supported for all product substrates and substrate locations where product substrates may reside. Some of the substrate locations that might exist include: handling robot, post-chuck substrate location.

13.2 The supplier may choose not to support substrate tracking for certain internal substrate locations. This is allowable if the substrate location will not be occupied by product substrates (e.g., Cleaning Media tray, AUX Tray). The supplier must document which substrate locations are available for substrate tracking.

13.3 A CMS 'CarrierReCreate' service will cause each of the substrates contained within a recreated carrier to be reset to the AT SOURCE and NEEDS PROCESSING state.

NOTE 5: A STS compliance checklist must be filled out to indicate the level of compliance to STS Fundamental and Additional capabilities.

14 Equipment Configuration

14.1 This Standard does not attempt to specify the physical equipment configuration. The intent of this Standard is to provide a generalized specification that applies to all configurations. The supplier is responsible for assuring that additional features integrate consistently with the relevant Standards impacted by the feature. The purpose of this section is to add clarification to baseline assumptions that are implied throughout this Specification.

14.2 *Pipeline*

14.2.1 A typical pipeline configuration consists of a pre-align stage used to pre-process a substrate before loading onto the chuck. The equipment can begin processing the substrate on the chuck while the next substrate is being prepared on the pre-align stage. For this configuration, the material flow is assumed to follow the path: source substrate location ⇨ pre-align stage ⇨ chuck ⇨ destination substrate location. There may be additional substrate locations both before and after the chuck.

15 Control Maps

15.1 Control Maps provide a mechanism for communicating the selective sites for processing in a pre-determined manner. Control Maps are not suitable for adaptive test where dynamic site selection is used.

15.2 *Control Map Uses*

15.2.1 *Inking* — The host can download a control map containing the sites to be inked. The host issues the INK DIE remote command specifying the control map as the source for the die list.

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15.2.2 *Normal Processing* — When using a Control Map, the host issues the INDEX remote command to move the prober coordinates to the next site listed in the Control Map. The host may issue a move related command other than INDEX to move the chuck to any location on the substrate. Move commands other than INDEX, do not impact the state of the Control Map. The prober processes subsequent INDEX commands by going to the next site listed in the Control Map. If the Control Map does not contain additional sites the equipment sends an event to the host indicating that the control map has been completed.

15.2.3 *Interrupted Processing* — If the processing of a substrate using a Control Map is interrupted (i.e., Correlation Test, Probe Cleaning with a cleaning substrate, Chuck Reset, etc.), the equipment shall resume processing with the Control Map from the point where processing was suspended when the substrate processing resumes. The exceptions to this requirement are:

15.2.3.1 If the current Process Job is altered such that the suspended substrate is no longer in the IN PROCESS state, the Control Map is no longer valid.

15.2.3.2 If the host issues a RESET-CONTROL-MAP command, the Control Map will resume at the first site. If the host designates coordinates with the RESET-CONTROL-MAP command, the prober will resume the Control Map with the designated coordinates. It is the responsibility of the host to assure that the coordinates provided with this command are contained in the Control Map.

15.3 If the host issues a SET-CONTROL-MAP command, the prober will begin processing the Control Map at the first site of the designated Control Map. If the host designates coordinates with the SET-CONTROL-MAP command, the prober will process the Control Map beginning with the designated coordinates. It is the responsibility of the host to assure that the coordinates provided with this command are contained in the Control Map.

15.4 *Control Map Transmission* — The method for downloading/uploading control maps is outside the scope of this Standard.

15.5 *Control Map Structure* — The structure of the control map is outside the scope of this Standard. The use of SEMI G81 or SEMI G85 Standards is recommended to describe map structures.

15.6 *Control Map Modifications* — The option to update a control map to register sites as they are processed is a user specific detail. In the event that control maps are modified on the prober, the prober must support uploading the modified maps to the host.

16 Service Tasks

16.1 The recipe on a PSEM300 compliant prober contains setup parameters and references to a collection of service recipes (refer to SEMI E42 for a description of Service Recipe's). The host can issue a command to execute a service task. The instructions for performing the specified task are contained in the respective service recipe. This Standard makes no attempt to define the full list of service tasks available for a given equipment. However, when a service task is available, the supplier is responsible for documenting the command and parameters required for the host to request the task. When a service task is performed, the Process State model transitions to the SERVICE TASK state and provides the host with a descriptive TaskID.

16.2 *Inking*

16.2.1 The host can perform inking on individual devices by issuing the INK-DEVICE command, or the host can ink a list of devices by issuing the INK-DIE command and a die list. The die list parameter may reference a Control Map containing the die selection.

16.3 *Inspecting*

16.3.1 There are several inspections the prober may be capable of performing such as inspecting the probes, inspecting ink marks, and inspecting the Probe to Pad alignment. The supplier must document the inspections that are supported and provide remote commands for selecting the designated inspection.

16.3.2 The Inspection associated with the maintenance activity is not to be confused with the process of Inspecting as defined in this section. The activity of inspecting the equipment in a maintenance capacity may involve the use of subsystems including one or more inspection process steps. While the use of an inspection subsystem in a process capacity constitutes a transition to the SERVICE TASK state, the equivalent use of the same subsystem in a maintenance capacity does not.

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16.4 *Probe Cleaning*

16.4.1 This Standard does not attempt to specify the full set of probe cleaning features. However, this Standard does require at minimum the ability to designate logical zones within a cleaning media type to prevent cross-contamination between wafer technology types. The supplier must provide suitable means through the use of Equipment Constants and Status Variables to allow the user full selectivity of the available options.

17 Material Movement

17.1 *Between Substrate Locations (Inter-Substrate Moves)*

17.1.1 *Loading Substrates*

17.1.1.1 The host issues the LOAD-SUBSTRATE command to load the next substrate identified in the current Process Job's PRMtlNameList attribute onto the chuck. The order by which the substrates of a process job are processed is fully defined within the Process Job.

17.1.1.2 If the equipment is configured with a multi-stage pipeline, upon receiving the LOAD-SUBSTRATE command from the host, the equipment will fill the pipeline up to the point where the substrate to be processed is loaded onto the chuck and readied for processing. Subsequent LOAD-SUBSTRATE commands will maintain a full pipeline as long as additional substrates are available for processing. This assures continuous material flow.

17.1.1.2.1 *Example* — if the equipment is configured with a two-stage pipeline consisting of a pre-align stage and a main chuck, A LOAD-SUBSTRATE command issued by the host while the Process State model is in the AWAITING LOAD state and the pipeline is empty will cause the first substrate to be processed through the pre-align stage and onto the chuck. The next substrate will then be loaded onto the pre-align stage.

17.1.2 *Loading Substrates — Spanning Process Job Boundaries*

17.1.2.1 When the host issues the LOAD-SUBSTRATE command that moves the last substrate of the current Process Job out of the first pipeline stage (or chuck for non-pipelined configurations) and another Process Job is defined with the PRProcessStart attribute set to TRUE, the equipment will automatically launch the next Process Job. If Process Job preconditioning is not required for the newly launched Process Job, the first substrate listed in the PRMtlNameList will be loaded into the first pipeline stage (or chuck for non-pipelined configurations).

17.1.3 *Loading Substrates — Substrate State Model*

17.1.3.1 Substrate Tracking events (SEMI E90) must be available to the host. When a substrate is moved from the source carrier to the first pipeline stage (or chuck for non-pipelined configurations), the substrate state model will transition from AT SOURCE to AT WORK.

17.1.3.2 When a substrate is loaded on the chuck, the substrate state model will transition from NEEDS PROCESSING to IN PROCESS for substrates that were not previously suspended (refer to § 17.1.5 for a description of suspending substrates). A substrate that was suspended will already be in the IN PROCESS state.

17.1.4 *Unloading Substrates*

17.1.4.1 *LOAD-SUBSTRATE Command* — When the host issues the LOAD-SUBSTRATE command, the substrate currently occupying the chuck is removed from the chuck and placed in the destination substrate location (This assumes that no additional post-chuck substrate locations exist). The substrate state model transitions from the IN PROCESS to PROCESSED state. When the substrate is loaded in its destination substrate location, the substrate transitions from the AT WORK to the AT DESTINATION state.

17.1.4.2 *UNLOAD-SUBSTRATE Command* — The host issues the UNLOAD-SUBSTRATE command to remove the substrate from the chuck and place it in its destination substrate location leaving the chuck unoccupied. For pipelined configurations, the substrate(s) in the pipeline remain in their current location. The state model for the substrate removed from the chuck transitions from the IN PROCESS to PROCESSED state. When the substrate is loaded in its destination substrate location, the substrate transitions from the AT WORK to the AT DESTINATION state. This command cannot be used to suspend the substrate occupying the chuck.

17.1.4.3 *UNLOAD-ALLSUBSTRATES Command* — The host issues the UNLOAD-ALLSUBSTRATES command to return all substrates occupying the chuck and pipeline stages to their respective carriers. For pipelined configurations, substrates occupying a pre-chuck pipeline stage are returned to their source substrate location. The state model for

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these substrates transitions from the AT WORK to AT SOURCE state while remaining in the NEEDS PROCESSING state.

17.1.4.3.1 *UNLOAD-ALLSUBSTRATES With SUSPEND* — If the host intends to continue processing the substrate occupying the chuck, the host includes the SUSPEND parameter with the UNLOAD-ALLSUBSTRATES command (refer to § 17.1.5 for a description of suspending substrates).

17.1.4.3.2 *UNLOAD-ALLSUBSTRATES No SUSPEND* — If the host has completed processing the substrate occupying the chuck, the host issues the UNLOAD-ALLSUBSTRATES without the SUSPEND parameter. The substrate occupying the chuck transitions from the IN PROCESS to PROCESSED state and is delivered to the destination substrate location. When the substrate is loaded in the destination substrate location, the substrate transitions from the AT WORK to the AT DESTINATION state.

17.1.5 *Suspending Substrates*

NOTE 6: Substrate Suspending and Resuming are not Job Control collection events (e.g., CJ/PJ PAUSE/RESUME). A substrate can be suspended as part of a normal process interrupt to allow a service task to be performed as directed by the host.

17.1.5.1 The host can suspend processing on a substrate in order to free the chuck for other purposes such as performing diagnostics or maintenance. A suspended substrate will be returned to its source substrate location and remains in the IN PROCESS state. When the substrate is loaded into the source substrate location, the substrate transitions from the AT WORK to the AT SOURCE state.

17.1.5.2 Suspending a substrate does not change the order in which substrates are processed within a Process Job.

17.1.5.3 The commands that result in a substrate being suspended are: UNLOAD-ALLSUBSTRATES with SUSPEND and LOAD-TEST-SUBSTRATE. It is expected that additional capabilities may exist that result in a substrate being suspended (such as cleaning probes with a cleaning disk).

17.1.6 *Resuming a Suspended Substrate*

17.1.6.1 A substrate that has been suspended will be the first substrate loaded onto the chuck when processing resumes.

17.1.6.2 If a substrate was suspended automatically as part of a service task, the equipment will automatically resume the suspended substrate prior to indicating that the service task has completed.

17.1.6.3 If the host suspended a substrate by issuing the UNLOAD-ALLSUBSTRATES with SUSPEND, the host resumes the suspended substrate by issuing the LOAD-SUBSTRATE command.

17.2 *Chuck Movement (Intra-Substrate Moves)*

17.2.1 When a control map is used to specify stepping, the INDEX Remote command must be used to move to the next die location. When a control map is not used, either the MOVE, MOVE-ABS or MOVE-SUBSTEP Remote commands must be used to specify motion.

17.2.2 Die coordinates are row and column numbers. Moving the wafer one row increases or decreases the DieYCoordinate by one. Moving the wafer one column increases or decreases the DieXCoordinate by one. Following an INDEX command the die coordinates can be retrieved from the variables ‘DieXCoordinate’ and ‘DieYCoordinate’.

17.2.3 The Z coordinate is zero if the wafer is out of contact (the chuck is down) with the probes and one if it is in contact (the chuck is up).

17.2.4 The MOVE command specifies the number of rows and columns to move from the current position. When the move is complete, DieXCoordinate will be changed to DieXCoordinate+X; DieYCoordinate will be changed to DieYCoordinate+Y. When the Z parameter is included in the MOVE command, a value of ($Z = -1$) moves the chuck to the down coordinate, a value of ($Z = +1$) moves the chuck to the up coordinate, and a value of ($Z = 0$) leaves the chuck in the starting Z coordinate.

17.2.5 The MOVE-ABS command specifies the new die coordinates. When the move is complete, DieXCoordinate will be changed to X; DieYCoordinate will be changed to Y; and the chuck will be down ($Z = 0$) or up ($Z = 1$).

17.2.6 The MOVE-SUBSTEP remote command moves the substrate in units smaller than the die size. The step resolution for the X, Y, and Z axis is available for query from the equipment status variables MinXStep, MinYStep and MinZStep. X, Y, and Z are all relative motions in the specified units. The prober may apply an appropriate compensation factor to adjust for thermal expansion, etc.

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18 Coordinate System

18.1 This Standard provides a coordinate system capable of describing simple geometries. Additional user-defined attributes may be required in addition to the attribute definitions contained in this Specification.

18.2 This coordinate system does not include information for establishing which devices on a substrate are 'good' devices. The guidelines for assigning the row and column index number are set forth in SEMI G81.

18.3 *General Coordinate Attributes*

18.3.1 *Rows* — The number of rows on a substrate in the *Y*-axis. A row must contain at least one complete device to be included in this count.

18.3.2 *Columns* — The number of columns on a substrate in the *X*-axis. A column must contain at least one complete device to be included in this count.

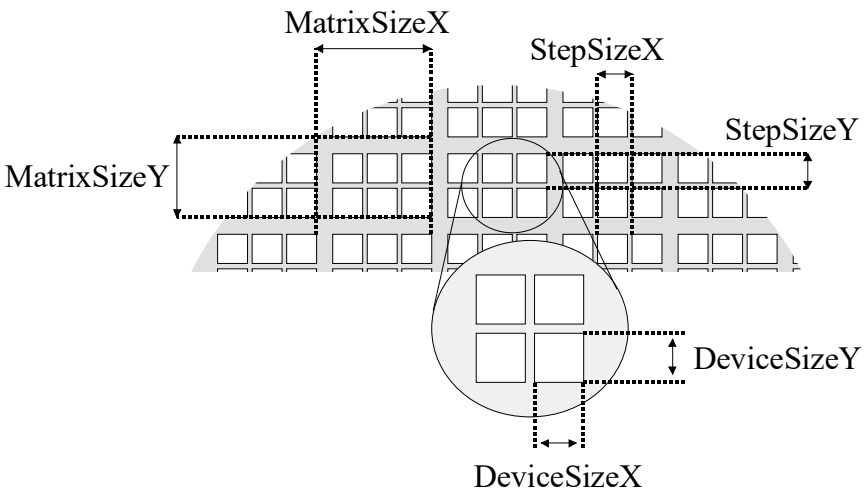

Figure 3
Dimensional Attributes

18.4 *Matrix Substrates*

18.4.1 The term 'matrix' is used to describe the step periodicity associated with an exposure field. Applicable when the step size between adjacent devices spanning an exposure field is different from the step size of adjacent devices within an exposure field.

18.4.2 This Standard does not address complex geometries where individual device sizes vary within an exposure field or between exposure fields or where exposure step sizes vary across the substrate.

18.4.3 A non-matrix substrate is a substrate where the step size between adjacent devices spanning an exposure field is no different from the step size between adjacent devices within an exposure field.

18.4.4 *Matrix Attributes*

18.4.4.1 *MatrixDeviceRows* — This is the number of device rows within an exposure field. This value is dependent upon the Orientation recipe attribute but not the OrientationOnChuck attribute. For non-matrix substrates, the value of this attribute is 1.

18.4.4.2 *MatrixDeviceCols* — This is the number of device columns within an exposure field. This value is dependent upon the Orientation recipe attribute but not on the OrientationOnChuck attribute. For non-matrix substrates, the value of this attribute is 1.

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18.4.4.3 *MatrixSizeX* — The *X*-axis step size in microns between a device in one exposure field and the same device in an adjacent exposure field. For non-matrix substrates, the value of this attribute is equal to the StepSizeX attribute. This attribute is dependant on the Orientation recipe attribute.

18.4.4.4 *MatrixSizeY* — The *Y*-axis step size in microns between a device in one exposure field and the same device in an adjacent exposure field. For non-matrix substrates, the value of this attribute is equal to the StepSizeY attribute. This attribute is dependant on the Orientation recipe attribute.

18.5 *Reference Device*

18.5.1 The Reference Device establishes the link between the coordinate system Row and Column and the physical location on the substrate.

18.5.2 *Reference Device Attributes*

18.5.2.1 *RefDevicePosX* — This is the offset of the center of the reference device in the *X* direction from the center of the substrate with the substrate Orientation at 0° and OriginLocation = 3.

18.5.2.2 *RefDevicePosY* — This is the offset of the center of the reference device in the *Y* direction from the center of the substrate with the substrate Orientation at 0° and OriginLocation = 3.

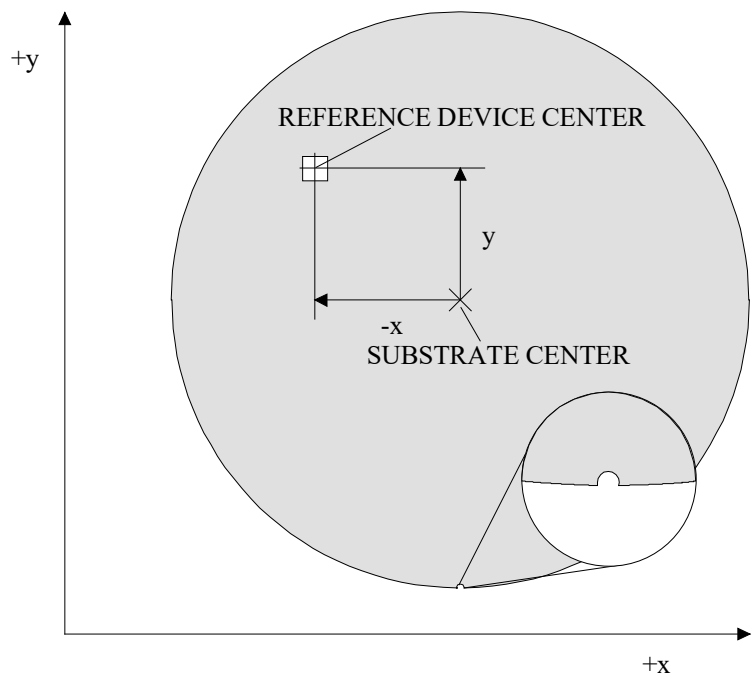

Figure 4
Reference Device Position (RefDevicePosX and RefDevicePosY)

18.5.2.3 *ReferenceDeviceX* — This is the Column number corresponding to the Reference Device. This value is dependent upon the Orientation and OriginLocation recipe attributes but not the OrientationOnChuck attribute.

18.5.2.4 *ReferenceDeviceY* — This is the Row number corresponding to the Reference Device. This value is dependent upon the Orientation and OriginLocation recipe attributes but not the OrientationOnChuck attribute.

18.5.2.5 *RefDeviceMatrixX* — This is the Column number corresponding to the Reference Device within a given exposure field. This value is dependent upon the Orientation and OriginLocation recipe attributes but not the OrientationOnChuck attribute. For non-matrix substrates, this attribute is 1.

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18.5.2.6 *RefDeviceMatrixY* — This is the Row number corresponding to the Reference Device within a given exposure field. This value is dependent upon the Orientation and OriginLocation recipe attributes but not the OrientationOnChuck attribute. For non-matrix substrates, this attribute is 1.

18.6 *Coordinate Origin* — The Coordinate Origin identifies the axis quadrant occupied by the substrate for addressing devices on the substrate.

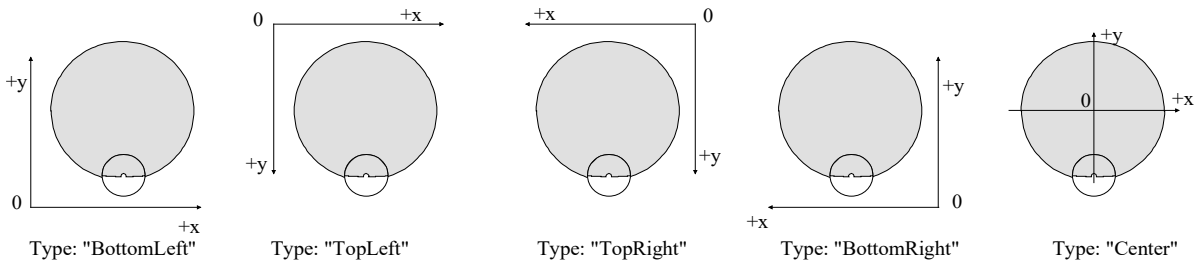

Figure 5
Coordinate Origin (OriginLocation)

18.6.1 *Origin Recipe Attributes*

18.6.1.1 *OriginLocation* — Coordinate system on substrate to address devices. Enumerated: 0 = Center, 1 = Upper Right, 2 = Upper Left 3 = Lower Left (default), 4 = Lower Right.

18.7 *Orientation*

18.7.1 Orientation addresses the location of the substrate primary fiducial (flat or notch).

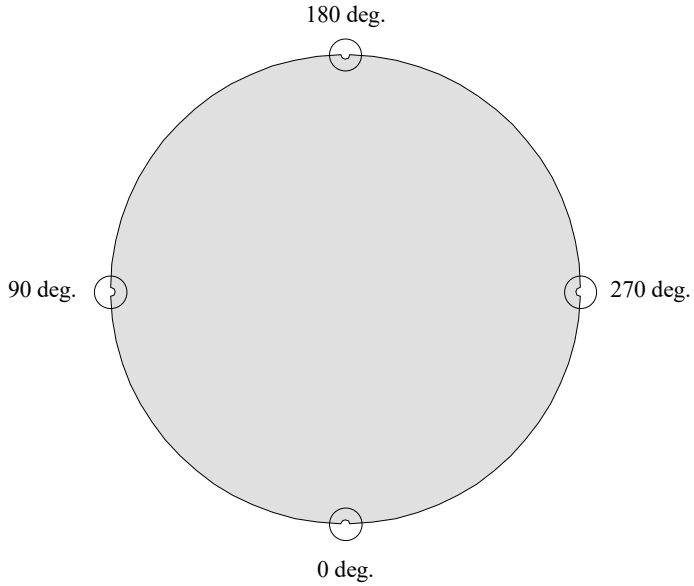

Figure 6
Orientation of the Substrate Notch

18.8 *Orientation Attributes*

18.8.1 *Orientation* — Identifies the orientation of the fiducial when defining the coordinate system on a substrate. This parameter in conjunction with the OriginLocation recipe attribute determines the coordinate and size attributes of devices on a substrate.

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18.8.2 *OrientationOnChuck* — Identifies the orientation of a substrate loaded on the chuck. This attribute does not affect the coordinate and size attributes of devices on a substrate.

18.9 *Example Coordinate References* — The values presented in this section are for demonstration purposes (measurements are not exact).

18.9.1 *Orientation* — The recipe attributes presented in Figure 7 reflect an Orientation attribute setting of 0°. The recipe attributes presented in Figure 8 reflect an Orientation attribute setting of 90°.

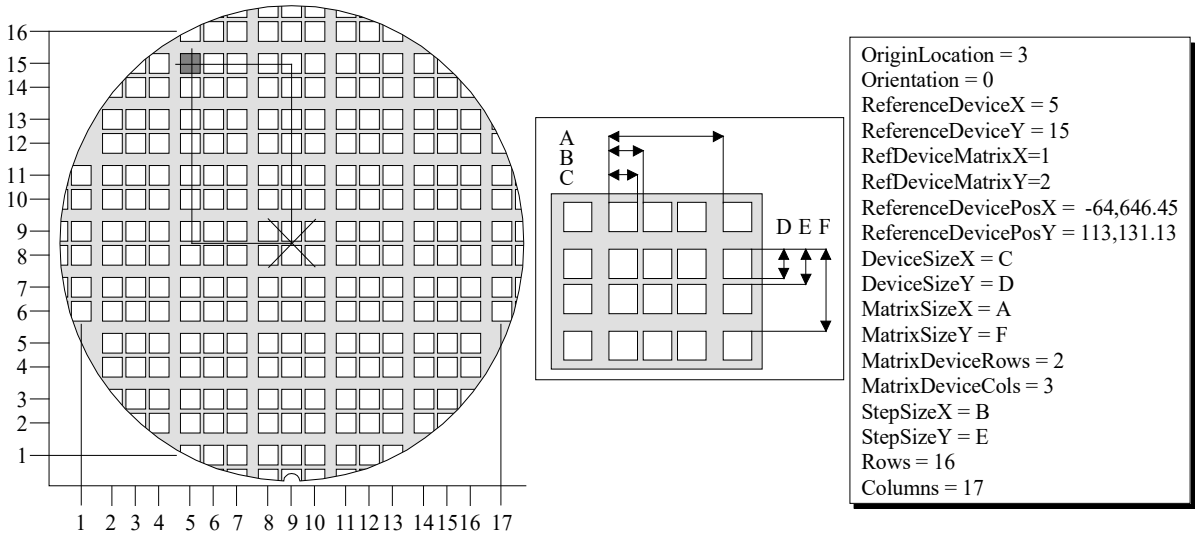

Figure 7
Example Coordinates Orientation = 0

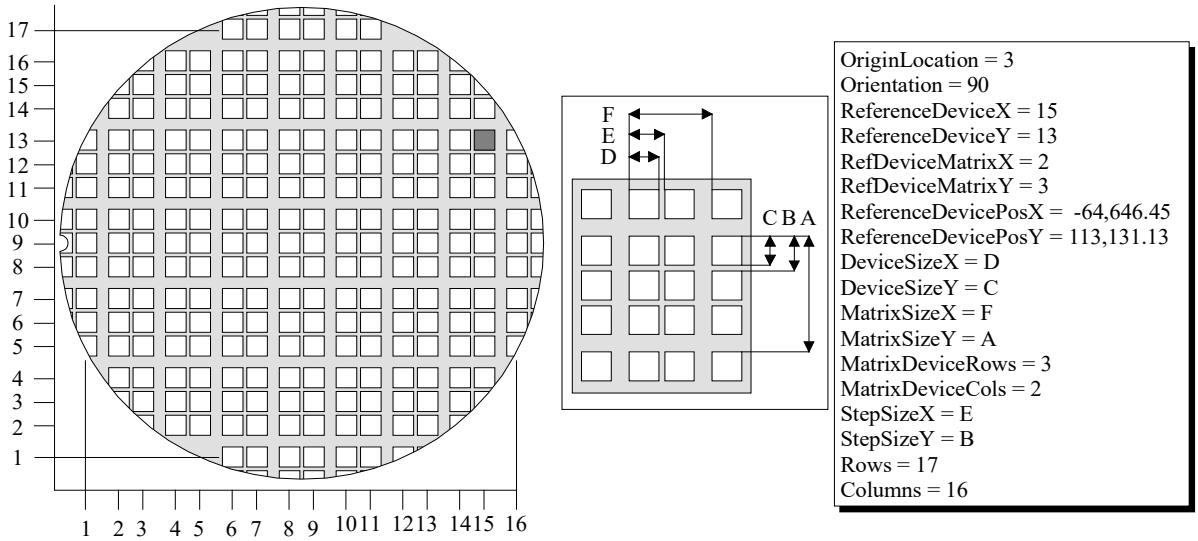

Figure 8
Example Coordinates Orientation = 90

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18.9.2 *Orientation on Chuck* — The following example demonstrates the effect of probing a substrate with different settings of the OrientationOnChuck recipe attribute. The OrientationOnChuck attribute has no impact on the coordinate values communicated between the host and the equipment.

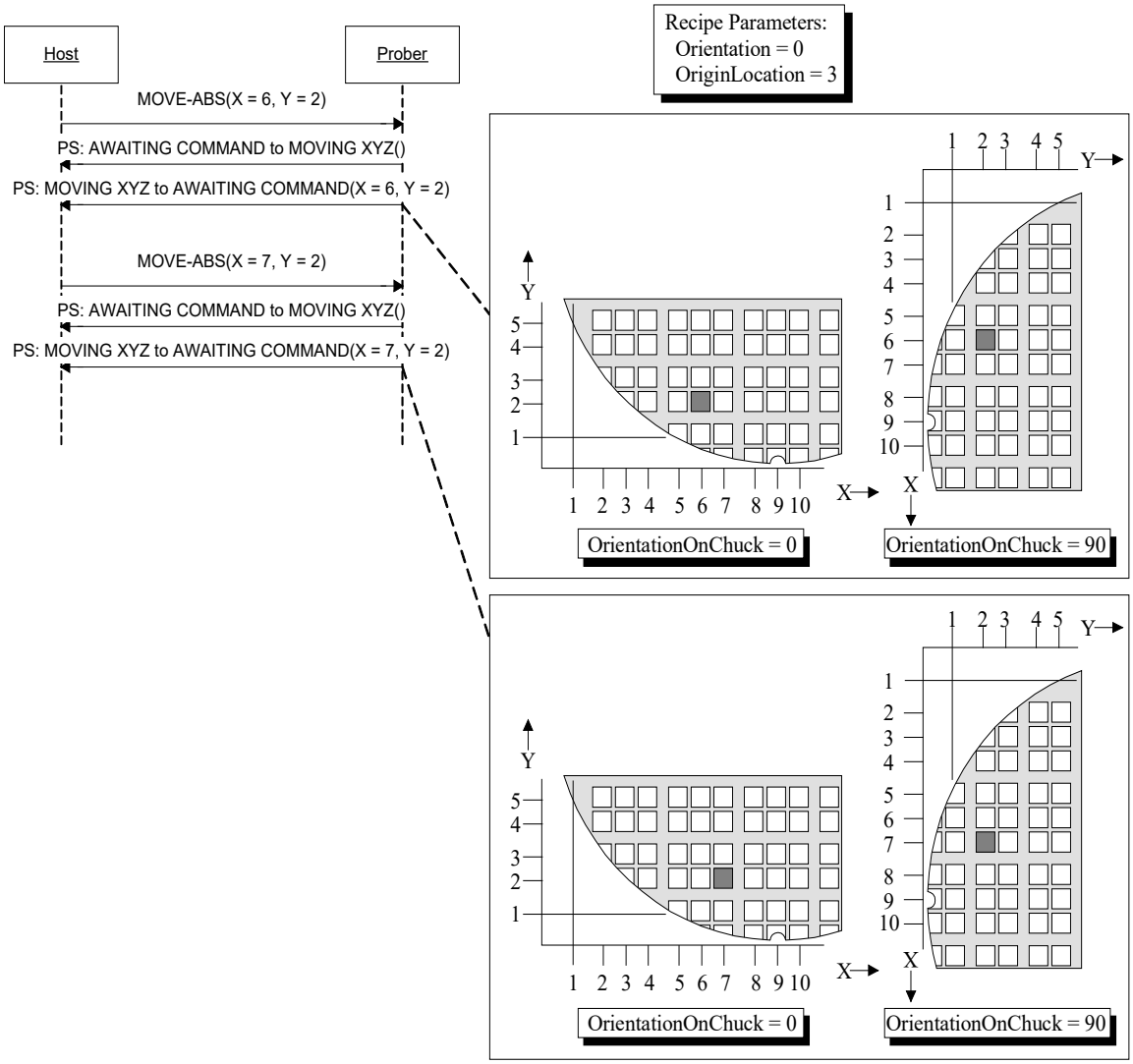

Figure 9
Example OrientationOnChuck

19 Collection Event List

19.1 *Requirements*

19.1.1 All GEM-required events are required by the PSEM300. Since Processing State Model is required by the PSEM300, all state transitions are required collection events.

19.1.2 All GEM-required events associated with the Communications, Alarm, and Spooling State Models are required. This section of the PSEM300 lists only those collection events that are not associated with a change of state or those requiring specific data variables or reports as defined in the PSEM300.

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19.2 *Collection Event Table*

19.2.1 Table 3 shows events and reports required for the PSEM300 process state transition. Table 4 shows other collection events.

Table 3 Collection Events Required by Process State Transition

Transition	*Transition No.*	*Current State*	*New State*	*Typical Variable Data*
Into IDLE	1	No state	IDLE	
	6	HANDLING MATERIAL		
	18	IDLE WITH ALARMS		
Into IDLE with ALARMS	17	IDLE	IDLE with ALARMS	Alarm Id
Into SETTING UP	2	IDLE	SETTING UP	
	7	HANDLING MATERIAL		
Into AWAITING LOAD	3	SETTING UP	AWAITING LOAD	
	5	HANDLING MATERIAL		
Into HANDLING MATERIAL	4	AWAITING LOAD	HANDLING MATERIAL	
	9	AWAITING COMMAND		
Into AWAITING COMMAND	8	HANDLING MATERIAL	AWAITING COMMAND	X, Y,Z
	11	MOVING XYZ		
	13	SERVICE TASK		X,Y,Z, Task Result
Into MOVING XYZ	10	AWAITING COMMAND	MOVING XYZ	
Into SERVICE TASK	12	AWAITING COMMAND	SERVICE TASK	Task Id
	14	SERVICE TASK		
Into PROCESSING BLOCKED	15	PROCESS	PROCESS BLOCKED	
Conditional	16	PROCESSING BLOCKED	PROCESS	

Table 4 Additional Collection Events

Event Name	*Contents*	*Typical Variable Data*
CleaningMediaDepleted	The cleaning media has been depleted.	Cleaning media identifier
InkingMediaDepleted	The inking media has been depleted.	
ProbeCardRemoved	The probe card has been removed from the prober.	ProbeCardId
ProbeCardInstalled	The probe card has been installed on the prober.	ProbeCardId
ControlMapCompleted	The prober has completed indexing to each of the sites identified in the control map.	

20 Data Item Variables

20.1 The purpose of this section is to define the list of data item variables required by the PSEM300. Values of these variables will be available to the host through collection event reports and host status queries.

20.2 *Requirements*

20.2.1 All generic variable data items defined in GEM are required by all PSEM300 equipment. Any supplier-defined variables shall be documented in the same format used by this Standard. The following minimum information is required:

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