12.4.3 *Modifying Process Program Variable Parameters* — The remote commands of PP-SELECT, PP-ASSIGN, or PP-UPDATE are used to modify any of the identified process program variable parameters within the process program. The modification is done by including CPNAME/CPVAL pairs within the "PROCESS-BLD-GROUP", which is part of the remote commands of PP-SELECT or PP-ASSIGN, or by including a different list name in the PP-UPDATE remote command. A CPNAME in a process program shall be identical to the process program variable parameter name as specified in the "PROCESS-BLD-GROUP". See next section for details of these parameters.

12.5 *Use of Process Programs, Remote Commands, and "PROCESS-BLD-GROUP"* — This is a brief description of the steps involved in using the process program structure, the process program variable parameters, the TABLE-DEFs, and the modification of process program variable parameters through the use of "PROCESS-BLD-GROUP" and CPNAME/CEPVAL pairs in the enhanced remote command (S2,F49).

- A process program is created with certain items in the body identified as process program variable parameters, along with their default values.
- The host sends to equipment one or more TABLE-DEFs: such as "TABLE-AREA-DEF" and "TABLE-ALIGN-DEF", along with the names of those tables using Stream 13 commands (See SEMI E5). These tables are now resident on the equipment.
- The host sends an enhanced remote command (S2,F49) to the equipment (either PP-SELECT or PP-ASSIGN) that contains the information needed for processing ("CARRIERBLD"). The "CARRIERBLD" contains a "PROCESS-BLD-GROUP" for each different set of run parameters that are needed during the inspection or review process.
- "PROCESS-BLD-GROUP" shall contain the ProcessBuildGroupID to identify which program is selected.
- If the default list of slots in the process program needs to be changed for this run, then "PROCESS-BLD-GROUP" contains a "MATERIALLIST" and the list of selected slots or substrates, designated by SlotIDs or SubstrateIDs.
- If the default set of inspection areas in the process program needs to be changed for this run, then "PROCESS-BLD-GROUP" contains the name of a specific "TABLE-AREA-DEF" (in AreaTable Name). If not all of the inspection areas given in that "TABLE-AREA-DEF" are needed for this run, then "AREALIST" is used and includes a list of the names of the specific inspection areas which are needed. Those names refer to inspection areas defined in the "TABLE-AREA-DEF".
- If the default set of alignment sites in the process program needs to be changed for this run, then "PROCESS-BLD-GROUP" contains the name of a specific "TABLE-ALIGN-DEF" (in AlignTable Name). If not all of the alignment sites given in that "TABLE-ALIGN-DEF" are needed for this run, then "ALIGNLIST" is used and includes a list of the names of the specific alignment sites which are needed. Those names refer to alignment sites defined in the "TABLE-ALIGN-DEF".
- If the SEMI M21 coordinate system is being used and a pattern has been defined with pattern element names and if only certain of those elements need to be inspected for this run, then "PROCESS-BLD-GROUP" contains an "ELEMENTLIST" and the list of selected elements, designated by ElementIDs.
- If certain equipment-specific process program variable parameters need to have different values for this run, then for each needed parameter, "PROCESS-BLD-GROUP" contains a CPNAME (unique name of a specific process program variable parameter) and the new CEPVAL (new value for that parameter).
- The equipment executes the process program with the new values.
- If indicated in the process program, the equipment generates the list of anomalies found and sends it to the host in the format of a "TABLE-ANOMALY-DEF" using the ISEM table definition and Stream 13 transfer messages (see SEMI E5 for format specification).
- The host would send the "TABLE-ANOMALY-DEF" to a review equipment. The host might need to modify part of the table if required by the review equipment. This anomaly table is now resident on the review equipment. (NOTE: The host might choose to not send all of the table of anomalies, but rather a desired selection of them.)
- The host sends the equipment the enhanced remote command (PP-SELECT or PP-ASSIGN) that contains a "CARRIERBLD". The "CARRIERBLD" has a "PROCESS-BLD-GROUP" for each different set of run parameters that is needed by the review equipment. It is required for the host to use the Enhanced Remote Command S2,F49 for transferring the information

to the equipment. "PROCESS-BLD-GROUP" includes the name of a specific "TABLE-ANOMALY-DEF" in the parameter AnomalyTableName. If not all of the anomalies given in that "TABLE-ANOMALY-DEF" are needed for this run, then either "ANOMALYLIST" or "M21-ANOMALYLIST" is used and includes a list of the names of the specific anomalies which are desired. Those names refer to anomalies defined in the named "TABLE-ANOMALY-DEF".

- The equipment runs the process program using the selected values and reviewing the specific anomalies indicated.
- The equipment adds review information to the ANOMALYATTRIBUTE list. Then the review equipment sends this modified "TABLE-ANOMALY-DEF" to the host.

13 Remote Commands

The purpose of this section is to identify remote commands, command parameters, and valid commands versus states pertinent to the SEM.

13.1 *Requirements*

- The equipment shall support the SEMI E30 required remote commands.
- All the remote commands defined by ISEM are required unless they have been qualified by the statement "if the equipment supports this functionality, it shall use this command." In this case, they are only required if the equipment supports the functionality necessary to support the command. A good example of this is the MAP-CARRIER command. If the equipment does not have the hardware necessary to scan a carrier for the presence of substrates in slots, then the command is not required by the ISEM.
- The alphanumeric strings defined by ISEM for RCMD and CPNAME are required.

Host Command Parameter (CPNAME/CPVAL) — A parameter name/value associated with a particular host command when using stream function (S2,F41) and a (CPNAME/CEPVAL) parameter name/value when using the enhanced remote command (S2,F49). This document specifies unique names (CPNAMEs) and values (CPVALs and CEPVALs) for many command parameters. Note that if there are no associated parameters, a zero length list is sent.

The purpose of the remote commands is to allow host control over the following capabilities:

- Start processing
- Stop processing
- Temporarily suspend processing
- Resume processing
- Abort processing
- Select process programs, material, and/or sites to measure
- Report location of material found

The following remote commands (RCMDs) shall be supported as described below:

NOTE 3: The terms "current cycle" and "safe point" used below are to be defined by the supplier.

13.2 *Remote Commands Description*

1. *ABORT* — Terminate the current cycle prior to its completion. ABORT has the intent of immediately stopping the process and is used because of abnormal conditions. ABORT makes no guarantee about the subsequent condition of material except as noted in the "ABORTLEVEL" description.
2. *CLEANUP* — De-selection of the current ISEM job ("CARRIERBLD") and process program ("PROCESS-BLD-GROUP"), including the removal of all material to output locations and any equipment-specific activities needed to transition into the IDLE state. Completion of this command should generate a collection event report. If the equipment supports this functionality, it will use this command.
3. *MAP-CARRIER* — Requests the equipment to provide a list of carrier slots that contain material. MAP-CARRIER has the intent of providing the host with enough information about the location and/or ID of material so it may select material for processing accordingly. Completion of this command shall generate a collection event report. If the equipment supports this functionality, it must use this command.
4. *NEXT-MATERIAL* — Processing of the current substrate is halted at the first safe point and unloaded to the target carrier location. NEXT-MATERIAL has the intent of allowing the host to skip measurement of the current substrate. This is a trigger for processing state transition from WORKING to UNLOAD. If the equipment supports this functionality, it will use this command.
5. *PAUSE* — Suspend processing temporarily at the next safe point. PAUSE has the intent of resuming the process at the same point where it was paused.

RESUME or PP-UPDATE may be used to resume the process.

6. *PP-ASSIGN* — Instructs the equipment that supports queuing to create a new ISEM job ("CARRIERBLD") for the specified port ("LOCATIONID") when more than one port is available for processing. If only one port is available, "LOCATIONID" is not required. Priority may optionally be specified with this command. The "PRIORITY" specifies the priority of the newly created job in the ISEM job queue (a value of 0 (zero) assigns the highest priority to the job). Without specifying a priority, the job is queued with the default priority. Jobs with equal priority are queued in the order the PP-ASSIGN commands are received. This command is valid in all PROCESSING states.

7. *PP-SELECT* — Instructs the equipment to make the requested ISEM job(s) ("CARRIERBLD") available in the execution area. This is a trigger for the processing state transition from IDLE to SETTING UP. The first process program ("PROCESS-BLD-GROUP") specified in the "CARRIERBLD" is also validated during SETTING UP.

8. *PP-UNASSIGN* — Removes the ISEM job assignment ("CARRIERBLD") for a carrier or port. The carrier or port is removed from the process queue.

9. *PP-UPDATE* — Provides the ability to alter the current process program being executed during the PAUSED state. The process program variables specified in the PP-UPDATE command will replace previous definitions in the "PROCESS-BLD-GROUP". This command will trigger transition to CHECKING for process program parameter verification. A RESUME command is implied with the validation of "all" replaced values to resume the process. If the PP-UPDATE fails, the process program variables present prior to the PP-UPDATE are retained. If no parameters values are specified, the defaults are used.

10. *RESUME* — Resume processing from the point where the process was paused. This is the trigger for processing state transition from PROCESS PAUSE to the previous PROCESS state.

11. *START* — Instructs the equipment to initiate processing. This is the trigger for the processing state transition from READY to LOAD. An "AUTOSTART" command parameter may be included to allow for continuous processing.

12. *STOP* — Complete the current cycle, stop in a safe condition, and return to the IDLE processing state. Stop has the intent of stopping the process entirely. This command can be used to both: stop the current ISEM job or to stop all queued jobs. The equipment is not required to support the continuation of processing.

13.2.1 *Remote Commands and Associated Host Command Parameters* — This table describes the allowable command parameters (CPNAME) for each remote command (RCMD). Equipment shall support all parameters. The column marked Req/Opt specifies which parameters are required to be sent by the host and which parameters may be optionally sent by the host.

Table 8 Allowable Command Parameters

Remote Command	*Parameters*		
	CPName	*Req/Opt*	*Comments*
ABORT	"ABORTLEVEL"	R	
CLEANUP	"CARRIERID" "LOCATIONID" "SLOTID"	O O O	PORT and SLOT may be used to define a different carrier/slot destination for the substrates.
MAP-CARRIER	"CARRIERID" "LOCATIONID"	R* R*	* One is required.
NEXT-MATERIAL	"CARRIERID" "LOCATIONID" "SLOTID"	O O O	PORT and SLOT may be used to define a different carrier/slot destination for the substrates.
PAUSE	None	NA	None
PP-ASSIGN	"PRIORITY" "CARRIERBLD"*	O R	* More than one "CARRIERBLD" may be specified.
PP-SELECT	"CARRIERBLD"*	R	* More than one "CARRIERBLD" may be specified.
PP-UNASSIGN	"CARRIERBLD"	R	None

PP-UPDATE	"PPBUILDID" "ALIGNLIST" "ANOMALYLIST" "AREALIST" "ELEMENTLIST" "SLOTLIST" "SUBSTRATELIST" "TABLE-ALIGN-DEF" "TABLE-AREA-DEF" "TABLE-ANOMALY-DEF" "TABLE-M21-ANOMALY-DEF"	R R* R* R* R* R* R* R* R* R* R*	* At least one is required.
RESUME	None	N/A	None
START	"CARRIERBLD"	0	None
STOP	"CARRIERBLD"	0	None

13.2.2 *Host Command Parameter Names and Values*

Table 9 Host Command Parameters CPNAMES

CPName	*Parameter Value*		
	Description	*Range*	*Format*
"ABORTLEVEL"	ISEM-defined abort levels: HALT — Process halts, and the ABORTING process state is entered. CLEANUP — Process halts, material cleanup is performed, and the ABORTING process state is entered.	"1= HALT" "2 = CLEANUP"	U2
"ALIGNLIST"	L,n 1. $AlignName_1$: n. For the SEMI M20 or M20P coordinate system.		List of A[1..16] data items
"ALIGNNAME"	Alignment name See the "TABLE-ALIGN-DEF" definition for further explanation.		A[1..16]
"ANOMALYLIST"	L,n 1. $AnomalyID_1$: n. For the SEMI M20 or M20P coordinate system.		List of A[1..16] data items
"ANOMALYID"	Anomaly identifier See the "TABLE-ANOMALY-DEF" or the "TABLE-M21-ANOMALY-DEF" definition for further explanation.		A[1..16]
"AREALIST"	L,n 1. $AreaName_1$: n.		List of A[1..16] data items
"AREANAME"	Unique identifier for an area to be inspected. See the "TABLE-AREA-DEF" definition for further explanation.		A[1..16]
"AUTOSTART"	Specifies whether a START command is required from an external source (operator or host) to exit the READY state. 0 = NoAutoStart (A START command required.) 1 = AutoStart (No external START command required to begin execution.)	0–1	U2
"CARRIERID"	Identifier of the carrier that the inspection/review data is associated with.		A[1..16]

CPName	*Parameter Value*		
	Description	*Range*	*Format*
"ELEMENTLIST"	L,n 1. ElementID$_1$: n. For the SEMI M21 coordinate system.		List of A[1..16] data items
"LOCATIONID"	Unique identifier of the location to be used for the "CARRIERBLD" assignment.		U2
"PPBUILDID"	ProcessProgramBuildID		A[1..80]
"PPNAME"	ProcessProgramName		A[1..80]
"PRIORITY"	Assignment priority	0–9 Highest priority corresponds to 0.	U2
"SLOTLIST"	Specifies carrier slots containing substrate for the ISEM job. L,n 1. SlotID$_1$: n. SlotIDn	Zero length list specifies all slots.	List of U2 data items
"STOPLEVEL"	Stop levels defined by the ISEM.	"1 = LOCATIONID" "2 = CARRIERID"	Use defined CPVALs
"SUBSTRATELIST"	Specifies identifiers of substrate for the ISEM job. L,n 1. SubstrateID$_1$: n. SubstrateID$_n$	Zero length list specifies all substrate (independent of substrate identifier).	List of A[0..16] data items
"CARRIERBLD" E5 Format	L, 3 Three ISEM required parameters 1. L, 2 ❖ 1. "CARRIERID" **A[9]** -- CPName 2. CarrierID **A[1..16]** -- CPValue 2. L, 2 ❖ 1. "LOCATIONID" **A[10]** -- CPName 2. LocationID **U2** -- CPValue 3. L, 2 1. "PROCESS-BLD-LIST" 2. L, n ❖ List of n jobs 1. L, 2 1. "PROCESS-BLD-GROUP" 2. L, m First ISEM job 2. L, 2 1. "PROCESS-BLD-GROUP" 2. L, m Next ISEM job . . . n. L, 2 1. "PROCESS-BLD-GROUP" 2. L, m Last ISEM job	m = 3	List
"PROCESS-BLD-GROUP" (for Inspection)	L,m 1. L,2 1. "PPBUILDID" 2. ProcessBuildGroupID	*m* ≥ 2	List of *m* data items

CPName	*Parameter Value*		
	Description	*Range*	*Format*
	2. L,2 1. “PPNAME” 2. ProcessProgramID 3. L,2 1. “SLOTLIST” 2. L,n 1. $SlotID_1$: n. ***Or*** 1. “SUBSTRATELIST” 2. L,n 1. $SubstrateID_1$: n. 4. L,2 1. “AUTOSTART” 2. AutoStart 5. L,2 1. “TABLE-AREA-DEF” 2. AreaTableName 6. L,2 1. “AREANAME” 2. L,n 1. $AreaName_1$: n. 7. L,2 1. “TABLE-ALIGN-DEF” 2. AlignTableName 8. L,2 1. “ALIGNNAME” 2. L,n 1. $AlignName_1$: n. 9. L,2 1. “ELEMENTLIST” ** 2. L,n 1. $ElementID_1$: n. 10. L,2 1. CPNAME* 2. CEPVAL* m. L,2 1. CPNAME* 2. CEPVAL* **NOTES:** “PPBUILDID” and “PPNAME” are required. “SLOTLIST”, “SUBSTRATELIST”, “AREALIST”, and “ALIGNLIST” are optional. * Supplier shall define as many of these CPNAME, CEPVAL		

CPName	*Parameter Value*		
	Description	*Range*	*Format*
	pairs as are supported by the equipment. ** “ELEMENTLIST” is required when using the SEMI M21 coordinate system in the definition of an AlignName or AreaName.		
“PROCESS-BLD-GROUP” (for Review Equipment)	L,m 1. L,2 1. “PPBUILDID” 2. ProcessBuildGroupID 2. L,2 1. “PPNAME” 2. ProcessProgramID 3. L,2 1. “SLOTLIST” 2. L,n 1. $SlotID_1$: 2. $SlotID_n$ ***Or*** 1. “SUBSTRATELIST” 2. L,n 1. $SubstrateID_1$: n. $SubstrateID_n$ 4. L,2 1. “AUTOSTART” 2. AutoStart 5. L,2 1. “TABLE-ANOMALY-DEF” 2. AnomalyTableName 6. L,2 1. “ANOMALYNAME” or “M21-ANOMALYNAME” 2. L,n 1. $AnomalyID_1$ or $M21AnomalyID_1$: n. 7. L,2 1. “ALIGN-TABLE-DEF” 2. AlignTableName 8. L,2 1. “ALIGNNAME” 2. L,n 1. $AlignName_1$: n. 9. L,2 1. “ELEMENTLIST”** 2. L,n 1. $ElementID_1$: n. 10. L,2	$m \geq 2$	List of *m* data items

CPName	*Parameter Value*		
	Description	*Range*	*Format*
	1. CPNAME* 2. CEPVAL* m. L,2 1. CPNAME* 2. CEPVAL* **NOTES:** "PPBUILDID" and "PPNAME" are required. "SLOTLIST", "SUBSTRATELIST", "AREALIST", and "ALIGNLIST" are optional. * Supplier shall define as many of these CPNAME, CEPVAL pairs as are supported by the equipment. ** "ELEMENTLIST" is required when using the SEMI M21 coordinate system in the definition of an AlignName or AreaName.		

NOTE 1: ❖ Required ISEM parameters: "CARRIERID", "LOCATIONID", "PROCESS-BLD-GROUP"

13.2.3 *Remote Commands vs. Processing States* — The following table indicates states where the remote commands are allowed. This is indicated with a "X" mark.

Table 10 Remote Commands vs. Processing States

	COMMAND											
PROCESSING STATE	*STOP*	*START*	*RESUME*	*PP-UPDATE*	*PP-SELECT*	*PAUSE*	*NEXT-MATERIAL*	*MAP-CARRIER*	*PP-ASSIGN*	*CLEANUP*	*ABORT*	*PP-UNASSIGN*
IDLE					X			X	X			X
ABORTED									X	X		X
PROCESSING ACTIVE												
STOPPING									X		X	
ABORTING												
PAUSE												
ALARM PAUSED	X								X		X	
PROCESS PAUSE												
PAUSING	X								X		X	
PAUSED	X		X	X					X		X	
CHECKING	X								X		X	
PROCESS												
SETTING UP	X					X		X	X		X	X
READY	X	X				X			X		X	X
EXECUTING												
LOAD	X					X			X		X	
UNLOAD	X					X			X		X	
WORKING												
INSPECT	X					X	X		X		X	
ALIGN	X					X	X		X		X	
REVIEW	X					X	X		X		X	

14 Scenarios

14.1 *Run Level Reporting Scenario* — This scenario only has expected events (i.e., no alarms or errors).

COMMENT	HOST	EQUIPMENT	COMMENT
			The equipment is in the IDLE processing state and in The ONLINE REMOTE control state. The host has defined, linked, and enabled RUN level report for CEIDs 2, 3, and 5.
Host sends a PP-SELECT command specifying a ″CARRIERBLD″	S2,F49-->		
		<--S2,F50	Command Acknowledge
			The equipment transitions from IDLE to SETTING UP, and material arrives at input port.
		<--S6,F11	SETTING UP -> READY (CEID 3)
Event Report Acknowledge	S6,F12-->		
START	S2,F41-->		
		<--S2,F42	Host Command Acknowledge
			READY -> LOAD. [WHILE] Note End of Run LOAD -> WORKING WORKING -> UNLOAD UNLOAD -> LOAD [END WHILE]
		<--S6,F11	LOAD -> STOPPING (CEID 5)
Event Report Acknowledge	S6,F12-->		
		<--S6,F11	Run Processed Data Valid event.
Event Report Acknowledge	S6,F12-->		
			The equipment transitions from STOPPING to IDLE.

14.2 *PP-UPDATE Remote Command Scenario* — Host issues the PP-UPDATE remote command.

COMMENT	HOST	EQUIPMENT	COMMENT
START	S2,F41-->		
		<--S2,F42	Positive Acknowledge.
		<--S6,F11	READY -> LOAD
Positive Acknowledge.	S6,F12-->		
			[WHILE] Not End of Run 1) LOAD -> WORKING 2) WORKING -> UNLOAD 3) UNLOAD -> LOAD [END WHILE]
Sometime during the [WHILE]:			
PAUSE	S2,F41-->		
		<--S2,F42	Positive Acknowledge.
		<--S6,F11	Transition to PAUSING
Positive Acknowledge.	S6,F12-->		
		<--S6,F11	PAUSING -> PAUSED
Positive Acknowledge.	S6,F12-->		
PP-UPDATE	S2,F49-->		
		<--S2,F50	Positive Acknowledge.
		<--S6,F11	PAUSED -> CHECKING
Positive Acknowledge.	S6,F12-->		
		<--S6,F11	CEID is posted. [IF] the updates are valid: Return to the previous process state through history. [ELSE] Return to the PAUSED state. The Process program remains unchanged. [ENDIF]
Positive Acknowledge.	S6,F12-->		

14.3 *PP-SELECT Remote Command Scenario*

COMMENT	HOST	EQUIPMENT	COMMENT
			The equipment is in the IDLE processing state and in the ONLINE REMOTE control state.
Host sends a TABLE-DEF to the equipment.(See Section 11.)	S13,F13-->		
		<--S13,F14	Table Data Acknowledge
Host sends more tables if needed.	S13,F13-->		
		<--S13,F14	Table Data Acknowledge
Host prepares the remote command to initiate an inspection run, including the “TABLE-AREA-DEF”, ”TABLE-ALIGN-DEF”, and ”ELEMENTLIST”, if required.			
Host sends a PP-SELECT command specifying a ”CARRIERBLD”.	S2,F49-->		
		<--S2,F50	Command Acknowledge
			The equipment transitions from IDLE to SETTING UP to READY.
START	S2,F41-->		
		<--S2,F42	Host Command Acknowledge
			READY -> LOAD. [WHILE] Not End of Run LOAD -> WORKING WORKING -> UNLOAD UNLOAD -> LOAD [END WHILE]
			LOAD -> STOPPING
		<--S13,F13	Equipment sends anomaly table with additional data, including the table name using Table Data Send command.
Table Data Acknowledge	S13,F14-->		
			The equipment transitions from STOPPING to IDLE.

14.4 *Event Report and ISEM Table Transfer Command Scenario*

COMMENT	HOST	EQUIPMENT	COMMENT
			The equipment is in the IDLE processing state and in the ONLINE REMOTE control state.
Host defines report with AnomalyTableName and AnomalyTableType	S2,F33-->		
		<--S2,F34	Define Report Acknowledge
Link report to RunDataComplete event	S2,F35-->		
		<--S2,F36	Link Event Report Acknowledge
Enable event	S2,F37-->		
		<--S2,F38	Enable Event Acknowledge
Host sends an ISEM table to the equipment.	S13,F13-->		
		<--S13,F14	Table Data Acknowledge
Host sends more tables if needed.	S13,F13-->		
		<--S13,F14	Table Data Acknowledge
Host sends a PP-SELECT command specifying a ”CARRIERBLD”	S2,F49-->		
		<--S2,F50	Remote Command Acknowledge The equipment transitions from IDLE -> SETTING UP -> READY.
START	S2,F41-->		
		<--S2,F42	Host Command Acknowledge READY -> LOAD. [WHILE] Not End of Run LOAD -> WORKING WORKING -> UNLOAD UNLOAD -> LOAD [END WHILE] LOAD -> STOPPING STOPPING -> IDLE
		<--S6,F11	RunDataComplete event with AnomalyTableName and AnomalyTableType.
Event Report Acknowledge	S6,F12-->		
Host sends Table DataRequest	S13,F15-->		
		<--S13,F16	Equipment sends requested table TBLACK = 0 if no errors.

15 GEM Capabilities

The purpose of this section is to specify any SEMI E30 additional capabilities that are required to be supported by this class of equipment.

15.1 *Requirements*

15.1.1 This standard requires that the SEMI E30 fundamental requirements and additional capabilities have been implemented on the ISEM equipment with the exception of limits monitoring and trace reporting. If these capabilities are implemented, they shall be implemented as required by the SEMI E30 document. The following SEMI E30 additional capabilities required by ISEM are:

- Dynamic Event Report Configuration
- Variable Data Collection
- Status Data Collection
- Alarm Management
- Remote Control
- Equipment Constants
- Process Program Management
- Spooling
- Trace Data Collection (optional)
- Control (Host-Initiated)

RELATED INFORMATION 1

NOTE: This related information is not an official part of SEMI E30.1 and was approved for publication by full letter ballot procedures on September 3, 1999.

R1-1 Defect Classification Code Management

The purpose of this section is to provide a method and specific formats to define, identify, and communicate coordinate systems and site locations on substrates for alignment sites, anomaly locations, and other sites used by the ISEM equipment.

R1-1.1 *Classification Codes and Defect Classification* — One function of review equipment is to view previously identified anomalies and to associate a defect classification code with each anomaly. A classification code is an identifier for a classification description.

Typically, the review equipment has a set of defect classification codes and their descriptions available to the operator. Then, for each anomaly, the operator selects a particular code to be associated with that anomaly. This action is defect classification.

The set of valid classification codes and their descriptions may change from one run to another. For example, the same main process program could be used with different substrate levels, and each level may use a different set of classification codes. The purpose of this section is to provide the requirements so that a user can both define several sets of classification codes and their descriptions and can also manage these sets on ISEM equipment.

R1-1.2 *Requirements*

- Each set of classification codes and their descriptions shall have an identifier, known as a classification code set ID.
- Review equipment shall provide a means for the user (the host or the operator) to define a classification code set, consisting of (a) the classification code set ID and (b) the list of classification codes and their descriptions.
- Equipment shall provide a means to manage the various classification code sets.
- A main process program shall include a process program variable that specifies the particular classification code set ID to be used.
- Equipment vendor shall provide documentation to the user regarding how to define and manage classification code sets.

Comment: In one implementation, the equipment considers a classification code set to be a sub-process program or an ISEM table. This would allow the user to identify a classification code set by name (using a PPID) or a table name and thereby managing this sub-process program with the SEMI E30 Process Program Capability or with SEMI E58 ARAMS tables.

R1-2 Reporting Coordinates and Coordinate Systems

The purpose of this section is to provide a method and specific formats to define, identify, and communicate coordinate systems and site locations on substrates for alignment sites, anomaly locations, and other sites used by ISEM equipment.

The ISEM-required formats are intended to minimize the number and type of site location format transformations needing to be supported by both equipment suppliers and users.

All ISEM-required site location formats involve the use of an ISEM-defined right-handed Cartesian coordinate system, established on substrates in an ISEM-defined manner. The scope of the detailed methods in this section are specific to unpatterned and patterned wafers in this release, but the section is intended to be general enough in methodology so that it can be extended to other substrate types in future revisions of ISEM, if required.

The purpose of inspection and review equipment is to locate, evaluate, classify, and report anomalies on substrates. ISEM equipment may deal with either unpatterned or patterned substrates or both. In most cases, the anomaly location is part of the information reported and/or used by ISEM equipment. An anomaly location is reported at a particular site with x,y coordinates in a particular coordinate system. Site coordinates are also used by ISEM equipment for the alignment sites for defining a coordinate system on a substrate. A standard method is needed to define a coordinate system and to report site coordinates for both alignment sites, anomaly locations, and any other reference sites needed by ISEM equipment. A standard method is essential in order to transfer the anomaly site information from one equipment to another.

R1-2.1 *Site Location Accuracy* — Each equipment has an accuracy with which it can define or locate a site as being within a certain area. This area associated with a site is determined by the equipment accuracy, based on the accuracy of its motion and imaging systems to locate a site, as well as on the accuracy with which it can define the coordinate system on the substrate.

When equipment shall locate a particular site on a substrate based on the expected or design-based location, then the location of a site or feature on an actual substrate is further affected by the accuracy of the equipment which placed the pattern on the substrate.

R1-2.2 *Expected or Designed Locations vs. Actual Locations* — The placement of patterns, sites, and coordinate systems is designed to be at certain mathematically described locations relative to one another and to an ideal substrate. These are the expected or designed locations. When a pattern is written by equipment onto a specific substrate, the actual placement of the pattern, the pattern-elements, and their features may differ from the expected locations, due to variations in equipment performance and variations in substrate shape and dimensions.

R1-2.3 *Substrate Coordinate Systems (Unpatterned)* — A substrate coordinate system is a coordinate system which has both origin and axes defined by the shape and dimensions of the substrate and which does not depend on whether there is a pattern on the substrate or whether it is unpatterned. This coordinate system is used to locate or define sites relative to the substrate.

R1-2.4 *Substrate Pattern Coordinate System* — A substrate pattern coordinate system is a coordinate system which has its origin and axes defined by the pattern as a whole on the substrate. This coordinate system is used to locate or to define sites relative to the pattern on the substrate. The expected or designed location of the pattern on the substrate can be defined in terms of the placement of the origin and axes of the substrate pattern coordinate system relative to those of the substrate coordinate system. The actual location of a pattern on a substrate may differ from the expected location. The actual location is determined by locating two or more alignment sites on the patterned substrate. The alignment sites are specific points of certain features in the pattern. The coordinates of the alignment sites are given in the substrate pattern coordinate system. In many cases, equipment does not align to the specific pattern elements but instead uses the defined locations of the pattern elements within the substrate pattern coordinate system.

R1-2.5 *Pattern Element Coordinate System* — A pattern-element coordinate system is a coordinate system which has its origin and axes defined by the pattern of one specific rectangular element in a pattern (a defined arrangement) of equal-sized rectangular elements. This coordinate system is used to locate or to define sites relative to that specific pattern-element. The expected or designed location of the pattern-element within a pattern can be defined in terms of the placement of the origin and axes of the pattern-element coordinate system relative to those of the pattern coordinate system. The actual location of a pattern-element within a pattern on a substrate may differ from the expected location. The actual location is determined by locating two or more alignment sites within the pattern-element. The coordinates of the alignment sites are given in the pattern-element coordinate system.

R1-2.6 *Parallel Coordinate Systems* — A second coordinate system is considered to be parallel to a first coordinate system if the origin of the second can be defined as a translation from the origin of the first and if the axes of the second are parallel and in the same direction as those of the first.

R1-2.7 *Requirements* — The following is a list of requirements for ISEM equipment regarding coordinate systems and reporting site locations:

- ISEM equipment shall document whether it deals with coordinate systems based on (a) a substrate, (b) a substrate pattern, or (c) a pattern-element or whether it deals with several of these coordinate systems.

- ISEM equipment shall establish a substrate coordinate system using a standard, documented method. This coordinate system is not based on any pattern on the substrate. This coordinate system shall be a right-hand Cartesian coordinate system and shall be identified by a name.

  NOTE: For wafers, this method is defined in SEMI M20 (Specification for Establishing a Wafer Coordinate System), and the coordinate system is named “M20.”

- For equipment dealing with substrate pattern coordinates, the substrate pattern coordinate system shall be established in a standard, documented method relative to the substrate coordinate system (the “unpatterned” coordinate system). This substrate pattern coordinate system shall be a right-hand Cartesian coordinate system and shall be designed to be parallel to the substrate coordinate system. The substrate pattern coordinate system shall be identified by a name. The location of its origin and axes relative to the substrate coordinate system shall be communicated in terms of the substrate coordinate system.

  NOTE: For wafers, this method is the one described below, and the substrate pattern coordinate system is named “M20P”, and its origin and axis relative to the SEMI M20 coordinate system are given in terms of “M20” coordinates and are communicated using XlateData.

- For equipment dealing with pattern-element coordinates, the pattern-element coordinate system shall be established in a standard, documented

method relative either to the substrate pattern coordinate system or to another pattern-element coordinate system. The pattern-element coordinate system shall be a right-hand Cartesian coordinate system which is designed to be parallel to the substrate pattern coordinate system. The pattern-element coordinate system shall be identified by a name. The location of its origin and axis relative to the substrate pattern coordinate system shall be communicated in terms of the substrate pattern coordinate system.

NOTE: For wafers, this method is based on SEMI M21, and the coordinate system is named "M21" and its origin and axis relative to the "M20P" coordinate system are given in terms of the M20P coordinates.

- ISEM requires that equipment have the capability to use site location information that is based on the user's product designs, which the user shall provide in the appropriate ISEM-required format.
- ISEM-compliant equipment shall have the capability to define, locate, and report site information using only the ISEM-defined right-handed Cartesian coordinate system formats. This requirement does not preclude equipment from having additional capability for defining or reporting site location information using other formats.
- Coordinate system name and placement relative to the "higher" coordinate system shall be defined and communicated using the following ISEM data items, in terms of either expected or actual placement: CoordSys, XlateData, and their included data items.
- Alignment site information shall be defined and communicated using the following ISEM items: the variable item AlignList, the "ALIGNLIST", the Process program class of "TABLE-ALIGN-DEF", and their included information.
- Areas to be inspected shall be reported using the specific coordinate system defined by the user. The following ISEM items are used to define and communicate area locations: the variable item "AREALIST", the "AREALIST", and the Process program class of "TABLE-AREA-DEF", and their included information.
- The displacement of an actual coordinate system relative to its expected location shall be communicated using the ISEM data item: XlateData and its included data items.
- The displacement of an actual site location relative to its expected site location shall be communicated using the ISEM data item: Offset and its included data items.
- The equipment vendor shall document the requirements for the ISEM data items used in alignment of a coordinate system.
- The equipment vendor shall provide and document a means for the user to define and communicate a pattern map using SEMI M21 data. A pattern map defines the layout of equal-sized rectangular pattern-elements which make up a pattern. Each pattern-element shall have a name, using the SEMI M21 naming convention.

  NOTE: For patterned wafers, the naming method shall be that described in SEMI M21, and the pattern-element information shall be communicated using the ISEM data item of SEMI M21Data.

- For ISEM compliance, inspection equipment shall report various anomaly data; AnomalyID, coordinates, and attributes. Review equipment shall receive this data for anomalies and be able to locate them and perhaps modify the coordinates. Anomaly coordinates shall be reported using ISEM table named "TABLE-ANOMALY-DEF" and its included data.

R1-3 Coordinate System for a Substrate

R1-3.1 *SEMI M20 Coordinate System* — The SEMI M20 standard (Specification for Establishing a Wafer Coordinate System) describes how to map a right-handed Cartesian coordinate system to a substrate so that its origin is at the center of the substrate, and its negative *y*-axis bisects the substrate's primary fiducial. This coordinate system is defined by ISEM to be the "M20" coordinate system. The only information required by equipment in order to establish an "M20" coordinate system is the substrate size and the type of fiducial, which are communicated using the ISEM data items named **SubstrateSize** and **Fiducial**. Another ISEM data item named **Orientation** identifies how the substrate is loaded on the equipment. Note that the SEMI M20 standard requires that the "M20" coordinate system is fixed on the substrate and is not affected by how the substrate is loaded on equipment. Also, as stated in the SEMI M20 standard, an orientation of "0" degrees designates a substrate loaded on equipment, with the primary fiducial towards the operator or "down."

R1-3.2 *M20P Coordinate System* — ISEM defines the M20P coordinate system to be one which is aligned to the pattern on the substrate. The M20P coordinate system is useful because in many cases, it is more significant to the user to know the location of an anomaly relative to the pattern on the substrate rather

than relative to the substrate shape and dimensions. ISEM also defines the M20P coordinate system to be one which is designed to be "parallel" to the SEMI M20 coordinate system. In practice, because of experimental errors, both the origins and the axes may differ slightly from their intended values of a simple translation and no rotation. Equipment should be designed to be able to locate the alignment sites, given the various possible experimental errors.

R1-3.3 *Establishing an M20P Coordinate System* — A minimum of two alignment sites is necessary to establish an M20P coordinate system on a substrate. Additional sites are often used to determine a scaling ratio of the dimensions of the actual coordinate system relative to the dimensions of the expected coordinate system and are reported using the ISEM data item of **ScaleFactor**.

XlateData is used to report actual coordinate system location. Most equipment cannot distinguish whether patterned substrate site location errors are due to the substrate, the layout on the substrate, or the equipment's ability to locate the sites. However, information that is available through the use of patterned-substrate alignment sites can provide a means for identifying potential equipment problems. For instance, assume that the only pattern-layout location error on a substrate is that due to the establishment of the location of the substrate center and fiducial. For many users and equipment systems, this is a good assumption. If this is the case, then the ISEM data item named **XlateData** can be used to track this error. Although the error may result from multiple sources, being able to track it on various equipment will enable users to apply statistical process control techniques to identify the specific sources.

Offset sites may be found by equipment at actual locations which deviate from their expected locations through either pattern layout errors or equipment "stage" or imaging errors. Again, in a controlled manufacturing process, these combined errors should be normally distributed, and non-normal deviations may indicate possible equipment problems. The actual position of a site relative to its expected position shall be reported through the use of the ISEM data item named **Offset**.

R1-4 Layout of Rectangular Pattern Elements on a Substrate Using SEMI M20 Coordinate System

Equipment shall be capable of routine, automated operation without needing substrate layout information (e.g., field or die maps). However, having the capability to provide substrate layout information to equipment from the host can be desirable. ISEM defines a means to do this in this section for substrates, based on SEMI M21 (Specification for Assigning Addresses to Rectangular Elements in a Cartesian Array.) The SEMI M21 standard is limited to defining how to assign "addresses" to elements and how to find the "array center" element. It does not specify how the rectangular pattern-elements are located on the substrate. In this section, ISEM defines how these pattern-elements are located on a substrate, using the data item named M21Data, and how to establish within-element coordinate systems. Any additional layout information, such as within-element structure details or element attribute information, is beyond the scope of ISEM.

R1-4.1 *ISEM "M21" Layouts*

- An "M21" layout consists of an array of equal-sized rectangular pattern-elements with no space between the pattern elements.
- ISEM defines the "M21" layout on a substrate to include all pattern-elements which are either wholly or partially within the circumference of the substrate.
- The ISEM approach is to define the pattern map by specifying the M20P coordinate for the lower left corner of the minimum number of pattern-elements needed to define the layout, along with the pattern-element addresses (names). For a non-tiled layout, the location and name of a single pattern-element is sufficient to establish the "M21" layout. For tiled layouts, the location and name of one pattern-element in each row or column are required. Note that the location of the lower left corner of some pattern-elements may be outside the circumference of the substrate.
- The "M21" pattern-element coordinate system shall have its *x* and *y* axes parallel to the respective M20P coordinate system axes and shall have their origins at the lower left corner of each element. The pattern-element coordinate system shall have a name and a specific pattern-element address identifier per SEMI M21.
- Layout definition is supported only for host-to-equipment communications. The user is responsible for ensuring that the pattern-element addresses provided to the equipment agree with the SEMI M21 specification. The equipment need not check this, other than to ensure that there are not conflicts within the provided layout, and shall report results with pattern-element addresses as provided by the user.

- "M21" layouts are established within the M20P coordinate system and need not require any additional alignment site data than is needed to establish the M20P coordinate system. However, as with M20P, additional alignment may be necessary because of errors in either the pattern layout or the equipment's ability to locate features. Offset shall be used to report the location corrections that result from any within-element alignments.

R1-5 How an M20P Coordinate System Is Established on a Substrate

The following example is fairly basic. For this example, the M20P coordinate system has a zero translation from the SEMI M20 coordinate system. Also, the equipment documentation states that 4 alignment sites are required. The equipment does M20P alignment on two alignment sites and does a low resolution and then a high resolution alignment at each site. Note that the specific alignment point is different at the two resolutions, so the coordinates are slightly different. The alignment sites are defined to the equipment via the process program class named "TABLE-ALIGN-DEF", as detailed below. The order of the sites in "TABLE-ALIGN-DEF" is not important. The sites are then selected via the CPNAME named "ALIGNLIST", which is included in the PP-SELECT command. The order of the sites listed in "ALIGNLIST" is important and is as-specified in the equipment's documentation. The first item is the alignment site for the first low resolution site, the second item is for the first high resolution site, the third item is the second low resolution site, and the fourth is the second high resolution site.

"TABLE-ALIGN-DEF"

AlignName	*Coordx*	*Coordy*	*Coordsys*	*Attribute (1)*
Coarse1	-60000	-200	"M20P"	
Fine1	-60020	-205	"M20P"	
Coarse2	+60000	+200	"M20P"	
Fine2	+59980	+195	"M20P"	

"ALIGNNAME"

L,4

1. <Coarse1>
2. <Fine1>
3. <Coarse2>
4. <Fine2>

Using this information, the equipment will go to the nominal "M20" location for Coarse1, then "find" where it actually is. The offset between the nominal "M20" location and the actual "M20" location is then used to "find" Fine1. The actual M20 location of Fine1 is saved. The process is then repeated for Coarse2 and Fine2. The equipment can now determine the "M20" to M20P offset from the nominal and actual coordinates. First, a summary of the data:

xN1 = -60020	yN1 = -205	Nominal *x* and *y* data for the first fine site
xA1 = -59800	yA1 = -150	Actual *x* and y data for the first fine site
xN2 = +59980	yN2 = +195	Nominal *x* and *y* data for the second fine site
xA2 = +60060	yA2 = +175	Actual *x* and *y* data for the second fine site

The equipment first calculates Theta, using, for example, the formula:

$$\Theta = tan^{-1}\left\lceil \frac{MA - MN}{1 + MA \;\; MN} \right\rceil$$

where *MA* and *MN* are, respectively, the slopes of the lines connecting the two actual fine sites and the line connecting the two nominal sites, in "M20" coordinates, calculated as follows:

$$MA = \left\lceil \frac{yA_2 - yA_1}{xA_2 - xA_1} \right\rceil \quad MN = \left\lceil \frac{yN_2 - yN_1}{xN_2 - xN_1} \right\rceil$$

The equipment then calculates *DeltaX* and *DeltaY*, using, for example, the formulas:

$$DeltaX = \left\lceil \frac{C\sin(\Theta) + D\cos(\Theta)}{(\sin(\Theta))^2 + (\cos(\Theta))^2} \right\rceil$$

$$DeltaY = \left\lceil \frac{C\sin(\Theta) - D\cos(\Theta)}{(\sin(\Theta))^2 + (\cos(\Theta))^2} \right\rceil$$

where *C* and *D*, the adjusted site 1 coordinates in a rotation-adjusted coordinate system, are calculated, for example, using the formulas:

$$C = yA1 - ((xN1 \;\; \sin\Theta) + ((yN1 \;\; \cos\Theta)$$

$$D = xA1 - ((xN1 \;\; \cos\Theta) - ((yN1 \;\; \sin\Theta)$$

The equipment can also calculate a ScaleFactor term to indicate the relative ratio between the length of the vector connecting the nominal alignment sites and the length of the vector connecting the actual alignment sites. This can be used, for example, to judge whether there is a problem with the alignment process, since the difference between these two vectors should be small.

$$ScaleFactor = \frac{VA}{VN}$$

where *VA* and *VN* are the length of the vectors connecting the actual and nominal alignment sites, calculated using the formulas:

$$VN = \sqrt{(yN_2 - yN_1)^2 + (xN_2 - xN_1)^2}$$

$$VA = \sqrt{(yA_2 - yA_1)^2 + (xA_2 - xA_1)^2}$$

M20/M20P COORDINATE SYSTEMS EXAMPLE (EXAGGERATED)

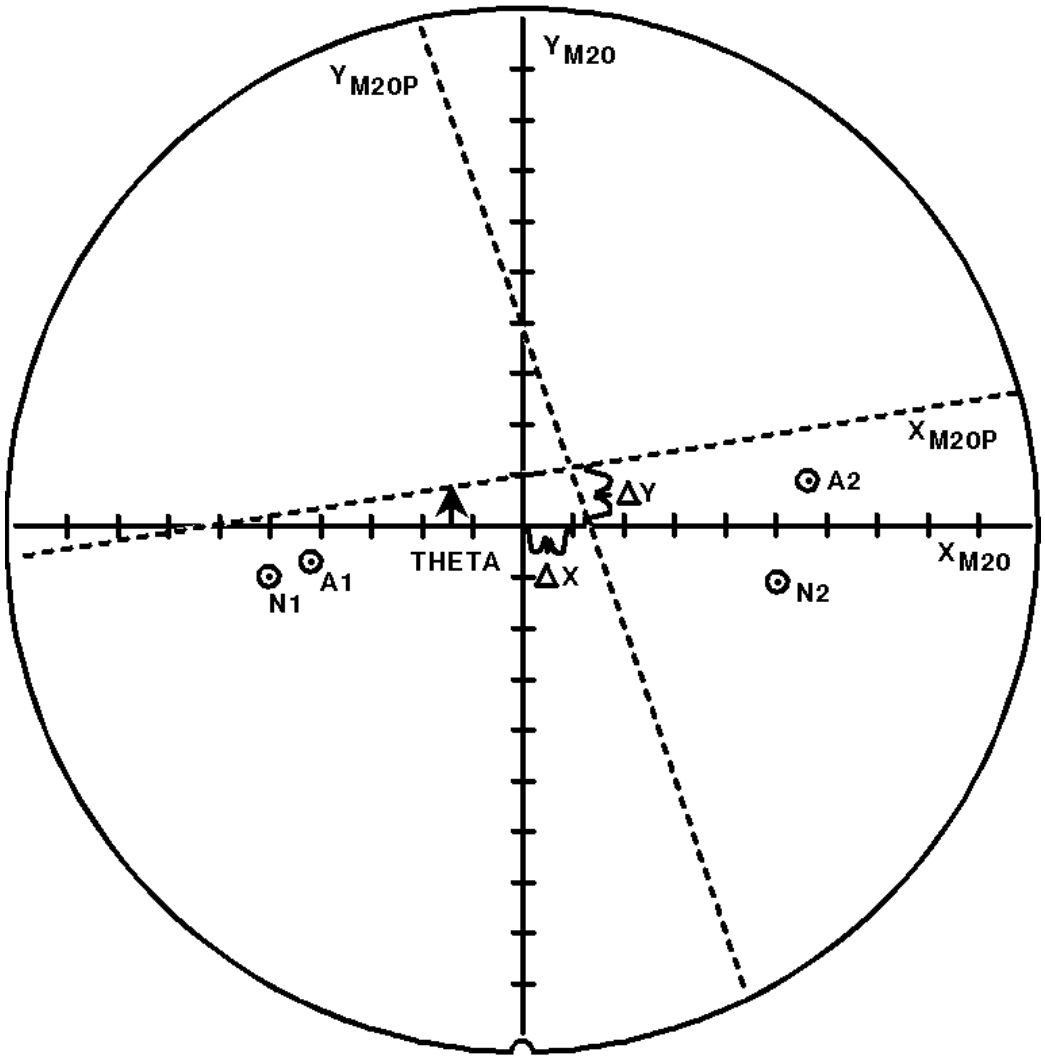

Figure 7
Review Data Management

RELATED INFORMATION 2
APPLICATION NOTES

NOTE: The material contained in these Application Notes is not an official part of SEMI E30.1 and is not intended to modify or supersede the official standard. Rather, these notes describe possible methods for implementing certain ISEM requirements described by the standard and are included as reference material.

R2-1 Using ISEM Table Attributes to Specify Process Related Data Item Variable Values

R2-1.1 Section 11.1 (ISEM Table Data) allows the host to use ISEM Table attributes to specify product and process related information related to the table data. The ISEM Variable Item Dictionary (Table 4) includes seven data items intended to be used for this purpose. They are identified with the comment "This information may be added by the host in the ISEM Tables." Identifying the value of variable data items in Table attributes is not covered in use of ISEM Tables. One method to accomplish this is to use attribute identifiers (ATTRID*n*) that are the same identifiers that are used for the equipment variable data items (Table R2-1). (This is very similar to the method specified in Section 12.5 to identify values to override the default values of variable process program parameters using the "PP-SELECT" remote commands).

Table R2-1 ISEM Variable Items and Their Equivalent ISEM Table Attribute Identifiers

Variable Item (Table 4)		*ISEM Table Attribute Identifier*	*Description*
Name	*Type*		
OperatorID	DV	OperatorID	Identification of the operator of the inspection/review equipment.
ProcessEquipmentID	DV	ProcessEquipmentID	Identification of the process equipment used with the current material immediately prior to the inspection/review.
ProcessEquipmentLocation	DV	ProcessEquipmentLocation	Location (code) of the process equipment used with the current material immediately prior to the inspection/review.
ProcessProgramID	DV	ProcessProgramID	Identification of the process program used with the process equipment used on the current material immediately prior to the inspection/review.
ProcessLevel	DV	ProcessLevel	Identification of the processing level of the current material.
ProductID	DV	ProductID	The product identification of the current material inspected/reviewed.
ProcessRunID	DV	ProcessRunID	Run identification for the process prior to current inspection/review.

NOTE 1: The variable item may be identified using any appropriate SECS II data item format.

R2-2 Example ISEM Table with Item Attributes That Specify ISEM Variable Values Using S13,F13 Table Data Send

R2-2.1 Typical values for Data Items are indicated.

L, 8

1. <DATAID>
2. <OBJSPEC=null>
3. <TBLTYP=DefectData>
4. <TBLID=null>
5. <TBLCMD=1>

6. L, 2
    1. L, 2
        1. <ATTRID= “ProcessProgramID”>
        2. <ATTRDATA= “My Recipe”>
    2. L, 2
        1. <ATTRID= “ProcessLevel”>
        2. <ATTRDATA= “My Level”>
7. L, c
    1. <COLHDR1= “Insp_Anomaly ID”>
    2. <COLHDR2= “Insp_Table specifier”>
    3. <COLHDR3= “Insp_Coordinate X”
    4. <COLHDR4= “Insp_Coordinate Y”
    : // etc…as defined by Table 11.3.5
    c. <COLHDRc>
8. L, r
    1. L, c
        1. <TBLELT11> // A[1..16]
        2. <TBLELT12> // I4
        3. <TBLELT13> // I4
        4. ETC…
        :
        c. <TBLELT1c> // A
    :
    r. L, c
        1. <TBLELTr1>
        :
        c. <TBLELTrc>

SEMI E30.5-0302
SPECIFICATION FOR METROLOGY SPECIFIC EQUIPMENT MODEL

This specification was technically approved by the Global Information and Control Committee and is the direct responsibility of the North American Global Information and Control Committee. Current edition approved by the North American Information and Control Committee on October 14 and November 27, 2001. Initially available at www.semi.org December 2001; to be published March 2002. Originally published July 2001.

The complete specification for this product includes all general requirements of SEMI E30.

1 Purpose

1.1 This document establishes a Specific Equipment Model (SEM) for Metrology equipment (MSEM). The MSEM consists of equipment characteristics and behaviors that are applicable to this class of equipment and are required to be implemented in addition to the SEMI E30 fundamental requirements and additional capabilities.

2 Scope

2.1 The scope of this document is limited to defining the behavior of Metrology equipment as perceived by a SEMI Equipment Communications Standard II (SECS II/SEMI E5) host that complies with the SEMI E30 model. It defines the view of the equipment through the SECS II link. It does not define the internal operation of the equipment. It includes a specific processing state model as the basis for all equipment behavior of this class.

2.2 This document assumes that the SEMI E30 fundamental requirements and all additional capabilities except those noted in SEMI E30 Capabilities Section in this document have been implemented on the MSEM equipment. This document expands the SEMI E30 Standard requirements and capabilities in the areas of the processing state model, collection events, Process Program management, remote commands, data item variables, and coordinate systems.

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 Limitations

3.1 The intent of this document is to facilitate the integration of Metrology equipment into an automated semiconductor factory. This document accomplishes this by defining an operational model for Metrology equipment as viewed by a factory automation controller. This definition provides a standard host interface and equipment operational behavior. This document applies specifically to Metrology equipment as used in a semiconductor factory environment. It is possible that this methodology and techniques may apply to other industries.

3.2 MSEM job parameters that specify material (e.g., carrier ID and substrate ID) and material locations (e.g., carrier location ID and carrier slot ID) are intended for metrology equipment for 200 mm and smaller substrate.

4 Referenced Standards

NOTE 1: As listed or revised, all documents cited shall be the latest publications of adopted standards.

4.1 *SEMI Standards*

SEMI E5 — SEMI Equipment Communications Standard II (SECS II)

SEMI M20 — Specification for Establishing a Wafer Coordinate System

SEMI M21 — Assigning Addresses to Rectangular Elements in a Cartesian Array

SEMI E37.1 — High Speed Messaging Service (HSMS-SS) Single Session

SEMI E58 — Automated Reliability and Availability Standard (ARAMS)

5 Terminology

5.1 *Definitions*

5.1.1 *alignment, n.* — a procedure in which a coordinate system is established on a substrate or a portion of a substrate.

5.1.2 *alignment mark, n.* — a feature on a substrate selectively used for alignment.

5.1.3 *alignment site, n.* — a point within a feature on a substrate selectively used for alignment.

5.1.4 *cleanup, n.* — deselection of the current Process Program and removal of all material to output locations and any equipment specific activities required to transition the equipment into the IDLE state.

5.1.5 *factory automation controller, n.* — a computer system that provides integration of factory shop control and business systems with semiconductor equipment.

5.1.6 *feature, n.* — a distinctive item in a pattern, or a physical characteristic of the substrate. (e.g., line, point, a wafer flat).

5.1.7 *field, n.* — an exposure repeated in a regular manner on a substrate.

5.1.8 *global alignment, n.* — procedure which establishes a coordinate system for the entire substrate (see alignment). For silicon wafers, this coordinate system is defined in MSEM as the SEMI M20 coordinate system.

5.1.9 *global pattern alignment, n.* — a procedure which establishes a coordinate reference system relative to repeating features on an entire substrate. For silicon wafers, this coordinate system is defined in MSEM as the M20P coordinate system.

5.1.10 *logical port, n.* — one or more physical input or input/output ports that are controlled by the same execution of a Process Program.

5.1.11 *M20P, adj.* — a designation used for the global coordinate system defined within MSEM, that is established relative to a pattern on a silicon wafer.

5.1.12 *material, n.* — a piece or pieces of substrate, one or more substrate, a lot, a batch, or a run.

5.1.13 *metrology equipment, n.* — any equipment that collects and reports information on specific predetermined sites or features on a substrate with consistent data structure, or reports general information about the entire substrate.

5.1.14 *notch, n.* — a cut on the edge of a wafer that is commonly located with respect to a specific crystal plane that adheres to the SEMI M1 standard.

5.1.15 *pattern, n.* — the physical features on a substrate.

5.1.16 *pre-align, n.* — any alignment done prior to placing a substrate on a measurement process location.

5.1.17 *registration, n.* — positioning error between two features on different layers of a substrate.

5.1.18 *safe state, n.* — a state in which the equipment presents no danger to the product or user. This implies that safety interlocks are in place such that the equipment can be serviced without harm to the operator and that the material being processed has been removed from the processing station into an accessible location.

5.1.19 *secondary alignment, n.* — a procedure which improves the accuracy of the coordinate system mapping on a substrate in a limited area of the substrate.

5.1.20 *site, n.* — a single point on a substrate used for alignment, or the center of an area of the substrate within which measurements are made.

5.2 *Abbreviations and Acronyms*

5.2.1 *GEM, n.* — Generic Equipment Model

5.2.2 *SEM, n.* — Specific Equipment Model

5.2.3 *SEM, n.* — Scanning Electron Microscope

5.2.4 *TCP/IP, n.* — Transmision Communication Protocol/Internet Protocol.

6 Communication Requirements

6.1 It is required that any MSEM compliant equipment follow the Communications State Model in SEMI E30. In addition MSEM compliant equipment shall support the High Speed Messaging Service (HSMS-SS) communication Standard, and the SECS-I standard for sending SECS II messages over TCP/IP or RS232. The user may determine which of these two lower level transmission protocols is used in each installation. The reason for HSMS-SS requirement is the large volume of data that can be generated by this class of equipment.

7 State Models

7.1 In this section are defined the equipment-specific processing state model and other state models necessary to portray the expected operational states of the equipment to enable host tracking and control in place of a local operator. See SEMI E30 and Other References section for additional information on state charts general rules and utilization.

7.2 *Processing State Model Requirements* — The Processing state model is required to be implemented as defined in the next sections of this document. A state model consists of the following: state model diagram, state definitions and a state transition table. A state model represents the host's view of the equipment, not necessarily the actual equipment operation. All MSEM state model transitions shall be mapped sequentially into the appropriate actual equipment events that satisfy the requirements of those transitions. In certain implementations, the equipment may enter a state and have already satisfied all of the conditions required by the MSEM state model for transition to another state. The equipment makes the required transition without any additional actions in this situation.

7.3 Some equipment may need to include additional states. Additional states may be added, but shall not change the MSEM defined state transitions. All expected transitions between MSEM states must occur.

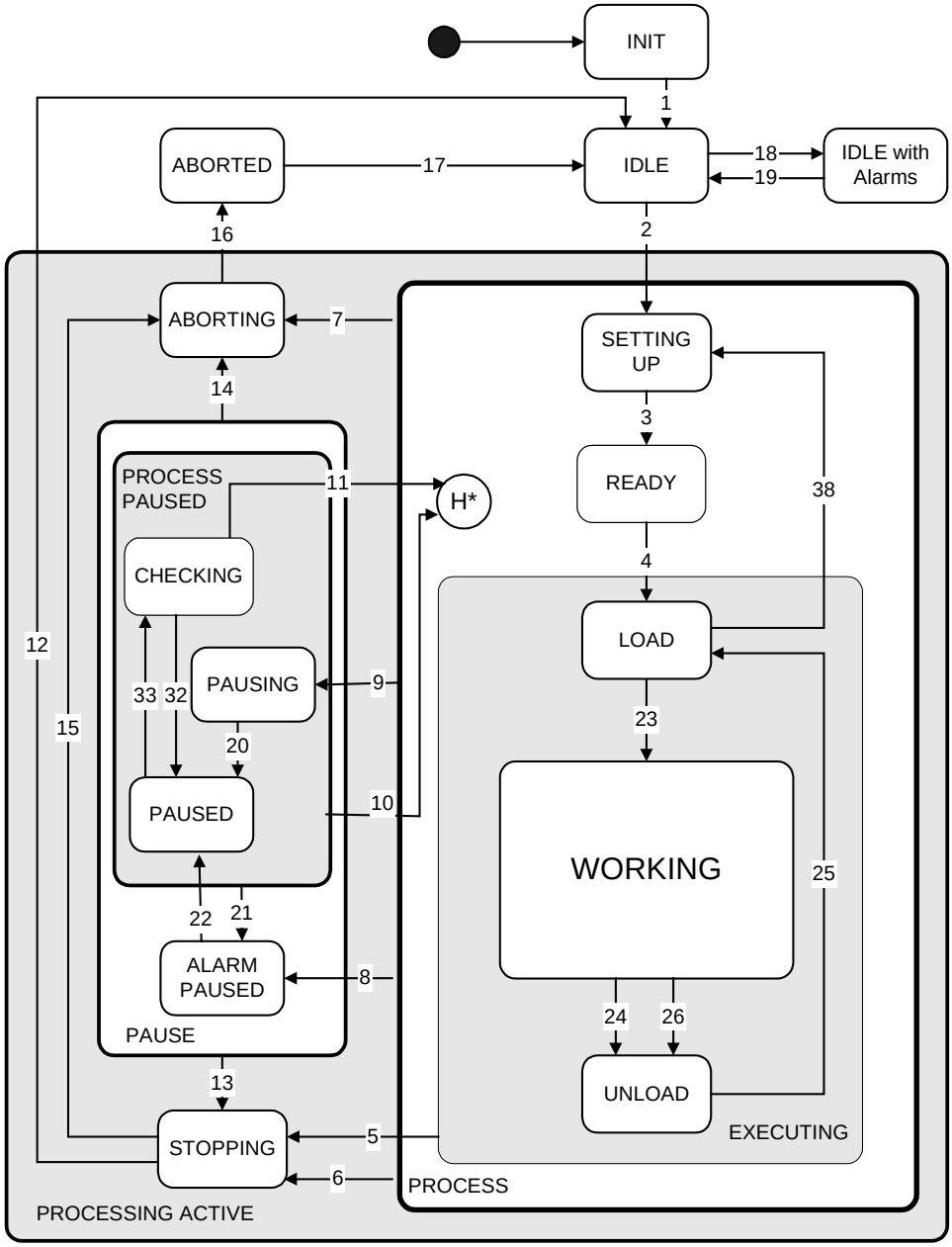

Figure 1
Generic MSEM Processing State Model Diagram

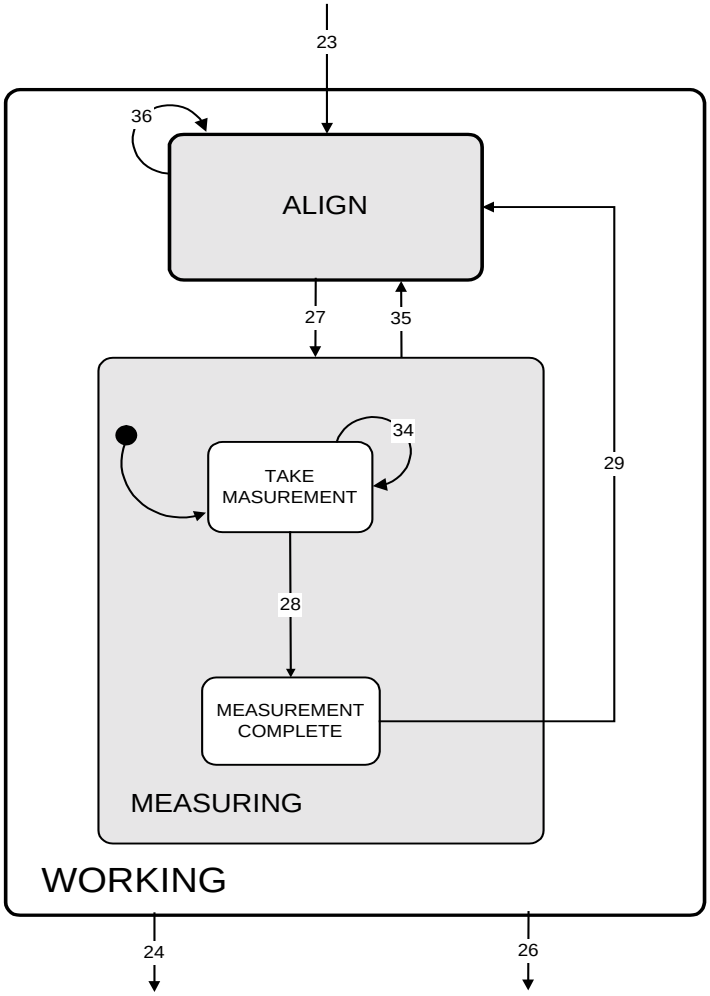

Figure 2
Working State of Processing State Model

7.4 *Processing State Model Diagram*

7.4.1 *Working State of Processing State Model*

7.4.2 *Working Sub-states of Processing State Model* — These states need not to be implemented in all Metrology equipment but if the equipment has the ability to multiple measurements at a site or provide raw scan date to the user this is how it is to be implemented.

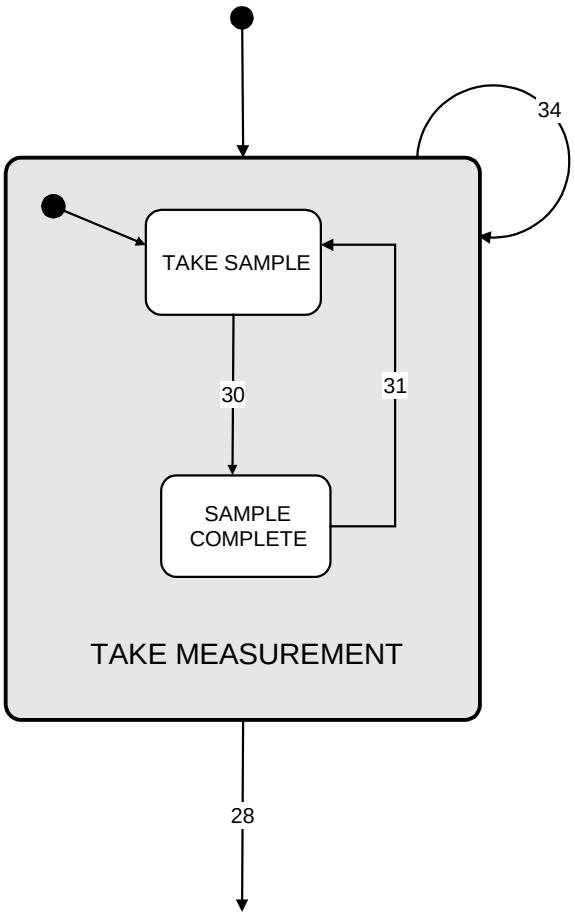

Figure 3
Working Sub-State of Processing State Model

7.5 *Processing State Definitions*

7.5.1 *ABORTED* — all activity is suspended as a result of an ABORT command. Any alarm and abort conditions must be cleared before exit from this state. The CLEANUP command is available to the operator or host to transition the equipment from the ABORTED state to IDLE state.

7.5.2 *ABORTING (PROCESSING ACTIVE Sub-state)* — the equipment has received an ABORT command. All normal activity is suspended. The equipment is taking appropriate action to put the equipment and material in a "safe state" where possible. Data may be invalid or not available.

7.5.3 *ALARM PAUSED (PAUSE Sub-state*) — an alarm has occurred in the Process or Process Pause states and the equipment is waiting for the alarm to be cleared.

7.5.4 *ALIGN (WORKING Sub-state)* — the equipment or operator is performing an alignment of the material to the equipment. Within this state the equipment shall refine or establish its SEMI M20 coordinate system and establish any secondary coordinate systems required.

7.5.5 *CHECKING (PROCESS PAUSE Sub-state)* — the equipment verifies that the updates made to the Process Program are valid. This is a similar procedure to that which is done in SETTING UP before the equipment is ready to transition to the READY state.

7.5.6 *EXECUTING (PROCESS Sub-state)* — the equipment is processing material automatically and can continue to do so without external intervention, but normally may include interaction with the host or operator.

7.5.7 *IDLE* — checks for queued process or awaits a command. IDLE is free of ALARM and error conditions. Any transitions into this state will clear the process area.

7.5.8 *IDLE with ALARMS* — an alarm has occurred in the IDLE state and the equipment is waiting for all alarms to be cleared.

7.5.9 *INIT* — equipment initialization is occurring.

7.5.10 *LOAD (EXECUTING Sub-state*) — the equipment is determining if processing is complete. If not, then the substrate is being transferred to the equipment processing location, such as the stage. A pre-alignment procedure may be performed prior to the LOAD state.

7.5.11 *PAUSE (PROCESS ACTIVE Sub-state*) — PROCESS is suspended at the next opportunity. Actions to put the equipment in a "safe state" shall be performed. The equipment is awaiting a command (RESUME, PP-UPDATE, STOP or ABORT), or for alarm(s) to be cleared.

7.5.12 *PAUSED (PROCESS PAUSE Sub-state*) — PROCESS shall be suspended and the equipment is waiting for a command (RESUME, PP-UPDATE, STOP or ABORT).

7.5.13 *PAUSING (PROCESS PAUSE Sub-state)* — PROCESS has been suspended at the next opportunity and the equipment is put in a "safe state".

7.5.14 *PROCESS (PROCESSING ACTIVE Sub-state)* — this state is the parent of those sub-states which refer to the active preparation and execution of a Process Program.

7.5.15 *PROCESSING ACTIVE* — this state is the parent of all sub-states where the context of a Process Program execution exists.

7.5.16 *PROCESS PAUSE (PAUSE Sub-state)* — the equipment is free of alarm conditions in the PAUSE state.

7.5.17 *MEASUREMENT COMPLETE (MEASURING Sub-State)* — the equipment has completed collecting data relative to an alignment location.

7.5.18 *MEASURING (WORKING Sub-State)* — the equipment is preforming an action between alignments.

7.5.19 *READY (PROCESS Sub-state)* — the equipment is ready to begin processing and is awaiting a START command from the operator or host. If an AUTOSTART is included, then the equipment starts processing immediately.

7.5.20 *SAMPLE COMPLETE (TAKE MEASUREMENT Sub-state)* — the equipment determines if additional samples need to be taken at this site.

7.5.21 *SETTING UP (PROCESS Sub-state)* — the equipment is being set up so that external conditions are satisfied to start processing the material. This includes the receipt of any Process Programs and material to be processed and their validation. Additional information may come from the host during the processing.

7.5.22 *STOPPING (PROCESSING ACTIVE Sub-state)* — the equipment has completed a Process Program or has been instructed to stop processing and shall do so gracefully at the next opportunity. All cleanup necessary is being completed within this state with regard to material, data, control system, etc. Data is normally preserved. Any alarm or error condition is cleared before exit from this state.

7.5.23 *TAKE MEASUREMENT (MEASURING Sub-state)* — the equipment is in the process of collecting data relative to an alignment location. (e.g. Site, Region, Substrate).

7.5.24 *TAKE SAMPLE (TAKE MEASUREMENT Sub-state)* — the equipment collects data from a single structure or of a single sample.

7.5.25 *UNLOAD (EXECUTING Sub-state)* — the substrate is being removed from the processing location.

7.5.26 *WORKING (EXECUTING Sub-state)* — the equipment is processing a specific material.

7.5.27 *Processing State Transition Table*

Table 1 Processing State Transition Table

Transition #	*Current state*	*Trigger*	*New State*	*Actions*	*Comments*
1	INIT	All equipment initialization is complete with no alarms or error conditions.	IDLE	None	If an alarm or error occurs during INIT, the equipment shall remain in this state.
2	IDLE	A process is queued or a command is received.	SETTING UP	The set up procedure is equipment dependent.	Commit has been made to set up.
3	SETTING UP	All setup activity has completed and the equipment is ready to receive a START command.	READY	The equipment is waiting for a START command. Start may be initiated by an operator.	The selected Process Program is available for execution.
4	READY	The equipment receives a START command.	LOAD	The equipment determines if processing is completed. If not, it transfers the next substrate to the processing location.	LOAD is an EXECUTING Substate.
5	EXECUTING	The processing is complete.	STOPPING	None	Equipment specific. Supplier must chose beween LOAD or UNLOAD states for completion.
6	PROCESS	The equipment has received a STOP command.	STOPPING	The equipment unloads the material and brings the equipment to a clean and safe state.	Data is typically preserved and is valid.
7	PROCESS	The equipment has received an ABORT command	ABORTING	The equipment is put in a "safe state” if necessary.	Data may be invalid or not available.
8	PROCESS	An alarm occurs.	ALARM PAUSED	PROCESS activity is suspended and the equipment is waiting for all alarms to be cleared.	ALARM PAUSED is a PAUSE Substate.
9	PROCESS	The equipment has received a PAUSE command.	PAUSING	PROCESS shall be suspended at the next opportunity. Actions to put the equipment in a “safe state” shall be performed.	PAUSING is a PAUSE Substate.
10	PROCESS PAUSED	The equipment has received a RESUME command.	Previous PROCESS State	Proceed with the suspended Substate.	PAUSED is a PROCESS PAUSE Substate.
11	CHECKING	The equipment has completed validating any updates made to the current Process Program being executed. Including a PP_UPDATE	Previous PROCESS State	Action is appropriate to the state and the changes made to the Process Program updated.	None

Transition #	*Current state*	*Trigger*	*New State*	*Actions*	*Comments*
12	STOPPING	The equipment clean up is complete and the equipment is free of alarms.	IDLE	None	None
13	PAUSE	The equipment has received a STOP command.	STOPPING	The equipment proceeds with clean up.	Normally, data is preserved and is valid.
14	PAUSE	The equipment has received an ABORT command.	ABORTING	Any unsafe condition is resolved if possible.	Data may be invalid or not available.
15	STOPPING	The equipment has received an ABORT command.	ABORTING	Any unsafe condition is resolved if possible.	Data may be invalid or not available.
16	ABORTING	Unsafe conditions have been resolved where possible.	ABORTED	The equipment is waiting for alarm and ABORT conditions to be cleared.	The only state change allowed is to IDLE.
17	ABORTED	All alarms and abort conditions have been cleared.	IDLE	None	If needed the CLEANUP command clears the abort conditions. IDLE is a “clean” state.
18	IDLE	An alarm is set.	IDLE w/ ALARMS	The equipment waits for all alarms to be cleared.	None
19	IDLE w/ ALARMS	All alarms have been cleared.	IDLE	None	IDLE is free of alarms.
20	PAUSING	The equipment has achieved a “safe state”.	PAUSED	The equipment is waiting for a command (RESUME, STOP or ABORT).	None
21	PROCESS PAUSE	An alarm is set.	ALARM PAUSED	The equipment waits for all alarms to be cleared, or a STOP or ABORT command.	None
22	ALARM PAUSED	All alarms are cleared.	PAUSED	The equipment is waiting for a command (RESUME, PP_UPDATE, STOP or ABORT).	None
23	LOAD	Material transfer to processing location is complete and global alignment has been completed.	WORKING	The substrate is being processed.	None
24	WORKING	The processing of the specific material being processed ended normally.	UNLOAD	This material is transferred from the processing location.	“Normal” completion of the substrate.
25	UNLOAD	The material unload is complete.	LOAD	The equipment checks if processing is complete and, if not, transfers the next substrate to the processing location.	None

Transition #	*Current state*	*Trigger*	*New State*	*Actions*	*Comments*
26	WORKING	The processing of the specific material being processed ended abnormally.	UNLOAD	This material is transferred from the processing location.	Abnormal exit from WORKING or Next Material command received.
27	ALIGN	The material alignment is complete.	MEASURING	The equipment determines if additional sites are required.	None
28	TAKE MEASURE-MENT	All data collection has been completed for the current site or alignment location.	MEASURE-MENT COMPLETE	The equipment determine if additional sites are required.	Determine if additional alignments are required or unload is required.
29	MEASURE-MENT COMPLETE	Additional sites are required.	ALIGN	The equipment moves and aligns to new data collection site.	None
30	TAKE SAMPLE	Data collection from scan or structure.	SAMPLE COMPLETE	Determine if additional samples are required.	None
31	SAMPLE COMPLETE	Additional samples are required.	TAKE SAMPLE	Start collecting next scan or structure data.	None
32	CHECKING	Validation of Process Program change fails or is cancelled. Includes PP_UPDATE.	PAUSED	The equipment is waiting for a new PP-UPDATE or RESUME command.	Process Program reverts to the conditions that existed prior to the PP-UPDATE.
33	PAUSED	The equipment receives a PP-UPDATE command.	CHECKING	The equipment begins validating the changes made to the Process Programs to be executed.	None
34	TAKE MEASURE-MENT	Another measurement is required at an alignment location.	TAKE MEASURE-MENT	The equipment performs a measurement.	None
35	MEASURING	An error or failure occurred during the measurement and a new alignment is required.	ALIGN	The equipment moves and aligns to new data collection site.	None
36	ALIGN	An error or failure occurred during alignment and a new alignment is required.	ALIGN	The equipment moves and aligns to new data collection site.	None
37	ASSIST	A failure occurred while executing and external assistance was required to continue.	PROCESS PAUSE	The execution is stopped and equipment waits for a resume command.	Resume command must be issued.
38	LOAD	Previous PROCESS-BLD-GROUP program has completed and there are additional process programs assigned to the “CARRIERBLD”. See Section 12.	SETTING UP	The equipment performs set up according to specifications of the next process program.	PROCESS-BLD-GROUP may include a AUTOSTART command within its body. Otherwise, the equipment waits for a START command.

Table 2 Processing State Events and Associated Reports

CENAME	*From State*	*To State*	*Required DVVAL's or Reports*
END of RUN	STOPPING	IDLE	RUN complete report available. All jobs specified by PROCESS-BLD-GROUP command parameter(s) in a CARRIERBLD command parameter complete.
END of JOB	LOAD	SETTING UP	JOB complete report available. A job specified by a PROCESS-BLD-GROUP command parameter in a CARRIERBLD command parameter that specifies multiple jobs for the same material completes.
END of SUBSTRATE	UNLOAD	LOAD	SUBSTRATE complete report available.
END of SITE	TAKE MEASURE	MEASURE COMPLETE	SITE complete report available. Only required if supporting sampling.
END of SAMPLE	TAKE SAMPLE	SAMPLE COMPLETE	SAMPLE complete report available. Only required if equipment performs measurements on individual sites.

8 Collection Event List

8.1 The purpose of this section is to identify data collection events for Metrology equipment and define reporting levels.

8.2 *Requirements* — Only those collection events that are not associated with a change of state, and those requiring specific DVVAL's or Reports defined in the SEM, are required to be included in this section. All SEMI E30 required events are required by this SEM.

8.2.1 *Common collection events* — collection events common to, and required on, all equipment of the class being addressed.

8.2.2 *Configuration-specific collection events*— collection events associated with a specific configuration of the equipment class being addressed.

8.3 *Collection Event Tables* — The first table contains processing state event transitions and associated reports. The second table contains additional events or actions and associated reports.

8.3.1 All remote commands (S2F41) that are not preformed by the equipment before responding to the host (S2F42) must generate an event indicating when the task was completed and whether it was successful.

Table 3 Additional Required Collection Events

ACTION or COMPLETED EVENT	*Required DVVAL's or Reports*
Remote command MAP-CASSETTE completed successfully.	SlotList
Operator hits button on equipment control panel.	OperatorAction

9 Data Item Variables

9.1 The purpose of this section is to define the list of data item variables pertinent to the specific equipment. Values of these variables shall be available to the host via collection event reports and host status queries.

9.2 *Requirement* — all generic variable data items defined in SEMI E30 are required by all Measurement equipment. Data item variables are categorized as follows:

9.2.1 *Common Variables (CV)* — variables common to all equipment of the class being addressed. These variables are covered in Table 4 and must be used to regardless of the measurement tool type.

9.2.2 *Configuration-specific variables (CSV)* — variables associated with a specific configuration of the above equipment class.

9.2.2.1 The following rules should be adhered to in the reporting of these variables.

- The information should be sent using the corresponding formats defined on Table 4 and 5.
- For ASCII variables A[n]. If the actual data does not fill the entire field, blanks shall be used to complete the field.
- For ASCII variables A[1..n]. All fields should be left justified.

9.3 Since MSEM is generic to all equipment it tries not to specify the names of the measurement variables to be sent to the host. MSEM does require that the data be reported at site, wafer and lot levels. It should include the option of reporting data at the individual scan level if supported by the equipment. It is a requirement that the equipment report at least: max, min, mean, standard deviation. Additional statistic calculations may be added by the equipment supplier. For each type of data collected by the equipment at the site level; the data must be summarized and available for reporting at the wafer and lot levels.

9.4 The following rules should be applied when reporting measurement values taken by the tool. The rules specify the units to be used whenever these values are reported.

- All values specified should be reported in floating point format.
- All critical dimensions (lines and spaces) should be in microns.
- All overlay measurements should be in microns.
- All FTIR transmittance values and corresponding wavelengths should be reported in percent units and microns, respectively.
- All film stress values should be reported in teradynes/cm-cm.
- All resistivity measurements should be reported in Ohm-cm.
- All film thickness measurements should be reported in Angstroms.

9.5 Data item variables should be documented in the MSEM data item variable dictionary using the following format:

Variable Name	*Category*	*Description*	*Class*	*Format*	*Comments*

Where:

Variable Name:	A unique name for the data item variable (this name is for reference only).
Category:	Defined as Common or Configuration-Specific variables.
Description:	If class is DVVAL, then the description must contain a statement of when data is valid in terms of MSEM events.
Class:	Data type of the item.
Format:	Acceptable formats are SEMI E5 lists, ASCII, floating point, unsigned integer or signed integer. A description of "ANY", indicates that any of the above formats are acceptable and is left to the tool vendor to decide. When required use SECS Message Language format.
Comments:	Any additional information pertinent to the variable name.

9.6 *Data Item Variable Types*

9.6.1 *Equipment Constants (ECV)* — can be changed by the host using S2F15. The operator may have the ability to change some of the values, but the equipment does not change the values on its own. The value of the equipment constant may be queried by the host at any time using the S2F13/14 transaction.

9.6.2 *Status Variables (SV)* — are valid at all times. A SV may not be changed by the host but may be changed by the equipment or the operator. The value of status variables may be queried by the host at anytime using the S1F3/4 or S6F19/20 transactions.

9.6.3 *Data Variables (DVVAL)* — are variables which are valid only upon occurrence of specific collection events. An attempt to read a data variable at the wrong time shall not generate an error, but the data reported may not have relevant meaning.

9.6.4 *Variable Data (V)* — this is a class of variable data which includes all the previously defined types of variables.

Table 4 Data Item Variable List

Variable name	*Category*	*Description*	*Class*	*Format*	*Comments*
AlignList	CSV	A list of alignment site information being used by the currently active Process Program.	DVVAL	L,n 1. <AlignName> . . n.	See Table 5 for additional information.
CarrierID	CV	ID of the Carrier that the measurement data is associated with.	DVVAL	A[1..16]	Valid in processing substate.
Coord	CV	The X,Y coordinate for a site in microns.	DVVAL	L,2 1.<CoordX> 2.<CoordY>	See Table 5 for additional information.
Coordsys	CV	The identification for applicable coordinate system.	DVVAL	A[1..16]	Options for silicon wafers are: SEMI M20, M20P, SEMI M21.
Default-Priority	CV	The default priority given a location or carrier ID if none is assigned.	EC	U4	
DeltaX	CSV	The x axis translation between the origins of two coordinate systems, in µm.	DVVAL	F4	Units are in microns.
DeltaY	CSV	The y axis translation between the origins of two coordinate systems, in µm.	DVVAL	F4	Units are in microns.
ElementID	CSV	The M21 address for a specific rectangular element on a patterned silicon wafer.	DVVAL	I4[2]	M21 row number, M21 column number.
ElementList	CSV	A list of M21 elements where measurements were attempted.	DVVAL	L,n 1. <ElementID> . . n	See Table 5 for additional information.
EquipID	CV	Unique ID of measurement equipment.	SV	A[1..16]	Valid in all sub states.
EquipName	CV	Name of equipment	SV	A[1..16]	Valid in all sub states.
LotID	CV	Lot ID that is associated with the measurement data.	DVVAL	A[1..80]	
M20Data	CV	The silicon wafer size, fiducial type, and orientation to use.	DVVAL	L,3 1.<WaferSize> 2.<Fiducial> 3. <Orientation>	See Table 5 for additional information.

Variable name	*Category*	*Description*	*Class*	*Format*	*Comments*
M21Data	CSV	The data necessary to establish an MSEM SEMI M21 layout on a silicon wafer.	DVVAL	L,2 1. L,3 1.<M21XSize> 2.<M21YSize> 3. <Tile> 2. L,n 1. L,3 1.<ElementID> 2.<CoordX> 3.<CoordY> : n	Coord x and Coord y are the X and Y coordinates in the M20P coordinate system of the lower left-hand corner of the element. See Table 5 for additional information.
QueuedJobList	CSV	An ordered list of CarrierID data items (A[1..16]) of material that is queued to run. The first item in the list is the ID of next carrier to run. A soon as a job specified by a PROCESS-BLD-GROUP starts, the CarrierID it specifies is removed from the head of the list.	SV	L	
Offset	CSV	The difference between the defined location of a site and the location at which it is found.	DVVAL	F4[2]	SiteDeltaX, SiteDeltaY
Operator Action	CV	Action taken by operator on equipment's front panel.	DVVAL	A[1..80]	
OperName	CV	Tool Operator name	ECV	A[1..16]	
Orientation	CV	The direction, in degrees, from the equipment's "0" location for a wafer's primary fiducial when initially positioned for measurements.	ECV	F4	This parameter has no effect on the "M20" based wafer coordinate system as discussed in SEMI standard SEMI M20.
PP-Name	CV	The PPID that is being used for measuring.	SV	A[1..80]	
Process SlotList	CV	The list of cassette slots whose contents are to be processed.	DVVAL	L,n 1. <SlotID> . . .	L,0 indicates all slots are to be processed. See Table 5 for additional information.
SiteDeltaX	CSV	The x axis translation between the defined and found locations of a site, in µm.	DVVAL	F4	Units are in microns.
SiteDeltaY	CSV	The y axis translation between the defined and found locations of a site, in µm.	DVVAL	F4	Units are in microns
SiteList	CV	The list of sites where measurements are made.	DVVAL	L,n 1.<SiteName> . . n	See Table 5 for additional information.
SiteName	CV	A unique identifier for a site.	DVVAL	A[1..16]	

Variable name	*Category*	*Description*	*Class*	*Format*	*Comments*
SlotID	CV	The cassette slot number.	DVVAL	U4	
WaferID	CSV	Physical wafer identifier.	SV	A[1..24]	
WaferIDRead	CSV	Tool read wafer identifier.	SV	A[1..24]	
WaferSize	CV	The nominal diameter of a silicon wafer.	EC	A[1..16]	mm
XlateData	CSV	Variable for the equipment to report the pattern-based coordinate system offset from the wafer-based coordinate system found on the wafer being tested.	SV	L,4 1 <DeltaX> 2 <DeltaY> 3 <Theta> 4 <ScaleFactor>	See Appendix 1 for an example. See Table 5 for additional information.

9.6.5 *Data Item Sub-variable List*

Table 5 Data Item Sub-Variable List

Data Item Sub-variables	*Description*	*Format*	*Comment*
AlignName	The identifier given to a alignment site.	A[1..16]	
CoordX	The x coordinate for a site.	F4	Units are in microns.
CoordY	The y coordinate for a site.	F4	Units are in microns.
DeltaX	The x axis translation between the origins of two coordinate systems, in µm.	F4	Units are in microns.
DeltaY	The y axis translation between the origins of two coordinate systems, in µm.	F4	Units are in microns.
ElementID	The M21 address for a specific rectangular element on a patterned silicon wafer.	I4[2]	M21 row number, M21 column number
Fiducial	The type of primary fiducial on a silicon wafer.	A[1..16]	Options are “FLAT” or “NOTCH”
M21XSize	The M21 element size in the x direction, in µm.	F4	Units are in microns.
M21YSize	The M21 element size in the y direction, in µm.	F4	Units are in microns.
ScaleFactor	The scaling factor required by the equipment to adjust from its SEMI M20 coordinate system to the coordinate system established through the use of pattern alignment “alignment site” information. In most cases, a scaling factor of 1 is expected.	F4	
SiteDeltaX	The x axis translation between the defined and found locations of a site, in µm.	F4	Units are in microns.
SiteDeltaY	The y axis translation between the defined and found locations of a site, in µm.	F4	Units are in microns.
SiteName	A unique identifier for a site.	A[1..16]	
THETA (Θ)	The clockwise rotation, in radians, between the SEMI M20 and M20P coordinate system axes.	F4	Radians
Tile	A flag to indicate whether the SEMI M21 layout is tiled, and in which direction.	A[1..16]	Options are: “NTILE” is untitled “CTILE” is column tiled “RTILE” is row tiled

10 Alarm List

10.1 Since each model of equipment differs in configuration, it is not practical to provide an exhaustive list of all possible alarms. Instead, the MSEM is requiring the two tables provided as described in SEMI E30 (Document Section). Alarm List Table which is intended to provide for equipment configuration specific alarms and Alarm ID, Alarm Set/Cleared Event Table.

10.2 *Alarm List Table*

10.2.1 The alarm list table contains examples of alarms that pertain to various configurational aspects of equipment. These examples are intended to illustrate that alarms pertain to situations in which there exists a potential for exceeding physical safety limits associated with people, equipment, and material being processed as per the SEMI E30 definition of an alarm. See SEMI E30 for further reference.

10.3 *Alarm ID, Alarm Set/Cleared Event Table*

10.3.1 The Alarm ID, Alarm Set/Cleared Event table documents the association of each ALID to a set and cleared event as required by SEMI E30. See SEMI E30 for further reference.

11 Process Program Management

11.1 *Requirements* — The MSEM requires that the SEMI E30 capability of Process Program Management be fully supported for this class of equipment. The MSEM is also requiring that the Process Program have a structure that enables the user to build Process Programs with default conditions that can be overridden for a run. MSEM is requiring the ability to vary; the quantity of substrates measured, the alignment information used and the number and/or location of the sites to be measured through the uses of Process Program variable parameters. The concepts of Process Program Structure and Process Program variable parameters are discussed in the following sections.

11.2 *Process Program Structure*

11.2.1 *Definition and Rules for Process Programs* — A Process Program contains information and/or instructions required for the metrology equipment to process a given run of material. Equipment constants can be used to supplement the information contained in a Process Program.

11.2.1.1 The Process Program shall supply all of the information required for a remotely executed run to be processed without operator intervention. Any information that is normally requested from the operator console in manual operation shall have default values assigned in the body of the Process Program.

11.2.1.2 Process-program parameters are used to tailor a specific run of material and do not permanently modify the Process Program. They will remain in effect only until the next run or until the next PP-UPDATE or PP-SELECT, PP-ASSIGN remote command.

11.2.1.3 MSEM is requiring the ability to define specific Process Program variable parameters to; define what substrates are to be measured (Process SlotList), what sites are to be measured (SiteList or M21SiteList) and what aligns are used by the Process Program (AlignList or M21AlignList). If the MSEM equipment is using the SEMI M21 coordinate system then an additional Process Program variable parameter is required what elements are to be measured (ElementList).

11.2.2 *Definition of Process Program Variable Parameters* — A process-program parameter specifies a value that temporarily modifies the value of a variable parameter in a Process Program. A variable parameter is formally defined within a process-program body and contains:

- a variable parameter name that is unique in the body
- a parameter initial value, known as default value, for use when the Process Program is selected for execution without specification of an override value for this variable parameter.

11.2.3 The Equipment may also support the definition including:

- a parameter restriction that represents one or more conditions that any value specified for the parameter must satisfy.
- a CP-NAME in a remote command must be identical to a variable parameter name in the Process Program specified in the remote command. If the Equipment allows Sub-process Programs, a Sub-process Program reference may also specify parameters.

11.2.4 *Relationship of Process Program Variable Parameter* — The PP-SELECT, PP-ASSIGN or PP-UPDATE remote commands can be used to modify variables within the Process Program. The modification to process-program variables is done by using CP-NAME/CP-VAL pairs within the command.

11.2.5 *Sub-Process Programs* — Equipment may allow a main Process Program to reference Sub-process Programs. A main Process Program is one that can be referenced by the host. A Sub-process Program is a Process Program that is referenced by a main Process Program or by other Sub-process Programs. No Sub-process Program may reference its main Process Program. If the Equipment supports sub-process-program references, it must be possible for the host to determine which Sub-process Programs are referenced in all Process Programs.

11.2.5.1 Before execution of a main Process Program can begin, the presence of all the Sub-process Programs that it references must be verified by the Equipment. If they are not all present, an error collection event must occur. It must be possible to include in the event report which Sub-process Programs are missing. For a formatted Process Program, the error is reported using an S7F27 message.

11.2.6 *Component Descriptions and Allowed Formats*

Table 6 Process Program Component Description and Format Table

Component Name	*Description*	*Format*	*Comments*
ALIGN-ATTRIBUTE (n)	Tool specific information associated with alignment site for which no specific MSEM data item has been defined.		Examples include information such as magnification, voltage, current, wavelength, number of scans, integration time, or film stack. The equipment supplier shall document all attributes that are supported.
ALIGN-NAME	The identifier given to a alignment site.	A[1..16]	
COORDSYS	The identification for applicable coordinate system.	A[1..16]	Options for silicon wafers are: SEMI M20, M20P, SEMI M21
COORDX	The x coordinate for a site or the lower left hand corner of an element.	F4	Units are in microns.
COORDY	The y coordinate for a site or the lower left hand corner of an element.	F4	Units are in microns.
ELEMENTID	The element identifier in the SEMI M21 coordinate system	U4[2]	
M21XSIZE	The SEMI M21 element size in the x direction in μm.	F4	
M21YSIZE	The SEMI M21 element size in the y direction in μm.	F4	
SITE-ATTRIBUTE (n)	Tool specific information associated with a measurement site for which no specific MSEM data item has been defined.		Examples include information such as magnification, voltage, current, wavelength, number of scans, integration time, or film stack. The equipment supplier shall document all attributes that are supported.
SITENAME	A unique identifier for a site.	A[1..16]	

11.2.7 *DEF-LIST-TABLE Description* — DEF-LIST types of tables are used by the equipment in conjunction with the Process Programs. The DEF-LIST table structures provide a means to transfer to equipment a list of a particular type of information. The DEF-LIST table structures are used by the host to send information to equipment for later use in association with a Process Program. Each DEF-LIST that is sent has a unique Table name and each list element in the DEF-LIST has several components including a name (Site-Name, or Align-Name) as well as other components. A specific list row can be accessed for use with a specific Process Program by giving the DEF-LIST table name and the specific row name.

11.2.7.1 There are five types of DEF-LIST tables:

- SITE-DEF-LIST: A list of Sites and their attributes, typically the list of sites to be measured.
- ALIGN-DEF-LIST: A list of alignment sites and their attributes.
- M21-ELEMENT-DEF-LIST: A list of element ID and their low left hand location in M20P or SEMI M20 coordinates.
- M21-ELEMENT-SITE-DEF-LIST: A list of ElementID's and what sites are to be measured within that element.
- M21-ELEMENT-ALIGN-DEF-LIST: a list of ElementID's and the alignment sites to be used at each.

NOTE 2: The attributes are equipment-defined.

11.2.7.2 To support the SiteList, and AlignList, for SEMI M20, M20P and SEMI M21, the following types of tables must be implemented: SITE-DEF-LIST, ALIGN-DEF-LIST, or M21-ELEMENT-SITE- DEF-LIST, M21-ELEMENT-ALIGN-DEF-LIST and M21-ELEMENT-DEF-LIST. A host would send a DEF-LIST to equipment using standard transfer methods for tables as defined by ARAMS (SEMI E58). MSEM requires that the following columns be included in the DEF-LIST tables. The DEF-LIST-TABLE components table defines the DEF-LIST column names and their allowable format is given below.

Table 7 SITE-DEF-LIST

Sitename	*Coordx*	*Coordy*	*Coordsys*	*Site- Attribute(n)*

11.2.7.3 For SEMI M21 Coordinate system an additional table is required.

Table 8 M21-ELEMENT-SITE-DEF-LIST

Element id	*Sitename*

Table 9 M21-ELEMENT-DEF-LIST

Element id	*Coordx*	*Coordy*	*Coordsys*	*m21xsize*	*m21ysize*

Table 10 ALIGN-DEF-LIST

Align-Name	*Coordx*	*Coordy*	*Coordsys*	*Align- Attribute(n)*

Table 11 M21-ELEMENT-ALIGN-DEF-LIST

Element id	*Align-Name*

12 Remote Commands

12.1 The purpose of this section is to identify the MSEM required remote commands, command parameters, and valid commands versus MSEM states.

12.2 *Requirements* — The following capabilities are required:

- StartProcessing
- Stop Processing
- Temporaly Suspend Processing
- Resume Processing
- Abort Processing
- Select Process Programs, Material and/or Sites to Measure
- Report Location of Material Found within a cassette

12.3 All the remote commands defined by MSEM are required unless they have been qualified by the statement "if the equipment supports this functionality it shall use this command". Then, they are only required if the equipment supports the functionality necessary to support the command. A good example of this is the MAP-CASSETTE command if the equipment does not have the hardware necessary to scan a cassette for the presence of substrates in slots then the command is not required by the MSEM. The alphanumeric strings defined by MSEM for RCMD and CPNAME are required.

12.4 *Definitions*

12.4.1 *Host Command Parameter (CPNAME/CPVAL)* — a parameter name/value associated with a particular host command (S2,F49). This document will specify unique names (CPNAMEs) and values (CPVALs) for many command parameters. Note that if there are no associated parameters a zero-length list is sent.

12.5 *Remote Commands Description* — this section describes required functionality, suppliers may implement additional commands. The following remote commands (RCMDs) must be supported as described below.

NOTE 2: The terms "current cycle" and "safe point" used below are to be defined by the supplier.

12.5.1 *ABORT* — terminate the current cycle prior to its completion. Abort has the intent of immediately stopping the process and is used because of abnormal conditions. Abort makes no guarantee about the subsequent condition of material except as noted in the CPNAME ABORT-LEVEL description.

12.5.2 *CLEANUP* — Process Program deselection, removal of all material to output locations and any equipment specific activities needed to transition into the IDLE state. Completion of this command should generate a collection event report.

12.5.3 *NEXT-MATERIAL* — processing of the current substrate is halted at the first safe point and unloaded to the target cassette location. Next-material has the intent of allowing the host to skip measurement of the current substrate. This is a trigger for processing state transition from WORKING to UNLOAD.

12.5.4 *PAUSE* — suspend processing temporarily at the next safe point. Pause has the intent of resuming the process at the same point where it was paused. RESUME or PP-UPDATE may be used to resume the process.

12.5.5 *PP-ASSIGN* — instructs the equipment to assign a process to a carrier ID(s)/location(s) and place the exchange station in the process queue with the given priority. Only one assignment is allowed for a exchange station. Without specifying a priority, the material is queued with the default priority. Material with equal priority are queued in the order the PP-ASSIGN commands are received. If the equipment supports the functionality of queuing material, it will use this command.

12.5.6 *PP-SELECT* — instructs the equipment to make the requested Process Program(s) available in the execution area. Additionally, to reduce the number of Process Programs on the equipment, PP-SELECT may define the material to be measured, measurement site locations, and/or the information needed for site alignment; default values shall be used if this information is not specified. This is a trigger for the processing state transition from IDLE to SETTING UP. All Process Programs specified in the command are to be validated

12.5.7 *PP-UPDATE* — provides the ability to alter Process Program variables during the PAUSED processing state. Any CPNAMEs specified in PP-UPDATE will replace the previous definitions. This command will RESUME the process. If the PP-UPDATE fails, the Process Program variables present prior to the PP-UPDATE are retained. If no parameters values are specified, the defaults are used.

12.5.8 *RESUME* — resume processing from the point where the process was paused. This is the trigger for processing state transition 10, from PROCESS PAUSE.

12.5.9 *START* — instructs the equipment to initiate processing. This is the trigger for the processing state transition from READY to LOAD.

12.5.10 *STOP* — complete the current cycle, stop in a safe condition and return to the IDLE processing state. Stop has the intent of stopping the process entirely. The equipment is not required to support the continuation of processing.

12.6 *Host Command Parameters Names (CPNAME)*

Table 12 Host Command Parameter Table

CPNAME	*CPVAL*		
	Description	*Range*	*Format*
CARRIERBLD	L,2 1. L,2 1. CP-CARRIERID ** 2. CARRIERID or 1. L,2 1. CP- LOCATIONID ** 2. (STORAGE)ID 2. L,N 1. L,2 1. PROCESS-BLD-GROUP 2. L,M : N. L,2 1. PROCESS-BLD-GROUP ** Both CP-CARRIERID and CP-LOCATION may be included if no carrier ID reader is available.		
CP-ABORT-LEVEL	MSEM defined abort levels HALT - halt, goto ABORTED CLEANUP - halt, preform cleanup procedure, goto ABORTED	"HALT" "CLEANUP"	A[7]
CP-ALIGNLIST	L,n 1. CP-ALIGNNAME : n. For the SEMI M20 or M20P Coordinate system		
CP-ALIGN-DEF-LIST	**As defined in Section 9**		
CP-ALIGNNAME	Alignment name		A[1..80]
CP-AUTOSTART	Defines if a START command is required from an external source (operator or host) to exit the READY state. 0 = START command required, 1 = AUTOSTART no external START command required to begin execution.	0–1	U1
CP-CARRIERID	ID of carrier that the measurement data is associated with.		A[1..16]
CP-ELEMENTID	The M21 address for a specific rectangular pattern on the wafer.		I4[2]

CPNAME	*CPVAL*		
	Description	*Range*	*Format*
CP-ELEMENTLIST	L,n 1. <CP-ELEMENTID> : n.		
CP-LOCATIONID	Unique identifier of the location to be used for the "CARRIERBLD" assignment.		U4
CP-LOTID	lot id		A[1..80]
CP-MATERIALLIST	L,n 1. <CP-SLOTID or CP-WAFERID> : n.		
CP-M21-ALIGNLIST	L,n 1. CP-ALIGNNAME : n. For the SEMI M21 Coordinate system		
CP-M21-SITELIST	L,n 1. CP-SITENAME : n. For the SEMI M21 coordinate system		
CP-PPNAME	Process Program name		A[1..80]
CP-PRIORITY	assignment priority	0–9 0–highest priority	U4
CP-SITELIST	L,n 1. CP-SITENAME : n. For the SEMI M20 or M20P coordinate system		
CP-SITE-DEF-LIST	As defined in Section 9.		
CP-SITENAME	unique identifier for a site		A[1..16]
CP-SLOTID	slot number	1–n	U4
CP-SLOTLIST	Specifies carrier slots that contains substrate to measure. L,n 1. CP-SLOTID : n.	0 indicates all slots	
CP-WAFERID	Physical wafer identifier		A[1..24]

CPNAME	*CPVAL*		
	Description	*Range*	*Format*
PROCESS-BLD-GROUP	L, n 1. L, 2 1. CP-PPBUILDID 2. PPBUILDGROUPID 2. L, 2 1. CP-PPNAME 2. PPNAME 3. L, 2 1. CP-LOTID 2. LOTID 4. L, 2 1. CP-AUTOSTART 2. START 5. L, 2 1. CP-MATERIALLIST 2. L, n 1. CP-SLOTID : n. ***or*** 1. CP-WAFERID 2. L, n : n.	$n \geq 2$	List of *n* data items

CPNAME	*CPVAL*		
	Description	*Range*	*Format*
PROCESS-BUILD-GROUP(continues)	6. L, 2 1. CP-SITE-DEF-LIST 2. SITE-TABLE-NAME 7. L, 2 1. CP-SITELIST 2. L, n 1. CP-SITENAME : n. 8. L, 2 1. CP-ALIGN-DEF-LIST 2. ALIGN-TABLE-NAME 9. L, 2 1. CP-ALIGNLIST 2.L, n 1. CP-ALIGN-NAME : n. 10. L, 2 1. CP-ELEMENTLIST ** 2. L, n 1. CP-ELEMENTID : n. **CP-ELEMENTLIST is required when using the SEMI M21 coordinate system in the definition of an ALIGNNAME or SITENAME . 10. L, 2 1. CPNAME supplier defines Process Program Variable Parameters 2. CPVAL CP-PPNAME is required, CP-SLOTLIST, CP-SITELIST, and CP-ALIGNLIST are optional.		

12.7 *Remote Commands and Associated Host Command Parameters* — This table describes the allowable command parameters (CPNAME) for each remote command (RCMD). Equipment must support all parameters. The column marked Req/Opt, specifies which parameters are required to be sent by the host and which parameters may be optionally sent by the host.

Table 13 Remote Command and Associated Host Command Parameters Table

Remote Command	*Parameter(s)*		
	CPNAME	*Req/opt*	*Description*
ABORT	CP-ABORT-LEVEL	O	
CLEANUP	CP-LOCATIONID CP-SLOTID	O O	Location and SLOT may be used to define a different cassette / slot destination for the substrates.
NEXT-MATERIAL	CP-LOCATIONID CP-SLOTID	O O	If no command parameters are specified, then the substrate is returned to its original source carrier and slot. If a CP-SLOT command parameter is specified, then the substrate is placed in that slot of its original source carrier. If a CP-LOCATIONID command parameter is specified, then the substrate is placed in an available slot of the carrier at the specified location. If both CP-SLOT and CP-LOCATION command parameters are specified, then the substrate is placed in specified slot of the carrier at the specified location.
PAUSE	None	N/A	None
PP-ASSIGN	CP-PRIORITY CARRIERBLD*	O R	* More than one CARRIERBLD may be specified. There may be more than one PROCESS-BLD-GROUP in each CARRIERBLD.
PP-SELECT	CARRIERBLD*	R	* More than one CARRIERBLD may be specified. There may be more than one PROCESS-BLD-GROUP in each CARRIERBLD.
PP-UNASSIGN	CP-LOCATIONID CP- CARRIERID	R* R*	* At least one is required.
PP-UPDATE	CP-SLOTLIST CP-SITELIST CP-ALIGNLIST	R* R* R*	* At least one is required. By default use the current active input port.
RESTAGE	CP-LOCATIONID	R*	* Some equipment may not support this feature.
RESUME	None	N/A	None
START	None	N/A	None
STOP	None	N/A	None

12.8 *Remote Command and Processing State Relationship*

Table 14 Remote Commands versus Processing States Table

Command	ABORT	CLEANUP	PP-ASSIGN	NEXT-MATERIAL	PAUSE	PP-SELECT	PP-UPDATE	RESUME	START	STOP
PROCESSING STATE										
IDLE					X			X		
PROCESSING ACTIVE										
PROCESS										
SETTING UP	X					X		X		X
READY	X	X				X		X		X
EXECUTING								X		
LOAD	X					X		X		X
WORKING										
ALIGN	X					X	X	X		X
MEASURING	X					X	X	X		X
TAKE MEASURE	X					X	X	X		X
TAKE SAMPLE	X					X	X	X		X
SAMPLE COMPLETE	X					X	X	X		X
MEAS COMPLETE	X					X	X	X		X
UNLOAD	X					X		X		X
STOPPING								X		X
PAUSE										
PROCESS PAUSE										
PAUSING	X							X		X
PAUSED	X		X	X				X		X
CHECKING	X							X		X
ALARM PAUSED	X							X		X
ABORTED								X	X	

13 Scenarios

13.1 The purpose of this section is to document any MSEM specific scenarios that must be performed by this class of equipment.

13.2 *Normal Reporting*

COMMENTS	*HOST*	*EQUIPMENT*	*COMMENTS*
			The equipment is in the IDLE processing state and in the ONLINE REMOTE control state. Material arrives on input port 1.
PP-ASSIGN	S2,F63-->		
		<--S2,F64	Positive Acknowledge.
		<--S6,F11	IDLE -> SETTING UP
Positive Acknowledge.	S6,F12-->		
		<--S6,F11	SETTING UP -> READY
Positive Acknowledge.	S6,F12-->		
START	S2,F41-->		
		<--S2,F42	Positive Acknowledge.
		<--S6,F11	READY -> LOAD.
Positive Acknowledge.	S6,F12-->		
			[WHILE] Not End of Run 1) LOAD->WORKING 2) Sample and/or Site level data reporting. 3) WORKING->UNLOAD 4) Substrate level data reporting. 5) UNLOAD->LOAD. [ENDWHILE].
		<--S6,F11	LOAD->STOPPING.
Positive Acknowledge.	S6,F12-->		
			Run level data reporting.
		<--S6,F11	STOPPING->IDLE.
Positive Acknowledge.	S6,F12-->		

13.3 *ABORT/ CLEANUP Remote Command Scenario* — Host issues the ABORT/CLEANUP remote command

COMMENTS	*HOST*	*EQUIPMENT*	*COMMENTS*
ABORT	S2,F41-->		("CLEANUP" not specified)
		<--S2,F42	Positive Acknowledge.
		<--S6,F11	Transition to ABORTED.
Positive Acknowledge.	S6,F12-->		
CLEANUP	S2,F41-->		
		<--S2,F42	Positive Acknowledge.
			Equipment performs cleanup activities.
		<--S6,F11	CEID is posted.
			[IF] cleanup is successful: Transition to IDLE [ELSE] Remain in the ABORTED state. [ENDIF].
Positive Acknowledge.	S6,F12-->		

13.4 *PP-UPDATE Remote Command Scenario* — Host issues the PP-UPDATE remote command.

COMMENTS	*HOST*	*EQUIPMENT*	*COMMENTS*
START	S2,F41-->		
		<--S2,F42	Positive Acknowledge.
		<--S6,F11	READY -> LOAD
Positive Acknowledge.	S6,F12-->		
			[WHILE] Not End of Run 1) LOAD->WORKING 2) WORKING->UNLOAD 3) UNLOAD->LOAD [ENDWHILE]
Sometime during the [WHILE]:			
PAUSE	S2,F41-->		
		<--S2,F42	Positive Acknowledge.
		<--S6,F11	Transition to PAUSING
Positive Acknowledge.	S6,F12-->		
		<--S6,F11	PAUSING -> PAUSED
Positive Acknowledge.	S6,F12-->		
PP-UPDATE	S2,F41-->		
		<--S2,F42	Positive Acknowledge.
		<--S6,F11	PAUSED->CHECKING
Positive Acknowledge.	S6,F12-->		
		<--S6,F11	CEID is posted. [IF] the updates are valid: Return to the previous process state thru history [ELSE] Return to the PAUSED state. The Process Program remains unchanged. [ENDIF]
Positive Acknowledge.	S6,F12-->		

13.5 *PP-ASSIGN / PP-UNASSIGN Scenario* — Host issues the PP-ASSIGN/PP-UNASSIGN remote commands.

COMMENTS	*HOST*	*EQUIPMENT*	*COMMENTS*
PP-ASSIGN	S2,F41-->		
		<--S2,F42	Positive Acknowledge.
PP-UNASSIGN	S2,F41-->		
		<--S2,F42	Positive Acknowledge. This may occur during the STOPPING state.

13.6 The host may setup the material for additional processing without the cassette being removed and replaced on the equipment.

14 SEMI E30 Capabilities

14.1 The purpose of this section is to specify any SEMI E30 Capabilities required by MSEM class equipment.

14.2 *Requirement* — The following SEMI E30 additional capabilities required by MSEM are:

- Dynamic Event Report Configuration
- Variable Data Collection
- Status Data Collection
- Alarm Management
- Remote Control
- Equipment Constants
- Process Program Management
- Spooling
- Trace Data Collection (optional)
- Control (Host Initiated)

15 Related Documents

Harel, D., "Statecharts: A Visual Formalism for Complex Systems," Science of Computer Programming 8 (1987) 231-274.

RELATED INFORMATION 1
SEM UNIQUE CAPABILITIES

NOTE: This related information is not an official part of SEMI E30.5 and was derived from work developed in the Metrology Specific Equipment Model Task Force in North America. This related information was approved for publication by full letter ballot on April 30, 2001.

R1-1. *Measurement Site Location* — Metrology equipment most often is used to make measurements and report results at specific sites on a substrate. Unfortunately, equipment suppliers and users have adopted different formats for describing measurement site location information. This has led to three problems which increase the cost of metrology. First, metrology equipment suppliers must provide formats which meet conflicting requirements of their customers, adding to equipment development costs. Second, users must transpose information from different systems to their own format in order to use metrology data. Third, site location information is often an integral part of recipe set up, often requiring that an actual product sample be available for "training" the site location information on the equipment. For users who manufacture many different products on common substrates, multiple metrology "recipes" must be developed where the only differences are site location information. This information is known to the user from product design data, and should not need to be "learned" uniquely on various metrology equipment.

R1-1.1 In order to avoid these problems, MSEM defines specific formats for identifying and reporting site location information on substrates. The MSEM-required formats are intended to minimize the number and type of site location format transformations needing to be supported by both metrology equipment suppliers and users. All MSEM-required site location formats involve the use of an MSEM-defined right-handed Cartesian coordinate system, established on substrates in an MSEM-defined manner. This release of MSEM defines these only for silicon wafer substrates, based on SEMI standard M20. Additional substrate types may be included in future revisions of MSEM, if required.

R1-1.2 MSEM requires that equipment have the capability to use site location information that is based on the user's product designs, which the user must provide in the appropriate MSEM-required format. In other words, equipment shall not require that a sample substrate be used to "train" site locations when users can provide this information from product design data.

R1-1.3 MSEM-compliant equipment shall have the capability to define, locate, measure, and report site information using only the MSEM-defined right-handed Cartesian coordinate system formats. This requirement does not preclude equipment from having additional capability for defining or reporting site location information using other formats. One such additional format is defined in MSEM for patterned silicon wafer substrates, based on SEMI standard SEMI M21. MSEM-compliant equipment is not required to have this "M21" format capability, but must use the MSEM "M21" format if it is provided.

R1-1.4 Specific MSEM information that defines site location information includes ; the data items AlignList and SiteList; the CPNAMEs CP-ALIGNLIST and CP-SITELIST and the TABLE type named ALIGN-DEF-LIST and SITE-DEF-LIST. Notice that multiple sites can first be Defined using the appropriate Process Program class named ALIGN-DEF-LIST or SITE-DEF-LIST, then selected by using the ALIGN-NAME or SITENAME in an MSEM defined remote command that use CP-ALIGNLIST AND CP-SITELIST. This information is similarly defined for the "M21" coordinate system plus an additional CPNAME of ELEMENTLIST which lists the ElementIDs to be measured on the silicon wafers.

R1-2 *Coordinate Systems For A Silicon Wafer*

R1-2.1 *Requirements* — MSEM defines two right-handed Cartesian coordinate systems for use on silicon wafers. These are identified as the "M20" and "M20P" coordinate systems. Both are based on SEMI standard M20. The SEMI M20 standard describes how to map a right-handed Cartesian coordinate system to a wafer so that its origin is at the center of the wafer, and its negative y-axis bisects the wafer's primary fiducial. This coordinate system is defined by MSEM to be the "M20" coordinate system. MSEM defines the "M20P" coordinate systems to be one which is aligned to the pattern on the wafer. Ideally, there is no difference between the "M20P" and "M20" coordinate system. In the real world, there is a difference, due to experimental errors. This is explained further in the following sections.

R1-2.2 *Implementation* — The only information required by equipment in order to establish an "M20" coordinate system is the wafer size and type of fiducial. This is provided by way of the MSEM data items named WaferSize and Fiducial. Another data item named Orientation provides for control over how the wafer is loaded on equipment. Note that the SEMI