

SEMI D18-0299^E

SPECIFICATION FOR CASSETTES USED FOR HORIZONTAL TRANSPORT AND STORAGE OF FLAT PANEL DISPLAY SUBSTRATES

This specification was technically approved by the Flat Panel Display Equipment Committee and is the direct responsibility of the North American Flat Panel Display Committee. Current edition approved by the North American Regional Standards Committee on August 15, 1998. Initially available at www.semi.org September 1998; to be published February 1999.

^E This document was editorially modified in October 2000 to correct a formatting error. Changes were made to Figure 5.

1 Purpose

1.1 This standard specifies the cassettes used to horizontally transport and store glass substrates 0.7 mm-1.1 mm thick (max) in a flat panel display (FPD) manufacturing facility.

2 Scope

2.1 This standard is intended to set an appropriate level of specification that places minimal limits on innovation while ensuring modularity and interchangeability at all mechanical interfaces. Most of the requirements given in this specification are in the form of algebraic expressions defining maximum or minimum dimensions referenced from the length and width of the intended substrate with very few required surfaces. Only the mechanical interfaces for cassettes are specified; no materials requirements or micro-contamination limits are given. However, this standard has been written so that cassettes of various designs and materials can be manufactured in conformance with it.

3 Referenced Standards

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

3.1 SEMI Standards

SEMI D3 — Quality Area Specification for Flat Panel Display Substrates

SEMI D5 — Standard Size for Flat Panel Display Substrates

SEMI D6 — Standard Edge Length and Thickness for Flat Panel Display Mask Substrates

SEMI D9 — Definitions for Flat Panel Display Substrates

SEMI D11 — Specification for Flat Panel Display Glass Substrate Cassettes

SEMI D21 — Terminology for Flat Panel Display Masks

SEMI E15 — Specification for Tool Load Port

SEMI E44 — Guide for Procurement and Acceptance of Minienvironments

4 Terminology

4.1 *bilateral datum plane* — a vertical plane that equally bisects the substrate and that is perpendicular to both the horizontal and facial datum planes.

4.2 *carrier capacity* — the number of substrates that a carrier holds.

4.3 *cassette* — (as defined in SEMI E44)

4.4 *cassette bottom domain* — volume (below z4 above the horizontal datum plane) that contains the bottom of the cassette.

4.5 *cassette bottom opening* — an opening through the cassette bottom domain that provides access to the glass substrates for external roller drive mechanisms to move substrates into/from the cassette.

4.6 *cassette front* — the area between the cassette top and bottom domains through which substrates pass during loading and unloading.

4.7 *cassette rear* — the area between the cassette top and bottom domains opposite the cassette front.

4.8 *cassette rear domains* — volumes (from z4 above the horizontal datum plane to z9 above the top substrate) that contain rear columns which prevent the substrates from exiting the cassette rear.

4.9 *cassette placement sensing pads* — surfaces on the bottom of the cassette for triggering optical or mechanical sensors.

4.10 *cassette side domains* — volumes (from z4 above the horizontal datum plane to z9 above the top substrate) that contain the mizo teeth and mizo plates that support the substrates.

4.11 *cassette top domain* — volume (higher than z9 above the top substrate) that contains the top of the cassette.

4.12 *conveyor rails* — features on the bottom of the cassette for supporting the cassette on roller conveyors.

4.13 *conveying surface* — entire bottom surface of cassette (z15 above the horizontal datum plane), excluding the V-rail, V-groove, and float roller zones, for supporting the cassette on roller conveyors

4.14 *facial datum plane* — a vertical plane that equally bisects the substrates when the centers of the substrates are aligned and that is parallel to the front side of the carrier (where substrates are removed or inserted) and is perpendicular to the bilateral datum plane. On tool load ports, it is also parallel to the load face plane (as defined in SEMI E15) on the side of the tool where the carrier is loaded and unloaded.

4.15 *first substrate end-effector clearance* — the distance (dimension z9) between the top of the cassette bottom domain and the first nominal substrate seating plane.

4.16 *first nominal substrate height* — the distance (dimension z5) from the horizontal datum plane to the first nominal substrate seating plane.

4.17 *horizontal datum plane* — load height as defined in SEMI E15.

4.18 *mizo plate* — a plate that contains mizo teeth and may provide structure to the cassette.

4.19 *mizo teeth* — elements that support the substrates in the cassette.

4.20 *nominal center line* — the intersection of the facial and bilateral datum planes.

4.21 *nominal substrate seating plane* — a horizontal plane that contains the nominal bottom surface of the substrate as it rests on the mizo teeth.

4.22 *optical substrate sensing paths* — lines of sight for optically sensing the positions of the substrates.

4.23 *robotic handling flanges* — projections on the cassette for handling of the cassette.

4.24 *substrate extraction volume* — the open space for extracting a substrate from the cassette.

4.25 *substrate pitch* — the distance between adjacent nominal substrate seating planes.

4.26 *substrate set-down volume* — the open space for inserting and setting down a substrate in the cassette.

4.27 *substrate pick-up volume* — the space that contains entire bottom of a substrate if the wafer is pushed to the rear of the cassette.

5 Ordering Information

5.1 *Intended Use* — This standard is intended to specify cassettes over a reasonable lifetime of use, not just those in new condition. The purchaser needs to specify the time period, the number of cycles and any special conditions to which the cassettes will be exposed. It is under these conditions that the cassettes must remain in compliance with the requirements listed in Section 6.

5.2 *Temperature Ranges* — The purchase of the cassettes needs to specify three sets of temperatures to which the cassettes might be exposed. An operating temperature range is the set of environmental temperatures in which the cassettes will remain in compliance with the requirements listed in Section 6 (e.g. $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$). A temporary temperature range is the set of environmental temperatures to which the cassettes can be exposed such that when the cassettes return to the operating temperature range, the cassettes will be in compliance with the requirements listed in Section 6 (e.g. 90°C maximum during cleaning of the cassette). Also, the purchaser needs to specify a range of temperatures for the substrates that might be inserted in the cassettes.

5.3 *Pitch and Capacity Options* — The purchaser needs to specify the pitch and capacity of the cassettes. Table 2 provides two options of pitch and capacity. Additional pitch and capacity options are not yet defined, but should be specified in the same manner.

5.4 *Material* — To be agreed upon between supplier and user. Construction may be of one or more molded or machines parts.

6 Requirements

6.1 *Dimensions* — Most of the dimensions of the cassette are determined with respect to the three orthogonal datum planes defined in that standard: the horizontal datum plane, the facial datum plane, and the bilateral datum plane (see Figure 1).

6.2 *Cassette Physical Alignment Interface* — The cassette should be registered to the tool interface by one of the three following types of registrations (Type A, B or C). The locations of the registration features have been chosen such that all three types may coexist on the same cassette

6.2.1 *Cassette Physical Alignment Interface-Type A* — This registration consists of three features (not specified, but recommended to be inverted V-shaped

grooves) placed on the bottom of the cassette that mate with three coupling pins located on the tool interface. The coupling pins are located by dimensions $x14$ and $y13$ relative to the bilateral and facial datum planes respectively.

6.2.1.1 Coupling Pin Shapes — The physical alignment mechanism on the bottom of the wafer carrier consists of features (not specified in this standard) that mate with three pins underneath. As shown in Figure 5 and defined in Table 3, each pin is radially symmetric about the vertical center axis line and can be seen as the intersection of a cylinder of diameter $d1$ and a sphere of radius $r3$ (which might contact a flat plate). An additional rounding radius $r5$ provides contact with angled mating surfaces, and blend radii $r4$ and $r6$ smooth the resulting edges. The final roughness height of the over-all surface finish must be less than or equal to $r7$. Dimensions $r2$ and $z13$ have zero tolerance because they only give a distance to another toleranced dimension. (Dimensions in parenthesis are not part of the requirements in this standard but are intended to clarify the preparation of manufacturing instructions.)

6.2.1.2 The three features on the bottom of the cassette that mate with the coupling pins must provide a lead-in capability that corrects a cassette misalignment of up to 10 mm (0.4 in.) in any horizontal direction, although 15 mm (0.6 in.) is recommended. The exclusion zones for the three coupling features on the cassette is shown in Figure 3 and Table 1 and specified by dimensions $x14$, $z9$ and $r1$.

6.2.2 Cassette Physical Alignment Interface-Type B — Consists of three features, a V-rail, float surface, and facial datum plane V-groove. The V-rail and float surface are located on the bottom of the cassette and mate with the two V-rail rollers and one float surface roller, respectively, mounted on the tool interface. The facial datum plane V-groove is located about the facial datum plane through the bottom surface of the cassette and mates with the facial datum plane lock pin located on the tool interface shown in Figure 3. The V-rail roller and the float surface roller are located by dimensions $x15$ and $x16$ relative to the bilateral datum plane respectively shown in Figure 6. The dimension relative to the facial datum plane for the V-rail rollers are not specified but recommended to be located furthest from and symmetrical about the facial datum plane as shown in Figure 3 and 6. The float surface roller revolute axis must lie on the facial datum plane.

6.2.2.1 The V-rail and float surface rollers are defined in Figure 7 and Table 4. Each roller is radially symmetric about the revolute axis. The rollers are circumferentially radiused of dimension $r8$. The diameter of the rollers is not specified but the tangential

surface created by dimension $r8$ must lie on the horizontal datum plane. The facial datum plane lock pin radius is equal to $r8$ and must be positioned into the facial datum plane V-groove to fully constrain the cassette to the facial datum plane. The facial datum plane lock pin is translated out of the facial datum plane V-groove to allow the cassette to be rolled in and out of the tool interface. Although only three rollers are specified it is recommended to increase the total number of rollers so that the cassette is fully supported while being loaded and unloaded to the tool interface. All rollers except for the V-rail and float roller must be positioned so that the tangent of the $r8$ dimension lies below the horizontal datum plane.

6.2.2.2 The three features on the bottom of the cassette that mate with the rollers and lock pin must provide a lead-in capability that corrects a cassette misalignment of up to 10 mm (0.4 in.) in any horizontal direction, although 15 mm (0.6 in.) is recommended. The V-rail and facial datum plane V-groove are not specified but recommended to be inverted V-shaped grooves. The V-rail is recommended to extend the full length of the cassette from the cassette front to the cassette rear. The float surface is not specified but recommended to be a flat surface extending the full length of the cassette from the cassette front to the cassette rear. The exclusion zones for these features are shown in Figure 3 and 6 and specified by dimensions $x15$, $x16$ through $x22$.

6.2.3 Cassette Physical Alignment Interface-Type C — to be developed.

6.3 Conveyor Rails — If the cassette is to be used on roller conveyors, each conveyor rail should extend the maximum distance from front to back. The exclusion zones for conveyor rails are shown in Figure 3 and 6 and specified by dimensions $x13$ and $x22$ and extends to the outer boundary of the cassette.

6.4 Conveying Surface—If the cassette is to be transported on roller conveyors that support the entire bottom of the cassette, the bottom surface excluding the V-rail, V-groove, and float roller zones is to be used. The location of this surface with respect to the horizontal datum plane is specified by dimension $z3$.

6.5 Substrate Orientation and Numbering — The substrates must be horizontal when the carrier is placed on the coupling, and the substrates are numbered in increasing order from bottom to top (so the bottom substrate is substrate number 1, the next substrate up is substrate number 2, etc.)

6.6 Cassette Sides and Rear — Figure 2 shows a top view of the boundaries of the cassette side domains (which contain the parts of the cassette higher than $z4$ above the horizontal datum plane and lower than $z9$

above the top substrate). Table 1 defines the dimensions shown in this and following figures.

6.7 Cassette Top — The boundaries of the cassette top domain contain any part of the cassette higher than $z9$ above the top substrate.

6.8 Cassette Bottom — Figure 3 shows a bottom view of the boundaries of the cassette bottom domain (which contains any part of the cassette lower than $z4$ above the horizontal datum plane). When the cassette is fully down, the cassette placement sensing pads must be $z2$ above the horizontal datum plane.

6.9 Vertical Dimensions — Figure 4 shows the vertical dimensions of the left half of the cassette as viewed from the rear. Note that $z5$ (the height of the bottom nominal substrate seating plane above the horizontal datum plane) and $z8$ (the distance between adjacent nominal substrate seating planes) are given as reference dimensions with no tolerance. This means that the sum of actual height variations in the cassette from the horizontal datum plane to the mizo tooth or slot holding each substrate must be contained within the tolerance of $z6$ with no further stack-up at each higher substrate.

6.9.1 The open space for the substrate extraction volume is indicated by dimensions $x6$ and $y7$ and is symmetric about the bilateral and facial datum planes, respectively. The top of the extraction volume is $z7$ above the nominal substrate seating plane and its bottom is half of the minimum $z7$ dimension above the nominal substrate seating plane. The cassette must give extra horizontal clearance once the substrate is picked

up from wherever it ends up (within the bounds of the substrate pick-up volume) after transport in the cassette.

6.9.2 The open space for the substrate set-down volume is indicated by dimensions $x5$ and $y6$ and is symmetric about the bilateral and facial datum planes, respectively. The top of this volume is half of $z7$ above the nominal substrate seating plane and its bottom is $z6$ above the nominal substrate seating plane. The substrate should be placed within the bounds of the substrate set-down volume to avoid touching the edge of the substrate to the side of the cassette.

6.9.3 The substrate pick-up volume is defined by an area indicated by dimensions $x5$ and $y5$ and is symmetric about the bilateral and facial datum planes, respectively. Its top and bottom are the upper and lower tolerance of $z6$ around the nominal substrate seating plane. If a substrate is placed in the substrate set-down volume and is then pushed to the rear of the cassette, then the entire bottom of the substrate must be contained in the substrate pick-up volume.

6.10 Pitch and Capacity — Table 2 shows the different options with regard to the substrate pitch (spacing) and the cassette capacity.

6.11 Inner and Outer Radii — All concave features may have as much as a 1 mm (0.04 in.) radius to allow for cleaning and to prevent contaminant build-up. All required convex features (such as the robotic handling flanges, and the corners of the cassette top and bottom domains) must also have a minimum radius of 1 mm (0.04 in.) to prevent small contact patches with large stresses that might cause wear and particles.

Table 1 Cassette Side Domains

Symbol Used	Shown in	Datum Measured From	Boundary or Feature Measured To:	Algebraic Relation or Value
$r1$	Figure 3	center of coupling exclusion zone	outside edge of coupling exclusion zone	<15
$x1$	Figure 2	bilateral datum plane	encroachment of cassette side domains on substrate extraction volume	$\geq \frac{W \times 0.57}{2}$
$x2$	Figures 2	bilateral datum plane	outside edge of cassette side domains	$\leq W1 + 37$
$x3$	Figures 2	bilateral datum plane	inside edge of rear cassette domains	$\geq x1 - 40$
$x4$	Figures 2	bilateral datum plane	outside edge of rear cassette domains	$\geq \frac{W \times 0.57}{2}$
$x5$	Figures 2 and 4	nominal substrate center line	outside edge of substrate pick-up volume	$\geq W1 + 2$
$x6$	Figures 2 and 4	nominal substrate center line	encroachment of cassette side domains on substrate extraction volume	$\geq x5$
$x7$	Figures 2	nominal substrate center line	outside edge of cassette top and bottom domain	$\leq W1 + 37$

Symbol Used	Shown in	Datum Measured From	Boundary or Feature Measured To:	Algebraic Relation or Value
x8	Figure 3	bilateral datum plane	inside edge of cassette sensing pad areas	$= W_1 \times 0.71 \pm 5.0$
x9	Figure 3	bilateral datum plane	outside edge of cassette sensing pad areas	$= W_1 \times 0.78 \pm 5.0$
x10	Figure 4	bilateral datum plane	encroachment of cassette top domain on robotic handling flange space	$\leq W_1 \times 1.02$
x11	Figure 4	bilateral datum plane	far side of robotic handling flanges	$\leq W_1 \times 1.05$
x12	Figures 3	bilateral datum plane	inside edge of conveyor rail exclusion zones	$\geq W_1 \times 0.752$
x13	Figures 3	bilateral datum plane	outside edge of conveyor rail exclusion zones	$\leq W_1 \times 0.877$
x14	Figure 3	bilateral datum plane	center of coupling exclusion zones	$= W_1 \times 0.9455 \pm 0.1$
x15	Figures 3 and 6	bilateral datum plane	centerline of V-rail roller	$= W_1 \times 0.815 \pm 0.2$
x16	Figure 6	bilateral datum plane	centerline of float roller	$= x_{19} \pm 2.0$
x17	Figure 3	bilateral datum plane	inside edge of facial datum plane V-groove	$= W_1 \times 0.0245 \pm 0.2$
x18	Figure 3	bilateral datum plane	outside edge of facial datum plane V-groove	$= W_1 \times 0.020 \pm 0.2$
x19	Figure 6	bilateral datum plane	left edge of V-groove exclusion zone	$\geq W_1 \times 0.069$
x20	Figure 6	bilateral datum plane	right edge of V-groove exclusion zone	$\geq W_1 \times 0.109$
x21	Figure 6	bilateral datum plane	inside edge of float roller exclusion zone	$\leq W_1 \times 0.742$
x22	Figure 6	bilateral datum plane	outside edge of float roller exclusion zone	$\geq W_1 \times 0.884$
y1	Figure 2	facial datum plane	encroachment of cassette side domain	$\geq L_1 \times 0.031$
y2	Figure 2	facial datum plane	encroachment of cassette side domain	$\leq L_1 \times 0.454$
y3	Figure 2	facial datum plane	encroachment of cassette side domain	$\geq L_1 \times 0.515$
y4	Figure 2	facial datum plane	encroachment of cassette side domain	$\leq L_1 \times 0.938$
y5	Figure 2	facial datum plane	outside edge of substrate pick-up volume	$\leq L_1 + 1$
y6	Figure 2	facial datum plane	encroachment of cassette side domains on substrate set-down volume	$\geq L_1 + 1$
y7	Figure 2	facial datum plane	encroachment of cassette side domains on substrate extraction volume	$\geq L_1 + 3$
y8	Figure 2	facial datum plane	boundary of rear cassette domain	$\leq L_1 \times 1.12$
y9	Figures 2	facial datum plane	outside edge of cassette top and bottom plate domain	$\leq L_1 \times 1.21$
y10	Figures 3	facial datum plane	inside edge of cassette top and bottom plate indent	$\leq L_1 \times 0.985$
y11	Figure 3	facial datum plane	inside edge of cassette sensing pad areas	$\geq L_1 \times 0.708$
y12	Figure 3	facial datum plane	outside edge of cassette sensing pad areas	$\leq L_1 \times 0.954$
y13	Figure 3	facial datum plane	center of coupling exclusion zones	$= L_1 \times 0.923 \pm 0.1$