METROBOOST

Boosting Metrology and Lithography Performance

MetroChip
Microscope Calibration Target

Product Description Guide

METROBOOST
Phone: (408) 243-1067
Fax: (408) 516-9435
www.metroboost.com

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Microscope Calibration Target

Product Description Guide

1. Introduction

This document describes the microscope calibration target layout and includes detailed description of features and their location.

MetroChip is a microscope calibration target. The sample can be used for calibration of several types of microscopes such as scanning electron microscopes, scanning ion microscopes, scanning probe microscopes (including AFM) and light optical microscopes in reflected mode.

There are more than 1000 features on each sample. Features are intended for calibration of length scale in X or Y dimensions and Field-of-View calibrations in two dimensions (planar XY).

Various features can be used for calibration of length scale from submicron to several millimeters, spanning four decades. For the last three decades of this range, the sample also provides two-dimensional XY targets for field-of-view distortion calibration.

MetroChip also includes targets for certain other calibrations that may be needed for the microcopy tool.

2. Important Notice and Warning

Whenever possible, text labels have been placed next to features for easy identification. Each label often includes feature periodicity (pitch) as well as feature width (line or space width).

Notice: For the two labels of any given feature, only the stated pitch is intended for use in calibrations. That is, only the stated pitch value is accurate (to within the limits of manufacturing process).

The feature width is provided solely as a guide. Actual feature width can deviate from its label by as much as 20% in submicron features.

Warning: Do not use feature width stated in the label for calibrations!

3. Periodic Structures

Dimensional calibrations (including magnification calibration) should be carried out using pitch of periodic structures (as opposed to using feature width). MetroChip provides many periodic structures for dimensional calibrations (linear dimensions in X and Y and two-dimensional planar XY).

One type of periodic structure consists of an array of lines in which parallel lines of equal width are placed at equal intervals. Depending on the periodicity, this type of structure is referred to as a grating or scale (microscale). MetroChip includes several microscales and a large number of gratings, mostly squares in extent, having either horizontal or vertical lines.

MetroChip also contains features that are periodic in two dimensions. These include grids, checkerboards, and arrays of squares, disks, and crosses.

Nearly every feature has text labels nearby for easy identification.

4. General Sample Information

Sample size is 20 mm by 20 mm. Sample thickness is 750 microns, approximately.

The samples are made with advanced semiconductor processing techniques. The finished product has patterns of etched poly-crystalline silicon over a thin oxide on silicon substrate. Polysilicon thickness is 1500 Angstroms (within +/- 10%). The oxide thickness under the polysilicon features is less than 50 Angstroms and is typically 25 to 30 Angstroms.

A special mask was designed and fabricated first. Features on the chips were manufactured using one particular mask. The patterns are printed with state-of-the-art step and repeat scanner lithography tools at 248 nm exposure wavelength.

Features with 0.26 micron pitch (approximately 3486 cycles per mm) and 0.25 micron pitch (4000 cycles per mm) are printed and guaranteed. Features with 0.24 micron pitch (approximately 4167 cycles per mm) exist and are printed, but not guaranteed. A few features with smaller pitch exist on the mask, but are not resolved properly with the current printing process.

5. Repeatability of Pitch – Sample to Sample Variations

In semiconductor manufacturing using advanced scan and repeat systems, and using the same mask to produce the features, the repeatability of periodicity (pitch) in any feature from one sample to the next is determined mainly by the stability of the exposure tool over the life of the product. Typically, magnification stability is maintained to better than 2 parts per million (ppm).

This is a measure of repeatability of pitch from one sample to another. It is not a measure of pitch accuracy. However, This extremely tight repeatability of pitch provides for an important characteristic of these samples. Once a single sample is certified for pitch of a certain feature, that certification also applies to that feature on all other samples within the limits of repeatability on the manufacturing process.

We emphasize again that the extreme level of repeatability in the ppm range, and hence the traceability chain applies to pitch of periodic structures. Sample to sample variations in film stack thickness and line or space width can be as much as +/- 10%. Feature sidewall angle can also vary from sample to sample.

6. Accuracy of Pitch

The accuracy of periodicity of the features is dominated by errors in the mask manufacturing process.

For very small features, the pitch accuracy depends on the method a measurement.

We emphasize again that the extreme level of repeatability in the ppm range, and hence the traceability chain applies to pitch of periodic structures. Sample to sample variations in film stack thickness and line or space width can be as much as +/- 10%. Feature sidewall angle can also vary from sample to sample.

7. Sample Layout

Each 20 mm by 20 mm chip consists of 16 tiles as shown in Fig. 1. Each tile is 5 mm per side.

When the sample is properly oriented, the lower left corner tile is mostly blank. The remaining tiles have patterns. When the chip is viewed with the naked eye under typical lighting conditions, the most easily discernible tile is the one with four quadrants (rightmost column, second row from the bottom).

The following features exist on the sample:

Two alignment marks

Many field-of-view distortion targets

Targets for par-axial calibration (zoom center)

"L-Bar" measurement features which double up as resolution targets

Focus Star

Special targets for stigmation

Gratings with various pitch sizes (Ronchi rulings)

Linear Microscale

Concentric circles and squares

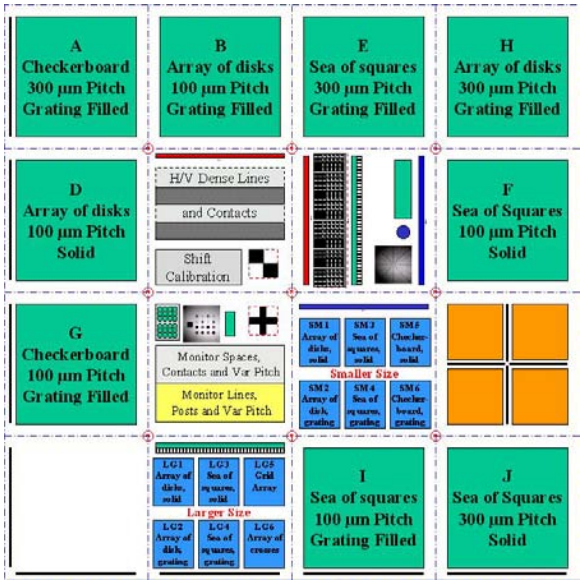


Figure 1. Sample Layout

The location of each of these features will be detailed in the following sections.

8. MetroMark

"MetroMark" is a special target designed with a well-defined center at both low and high imaging magnifications. In addition, the target is visible in both optical microscope and SEM images. MetroMark is suitable for characterizing image shift when image magnification is changed (par-axial calibration of optical microscopes and zoom center calibration of scanning electron microscopes).

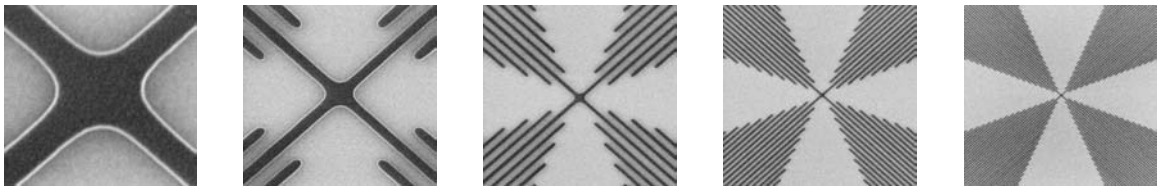


Figure 2 – SEM images of MetroMark with 1, 3, 8, 16, and 32 micron Field-of-View

9. Sample Center

Each sample has nine "MetroMark" patterns that are visible both at high and at low magnifications in both optical and SEM images. As shown in Fig. 3 and schematically in Fig. 4, one of these marks is placed at the center of the sample.

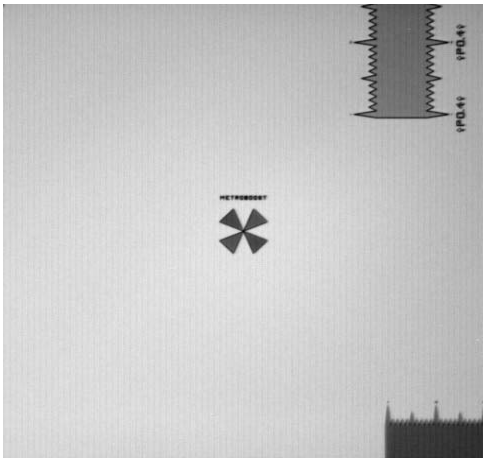


Figure 3. Sample Center

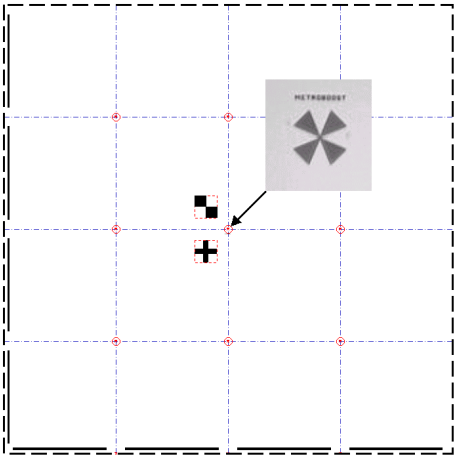


Figure 4. Center Mark

The MetroMark located at the sample center is not unique within the sample. There are eight other copies of this feature. They are located away from the sample center by 5mm in x or y or both. However, each such mark is uniquely labeled. The text above the sample center is "METROBOOST".

Coordinates of other features that appear in the rest of this document are given with respect to the sample center mark.

10. Arrows as Navigation Signposts

To make manual navigation easier, arrows with additional identifying marks are printed on the frame. The image of any single arrow is sufficient for identifying the position of imaged area within the sample. An example is shown if Fig. 5 below.

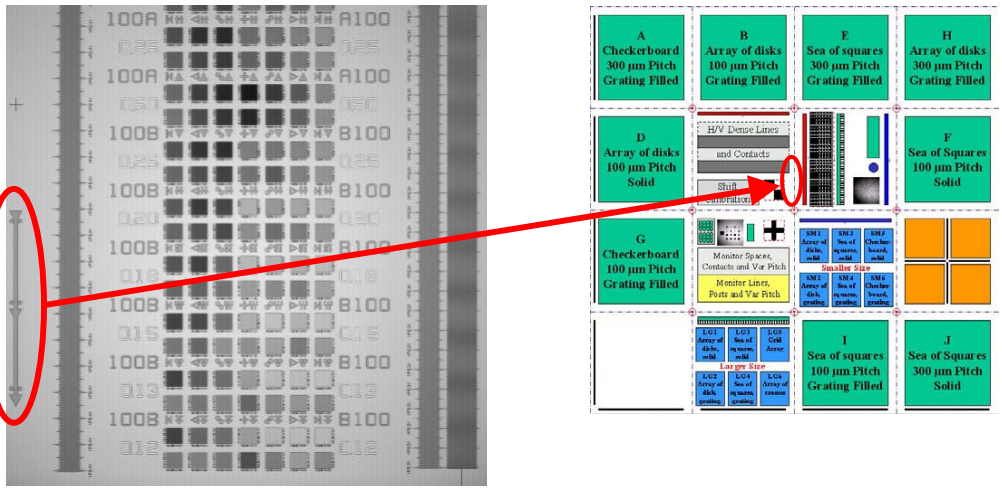


Figure 5. Example of spotting position within sample from the image of an arrow

Arrows are placed on the borders of all 5mm by 5mm tiles and point towards the sample center. Each arrow on MetroChip has uniquely identifiable auxiliary features that consist of a number of disks as shown in Fig. 8.

The arrows on the horizontal and vertical lines that cut the sample in half are drawn with two sets of disks; one set on either side (e.g. as shown in Fig. 7), while the remaining arrows have disks on one side only, the side closer to sample center. The number of marks is indicative of the distance from the (horizontal or vertical) middle of the sample. Arrows with one auxiliary mark are closest to the middle of the sample while the ones with four marks are farthest away.

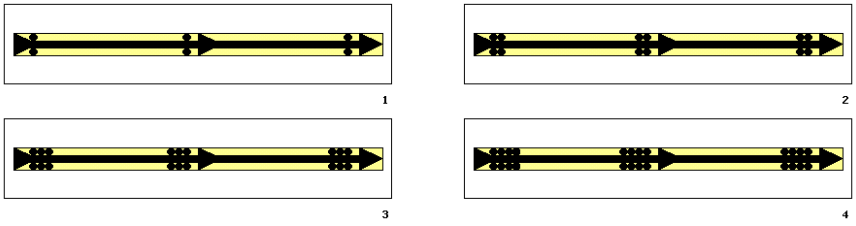


Figure 6 – Arrow shapes for position identification

11. Linear Microscales (Rulers)

MetroChip contains six long gratings referred to as "rulers" based to their appearance in optical microscope images. Each ruler is approximately 4.5 mm long by 200 microns wide. Like a normal ruler, the lines in each grating are perpendicular to the long axis of the features. Three gratings are in the horizontal direction while the other three are in the vertical direction. Each group of three horizontal or vertical gratings consists of lines and spaces with a different periodicity. Pitch values in the three horizontal or vertical gratings are 0.4, 0.3 and 0.25 micron. The approximate locations of the gratings are indicated in Figure 7 below.

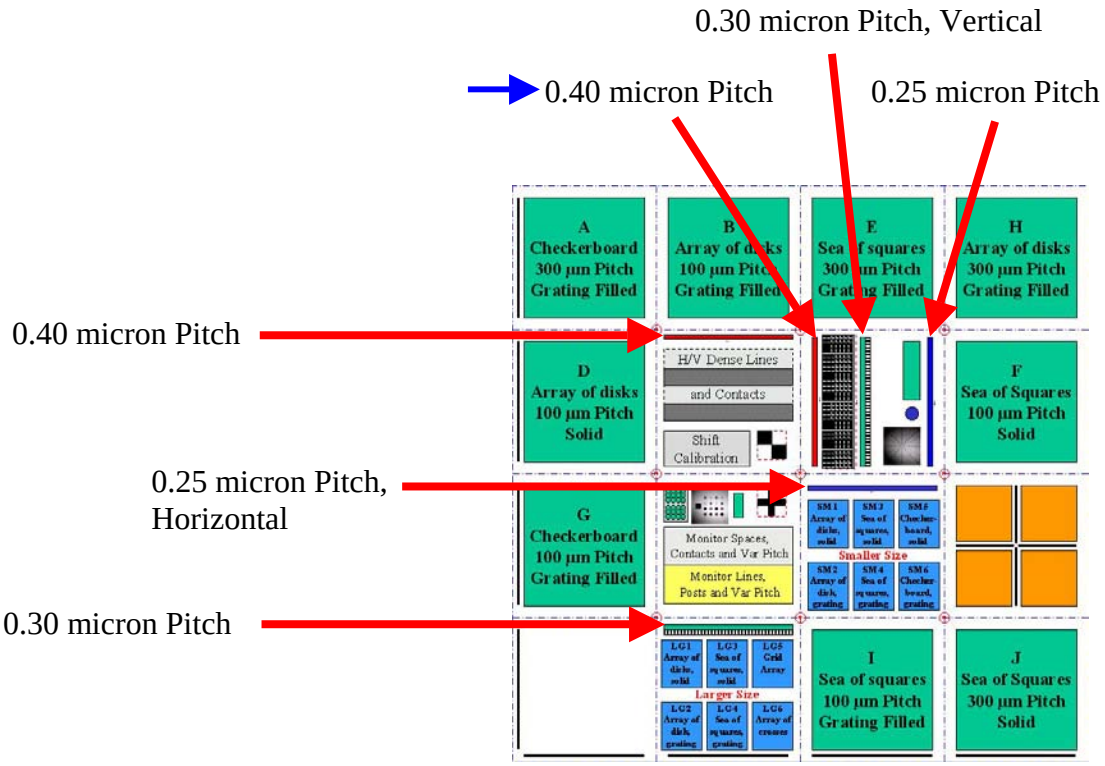


Figure 7. Horizontal and Vertical Long Gratings

The (x,y) coordinates of the center of the rulers relative to the center of the sample are:

1 – Vertical Ruler, 0.25 micron pitch: (+4500, +2500)

2 - Vertical Ruler, 0.30 micron pitch: (+2500, +2500)

3 - Vertical Ruler, 0.40 micron pitch: (+500, +2500)

4 - Horizontal Ruler, 0.25 micron pitch: (+2,500, -500)

5 - Horizontal Ruler, 0.30 micron pitch: (-2,500, -5,500)

6 - Horizontal Ruler, 0.40 micron pitch: (-2,500, +4,500)

Ruler Design Details

The grating lines in each ruler are perpendicular to the longer axis of the grating. All lines in each grating have the same designed width. However, the length of each line in the grating is individually adjusted so that much like a normal ruler, the grating appears as having major and minor tick marks when observed with an optical microscope at a suitable magnification. The design is shown in the drawing below:

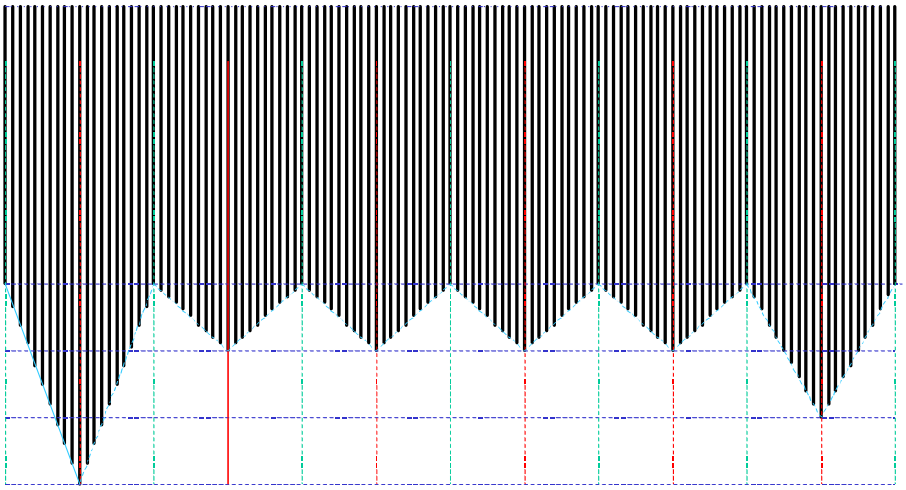


Figure 8. Image of ruler with 0.4 micron pitch

Major and minor tick marks exist on both top and bottom of the rulers. Major tick marks are labeled for their distance from the left side of horizontal rulers and from the bottom of vertical rulers. An image of a horizontal gratings acquired from an optical microscope is shown in Fig. 9 below:

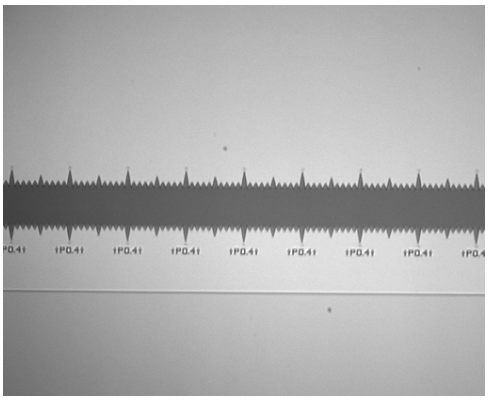


Figure 9. Image of ruler with 0.4 micron pitch

Ruler Design Details

Compared to gratings with other pitch values, both vertical and horizontal rulers with 0.3 micron pitch have a feature them makes it easy to spot at low magnification images. Adjacent to each 0.3micron pitch ruler, a second grating with the same extent (length and width) is printed. These neighboring gratings have a pitch of 6 microns, and are printed with lines that are about 2 microns wide. Together, the 0.3 micron pitch ruler and its neighboring grating form an easy-to-spot pair as shown in Fig. 10 below. For the horizontal ruler, the neighboring grating is immediately below the structure as shown in the image. For the vertical ruler, the neighboring grating is to its right.

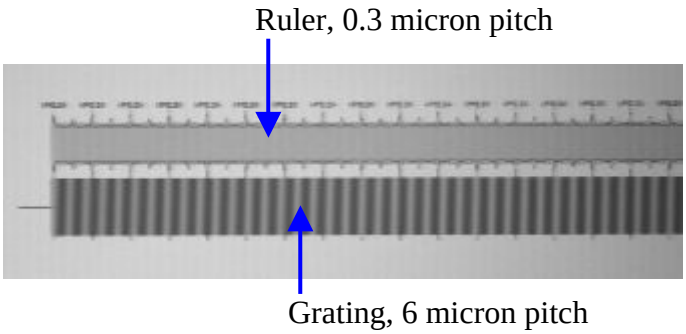


Figure 10. Image of ruler with 0.3 micron pitch

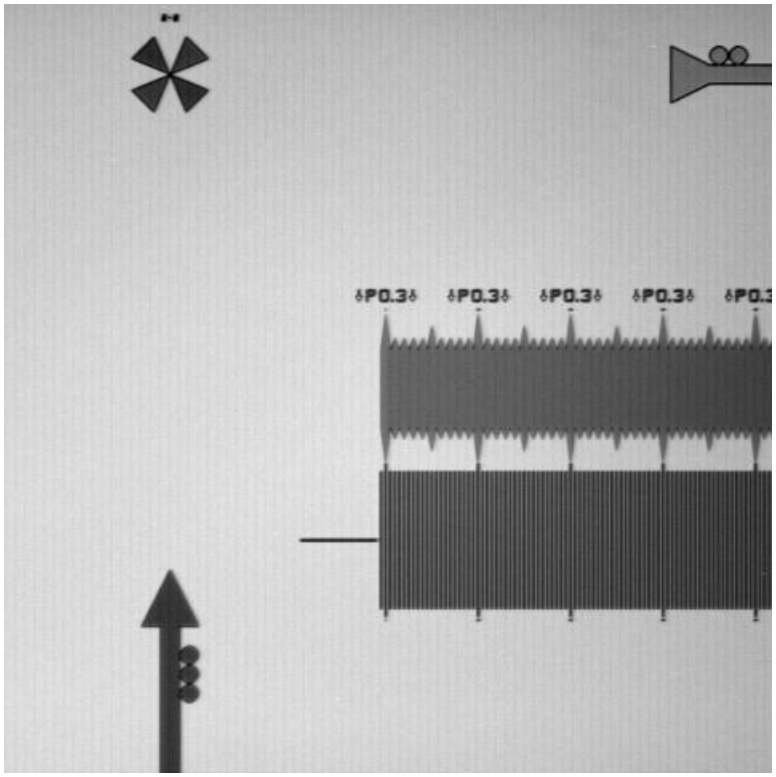


Figure 11. Another image of ruler with 0.3 micron pitch in the vicinity of the left hand side of Fig. 10 above

An image from the CAD drawing of the lower left portion of Fig 10 and also in Fig 11 is shown in Fig. 12 below. There are features to assist with measurement. For example, a horizontal line is drawn at the end of the grating. This line, together with its mirror image on the opposite end of the grating can assist with proper angular placement of the sample. Also, there are longer vertical lines that extend by 10 microns per side from the grating. These longer lines have a spacing of 120 microns. There are 38 such lines along the length of the grating. These lines are 200 microns long. The bulk of the grating consists of lines that are 180 microns long. The right hand side of the grating is a mirror image of what is shown in Fig. 12 below.

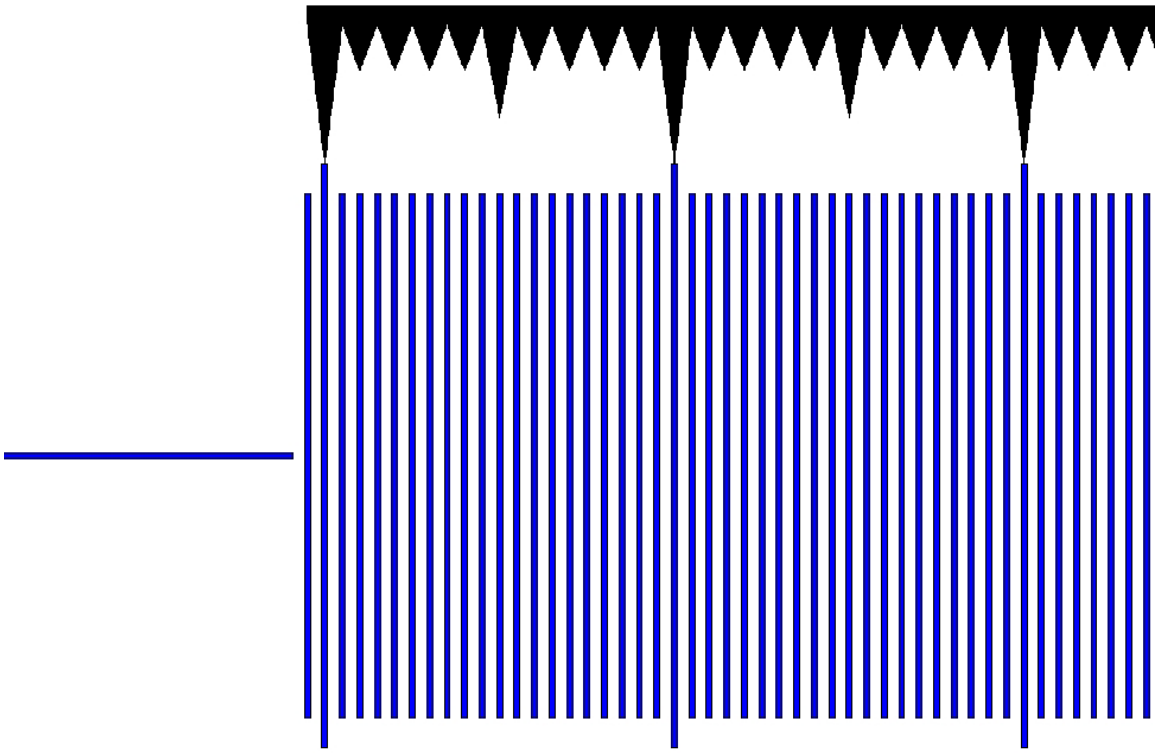


Figure 12. Image of ruler with 0.3 micron pitch

SEM images of the upper left portion of the grating where the 0.3 micron ruler touches the extended line are shown in images below:

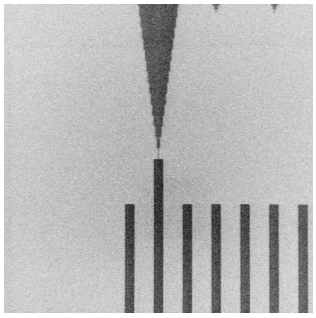


Figure 13. SEM image, 64 micron FOV

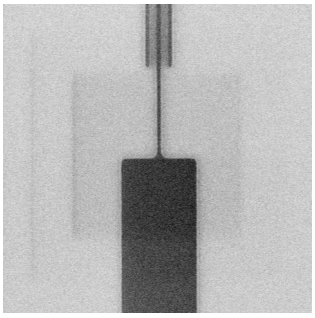


Figure 14. SEM image, 8 micron FOV

12. Scatterometry Targets

What are scatterometry Targets?

Scatterometry targets are gratings that are square in extent. These are another set of targets suitable for magnification calibration. Each scatterometry target is typically a 50 or 100 micron square filled with either horizontal or vertical lines. Unlike the rulers, there are gratings with unequal lines and spaces in the scatterometry targets.

Location within Sample

Three sets of scatterometry targets exist in each sample. These targets are located in the 5mm by 5mm square that is immediately to the right and above the center of the sample as shown in Fig. 15.

Figure 16 is a schematic layout of all the targets in that 5mm by 5mm square which also includes several long gratings, overlay targets with built-in offsets, and a focus star.

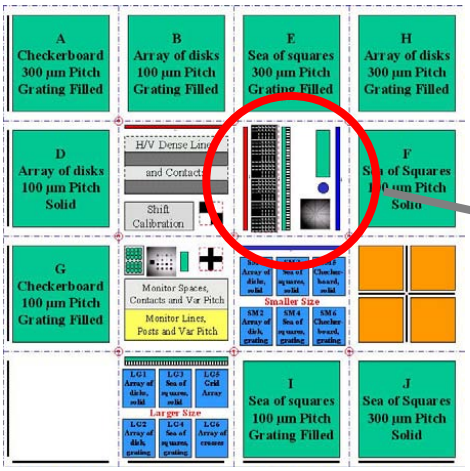


Figure 15 – Schematic location of scatterometry targets on MetroChip

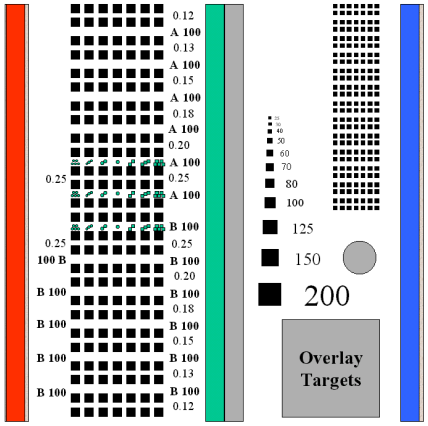


Figure 16 – Schematic layout of targets in 5mm by 5mm square

The scatterometry targets in the first set are located in the left half of the square in Fig. 16. This set consists of a matrix of squares that are 100 microns per side. The second set which is located near the upper right area in Fig. 16 is nearly identical to the first except that its square targets are 50 microns per side.

The third set consists of a series of squares of different sizes. Each square is filled with grating of vertical lines with 300nm pitch at 50% duty cycle (line-to-space width ratio, L:S is nominally 1:1). The largest target is 200 microns per side while the smallest is 25 microns per side.

Scatterometry Targets: Matrix Layout

There are two sets of scatterometry targets placed in the form of a matrix. Each matrix consists of 7 columns by 26 rows of squares as shown in Fig 17. Each square is either a horizontal or a vertical grating of lines and spaces. One set of scatterometry targets consists of squares that are 100 microns in size while the other set consists of 50 micron squares.

Gratings of vertical and horizontal lines exist in each pair of rows. The top row of each pair consists of gratings with vertical lines while the bottom row has the same gratings with horizontal lines. To emphasize this point, rows of targets shown in Fig. 17 are displayed in a color scheme that ignores column-to-column differences.

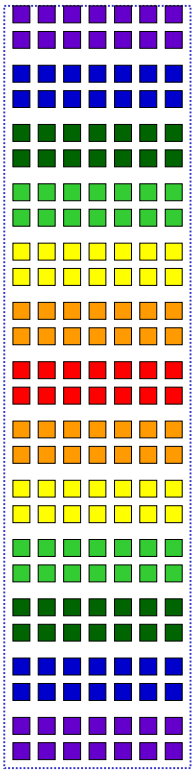


Figure 17 – Matrix Layout of scatterometry targets

Targets by Column

In each column from left to right, the line to space width ratio (L:S) is 1:5, 1:3, 1:2, 1:1, 2:1, 3:1, 5:1. The squares in the center column have nominally equal line and space widths. The targets to the left of the center column have narrower lines while the targets to the right have narrower spaces. It must be emphasized that line and space widths may vary from the nominal, but the sum of line plus space width (that is, the pitch) is exact, within printing errors of the mask and the exposure tool.

Targets by Row

There are 26 rows of squares in each set of scatterometry targets. Horizontal and vertical gratings of the same size are placed in a pair of adjacent rows.

From top to bottom, the 13 pairs of rows are 0.12 A, 0.13 A, 0.15 A, 0.18 A, 0.25 A, 0.5 A, 0.25 B, 0.18 B, 0.15 B, 0.13 B, 0.12 B.

The difference between scatterometry targets in group A and in group B is that line and space widths within each group are biased differently on the mask to help with printing. All targets in set B print on the wafer. For the targets in set A, a couple of targets in the top pair of rows (0.12 size) are not printed properly due to exposure tool limitations. Those two targets are shown in Fig. 18.

PLEASE USE TARGETS IN SET B, since all targets are printed properly.

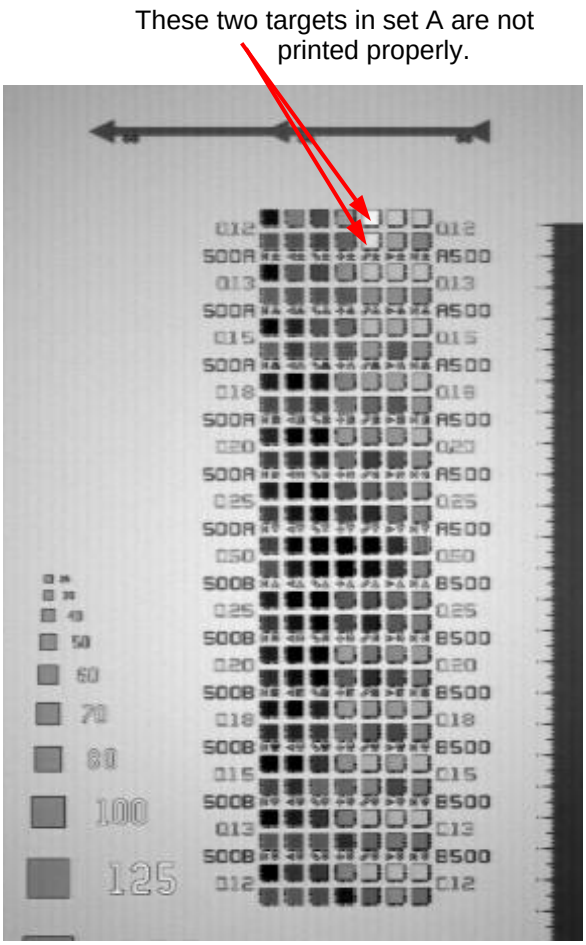


Figure 18 – Optical image of one set of scatterometry targets (50 micron)

Scatterometry Target Labels

The scatterometry targets are labeled for easy identification when viewed at either low or high magnification. Larger labels such as “A500” and “500A” are placed to the left and right of the matrix as shown in Fig. 18. These labels include the text such as “100” or “500” to denote the set of targets being viewed. Thus in Fig. 18, the label “500” represents targets that are 50 microns square while “100” as in Fig. 19 on the next page represents 100 micron targets. The letter “A” or “B” represents different bias on the mask. Those targets are either **A**bove or **B**elow the mid line of the matrix. The other letters in between such text represent the smallest line in each pair of rows. The labels “0.12” in Fig. 19 signifies 0.12 micron line or space for the targets in the bottom pair of rows.

Smaller labels are placed on two or three sides of each square grating as shown in Fig. 20. Labels for scatterometry targets would, for example, be 0.15 A (or B) 1:2 H (or V). The last letter represents horizontal or vertical grating lines. The letters 1:2 (the two digits separated by a column) represent the nominal ratio of Line to Space width (L:S). The first few letters represent the nominal size for line or space. The letter A or B designates the set A or B as described in the previous paragraph. The first few letters represent the smallest line or space in the target.

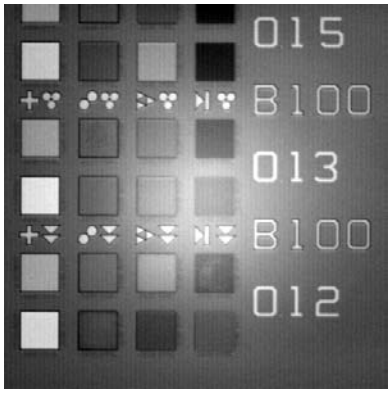


Figure 19 - Large labels of Scatterometry targets

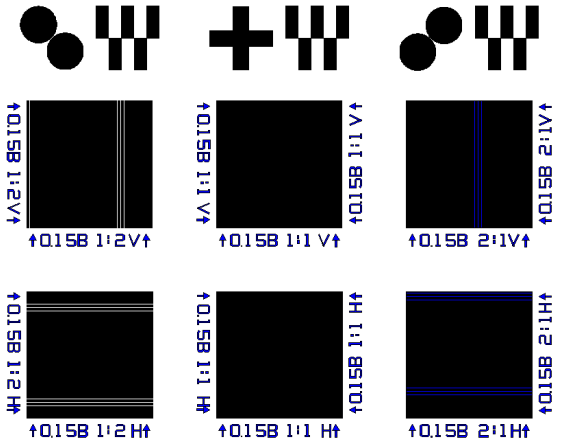


Figure 20 - Example of small labels for Scatterometry targets

Pitch versus Line or Space Width

The line and space widths shown in target labels are nominal. Only the pitch, that is the sum of line and space widths, can be relied upon for calibrations. Due to space constraints, the value of pitch is not spelled out in the label, but can be easily calculated. For example, in scatterometry target labeled “0.15 B 1:2 V”, the pitch can be derived as follows:

$$\text{Pitch} = 0.15 * (1+2) = 0.45 \text{ micron}$$

13. Measurement Features – First Set

MetroChip design includes two groups of measurement features. Figure 21 depicts the location of the first of the two groups. These targets consist of four rows of features that include normal and reverse tone shapes, that is, lines and trenches, contacts and posts.

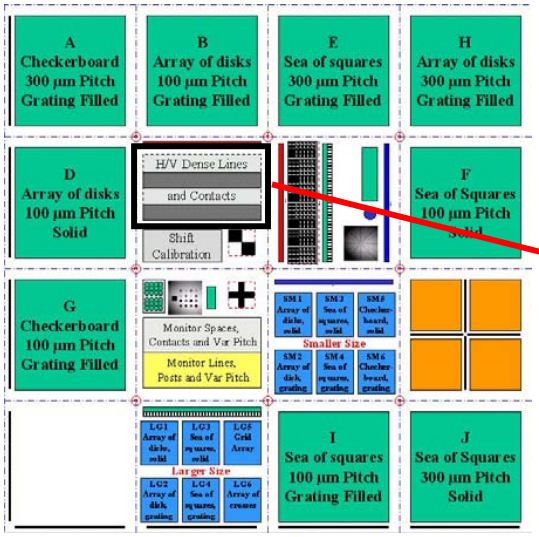


Figure 21. Location of the first of two groups of measurement features

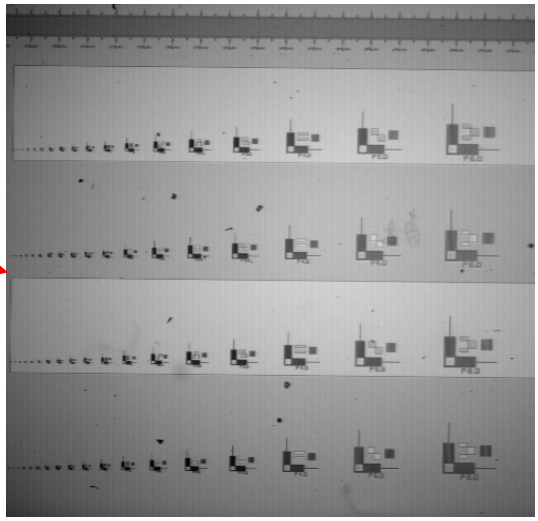


Figure 22 - Optical microscope image of measurement features

Fig. 22 is an optical microscope image of the measurement features of this group. Two different feature tones, normal and reverse, are visible in the image.

Each row in this set of features contains horizontal and vertical isolated and dense lines (or spaces) and isolated and dense contacts (or posts). Feature pitch increases from left to right as shown in Fig. 22. The smallest pitch in this set of features is 0.24 micron while the largest is 10 microns. Thus, nominal feature size ranges from 0.12 micron to 5 microns.

Each feature size is labeled with text indicating feature pitch. The letter "N" visible in Fig. 23 denotes negative tone targets that consist of trenches in polysilicon film.

The largest pitch Lbar targets on MetroChip can be found in this set of measurement features. An image of a 10 micron pitch target is shown in Fig 23. Note that this target would be to the right of the group shown in Fig. 22.

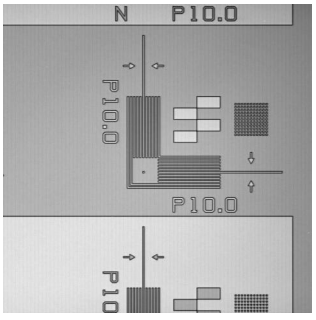


Figure 23 – Lbars with 10 micron pitch

14. Measurement Features – Second Set

A second set of measurement features consists of dense and isolated lines and spaces, dense and isolated posts and contact, and dense lines and spaces with pitch that increases from feature to neighboring feature (referred to as lines with varying pitch).

This set is located below the first set of measurement features shown in Fig. 24.

The positive tone structures are grouped together near the bottom of the 5 mm by 5 mm square.

From left to right, the features are grouped as dense and isolated lines, posts, and Lbars with varying line to space ratios.

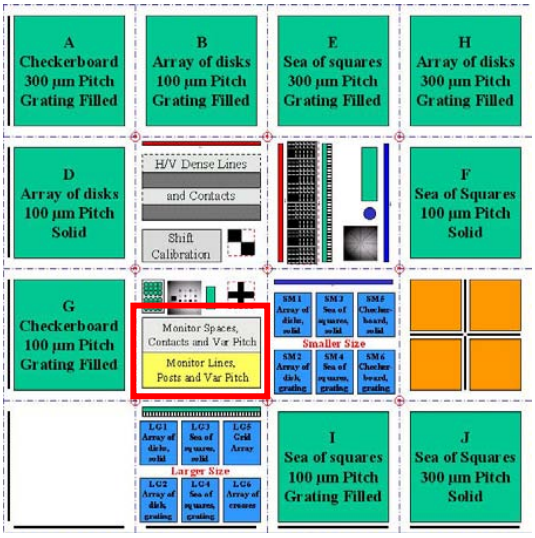


Figure 24 - Location of the second of two groups of measurement features

These structures are labeled with three different size texts. At very low magnifications, large labels below the positive tone features are “MONITOR LINES”, “POSTS” and “VAR PITCH”. This is shown in Fig. 25 below.

Figure 25 – Outline of Monitor Targets, Positive Tone

Nine identical rows of features exist on each sample. The rows are 100 microns apart. As can be seen in Fig. 25, each row of features contains 3 repeats of dense line targets on the left side, one set of posts in the middle, and a set of lines with varying pitch on the right side.

Monitor Targets: Lines

In every MetroChip, there are 27 replicas of each monitor line target on a grid pattern of 3 columns by 9 rows. The columns repeat every 600 microns, while the row spacing is 100 microns. As shown in Fig. 26, individual rows are labeled to help identify targets.

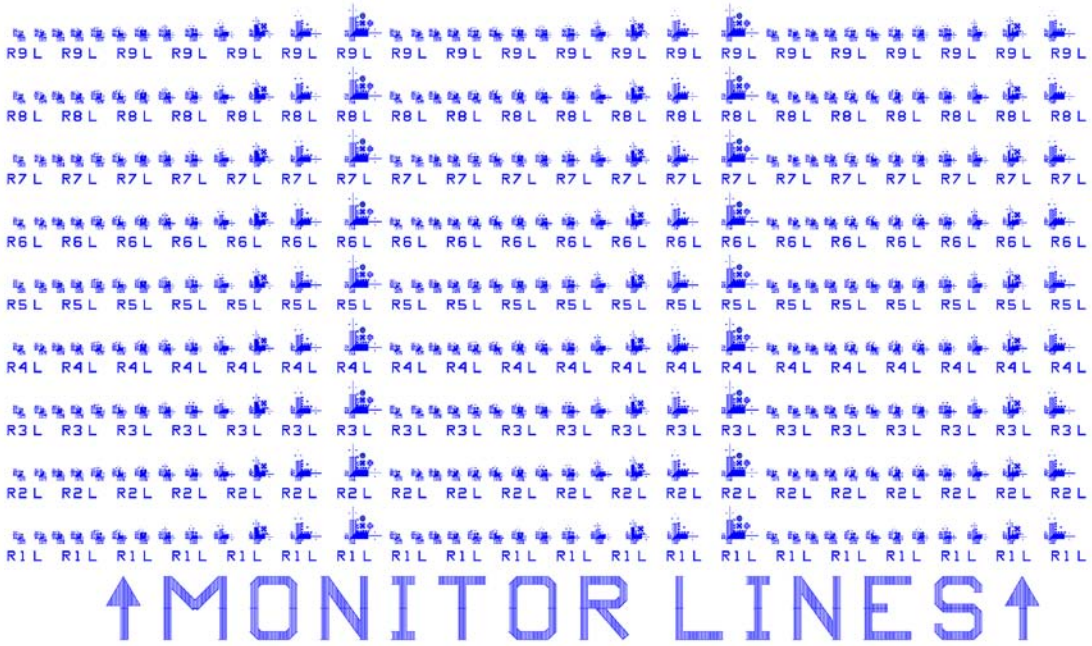


Figure 26 –Monitor Line Targets

Each monitor line feature consists of horizontal and vertical dense and isolated lines with several pattern recognition targets and two sets of labels in horizontal and vertical directions. The labels denote nominal line size for both dense and isolated lines and the pitch for the dense lines. An example is shown in Fig. 27.

In each of the three columns, feature sizes increase from left to right. The reticle design includes features starting at pitch of 0.2 microns (which are not resolved) and increasing initially in 0.02 micron increments.

Minimum guaranteed feature size is at a pitch of 0.26 micron having nominal 0.13 lines (with nominal 1:1 line/space ratio). However, in this group of targets, 0.12 micron pitch features are also resolved.

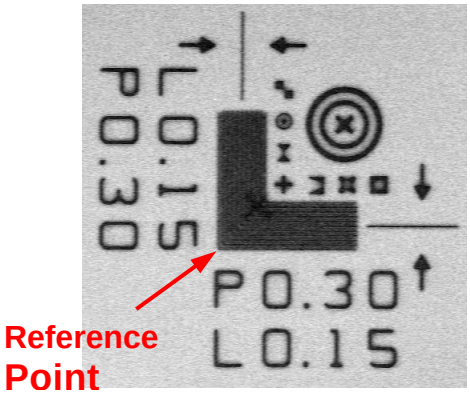


Figure 27 – A sample feature in "MONITOR LINES"

The coordinates of the features in "MONITOR LINES" are given in the table below. Coordinates represent location of the lower left corner of the dense line set (as shown in Fig. 27) relative to lower left corner of MetroChip. To obtain coordinates relative to sample center, subtract 10,000 microns from each of the X and Y coordinates in the table. Only the coordinates for the bottom row are listed. Y coordinates of features in the second row from the bottom can be obtained by adding 100 microns to the Y coordinates in the table.

No.	Nominal Linewidth (µ)	Pitch (µ)	Feature Label Line 1	Feature Label Line 2	First Col X (µ)	Bottom Row Y (µ)	Repeat 2 X (µ)	Repeat 3 X (µ)
1	0.1	0.2	**P 0.20**	**L 0.10**	**5283**	5565	5883	6483
2	0.11	0.22	**P 0.22**	**L 0.11**	**5317**	5565	5917	6517
3	0.12	0.24	**P 0.24**	**L 0.12**	**5345**	5565	5945	6545
4	0.13	0.26	**P 0.26**	**L 0.13**	**5375**	5565	5975	6575
5	0.14	0.28	**P 0.28**	**L 0.14**	**5407**	5565	6007	6607
6	0.15	0.3	**P 0.30**	**L 0.15**	**5441**	5565	6041	6641
7	0.16	0.32	**P 0.32**	**L 0.16**	**5477**	5565	6077	6677
8	0.18	0.36	**P 0.36**	**L 0.18**	**5515**	5565	6115	6715
9	0.2	0.4	**P 0.40**	**L 0.20**	**5557**	5565	6157	6757
10	0.25	0.5	**P 0.50**	**L 0.25**	**5603**	5565	6203	6803
11	0.3	0.6	**P 0.60**	**L 0.3**	**5659**	5565	6259	6859
12	0.4	0.8	**P 0.80**	**L 0.4**	**5725**	5565	6325	6925
13	0.5	1	**P 1.0**	**L 0.5**	**5811**	5565	6411	7011

Coordinates of reference points in "MONITOR LINES" relative to sample corner

Monitor Targets: Varying Pitch Lines

Grouped lines with varying pitch are placed on the right side of each row. The purpose for this set of features is to provide very narrow lines. Lines as narrow as 100 nm exist in this set. An example is shown in Fig. 28. Note that exact sizes cannot be guaranteed.

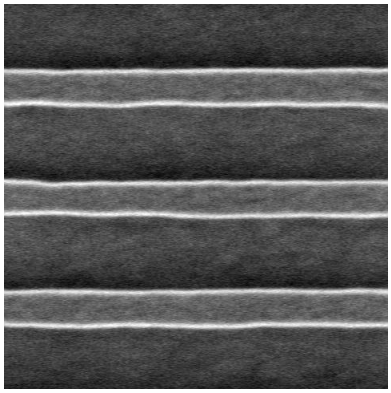


Figure 28 – 100 nm lines (1.0 micron Field of View)

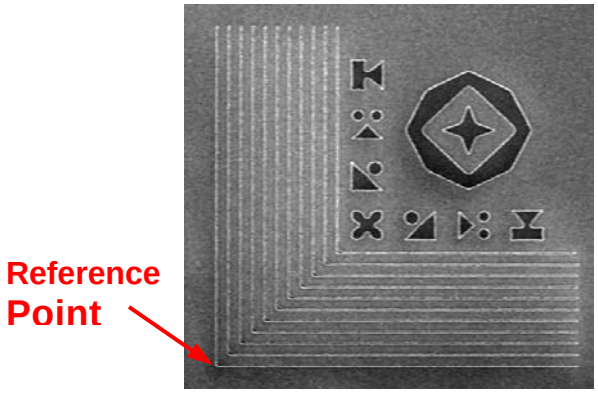


Figure 29 – A sample feature in "Lines Var P"

The layout for these features is shown in Fig. 30 below.

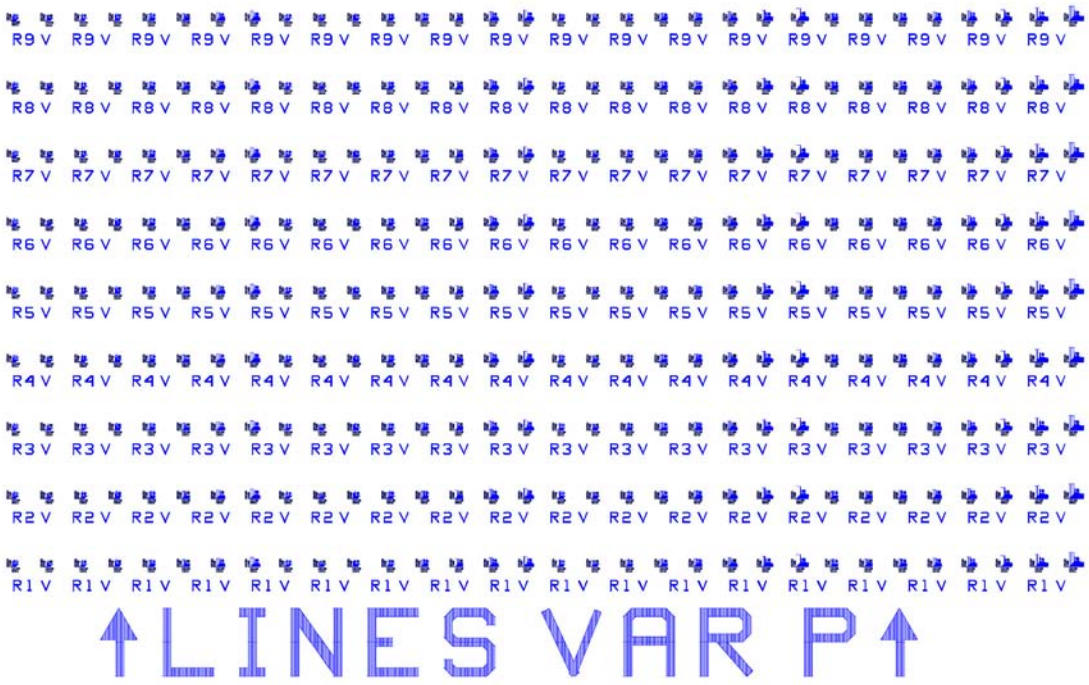


Figure 30 – Layout of Lines with Varying Pitch

There are 32 features in each row, arranged in four groups of eight each. Within each group, the lines are drawn on the mask with a constant width while spaces between the lines increase from one target to the neighboring target on its right. The coordinates of the features are given in the table on the next page. The coordinates are for the lower left corner of the dense lines as shown in Fig. 29, and are relative to the lower left corner of the sample. To obtain the coordinates relative to sample center, subtract 10,000 microns from each of the X and Y coordinates given in the table.

No.	Nominal Linewidth (µ)	Ratio, Space to Line	Feature Label Line 1	Feature Label Line 2	Lower Left Corner X (µ)	Lower Left Corner Y (µ)
1	0.12	1	**L 0.12**	**1:1**	**8140**	5565
2	0.12	1.1	**L 0.12**	**1:1.1**	**8190**	5565
3	0.12	1.2	**L 0.12**	**1:1.2**	**8240**	5565
4	0.12	1.4	**L 0.12**	**1:1.4**	**8290**	5565
5	0.12	1.7	**L 0.12**	**1:1.7**	**8340**	5565
6	0.12	2	**L 0.12**	**1:2**	**8390**	5565
7	0.12	2.5	**L 0.12**	**1:2.5**	**8440**	5565
8	0.12	3	**L 0.12**	**1:3**	**8490**	5565
9	0.13	1	**L 0.13**	**1:1**	**8540**	5565
10	0.13	1.1	**L 0.13**	**1:1.1**	**8590**	5565
11	0.13	1.2	**L 0.13**	**1:1.2**	**8640**	5565
12	0.13	1.4	**L 0.13**	**1:1.4**	**8690**	5565
13	0.13	1.7	**L 0.13**	**1:1.7**	**8740**	5565
14	0.13	2	**L 0.13**	**1:2**	**8790**	5565
15	0.13	2.5	**L 0.13**	**1:2.5**	**8840**	5565
16	0.13	3	**L 0.13**	**1:3**	**8890**	5565
17	0.15	1	**L 0.15**	**1:1**	**8940**	5565
18	0.15	1.1	**L 0.15**	**1:1.1**	**8990**	5565
19	0.15	1.2	**L 0.15**	**1:1.2**	**9040**	5565
20	0.15	1.4	**L 0.15**	**1:1.4**	**9090**	5565
21	0.15	1.7	**L 0.15**	**1:1.7**	**9140**	5565
22	0.15	2	**L 0.15**	**1:2**	**9190**	5565
23	0.15	2.5	**L 0.15**	**1:2.5**	**9240**	5565
24	0.15	3	**L 0.15**	**1:3**	**9290**	5565
25	0.18	1	**L 0.18**	**1:1**	**9340**	5565
26	0.18	1.1	**L 0.18**	**1:1.1**	**9390**	5565
27	0.18	1.2	**L 0.18**	**1:1.2**	**9440**	5565
28	0.18	1.4	**L 0.18**	**1:1.4**	**9490**	5565
29	0.18	1.7	**L 0.18**	**1:1.7**	**9540**	5565
30	0.18	2	**L 0.18**	**1:2**	**9590**	5565
31	0.18	2.5	**L 0.18**	**1:2.5**	**9640**	5565
32	0.18	3	**L 0.18**	**1:3**	**9690**	5565

Coordinates of reference points in “LINES VAR P” relative to sample corner

Structures are labeled for easy identification. The text includes drawn line width and nominal line to space ratio.

The reverse tone structures include spaces, contacts, and spaces with varying pitch. These features also appear in 9 identical rows grouped together in the same 5 mm by 5 mm square just above the positive tone features.

15. Distortion Targets

There are twelve sets of distortion targets that are suitable for calibration of relatively small fields of view, up to 640 by 480 microns. (There are other targets for calibration of larger fields of view up to 4 mm by 4 mm).

Each set of these distortion targets consists of 22 arrays of specific sizes. As examples, grid arrays are shown in the images in Fig. 31 below.

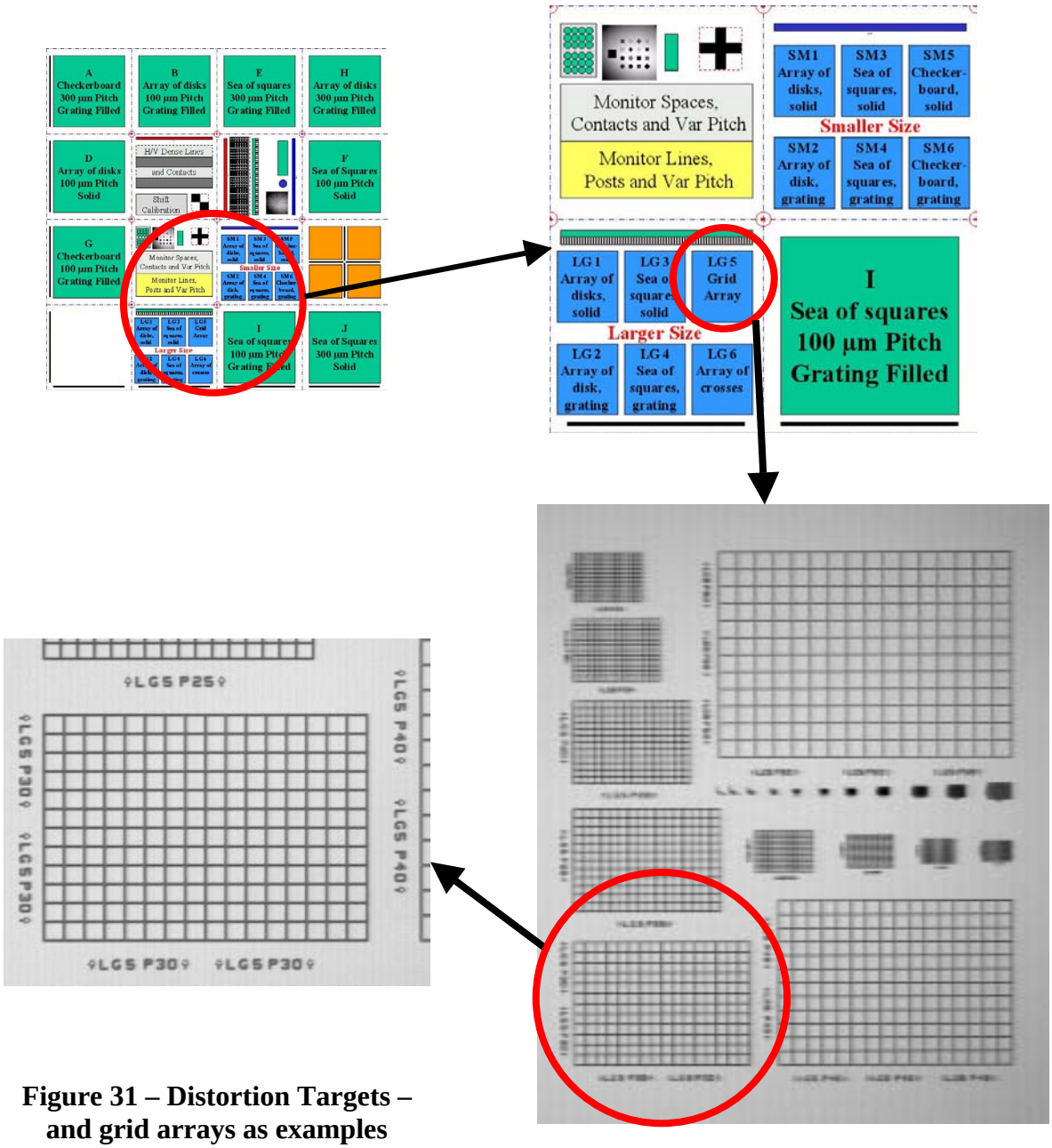
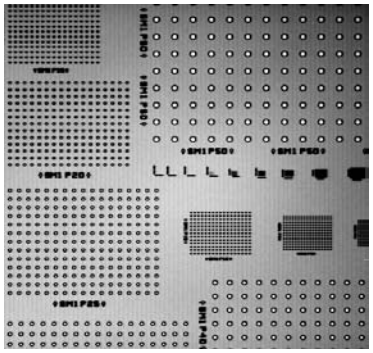
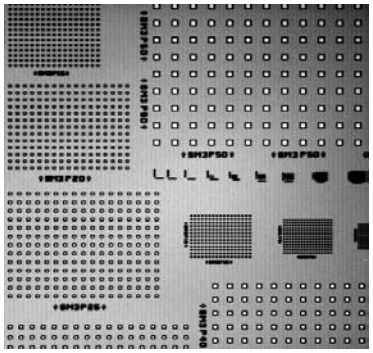


Figure 31 – Distortion Targets – and grid arrays as examples

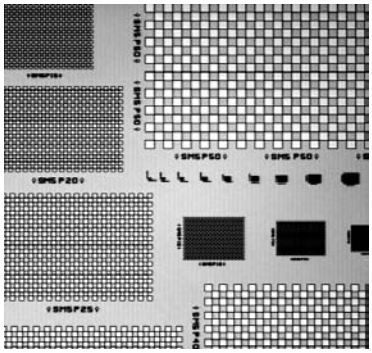
SM1

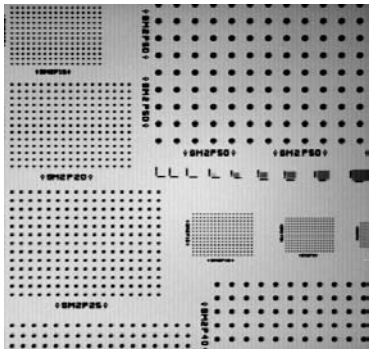


SM3

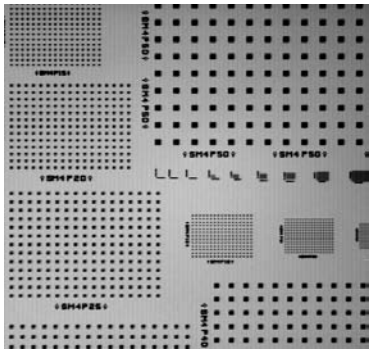


SM5

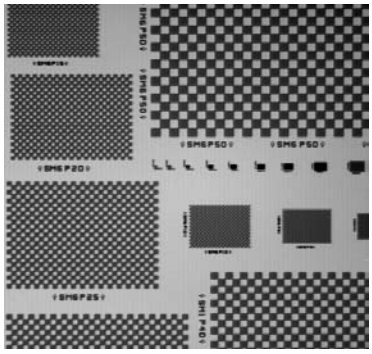




SM2

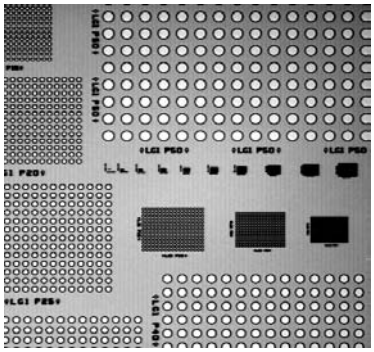


SM4

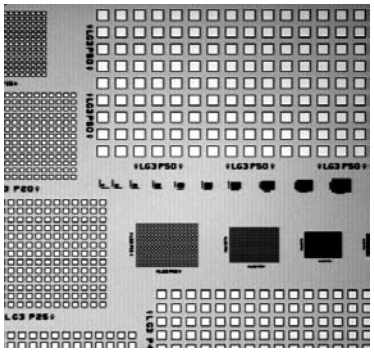


SM6

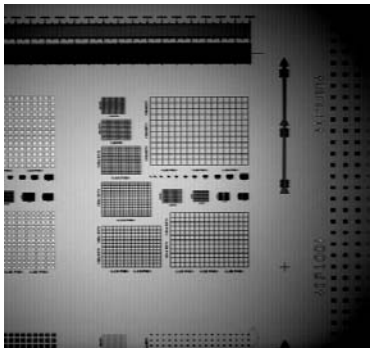
LG1

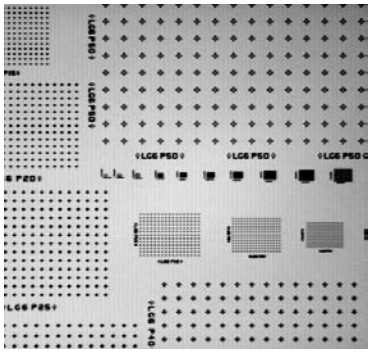


LG3



LG5





LG6

Figure 32 – Various Distortion Targets

The twelve sets of distortion targets are labeled as SM1 to SM6 and LG1 to LG6. A number of these targets are shown in Fig. 32. Each set consists of 22 arrays of features.

Each array consists of 17 features in X by 13 features in Y. The pitch in each array corresponds to feature-center-to-feature-center spacing, for example, the spacing between centers of disks. There are 22 arrays in each set. The array pitch for each set ranges from 0.4 micron to 50 microns. They are 50, 40, 30, 25, 20, 15, 12, 10, 8, 6, 5, 4, 3, 2.5, 2, 1.5, 1.2, 1, 0.8, 0.6, 0.5, and 0.4 microns. Note that due to the limitations of mask and printing optics, some of the smallest features do not print properly.

A number of features are filled with gratings. The gratings are vertical lines with 0.4 micron pitch (2500 cycles per mm) with approximately equal line and space.

SM1 – Arrays of dots (solid disks) – Dot size is less than half dot-to-dot spacing.

SM2 – Arrays of disks filled with gratings– Disk size is less than half pitch.

SM3 – Arrays of squares (solid) – Square size is less than half pitch.

SM4 – Arrays of squares filled with gratings– Square size is less than half pitch.

SM5 – Arrays of checkerboards (solid)

SM6 – Arrays of checkerboards filled with gratings.

LG1 – Arrays of dots (solid disks) – Dot size is greater than half dot-to-dot spacing.

LG2 – Arrays of disks filled with gratings– Disk size is greater than half pitch.

LG3 – Arrays of squares (solid) – Square size is greater than half pitch.

LG4 – Arrays of squares filled with gratings– Square size is greater than half pitch.

LG5 – Arrays of grids

LG6 – Arrays of crosses

16. Other Distortion Targets

There are other distortion targets as shown in the images in Fig. 33 below.

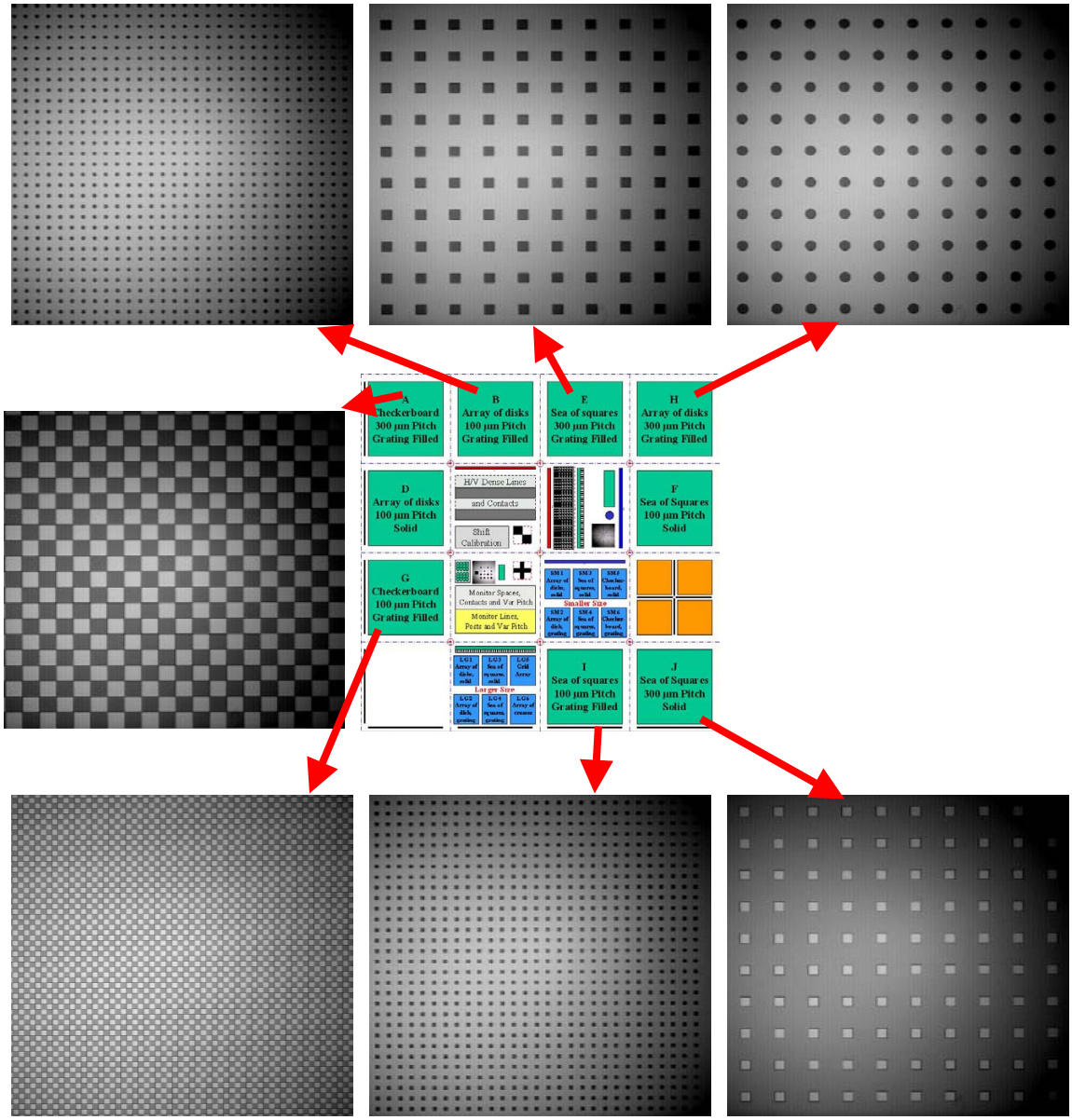


Figure 33 – Large Distortion Targets

Within this group, there are larger pitch (300 micron pitch) arrays suitable for calibrations of larger fields of view up to 4 mm. Other targets with 100 micron pitch cover the gap between these features and the set of features described earlier.

Fig. 34 shows checkerboard patterns at 100 micron and 300 micron pitch. The field of view in both images is about 3 mm.

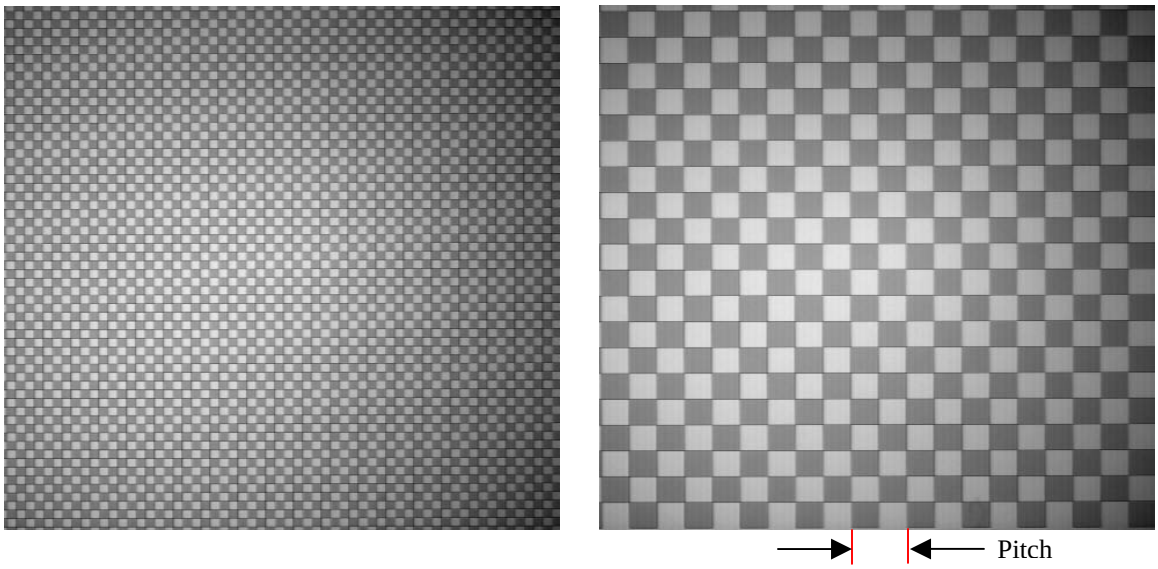


Figure 34 – Checkerboards

Some arrays consist of solid features (polysilicon) as shown on the left image below while features in other corresponding targets are filled with gratings at 0.4 micron pitch as shown on the right. The features with gratings will be darker in normal reflective mode as shown in Fig. 35 and will exhibit contrast in reflective imaging systems for almost any visible wavelength and illumination condition.

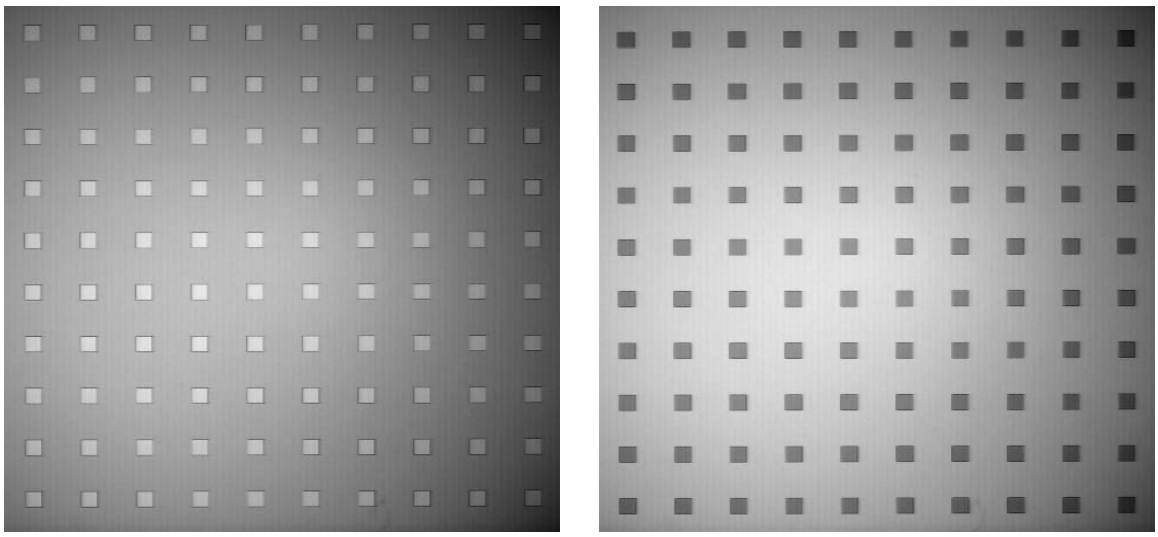


Figure 35 – Arrays of features: solid (left) and filled with grating (right)

17. Concentric Rings

MetroChip includes a set of concentric rings. These features are useful for stigmation and for verifying normal beam incidence angle.

There are 24 groups of targets as shown in Fig. 36 below. Each group of targets consists of a number of concentric rings placed in a matrix. The matrix of targets consists of 4 columns and six rows. From left column to the right, the number of rows and columns of concentric rings in each group is 40, 20, 10 and 5.

In the top three rows, the ring radius (center-to-center or edge-to-edge) increases by 0.15 micron per ring while in the bottom three rows, the increase in ring radius is 0.2 micron per ring.

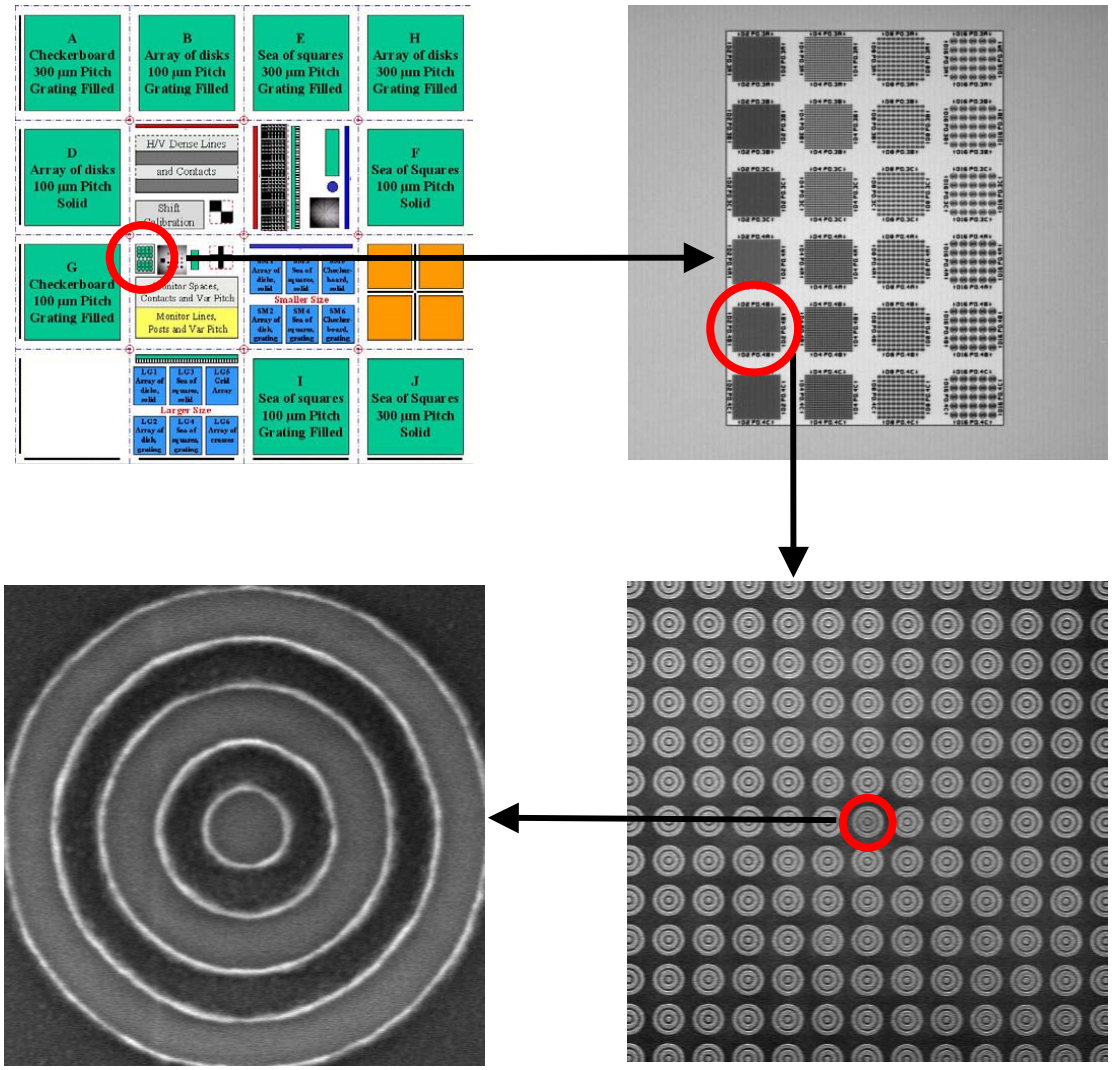


Figure 36 – Concentric rings and location within sample

18. Special Features

Fig. 37 shows a number of features that are useful for stigmation and other beam related calibrations. The approximate position of these marks relative to the sample center is shown in Fig. 38.

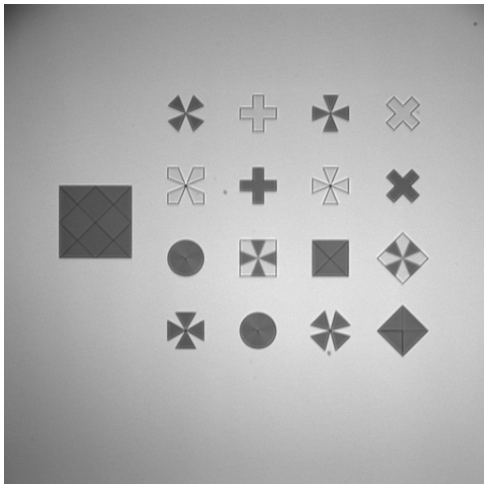


Figure 37. Special Features

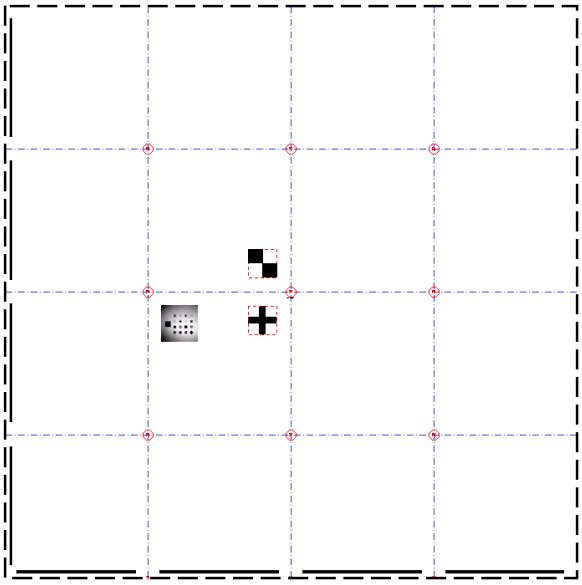
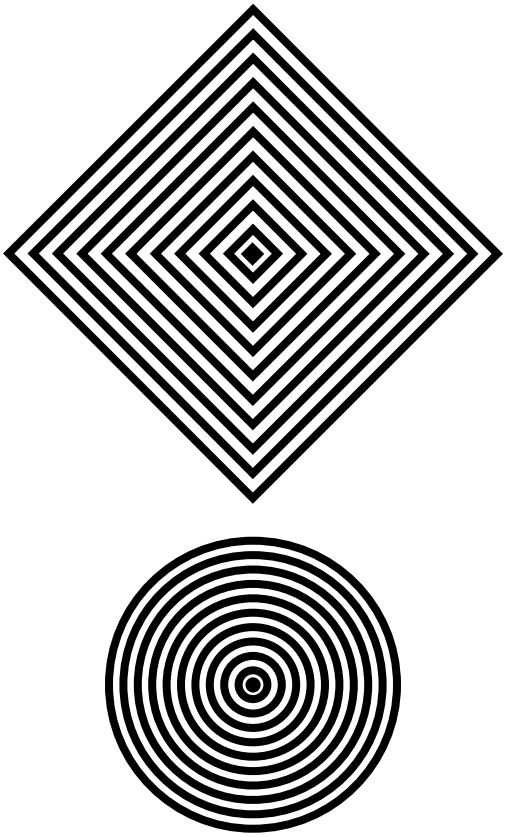


Figure 38. Position of Special Marks



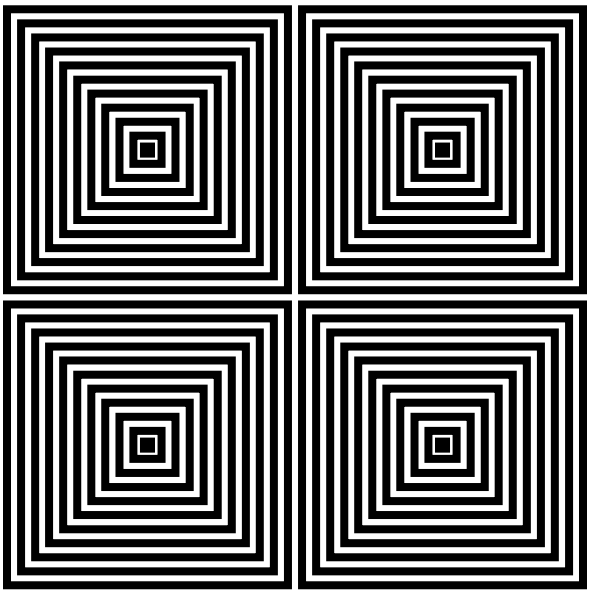


Figure 39. Three of the special shapes