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SEMI 4580 Ballot: Specification of Fiducial Marks

02.21.2010, San Jose

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What's to be Focused on, What's Not

- **What will be discussed:**
  1. Ballot voting summary
  2. Major comments received
  3. Specification of Fiducial Marks
     (SEMI-4580: "Specification of Fiducial Marks for EUVL Mask Blank")
  4. Forward going plans

- **Please discuss off-line on topics such as:**
  1. Procedures how to engineer those marks
  2. Details on how each tool uses FM, especially for uses post mask patterning

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SEMI-4580 Blue Ballot Voting Results

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DRAFT
Document Number: 4580
Date: 11/25/2009

SEMI Draft Document 4580
New Standard: SPECIFICATION OF FIDUCIAL MARKS FOR EUVL MASK BLANK

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

(BLUE) BALLOT

- **Blue Ballot open for voting from 12/11/09 to 2/19/10.**
- **Voting results:**

Accepts	Abstains	Rejects
10	24	1

- **Received a total of 24 Comments and 9 Negatives.**

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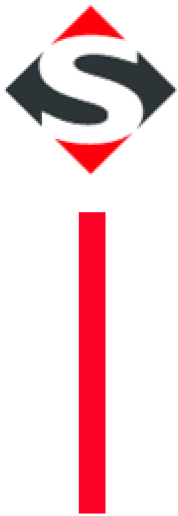
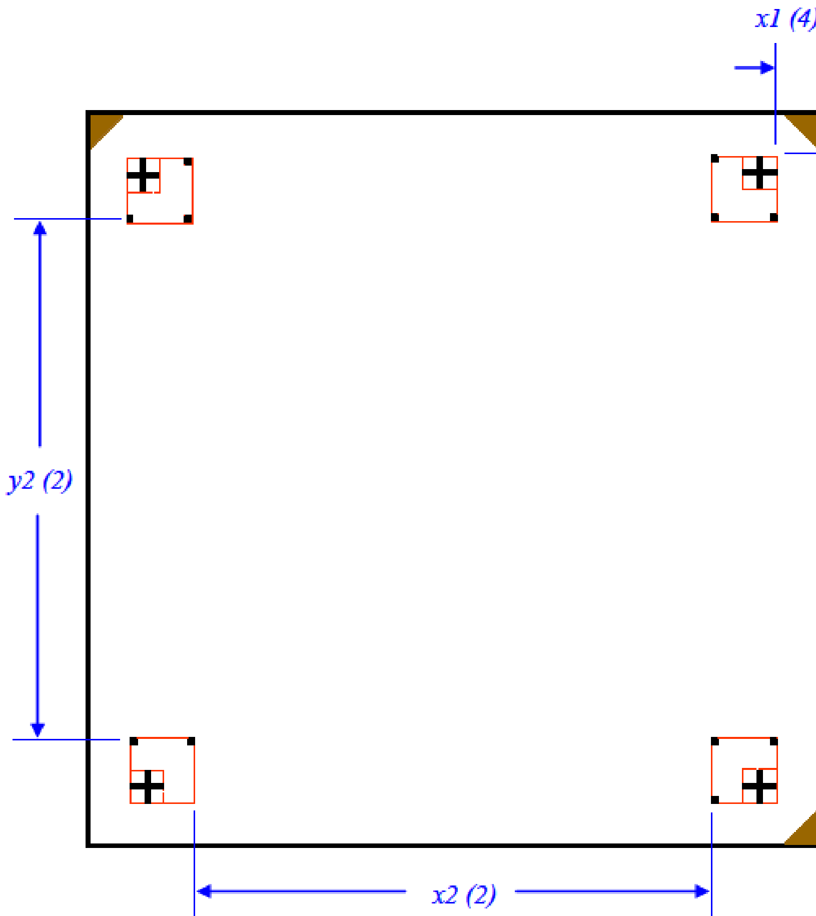


SEMI-4580 as Balloted



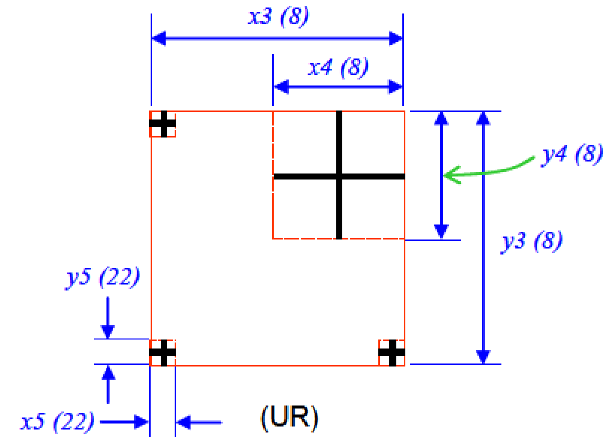


Table 1 Fiducial Mark Specification

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

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Summary of Comments / Negatives

	Comment / Negative		Disposition
C-1	Fine mark size; mark CD	AR	No change
C-2	Typo in Sec 5.3.2	Editorial	Change
C-3	Wording in Sec 1.1	Editorial	Change
C-4	Wording in Sec 2.1	Editorial	Change
C-5	Drawing line type change in figures	Editorial	Changed
C-6	Reserve spaces for FM, but not actually define marks	AR	No change
C-7	Allow more marks in the reserved FM areas	AR	Withdrawn
C-8	Blank edge exclusion areas not clear; reference FM to the lower left corner of blank	AR	Changed
C-9	Wording in Sec 5.2.4	Editorial	No change
C-10	Require various tools built capable to read FM	AR	Yes, except for blank inspection and ebeam writer which require readability provided
C-11	Proposed improvement to Figures 1 and 2 captions	Editorial	Change
C-12	Need to prevent skew of the 4 FM areas (corners)	AR	Changed
C-13	A summary comment	N/A	N/A
C-14	Editorial in Background statement	Editorial	Change
C-15	Editorial in Background statement	Editorial	Change
C-16	Wording in Sec 5.1.2	Editorial	Change
C-17	Wording in Sec 5.1.3	Editorial	Change
C-18	Require readability even if absorber is etched away, such as possibly in VSB writer application	AR	No Change
C-19	Add section to recommend how to use in different tools.	AR	Spec will be defined, but how to use it is up to users.
C-20	Editorial in Sec 4.2.2.	Editorial	Change as appropriate
C-21	Comment	N/A	N/A

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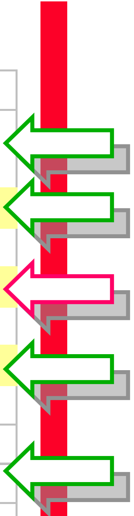
Summary of Comments / Negatives

	Comment / Negative		Disposition
C-22	Expand on how to use fiducials, especially for blank inspection and writer	AR	Add an Application Note for blank inspection and writer
C-23	marks should be outside cnetral 142x142 area	AR	Consensus reached for 136x136
C-24	Distance tolerance between FM should be ~10 um	AR	Changed
N-1	Define mark location by its center	AR	Changed
N-2	x1, y1 in Figure 1 and Table 1 are hard to comply	AR	It will go away it. (changed!)
N-3	Distance between marks should be as accuary as possible	AR	Changed to 10um (see C-24)
N-4	Comment on N-3	N/A	N/A (addressed in N-3)
N-5	Comment on mark location and line width	N/A	N/A (addressed in N-3)
N-6	On mark location torlerances, 10 um is tool large	AR	To combine with N-3
N-7	Comment on negative impact of big mark location error	AR	To combine with N-3
N-8	0.5 degree rotatinoal spec should apply to FM skew (i.e. the 136x136 area)	AR	To combine with N-3
N-9	On mark lines, >100nm LER is OK. A 10nm LER spec is not needed	AR	OK, yet to be discussed



Go to discussion….

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Comment #1

Name: IWAO HIGASHIKAWA

Company: TOSHIBA Corp.

4580 Accept with Comments:

Action Request (AR)

C-1. Corce and fine mark area size has too enough. My comment is that the half size. Table 1, CD value 4.0~8.0 has large for e-beam readable size. so, 0.1~8.0 is my comment.

No change per user inputs. Fine mark size is OK and e-beam accepts 4~8 um CD.

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Comment #2

Name: Rafael Vargas-Bernal

Company: Instituto Tecnológico Superior de Irapuato

4580 Accept with Comments

Editorial

C-2. In Section 5.3.2, a change must be realized: "Fidicial" by "Fiducial". A good work was done.

Consensus: Change

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Comment #3

Name: John Zimmerman

Company: ASML

4580 Accept with Comments

Editorial

C-3.

Paragraph 1.1

Original:
This standard specifies key requirements of fiducial marks that can be used as a coordinate system for referencing defect locations on EUV blanks

Proposed change:
This standard specifies key requirements of fiducial marks that can be used ~~as a~~ to establish a common coordinate system for referencing defect locations on EUV blanks

Consensus: Change

Comment #3

Editorial

C-4.

Paragraph 2.1

Original:
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.

Proposed change:
This standard is intended to set an appropriate level of technical specifications ~~of~~ for mask fiducial marks, such as their locations, shapes, sizes, line dimensions, and limits of variation. The marks must be readable by mask metrology, inspection, review and pattern write tools.

Consensus: Change

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Comment #3

Section 5

Editorial **C-5** Please change the "red" lines to "dotted" lines. This emphasizes the imaginary lines and allows black and white printing.

Consensus: Change

It is not good to limit innovation on the FM target design because the alignment requirements are quite tight. In order to lift some of these restrictions the following is proposed:

AR **C-6**

1. Change 5.1.6 and 5.1.7 to be exclusion areas reserved for the "standard" FM. The CD would be the exclusion area width. This would allow multiple lines in the cross and might allow better alignment if required in the future.

AR **C-7**

2. Change figures 1 and 2 to allow the non-used area defined by x3 and y3 to be used for experimental FM. For example the shaded area in the Figure 1 or the hatched areas shown in Figure 2 as a more specific example.

Withdrawn due to blank inspection requirements

Figure 1. Upper left FM target showing reserved area for future FM designs

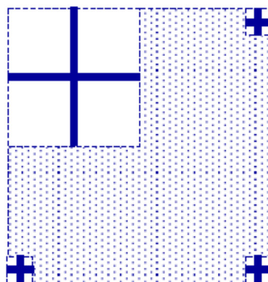
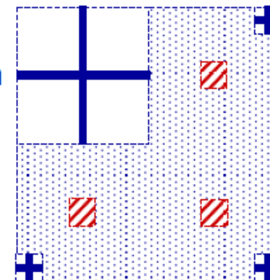


Figure 2. Upper left FM target with alternative mark locations for developing alternative alignment marks shown with the diagonal striped areas



C-6 consensus: No change. Need some marks to start with, which can be changed through standard update later on.

Comment #3

AR

C-8

Paragraph 5.1.8

Original:
EUV blank edge exclusion areas are defined in Figure 1 and Table 1 by x1 and y1

Note:
The edge exclusion areas are not described in Figure 1.

Consensus: Make the change as proposed

Proposed change:
Distance from EUV blank edge at the lower left hand corner to the closest fiducial mark outer corner is defined in Figure 1 and Table 1 by x1 and y1.

Note:
There can only be one each of these dimensions (x1 and y1) and still have x2 and y2. The proposed change fixes the FM relative to the lower left corner.

Proposal: FM placement and its accuracy are so specified that one can reference then to the lower left corner if one chooses to.

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Comment #3

Editorial

C-9.

Paragraph 5.2.4

Original:
Orthogonality of crosslines of both course and fine marks are specified to ≤0.5 degrees

Proposed change:
The orthogonality of each individual cross in the fiducial mark locations are specified to ≤0.5 degrees

Consensus: No change. It would effectively change the intended specification.

Comment #3

AR

C-10.

Section 5.3 Fiducial mark readability during mask fabrication

Either the tools needing the FM have to comply to be able to align to the FM or the FM must be made so that it can be used in all of the mentioned tools. There will be a problem in either case. If the FM is made so that it can be used in all of the mentioned tools, then the wavelengths need to be specified. This may require additional films or film modifications that will put an extra burden on the mask substrate, and mask blank suppliers.

The better option is to describe the 2 cross sections (substrate and ML) and state that the various tools must be able to align to these target cross sections.

Readability must be provided to both blank inspection and ebeam writers. However, readability by other tools should be negotiated between tool and blank suppliers.

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Comment #3

Editorial

C-11.

Figure 1 and Figure 2

- Figure 1

1. Specify the view. This should be multilayer side up.
2. Add a note that the bevels are on the reticle backside.
3. Use dotted lines instead of red lines.
4. Move x1 and y1 to lower left hand corner. There is only 1 of each of these dimensions. y2 and x2 constrain this to only one corner since the blank has a tolerance of ±0.1mm.

Consensus:
#1-3 are editorial. Change as proposed.
#4 is identical to C-8.

- Figure 2

1. Specify the view. This should be multilayer side up.
2. Add a note that the bevels are on the reticle backside.
3. Use dotted lines instead of red lines.

Consensus: #1-3 are editorial. Change as proposed

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Comment #4

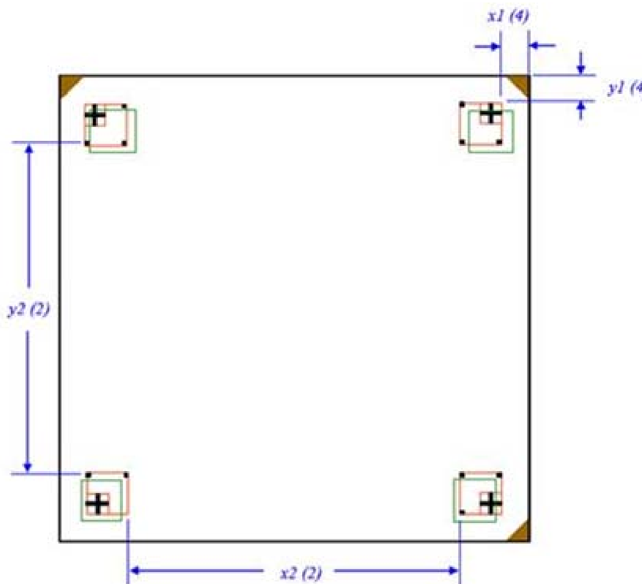
John Gookassian

Synopsys Inc.

Comments (email, not included in SEMI summary report)

AR

C-12. Just a question: I couldn't find in the proposal anything that controls skew of the fiducials. For example, if they are placed like the green rectangles, all the requirements can be met. Is this unimportant or I missed something?



Consensus: Skew will be controlled by "squareness"

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Reject #1

Name: Rik Jonckheere

Company: IMEC

4580 Reject

Comments

C-13. I support the need for such standard, but I have difficulties with the apporach taken. See detailed comments attached.

Editorial — C-14. The background statement (not part of ballot) incorrectly refers to P38 instead of P37

Editorial — C-15. In the background statement (not part of ballot) indexing is mentioned, but there is nothing about it in the draft.

Editorial — C-16. In 5.1.2 replace “multiple” by “a number of” (it is 2 or 3)

Editorial — C-17. 5.1.3 and last line of caption of figure 2 is not clear (if stil relevant in a center position approach)

Consensus: Changes to be made

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Reject #1

Comments:

AR

Consensus: No change. Address it in the future when needs are well defined.

C-18. 5.3.2: defect review and repair are normally done after the reticle is patterned. The important message to be given is that the fiducials should be readable regardless of the absorber being etched away from them or not. Normally this area of the reticle remains covered, but in case of negative resist used on a VSB writer the absorber might potentially be etched away.

AR

Consensus: No change. Spec will be defined, but how to use it is up to users.

C-19. Once the layout requirements are fixed, an additional section in the standard should make recommendations how to USE these fiducials on the different tools: how to refer to the fiducials ? Align to them ? Correct for translation, magnification, rotation, orthogonality, skew ?? (see comment on example of mask writer here above)

Editorial

Consensus: Change as appropriate

C-20. In 4.2.2 (comment): I would consider replacing the “and” by or. In principle one calls a substrate a blank when there is at least one of the mentioned layers on… Anyhow this document is about blanks with which masks will be made. So in this case we need all 3 mentioned.

Consensus: Change as proposed

C-21. Wrong approach taken. Use center position to reference the fiducial position.

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Reject #1

Comments:

AR

C-22. expand on how to use these markers. Thereby it is especially critical for the writer, because, most likely tools later in the process (for inspection, for review, for repair) will use reference points that eare part of the layout patterned by the mask writer. Only the mask writer and anything before that (mainly the blank inspection tool) will need to use the blank fiducials. Especially guidelines are required which coordinate system to use for these 2 tools. A blank inspection tool and a mask writer can only build the (within tolerances) same coordinate system if they align in the same way on these 4 marks. But for the mask writer this will give rise to incorrect coordinate system for writing the pattern, in absolute sense or relative to mask registration standards.

Proposal: Add an application note to elaborate on one option to use fiducials for blank inspection and writer. But, it's the user's responsibility on how to use fiducials to meet their needs.

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Reject #1

AR

Negatives:

Section 5, figures 1, 2 and Table 1 are not enough to the point:

N-1 It is much simpler to explain if all markers would be referenced by their center position (not by their left edge, or bottom, etc. depending on which side is relevant).

Consensus: Change

N-2 In Table 1 it is odd that dimensions x1&y1 are regarded the most critical ones. I think this is hard to comply with, in view of the fact that an EUV substrate has a tolerance of +/-0.1mm on its edge length of 152.0mm

Consensus: it will go away if proposal is implemented

N-3 In my opinion it is much more important to have the markers at an as accurate as possible distance away from each other, i.e. the center-to-center distance of the coarse markers should be within what is realistic (<10nm if done with a mask writer)

Consensus: Change as realistic

N-4 In such case the total centrality and rotation error can be given a realistic value.

Consensus: See N-3

N-5 Accuracy of the center positions of markers is what is critical, the length and width of the limbs is not

Consensus: See N-3

N-6 Col 4 of Table 1: really as loosely defined as 10 micron !!!??? Edges I agree, but center positions much more critical.

Consensus: Combine with N-3

Reject #1

AR

Negatives:

N-7 In view of the big error that is allowed on the positions (of the edges), assuming that the spirit of the draft also allows big errors on the center positions: HOW should the fiducials be used ? If for example the mask writer should adapt it coordinate system to these markers one can expect big absolute overlay errors between 2 reticles made on 2 different blanks, each with a best fit coordinate system based on the fiducials

Consensus: Combine with N-3

N-8 0.5 degrees in 5.2.3&4 should also be considered from this perspective

Consensus: Combine with N-3

N-9 Difficult to understand that a tolerance on LER can be Maximal ? Why not skip LER as spec as a whole then ? I think LER is not critical as long as it is assured that the length, over which the limb is used to determine the position of the cross, is long enough as to cancel out any LER issue. It is not as critical as 10nm. Even >100nm can be usable.

OK, but yet to be discussed

Additional Comments

Comments

C-23. AGC: Fiducial marks should be outside the central 142x142 mm area, to minimize defect contamination during FM generation into central quality area.

Consensus reached for 136x136mm area

C-24. KLA-Tencor: Distance tolerance between FM should be ~10um.

Consensus: Combine with N-3

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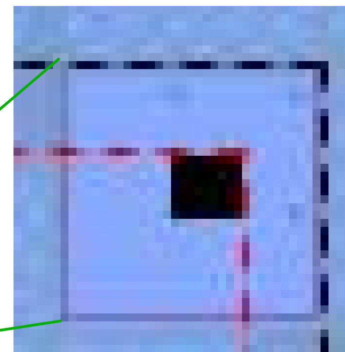
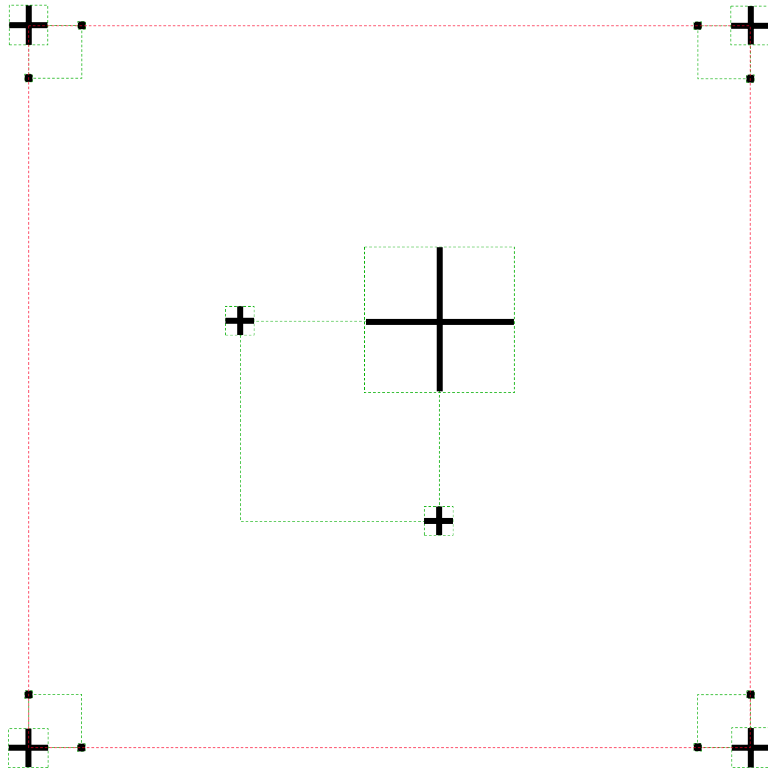
Available Real Estates



Overlay of ASML and NIKON reticle layouts
(Sean Huh /SEMATECH/Samsung)

- The 11x11mm squares next to corners of the 142x142mm area are available to FM.
  - ✓ SEMI E152 EUV-POD
  - ✓ ASML reticle layout
  - ✓ NIKON reticle layout
- Central 1.5x1.5mm black square in each 11x11mm square proposed for FM use
  - ✓ Writer maker
  - ✓ Blank Maker
- Compared to current ballot, the central, clear space (dotted red line) is increased by 4.5mm, from 131.5x131.5mm to 136x136mm.

Specifications (1)



- **Each fiducial mark consists of:**

  1 big cross + 2 small crosses

- **Central, clear quality area**
  1. **Sizing:**

     136 mm x 136mm
  2. **Squareness:**

     0.01/25.40

- **FM placement**
  1. **One at each corner**
  2. **Center of big cross aligns to corner**
  3. **Centers of small crosses aligns to dotted lines**

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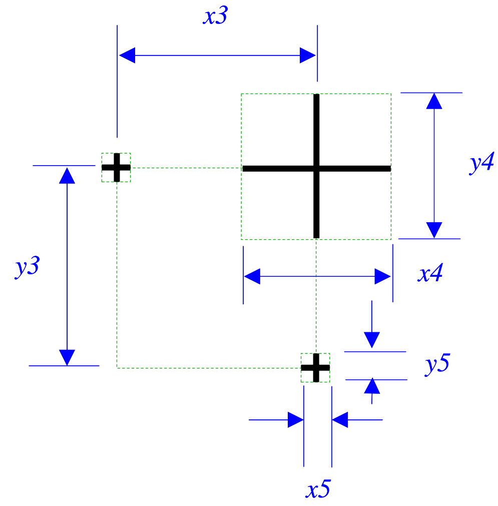
Specifications (2)



d4
y2
d3
d1
x2
d2
FRONT

One can call this red spot (-68, -68), or (8, 8), or anything else.... as one wishes!

Parameter	Value (mm)	Tolerance (mm)
x2, y2	136.000	± 0.010
x3, y3	1.500	± δ3
x4, y4	0.500	± δ4
x5, y5	0.100	± δ5
d1-d2	0.00	± 0.050
d3-d4	0.00	± 0.050
Squareness*		0.01/25.40

*of the square defined by 4 centers of big crosses

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Yellow Ballot Submission

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Critical Dates for SEMI Standards Ballots – Submission Deadlines and Voting Periods

Cycle 1 (Committee Meetings after February 24, 2010)

- Ballot Submission Date: January 4, 2010
- Voting Period Starts: January 18, 2010
- Voting Period Ends: February 17, 2010

Cycle 2 (Committee Meetings after March 29, 2010)

- Ballot Submission Date: February 8, 2010
- Voting Period Starts: February 22, 2010
- Voting Period Ends: March 24, 2010

Cycle 3 (Committee Meetings after May 31, 2010)

- Ballot Submission Date: April 12, 2010
- Voting Period Starts: April 26, 2010
- Voting Period Ends: May 26, 2010

Cycle 4 (Committee Meetings after July 5, 2010)

- Ballot Submission Date: May 17, 2010
- Voting Period Starts: May 31, 2010
- Voting Period Ends: June 30, 2010

Cycle 5 (Committee Meetings after September 13, 2010)

- Ballot Submission Date: July 30, 2010
- Voting Period Starts: August 9, 2010
- Voting Period Ends: September 8, 2010

Cycle 6 (Committee Meetings after October 18, 2010)

How about to target for Cycle 2 or 3?

Will request approval for yellow ballot submission. (SEMI standard meeting, 2/24, San Jose)

Backup