SEMI P44-1216
SPECIFICATION FOR OPEN ARTWORK SYSTEM INTERCHANGE STANDARD (OASIS®) SPECIFIC TO MASK TOOLS

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1 Purpose

1.1 This Document defines the common mask data format specifications based on OASIS for mask tools, namely "OASIS.MASK".

2 Scope

2.1 OASIS.MASK specification applies to the input data format for mask tools.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 In the future, a part of restrictions on OASIS.MASK may be relaxed, and OASIS.MASK specification may be extended. In view of this possible enhancement of the Specification, mask tools, EDA software, and other products, which support OASIS.MASK format, are advised to parameterize these restrictions (see Figure 1). The details of these restrictions are shown in § 6.

3.2 This Document will always be required to remain compliant with SEMI P39, OASIS, so that this Document is always a formal subset of SEMI P39, OASIS.

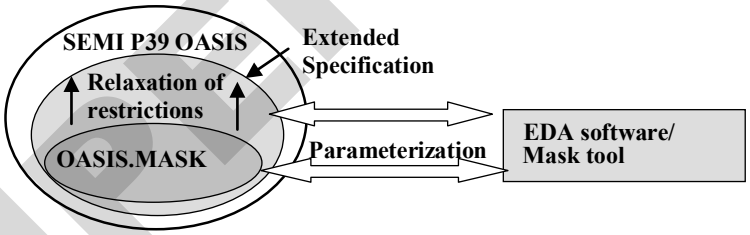

Figure 1
Extension of OASIS.MASK Specification

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI P39 — Specification for OASIS® – Open Artwork System Interchange Standard

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

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *EDA* — electronic design automation

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5.1.2 *OASIS®* — Open Artwork System Interchange Standard[1]

5.1.3 *OASIS.MASK* — Open Artwork System Interchange Standard (OASIS®) specific to mask tools

5.1.4 *UTC* — Coordinated Universal Time

5.1.5 *VSB* — variable shaped beam

5.2 *Definitions*

5.2.1 *bottom level cell* — a cell which contains no placements of other cells.

5.2.2 *cell size* — width and height of cell that is defined by S_BOUNDING_BOX of PROPERTY record. S_BOUNDING_BOX must be axis-aligned and the minimal area within which all points lie.

5.2.3 *chip window* — a drawing area of mask tools.

5.2.4 *common cell* — a cell which is placed in multiple localization areas.

5.2.5 *data compaction* — expressions for reducing the data of repetition, modality, etc.

5.2.6 *empty cell* — a cell which has no figure in itself or in any cells under the cell.

5.2.7 *figure operation* — operations of modifying a figure, required when converting a layout data to a mask data.

5.2.8 *localization* — grouping cells according to the specified area size for the efficiency improvement of the input process and the parallel processing of OASIS.MASK. The records of each cell group are also localized in the OASIS.MASK file.

5.2.9 *localization area* — an area which contains one of the cell groups divided by the localization.

5.2.10 *localized cell* — a cell which is placed in single localization area.

5.2.11 *mask restrictions* — restrictions on OASIS format which enables to input the mask data to mask tools.

5.3 *Symbols*

5.3.1 *A* — acceptable record.

5.3.1.1 The records generated as needed in the input data for mask tools by the software. The mask tools perform processing according to the contents of the records.

5.3.2 *I* — ignore record.

5.3.2.1 The records that may be generated in the input data for mask tools by the software, but which contain information that is not expected to be used by the mask tools. The mask tools do not respond to the information in these records.

5.3.3 *M* — mandatory record.

5.3.3.1 The records that must be generated in the input data for mask tools by the software. If the records do not exist, the mask tools treat it as an error.

5.3.4 *X* — prohibited record.

5.3.4.1 The records prohibited to exist in the input data for mask tools. If the records exist, the mask tools treat it as an error.

6 Requirements

6.1 *Concept of OASIS.MASK*

6.1.1 The concept of OASIS.MASK is shown in Figure 1. OASIS.MASK is a format that defines restrictions to the OASIS format for mask tools. Therefore, OASIS.MASK can be used without modifying OASIS tools.

[1] OASIS® is a registered trademark of Thomas Grebinski, and is licensed for use by SEMI.

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6.2 *OASIS Format Specification*

6.2.1 See SEMI P39 for OASIS Format Specification.

6.3 *Additional Records in OASIS.MASK*

6.3.1 In OASIS.MASK, following user properties are added to PROPERTY record.

6.3.2 *File-Level Properties*

6.3.2.1 The following file-level properties can be specified only once immediately after the START record.

6.3.2.2 *P44_FORMAT*

6.3.2.2.1 This property declares the format type indicating the levels of mask restrictions. Its value consists of a single a-string (or implied a-string) record. The value is '1' with this Specification. It is a mandatory record in OASIS.MASK.

6.3.2.2.2 *EXCEPTION HANDLING* — The absence of a P44_FORMAT property in an OASIS.MASK file must be treated as a fatal error. A value of the format type which is not '1', must also be treated as a fatal error.

6.3.2.3 *P44_CHIP_WINDOW*

6.3.2.3.1 This property declares the size of a window in terms of the coordinate system of the top cell. Its value consists of four signed-integer records, <*x1*>, <*y1*>, <*x2*>, and <*y2*>. <*x1*> is the *x*-coordinate of the lower left corner of a window, <*y1*> is the y-coordinate of that lower left corner, <*x2*> is the *x*-coordinate of the upper right corner, and <*y2*> is the *y*-coordinate of that upper right corner. It is a mandatory record in OASIS.MASK.

6.3.2.3.2 *EXCEPTION HANDLING* — The absence of a P44_CHIP_WINDOW property in an OASIS.MASK file must be treated as a fatal error. A value of <*x2*> which is not larger than <*x1*>, must be treated as a fatal error. A value of <*y2*> which is not larger than <*y1*>, must also be treated as a fatal error. A geometric figure outside the window defined by this property must be treated as a fatal error.

6.3.2.4 *P44_VERSION*

6.3.2.4.1 This property declares the version of OASIS.MASK specification. Its value consists of a single a-string (or implied a-string) representing the SEMI Standard number of this Specification in the form of P44-MMYY. It is a mandatory record in OASIS.MASK.

6.3.2.4.2 *EXCEPTION HANDLING* — The absence of a P44_VERSION property in an OASIS.MASK file must also be treated as a fatal error. The handling of a P44_VERSION property-value mismatch is application-dependent.

6.3.2.5 *P44_FILE_SIZE*

6.3.2.5.1 This property declares the file size by the number of bytes. Its value consists of a single unsigned-integer record. It is a mandatory record in OASIS.MASK.

6.3.2.5.2 *EXCEPTION HANDLING* — The absence of a P44_FILE_SIZE property in an OASIS.MASK file must be treated as a fatal error. It is also a fatal error if the number of bytes defined by this property does not match the file size.

6.3.2.6 *P44_TOP_CELL_NUMBER*

6.3.2.6.1 This property declares the reference number of the top cell to accelerate the search of the top cell. Its value consists of a single unsigned integer record. It is a mandatory record in OASIS.MASK.

6.3.2.6.2 *EXCEPTION HANDLING* — The absence of a P44_TOP_CELL_NUMBER property in an OASIS.MASK file must be treated as a fatal error. Use of a reference-number for which there is no corresponding CELLNAME record within the same OASIS.MASK file must be treated as a fatal error.

6.3.2.7 *P44_CONVERSION_TOOL*

6.3.2.7.1 This property declares the name and the version number of the conversion tool which outputs the OASIS.MASK file. Its value list consists of the following two fields: <name> <version>. The name and version fields are a-strings (or implied a-strings). It is an optional record in OASIS.MASK.

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6.3.2.8 *P44_CONVERSION_DATE*

6.3.2.8.1 This property declares the date when the OASIS.MASK file is output. Its value consists of the following three fields: <date> <time> <zone>. The date field is an a-string (or implied a-string) representing the date in the form of DD-MM-YYYY. DD, MM, and YYYY represent the day, month, and year respectively. The time field is an a-string (or implied a-string) representing the time in the form of HH:MM:SS. HH, MM, and SS represent the hour, minute, and second respectively. The zone field is a real number representing the time difference with UTC. The unit of the time difference is hour. It is a mandatory record in OASIS.MASK.

6.3.2.8.2 *EXCEPTION HANDLIN*G — The absence of a P44_CONVERSION_DATE property in an OASIS.MASK file must be treated as a fatal error.

6.3.2.9 *P44_BOUNDING_BOX_MAX*

6.3.2.9.1 This property declares the upper limit of the cell bounding box permitted in any cell except the top cell. This property declares not the largest cell bounding box but the upper limit of the cell bounding box except the top cell. Its value list consists of the following two fields: <width> <height>. The width and height fields are unsigned-integers. It is a mandatory record in OASIS.MASK.

6.3.2.9.2 *EXCEPTION HANDLING* — The absence of a P44_BOUNDING_BOX_MAX property in an OASIS.MASK file must be treated as a fatal error. It is also a fatal error if the bounding box defined by this property is smaller than any cell bounding box except the top cell defined by the S_BOUNDING_BOX property.

6.3.2.10 *P44_LOCALIZATION*

6.3.2.10.1 This property declares the largest bounding width and the largest bounding height discoverable across all localized areas. Each can be from different localization areas. Furthermore, this property declares the largest discoverable localized area cell volume (bytes), the cell volume for localized common cells, the number of localized areas and the byte-offset from the beginning of the OASIS.MASK file (byte 0) to the CELLNAME or CBLOCK record of the top cell. Its value list consists of the following six fields: <largest-localization-width> <largest-localization-height> <largest-localized-area-cell-volume> <common-cell-volume> <localization-area-count> <top-cell-cellname-offset>. All fields are unsigned-integers. Use of localization is allowed. If this property is defined, the OASIS.MASK file is localized in a manner as specified by the property. Otherwise, the OASIS.MASK file is not localized.

6.3.2.10.2 If CBLOCK is used for CELLNAME records in a localized OASIS.MASK file, the CELLNAME record of the top cell and the other CELLNAME records must not be compressed in the same CBLOCK record so that the value of the <top-cell-cellname-offset> field can be defined.

6.3.2.10.3 *EXCEPTION HANDLING* — It is a fatal error if the localization area size, the record volume, the localization area count, and the byte offset defined by this property do not match their values in the OASIS.MASK file.

6.3.2.11 *P44_GEOMETRY_OFFSET_AVAILABLE*

6.3.2.11.1 This property indicates whether or not P44_GEOMETRY_OFFSET properties appear in CELLNAME records. Its value list consists of a single unsigned-integer. A value of 0 means that P44_GEOMETRY_OFFSET properties are not provided. A value of 1 means that P44_GEOMETRY_OFFSET properties are provided for every CELLNAME record excluding the top cell and the bottom level cells. It is a mandatory record in OASIS.MASK.

6.3.2.11.2 *EXCEPTION HANDLING* — The absence of a P44_GEOMETRY_OFFSET_AVAILABLE property in an OASIS.MASK file must be treated as a fatal error. A value of the property which is other than 0 and 1, must also be treated as a fatal error.

6.3.3 *Cell-Level Properties*

6.3.3.1 These properties are cell-level user properties and can be specified immediately after the corresponding CELLNAME record.

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6.3.3.2 *P44_GEOMETRY_COUNT*

6.3.3.2.1 This property declares the total count of the RECTANGLE record, the TRAPEZOID record, and the CTRAPEZOID record in each cell and appears only once immediately after the corresponding CELLNAME record. It includes only cell-native geometry and does not include expansion of repetitions. Its value list consists of a single unsigned-integer. It is a mandatory record in OASIS.MASK.

6.3.3.2.2 *EXCEPTION HANDLING* — The absence of a P44_GEOMETRY_COUNT property in an OASIS.MASK file must be treated as a fatal error. It is also a fatal error if the count defined by this property does not match the geometry record count in each cell.

6.3.3.3 *P44_GEOMETRY_OFFSET*

6.3.3.3.1 This property declares the byte offset from the beginning of the corresponding CELL record to the first geometry record, the first TEXT record, or the CBLOCK record to which geometry and TEXT records are stored in the cell. In case that this property is present, all PLACEMENT records in each cell are gathered and appear before geometry records (RECTANGLE/TRAPEZOID/CTRAPEZOID) and TEXT records. If the CBLOCK record is used for the CELL record with this property, then a single CBLOCK record cannot contain the PLACEMENT records with geometry records and TEXT records together. It appears only once immediately after the corresponding CELLNAME record. Its value list consists of a single unsigned-integer. Whether this property is defined or not depends on P44_GEOMETRY_OFFSET_AVAILABLE.

6.3.3.3.2 This property enables direct access to a cell's geometry and TEXT records. An OASIS.MASK writer must ensure that correct interpretation of the cell's geometry and TEXT records does not depend on any modal variable state altered by parsing prior records in the placement portion of the localized cell (in particular, modal variables *xy*-mode and repetition). An OASIS.MASK writer can ensure this by treating *all* modal variables as 'undefined' prior to writing each localization area.

6.3.3.3.3 The value of the byte offset is zero (0) where there is no geometry record in the cell.

6.3.3.3.4 Note that this property is unnecessary for the top cell and the bottom level cells.

6.3.3.3.5 *EXCEPTION HANDLING* — It is a fatal error if the byte offset defined by this property does not indicate the first geometry record, the first TEXT record, or the CBLOCK record to which geometry record are stored.

6.3.3.4 *P44_LOCALIZATION_AREA*

6.3.3.4.1 This property declares the bounding box of a localization area with other associated properties. It appears immediately after the CELLNAME record of the top cell and may be repeated if there are multiple localization areas. Its value list consists of the following 10 fields: <lower-left-x> <lower-left-y> <upper-right-x> <upper-right-y> <cell-offset> <cell-volume> <cellname-offset> <cellname-volume> <placement-offset> <placement-count>.

6.3.3.4.2 The bounding box fields are defined with respect to the coordinate system of the top cell and they are signed-integers.

6.3.3.4.3 CELL records of localized cells belonging to a particular localization area are contiguously defined in OASIS.MASK file. Cell-offset is the byte offset from the beginning of the file to the head of the CELL records of localized cells in the particular localization area, and cell-volume is the data volume of the contiguous CELL records of localized cells in the localization area. Cell-offset and cell-volume are zero where there is no placement of localized cells (but placements of common cells) in the localization area.

6.3.3.4.4 CELLNAME records of localized cells are also localized in the same manner. Then, cellname-offset declares the byte offset from the beginning of the file to the head of the CELLNAME records of localized cells belonging to the said localization area, and cellname-volume is the data volume of contiguous CELLNAME records of localized cells in the localization area. Cellname-offset and cellname-volume are zero where there is no placement of localized cells (but placements of common cells) in the localization area.

6.3.3.4.5 PLACEMENT records which belong to the same localization area are contiguously defined in the CELL record of the top cell. Placement-offset is the byte offset from the head of the CELL record of the top cell to either the head of the PLACEMENT record of the particular localization area or the CBLOCK record to which the PLACEMENT records of the particular localization area are stored. Placement-count is the count of the contiguous PLACEMENT records of the localization area. Any PLACEMENT record in the top cell must belong to a single localization area.

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6.3.3.4.6 All of cell-offset, cell-volume, cellname-offset, cellname-volume, placement-offset, and placement-count are unsigned integers. This property must be defined for each localization area when an OASIS.MASK file is localized.

6.3.3.4.7 If CBLOCK is used for CELLNAME records in a localized OASIS.MASK file, CELLNAME records from two or more localization areas must not be compressed in the same CBLOCK record. The cell-volume and the cellname-volume are the volume after the CBLOCK compression.

6.3.3.4.8 If CBLOCK is used for the records of the top cell in localized OASIS.MASK file, PLACEMENT records from two or more localization areas must not be compressed in the same CBLOCK record.

6.3.3.4.9 This property enables direct access to the PLACEMENT records in the top cell associated with each localization area. An OASIS.MASK writer must ensure that correct interpretation of the PLACEMENT records of each localization group does not depend on any modal variable state altered by parsing prior records within the top cell (in particular, modal variables placement-x, placement-y, placement-cell, *xy*-mode, and repetition). An OASIS.MASK writer can ensure this by re-initializing all of its modal variables, and emitting an XYABSOLUTE record, prior to writing each localization group's PLACEMENT records.

6.3.3.4.10 *EXCEPTION HANDLING* — It is a fatal error if the bounding box, the byte offset, the data volume, and the record count defined by this property do not match their values in the OASIS.MASK file. A value of <upper-right-x> which is not larger than <lower-left-x>, must be treated as a fatal error. A value of <upper-right-y> which is not larger than <lower-left-y>, must also be treated as a fatal error. The absence of a P44_LOCALIZATION_AREA property for each localization area must be treated as a fatal error when an OASIS.MASK file is localized.

6.3.3.5 *P44_COMMON_CELL*

6.3.3.5.1 This property declares the byte offset and the data volume of CELL records and CELLNAME records of common cells. It appears only once and immediately after the CELLNAME record of the top cell. Its value list consists of the following four fields: <cell-offset> <cell-volume> <cellname-offset> <cellname-volume>.

6.3.3.5.2 CELL records of common cells are contiguously defined in OASIS.MASK file. Cell-offset is the byte offset from the beginning of the file to the head of the CELL records of the common cells, and cell-volume is the data volume of the contiguous CELL records of the common cells.

6.3.3.5.3 CELLNAME records of common cells are also defined in the same manner. Then, cellname-offset declares the byte offset from the beginning of the file to the head of the CELLNAME records belonging to the said common cells, and cellname-volume is the data volume of contiguous CELLNAME records of the common cells.

6.3.3.5.4 All of cell-offset, cell-volume, cellname-offset, and cellname-volume are unsigned integers. This property must be defined when an OASIS.MASK file is localized and a common cell is placed in the file.

6.3.3.5.5 If CBLOCK is used for CELLNAME records of common cells, the CBLOCK record cannot contain CELLNAME records of localized cells. The cell-volume and the cellname-volume are the volume after the CBLOCK compression.

6.3.3.5.6 This property is unnecessary when there is no common cell in OASIS.MASK file.

6.3.3.5.7 *EXCEPTION HANDLING* — It is a fatal error if the bounding box, the byte offset and the data volume defined by this property do not match their values in the OASIS.MASK file. The absence of a P44_COMMON_CELL property must be treated as a fatal error when an OASIS.MASK file is localized and a common cell is placed in the file.

6.4 *Specification of the Mask Restrictions*

6.4.1 *Concept*

6.4.1.1 The restrictions are common among mask tools.

6.4.1.2 The specification reduces the load in the conversion process of mask tools as much as possible, and aims for the direct input to mask tools.

6.4.1.3 The specification maintains the data compaction expression in OASIS as much as possible.

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6.4.2 *Restrictions on Figure Operation*

6.4.2.1 Figure operations described in Table 1 should be executed before generating of OASIS.MASK, since these are not done by mask tools.

6.4.3 *Restrictions on OASIS Record*

6.4.3.1 *Common Restrictions*

6.4.3.1.1 The 63 kinds of characters are allowed to be used for cell names and properties, including uppercase (A–Z), lowercase (a–z), numeric character (0–9), and underline (_).

6.4.3.2 *Individual Restrictions*

6.4.3.2.1 The restrictions on each record of OASIS are shown in Table 2. Also, Table 3 shows restrictions in OASIS.MASK to OASIS Standard Properties. The restrictions on user properties are shown in Table 4.

6.4.3.3 *Restrictions on Cell Hierarchy*

6.4.3.3.1 The restrictions on cell hierarchy of OASIS.MASK are shown in Table 5.

6.4.3.3.2 The restrictions on cell hierarchy of OASIS.MASK are shown in Figure 2.

6.4.3.3.3 An example of cell hierarchy is shown in Figure 3.

6.4.3.3.4 An example of localization is shown in Figure 4.

6.4.3.4 *Restrictions on File Name*

6.4.3.4.1 The restrictions on a file name of OASIS.MASK are shown in Table 6.

Table 1 Figure Operation List

No.	*Figure Operation*	*Content of Operation*
1	Window extraction	Generate the drawing window size and extract figures in the drawing area
2	Layer merge	Merge multiple layers into a single layer
3	Logical operation	Generate a new figure from the figures in different layers by logical operation on them
4	Sizing	Change the size of a figure
5	Scaling	Enlarge or reduce the size of the whole figure in a uniform ratio
6	Mask scaling	Apply mask scaling (such as x4, x5, etc.) to the whole data
7	Mirroring	Make the whole data reflective symmetry about *X*-axis or *Y*-axis
8	Inverting	Invert black/white coloring on the whole data
9	Rotation	Rotate a figure about the origin point
10	Overlap removal	Remove overlaps between two figures on the whole data
11	OPC	Correct the layout data for optical proximity effects
12	Trapezoid division	Divide a polygon geometry into trapezoid figures (including rectangles and triangles)

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Table 2 Restrictions on OASIS Record

No.	*Record Name*	*Field Name*	*Restriction Item*	*Content of Restriction*					*Propriety*[#2]	
				Min.	*Max.*	*Step*	*Unit*	*Comment*	*Record*	*Field*
1	PAD	-	Byte alignment	-	-	-	-	-	A	A
2	START	version-string	OASIS version	-	-	-	-	-	M	M
		unit	Grid/µm	1	1000000	1	grid	Recommended value is 1, 2, 4, 5, 8, 10, 16, 20, 25, 40, 50, 80, 100, 125, 200, 250, 400, 500, 625, 800, 1000, 1250, 2000, 2500, 5000, and 10000. The rounding error might occur in the calculation of coordinates when other units are specified.		M
		offset-flag	Table offset location	-	-	-	-	0 or 1		M
		cellname-flag propname-flag	Strict flags and byte-offset fields	-	-	-	-	Fixed to 1 when offset-flag is 0		A
		propstring-flag	Strict flags and byte-offset fields	-	-	-	-	Fixed to 1 when a PROPSTRING record is specified and offset-flag is 0		A
		textstring-flag layername-flag xname-flag	Strict flags and byte-offset fields	-	-	-	-	Refer to the specification of SEMI P39		I
3	END	padding-string	Byte alignment	-	-	-	-	Necessary when the size of the END record except the padding-string is less than 256 bytes	M	A
		validation-scheme	Verification specification	-	-	-	-	Fixed to 1 or 2		M
		validation-signature	Contents of verification	-	-	-	-	Fixed to CRC32 or CHECK-SUM32		M
		cellname-flag propname-flag	Strict flags and byte-offset fields	-	-	-	-	Fixed to 1 when offset-flag is 1		A
		propstring-flag	Strict flags and byte-offset fields	-	-	-	-	Fixed to 1 when a PROPSTRING record is specified and offset-flag is 1		A
		textstring-flag layername-flag xname-flag	Strict flags and byte-offset fields	-	-	-	-	Refer to the specification of SEMI P39		I

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