Extreme Ultraviolet Lithography (EUVL) presents new challenges to lithography technology. Defect-free EUVL multilayer (ML) mask blank fabrication with high yield will be extremely difficult. For ML blanks with a few defects, defect compensation methods have been proposed to mitigate the impact of the defects in such blanks. The ML defect mitigation strategies include using absorber pattern to cover the ML defect, proximity repair to compensate the impact of the ML defects, etc. In order to implement such mitigation strategies, an effective location indexing (mark) is required on the EUVL ML blanks such that the precise defect positions can be identified and located during the defect mitigation processes. The indexing will also serve the purpose of identifying each individual blank which will carry specific flatness and defect information. The proposed specifications will cover general requirements of the reference fiducial marks on ML.

This specification details the physical requirements for permanent reference fiducial marks on a EUVL mask multilayer blank. The marks must be readable by certain set of process tools with or without absorber coverage (films specified in SEMI P38).

The design feature of proximal locator of the reference fiducial mark shall be specified, including size, shape, and permissible variations.

The number of reference fiducial marks and their locations on the mask substrate shall be specified.

Test methods of the reference fiducial mark shall be specified.

Method to create the reference fiducial marks on the mask shall be specified to allow for innovations.

The results of this ballot will be reviewed by the EUV Fiducial Mark task force through teleconference meetings once available, after which it will be yellow balloted.

For technical questions, please contact Long He at long.he@intel.com and David Chan at david.chan@sematech.org. For procedural questions, please contact Susan Turner at sturner@semi.org.
1 Purpose
1.1 This standard specifies key requirements of fiducial marks that can be used as a coordinate system for referencing defect locations on EUV blanks.

2 Scope
2.1 This standard is intended to set an appropriate level of technical specifications of mask fiducial marks, such as their locations, shapes, sizes, line dimensions, and limits of variation. The marks must be readable by mask metrology and pattern write tools.
2.2 To allow innovation, this standard does not specify techniques to be used, or how the fiducial marks are generated.

NOTICE: 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 or other limitations prior to use.

3 Referenced Standards and Documents
3.1 SEMI Standards
SEMI P1 — Specification for Hard Surface Photomask Substrates
SEMI P37 — Specification for Extreme Ultraviolet Lithography Substrates and Blanks
SEMI E152 — Specification of EUV Pod For 150 mm EUVL Reticle

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

4 Terminology
4.1 Abbreviations and Acronyms
4.1.1 CD – Critical Dimension
4.1.2 CDL – Charging Dissipation Layer
4.1.3 EUV – Extreme Ultraviolet
4.1.4 EUVL – Extreme Ultraviolet Lithography
4.1.5 LER – Line Edge Roughness
4.2 Definitions
4.2.1 Absorber Film Stack – Stack of film layers deposited on top of the multilayer film stack to block reflection of the light in desired areas, with optional buffer layer for use in some absorber repair operations.
4.2.2 EUV Mask Blank (or EUV Blank) – An EUV substrate which has had deposited upon it a backside conductive layer, a multilayer film stack, and an absorber film stack. For pattern generation, a resist must be coated on top of a EUV blank. It may be done either by the blank supplier or by the mask shop.
4.2.3 EUV Mask Substrate (or EUV Substrate) – The base glass or ceramic material upon which films are deposited to make EUV blanks and EUV masks.
4.2.4 EUV Multilayer Film Stack – Stack of film layers deposited on the EUV substrate to provide high EUV reflectivity, and any capping layers for environmental protection and absorber film etch stops.
4.2.5 Fiducial Marks – Set of coarse and fine marks on EUV blanks readable by pattern writers and metrology tools for alignment and defect coordinates. These marks are fabricated prior to absorber deposition, either onto substrate or in multi layers.
4.2.6 Lower left corner of blank (or EUV blank) – When facing the front side of a blank, the un-beveled corner is designated as lower left corner of blank.
5 Requirements

5.1 Fiducial Mark Layout Requirements

5.1.1 A EUV blank must have four (4) fiducial marks, one at each corner as indicated in Figure 1.

5.1.2 Each fiducial mark consists of multiple fine marks and one coarse mark which is located in the outmost corner of fiducial mark areas. Fine marks are located in other corners of the areas as defined by the red, imaginary lines in Figures 1 and 2. Note there are two fine marks in the lower left blank corner and three in other corners. This layout configuration is illustrated in Figures 1 and 2.

5.1.3 One line end of all fine/coarse mark crosslines is aligned with the red, imaginary lines, as defined in Figure 2.

5.1.4 Relative position between fiducial marks, are defined in Figure 1 and Table 1 by x2 and y2.

5.1.5 Relative positions of fine and coarse marks in each fiducial mark areas are defined in Figure 2 and Table 1 by x3, y3, x4, y4, x5, and y5.

5.1.6 The dimensions of coarse marks are defined in Figure 2 and Table 1 by x4, y4, and CD.

5.1.7 The dimensions of fine marks are defined in Figure 2 and Table 1 by x5, y5, and CD.

5.1.8 EUV blank edge exclusion areas are defined in Figure 1 and Table 1 by x1 and y1.

5.2 Mark CD Control, LER, Rotation, and Orthogonality

5.2.1 CD control for coarse and fine marks is defined in Table 1.

5.2.2 LER of crosslines of fiducial marks is defined in Table 1 for both sides of the line.

5.2.3 Both course and fine mark rotation tolerance are defined to ≤0.5 degrees, relative to the red, imaginary lines.

5.2.4 Orthogonality of crosslines of both course and fine marks are specified to ≤0.5 degrees.

5.3 Fiducial Marks Readability During Mask Fabrication

5.3.1 Fiducial marks must be readable by blank inspection tools prior to and after absorber deposition.

5.3.2 Fiducial marks must be readable by defect review and repair tools after absorber deposition.

5.3.3 Fiducial marks must be readable by e-beam writing tool after resist and CDL coating.

5.3.4 Fiducial mark readability by other EUV metrology tools should be determined between mask blank suppliers and mask makers.
Figure 1
Layout of Fiducial Mark Areas on EUV Blank

Note: Figure is not drawn to scale. One fiducial mark is placed at each corner. Note there are only two fine marks in the lower left corner, vs. three in other corners. The red lines are guide of eyes.
Figure 2
Layout of coarse and fine marks for each of the four (4) fiducial marks

Note: Figure is not drawn to scale. Upper Left (UL), Upper Right (UR), Lower Left (LL), and Lower Right (LR). Note only two fine marks are for LL FM vs. three for UL, UR, and LR FM. The red lines are guides to eyes. One end of crossline of all marks is aligned to the imaginary red squares.
### Table 1 Fiducial Mark Specification

<table>
<thead>
<tr>
<th>Symbol Used</th>
<th>Figure</th>
<th>Value (mm unless specified)</th>
<th>Tolerance (mm unless specified)</th>
<th>Reference Measured From</th>
<th>Feature Measured To</th>
</tr>
</thead>
<tbody>
<tr>
<td>x1</td>
<td>1</td>
<td>8.45</td>
<td>Minimal</td>
<td>Nearest edge of mask blank</td>
<td>Outmost line end of coarse mark</td>
</tr>
<tr>
<td>x2</td>
<td>1</td>
<td>131.500</td>
<td>±0.010</td>
<td>Inmost line ends of the fine marks on the left</td>
<td>Inmost line ends of the fine marks on the right</td>
</tr>
<tr>
<td>x3</td>
<td>2</td>
<td>1.750</td>
<td>±0.010</td>
<td>The left line ends of fine/coarse marks</td>
<td>The right line ends of other fine/coarse marks in the same corner.</td>
</tr>
<tr>
<td>x4</td>
<td>2</td>
<td>1.000</td>
<td>±0.010</td>
<td>Left line end of coarse mark</td>
<td>Right line end of coarse mark</td>
</tr>
<tr>
<td>x5</td>
<td>2</td>
<td>0.100</td>
<td>±0.010</td>
<td>Left line end of fine mark</td>
<td>Right line end of fine mark</td>
</tr>
<tr>
<td>y1</td>
<td>1</td>
<td>8.45</td>
<td>Minimal</td>
<td>Nearest edge of mask blank</td>
<td>Outmost line end of coarse mark</td>
</tr>
<tr>
<td>y2</td>
<td>1</td>
<td>131.500</td>
<td>±0.010</td>
<td>Inmost line ends of fine marks on top</td>
<td>Inmost line ends of fine marks on bottom</td>
</tr>
<tr>
<td>y3</td>
<td>2</td>
<td>1.750</td>
<td>±0.010</td>
<td>Top line ends of fine/coarse marks</td>
<td>Bottom line ends of other fine/coarse marks in the same corner</td>
</tr>
<tr>
<td>y4</td>
<td>2</td>
<td>1.000</td>
<td>±0.010</td>
<td>Upper line end of coarse mark</td>
<td>Lower line end of coarse mark</td>
</tr>
<tr>
<td>y5</td>
<td>2</td>
<td>0.100</td>
<td>±0.010</td>
<td>Upper line end of fine mark</td>
<td>Lower line end of fine mark</td>
</tr>
<tr>
<td>CD</td>
<td>4.0 ~ 8.0 um</td>
<td>0.1 um</td>
<td>Line width of both fine and coarse marks.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LER</td>
<td>10.0 nm</td>
<td>Maximal</td>
<td>3σ variations as measured on each side of crosslines</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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