isolated line — a clearfield, dark line as shown in Figure 2 (SYN: island).

Figure 2
Isolated Line

isolated space — A darkfield, clear line as shown in Figure 3 (SYN: window, trench, contact, opening).

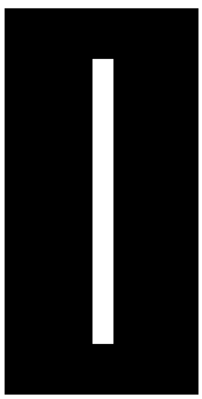


Figure 3
Isolated Space

2 Detail Specification

2.1 *Introduction*

2.1.1 This specification describes the pattern cells, which are illustrated in the figures at the end of this document. These cells are to be placed photolithographically or by other direct patterning methods onto wafer substrates at different masking levels during the IC manufacturing process.

2.1.2 Many details of the pattern cells, such as the orientation, magnitude, range of the linewidths, and polarity of tone (clearfield vs. darkfield) will be defined by the user, unless otherwise noted. When reporting results based on tests using these cells, details such as field polarity, orientation, and topographic considerations must be indicated.

2.1.3 All critical dimensions given in this document are the actual CAD values at 1X. For a given magnification, M, the target dimensions on the reticle should be exactly M times the dimension given in this specification. The reticle dimensions must not be sized to compensate for any wafer process-induced bias.

2.2 *Applications*

2.2.1 These cells are intended to be used in several applications. The following applications list some of the intended uses for the pattern cells.

2.2.1.1 *in-line process monitoring* — To establish patterns to determine if the layer has been processed to design specifications.

2.2.1.2 *process transfer* — To standardize the patterns for process monitoring within manufacturing fabrication sites and to facilitate process and technology transfers between sites.

2.2.1.3 *equipment evaluation* — To standardize the patterns used to evaluate semiconductor equipment.

2.2.1.4 *equipment characterization* — To standardize the patterns for the characterization process of different metrology equipment.

3 Guidelines for Applications

3.1 *General*

3.1.1 The cells described here represent a primary metrology set from which composite patterns may be constructed.

3.1.2 A composite pattern set meets this standard if it consists of any number of the basic cells described herein, provided all design rules for each cell are obeyed.

3.1.3 Each basic cell contains a fundamental design feature. This feature may be repeated at different (user-defined) dimensions within a modified metrology cell. The user will determine all appropriate dimensions for the feature as they apply to specific processing/equipment situations.

3.1.4 The figures provided within this document are intended to illustrate the proper layout of each pattern cell and to define the appropriate design elements used within each basic cell. The pattern cell dimensions are provided when appropriate.

3.1.5 All feature groups must be separated by at least five times the largest feature width. This proximity rule is defined in order to ensure that patterns intended to be independent are indeed non-coupled.

3.1.6 Labels, border lines, indicator marks, or any other adjacent feature will be separated by a minimum of 5 µm.

3.1.7 A label to indicate the nominal feature width must be placed near each basic cell, except the linearity cell, which has no user-defined features. The units of the CD labels must be micrometers and at least two significant figures must be used. The labels must be of a clearly printable size. Decimal points are optional. If decimal points are eliminated, digits to the left of the imaginary decimal point must be slightly larger than those digits to the right. Characters to the left of the decimal are optional. All CD labels that are printed with one size only will correspond to numbers less than 1.0 µm, and any number greater than 1.0 µm must contain at least one character to the right of the decimal place. If the cell includes a bias, a label to indicate this bias, including a "+" sign, must be placed near the basic cell. One significant figure may be used for bias labels if the bias is less than 1.0 µm and a multiple of 0.1 µm. (e.g., + 4 = + 0.4 µm).

3.1.8 It is recognized that there are design limitations dictated by the equipment used to generate the pattern (e.g., CAD grids, PG rectangles, E-beam spot sizes). It is permitted within this standard to modify these cells in order to meet these equipment limitations (e.g., stay on grid).

3.2 *Specific*

3.2.1 *L-Bar Cell* — (See Figure 4.)

3.2.1.1 The L-bar cell is designed to be a measurement site for isolated features as well as line and space groups in orthogonal axes. The cell can be used to measure the quality of pattern transfer and metrology of imaged features. The cell is also a qualitative visual test site for resolution of straight lines and lines bent at right angles.

3.2.1.2 The design elements are the nominal feature width, the inter-feature spacing, the minimum feature length, and the intergrouping linewidth difference (bias).

3.2.1.3 The basic cell consists of one or more groups of nested L-shaped lines at a specific pitch. The pitch is defined at twice the nominal feature width. (See Figure 5.)

W_0 = Nominal feature width

S = Interfeature spacing

L = Nominal feature length

W_0-W_1 = Intergrouping linewidth difference (bias)

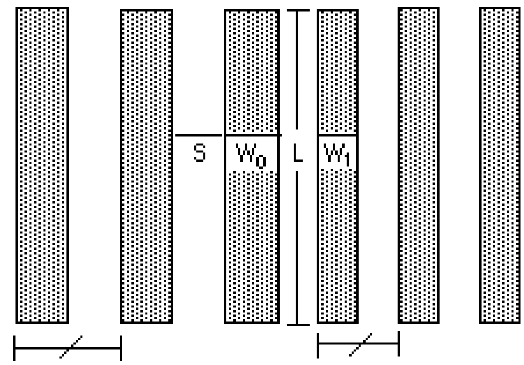


Figure 5

Table 1

Nominal Feature Width	*Number of Nested L-bars*	*Minimum Length*
>1 µm	3	10 W_0
≤1 µm	5	10 µm

The center L-bar of each group shall extend beyond the ends of the other L-bars by at least 10 µm. If these cells are to be used for cross-section analysis, the length of the L-bars may be designed considerably longer than the minimum length.

3.2.1.4 The L-bar basic cell consists of one, three, five, or seven feature groups. If the basic cell only consists of a single feature group, then the lines and spaces must both be equal to the nominal feature width. If the basic cell consists of three, five, or seven groups, then the groups are nested. For the middle group, the lines and spaces must both be equal to the nominal feature width. The feature widths in each successive feature group nested outside the middle group are incrementally increased by the bias. The feature widths in each successive feature group inside the middle group are incrementally decreased by the bias. The pitch for all L-bar groups within a basic cell must be held constant and equal to twice the nominal feature width.

3.2.2 *Straight-Line Cell* — (See Figure 6.)

3.2.2.1 The straight-line cell is a version of the L-bar cell, modified for tilted SEM inspection by removing the elbows.

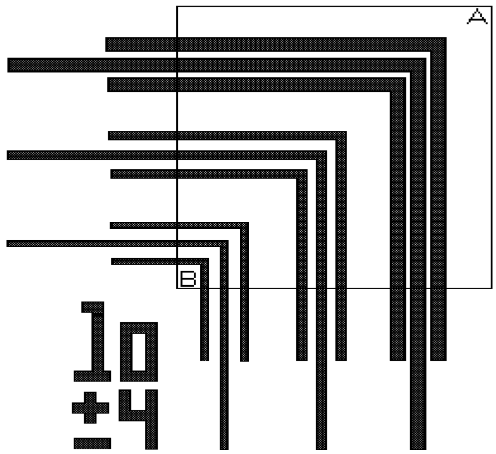


Figure 7
The square area, shown above, is removed to create straight-line cell.

3.2.2.2 To create the straight-line cell from the L-bar cell, the area removed will be a square defined by two diagonal corners referred to as "A" and "B" in Figure 7. Corner "A" is the outer edge of the outermost elbow. Corner "B" is a point inside the innermost elbow whose distance to the nearest edge is five times that of the smallest CD — or 5.0 µm if the smallest CD is less than 1.0 µm. This square area must remain unpatterned.

3.2.3 *Proximity Dagger Cell* — (See Figure 8.)

3.2.3.1 The proximity dagger cell is designed to provide information on the proximity effects of isolated lines/spaces in relation to large area blocks. This cell design allows clear and dark features to be measured simultaneously in one layout.

3.2.3.2 The design elements within the cell are the nominal feature linewidth, the nominal feature spacewidth, and the staircase stepwidth. The stepwidth is user-selected, but it is recommended to be at least 25% of the nominal feature pitch (i.e., pitch equals nominal linewidth plus nominal spacewidth).

3.2.3.3 The cell consists of a nine-tier staircase reproduced symmetrically in both clear and darkfields. A full description of the clearfield staircase (i.e., large chrome islands) is given. The same descriptions apply for the darkfield staircase except the polarities are reversed. Each tier is 10 microns tall. The full width of the cell is 40 microns and the full height is 180 microns. The first tier separates the nominal feature width symmetrically from the large chrome islands by an amount equal to the nominal width. Tiers 2–7 are successively wider by the indicated bias. The 8th and 9th tiers will be 5 and 10 times the nominal feature width respectively.

3.2.4 *Contact Array Cell* — (See Figure 9.)

3.2.4.1 The contact array cell is designed to provide resolution and proximity-effect information over a wide range of contact sizes.

3.2.4.2 The design elements are the nominal square contact dimension, the inter-contact dimension within the 5 × 5 and the 3 × 3 arrays. The latter dimension will be equal to the contact dimension.

3.2.4.3 The contact array cell will consist of three subgroups: a 5 × 5 contact array, a 3 × 3 contact array, and an isolated contact. The 5 × 5 array will produce the maximal proximity (i.e., dense printing) for the center contact. The center contact in the 3 × 3 array will exhibit proximal printing effects different from both the isolated contact and the dense contact.

3.2.5 *Staggered Contact Array* — (See Figure 10.)

3.2.5.1 The staggered contact array cell is designed to improve the probability of cross-sectioning small contacts for SEM metrology analysis.

3.2.5.2 The design elements are the square contact dimension, the column-to-column vertical offset — or staggering — and the contact-to-contact spacing. The contact-to-contact spacing will be equal to the square contact dimension.

3.2.5.3 The contacts are laid out using a minimum of three columns of contacts. The user-selected offset between columns should allow the contacts to remain on grid.

3.2.5.4 The lines (or spaces) shown on the left side of Figure 10 are optional. They have been placed to provide feature identification of pitch calibration. If the widths are to be submicron, 5 lines (or spaces) instead of 3 will be required.

3.2.6 *Linearity Cell* — (See Figure 11.)

3.2.6.1 The linearity cell is designed to test (1) the linearity of the measurement method, assuming the lithographical process is linear over all line sizes used, or (2) the linearity of the process, assuming that the metrological method is linear over all line sizes used.

3.2.6.2 The design elements of this cell are the linewidths, the interfeature spacing, and the minimum line lengths. Unlike the other cells, its elements are not adjusted to a nominal critical dimension, but rather are numerically specified as constants for all applications.

3.2.6.3 The cell consists of nine parallel lines, placed on a five-micron pitch. The linewidths are 1.2, 1.1, 1.0, 0.9, 0.8, 0.7, 0.6, 0.5, and 0.4 microns. The line lengths are a minimum of ten microns. A two-micron top and bottom border (running orthogonal to the parallel lines, across the ends) is provided on the array to allow recognition of the cell as a unit.

3.2.7 *Electrical Cell* — (See Figure 12.)

3.2.7.1 The electrical cell is designed to provide very precise and relatively fast determinations of the average linewidth of a conductive film using an automated test system, but can also be used with a manual prober.

3.2.7.2 The design elements of this cell are the bridge resistor linewidth, W_b, the center-of-tap to center-of-tap bridge length, L_b, the sheet and bridge tap widths, W_c and W_t, the sheet and bridge tap lengths, L_c and L_t, the extension of the bridge resistor line to the nearest discontinuity in that line, L_e, and the size of the square sheet will be 35 – 100 µm. See Figure 13 for the labeling of these elements. The rules for these elements are as follows:

$W_t \leq W_b$ (for $L_b < 100\ W_b$)	(1)
$W_t \leq 1.2{*}W_b$ (for $L_b \geq 100\ W_b$ and W	(2)
$L_b \geq 15W_b$ for 80 µm, whichever is larger)	(3)
$L_t > 2W_t$	(4)
$L_e > 2W_b$	(5)
$L_c > 2W_c$	(6)

3.2.7.3 The cell consists of two types of four-point Kelvin structures: a van der Pauw sheet resistor and one or more bridge resisitors. The orientation of the individual bridge resistors is user-defined. The bridge resisitors also can be surrounded by dummy lines to measure the process bias due to proximity effect. On structures containing the dummy lines, the interconnects will hook up to the bridge resistor in a perpendicular fashion, as shown in Figure 14.

3.2.7.4 The pad labeled with a V in Figures 13 and 15 will be used for voltage measurement only, and will be used as the fourth point in the sheet resistivity measurements that will be used to make the linewidth determination.

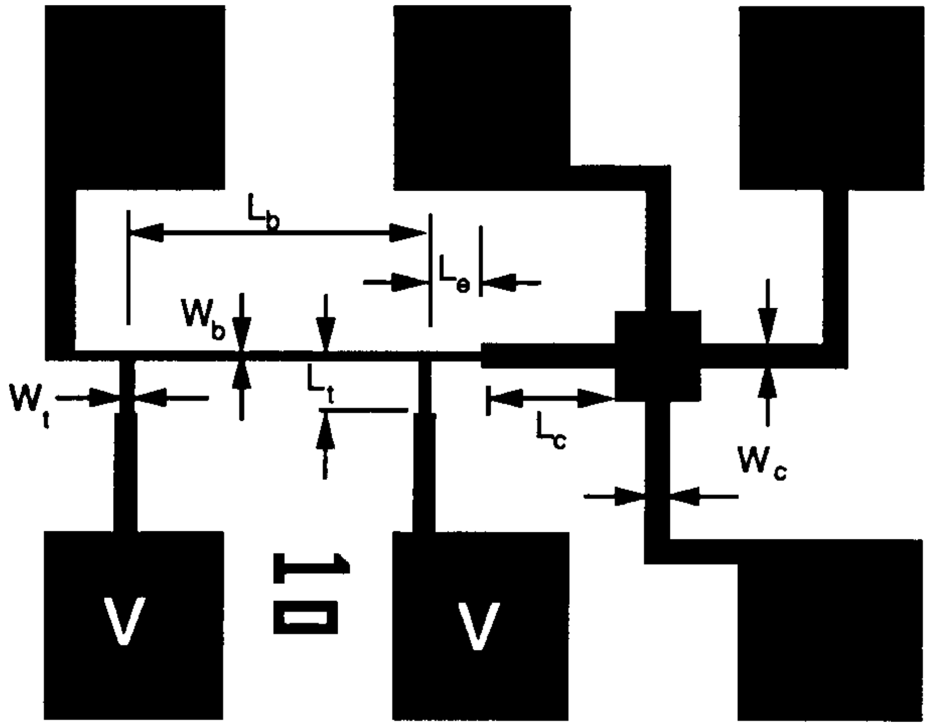


Figure 13
Electrical Cell, 2 × n Configuration with Labeling

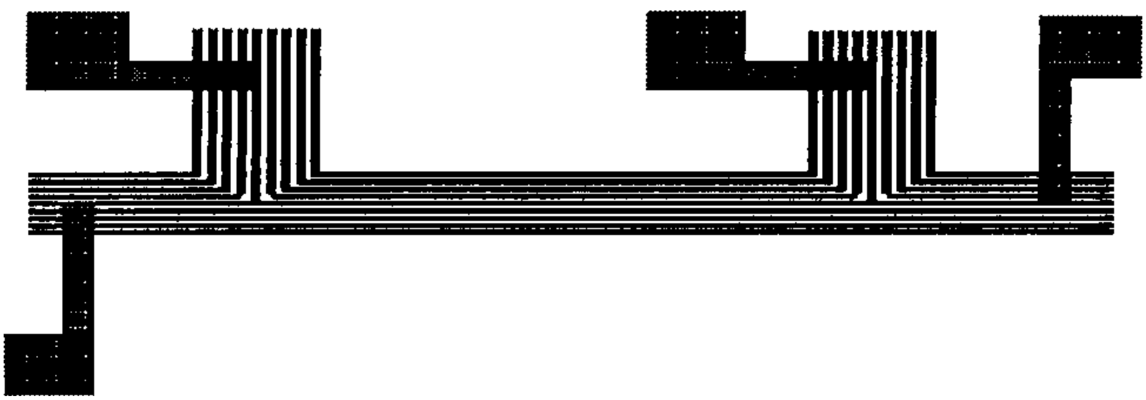


Figure 14
Blow-Up of Bridge Resistor with Proximity Lines

3.2.7.5 The pads can be arranged in a 1 × n layout for scribeline placement (see Figure 15), or the conventional 2 × n layout can be used if the spatial constraints are minimal. Pad size and pitch are user-defined. For automatic testing in a production environment, it is recommended that the pads be 80 – 100 mm per side.

3.3 *User Considerations*

3.3.1 *Target CD versus Resolved CD*

3.3.1.1 The desired size of a critical dimension (CD) on an integrated circuit can be considered its nominal value and is herein designated the “target CD.” The size actually achieved (resolved CD) on the circuit may be different from this nominal value.

3.3.1.2 Measurements of the resolved CD may not be accurate because of the difficulty in determining the actual location of the edge in the optical or SEM image profile.

3.3.1.3 Even if inaccurate, measurement of the resolved CD can be valuable for comparison purposes if the measurement method has adequate precision and sensitivity to detect the dimensional changes of interest.

3.3.1.4 The traditional definition of resolution may not be adequate (e.g., ability to distinguish closely spaced points) for specifying the sensitivity to small dimensional changes.

4 References

4.1 Yen, D., Linholm, L.W., and Buehler, M.G., “A Cross-Bridge Test Structure for Evaluating the Linewidth Uniformity of an Integrated Circuit Lithography System,” J. Electrochemical Society 1_2_9_ (1982), 2313.

4.2 Hasan, T.F., Perloff, D.S., and Mallory, C.L., “Test Structures for the Measurement and Analysis of VLSI Lithographic and Etching Parameters”, Semiconductor Silicon/1981, H.R. Huff, R.J. Kriegler and Y. Takeishi Eds., (Electrochemical Society, Pennington, NJ) 1981, 866.

4.3 Carver, G.P., Mattis, R.L., and Buehler, M.G., “Design Considerations for the Cross-Bridge Sheet Resistor,” NBSIR 82-2548, National Bureau of Standards, Washington, DC, (1982).

4.4 Buehler, M.G., Hershey, C.W., “The Split-Cross-Bridge Resistor for Measuring the Sheet Resistance, Linewidth, and Line Spacing of Conducting Layers,” IEEE Transactions on Electron Devices, (1986), 1572.

4.5 Lin, Burn J., “Proximity and Astigmatism Tolerant Testsites for Electrical Linewidth Measurement,” SPIE Proc., Vol. – (1989).

Figure 15
Electrical Cell, 1 × n Configuration

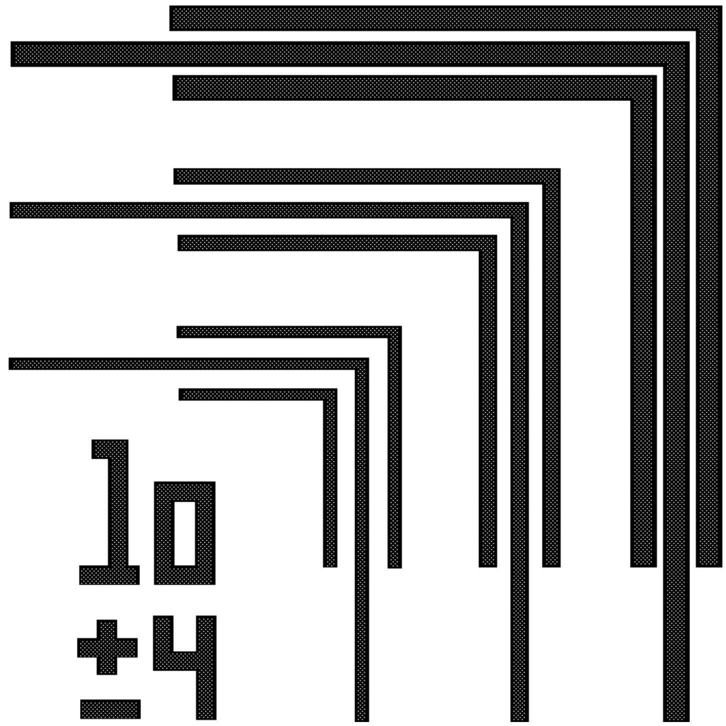


Figure 4
L-Bar Cell

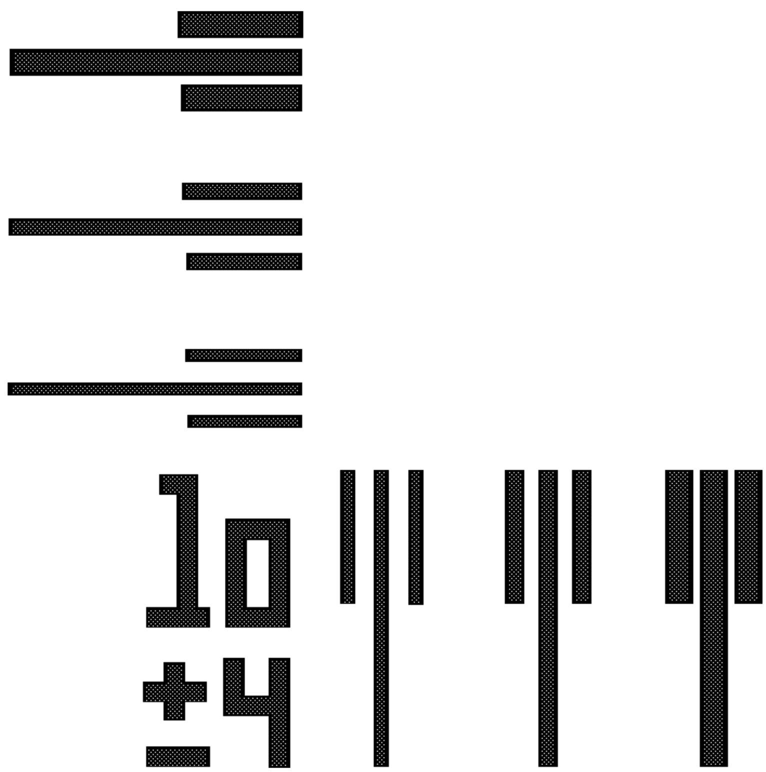


Figure 6
Straight Line Cell

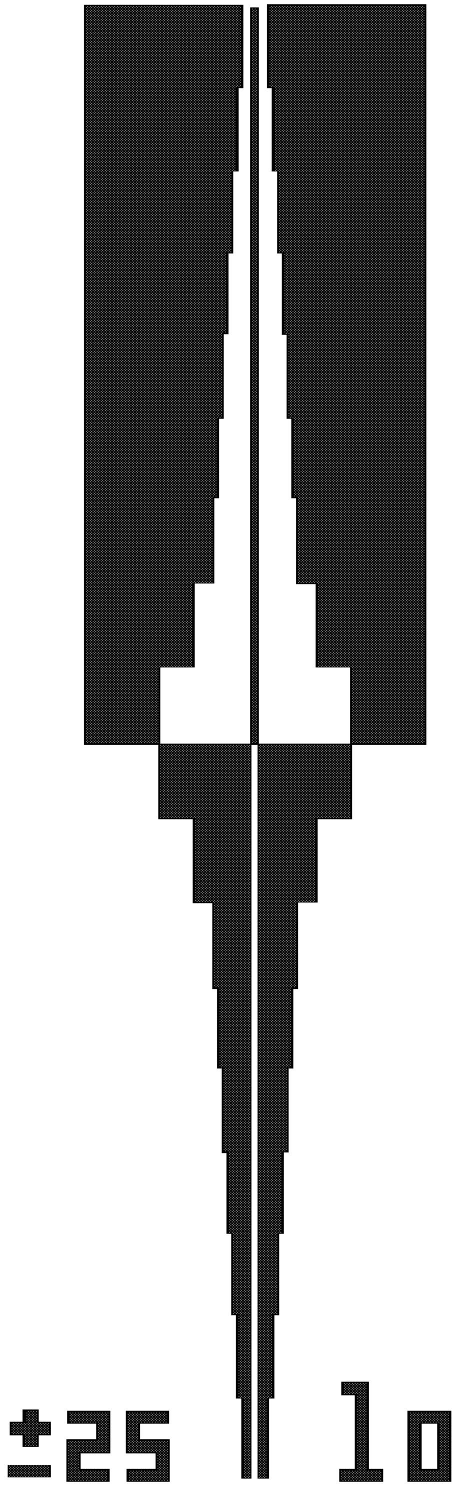


Figure 8
Proximity Dagger Cell

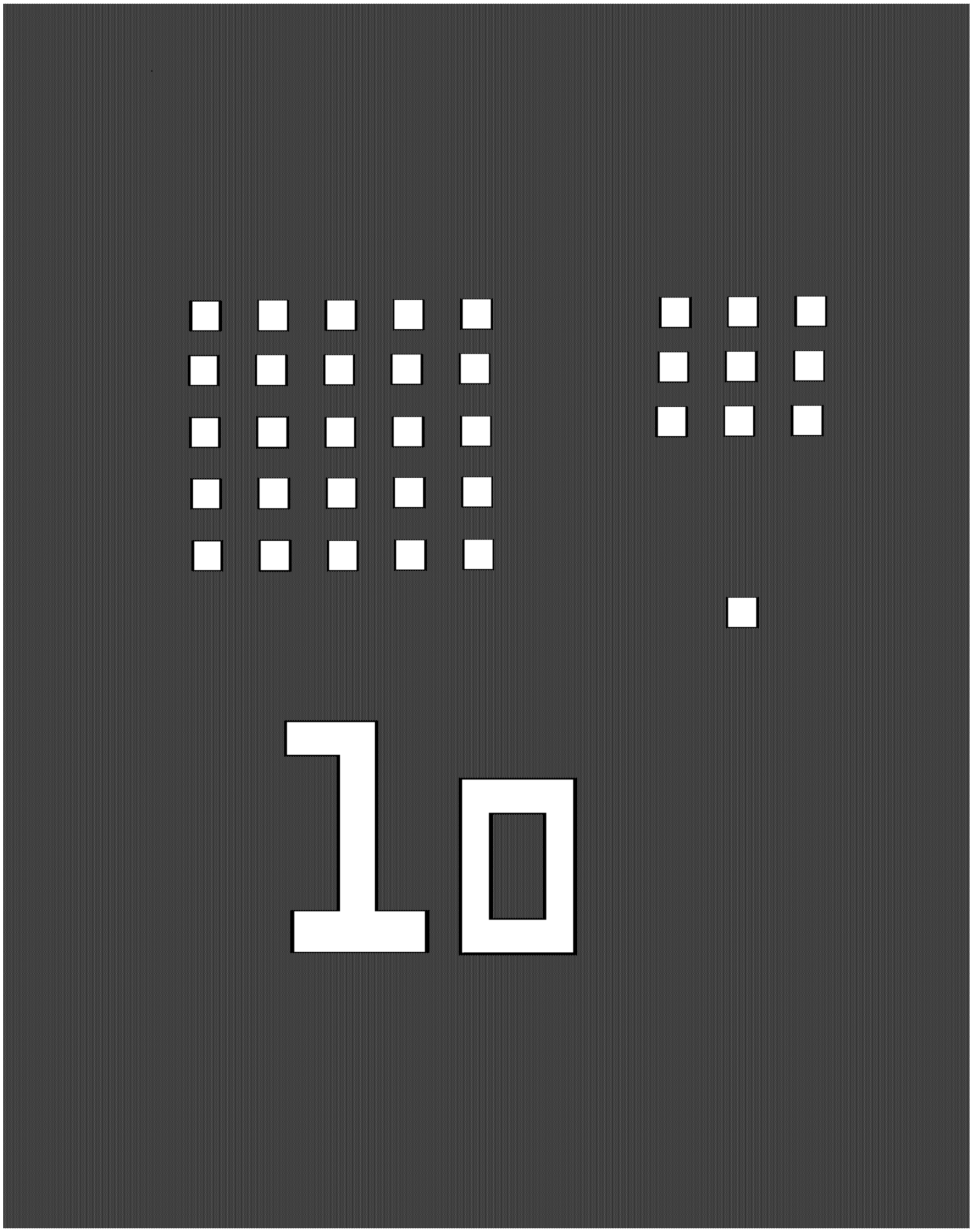


Figure 9
Contact Array Cell

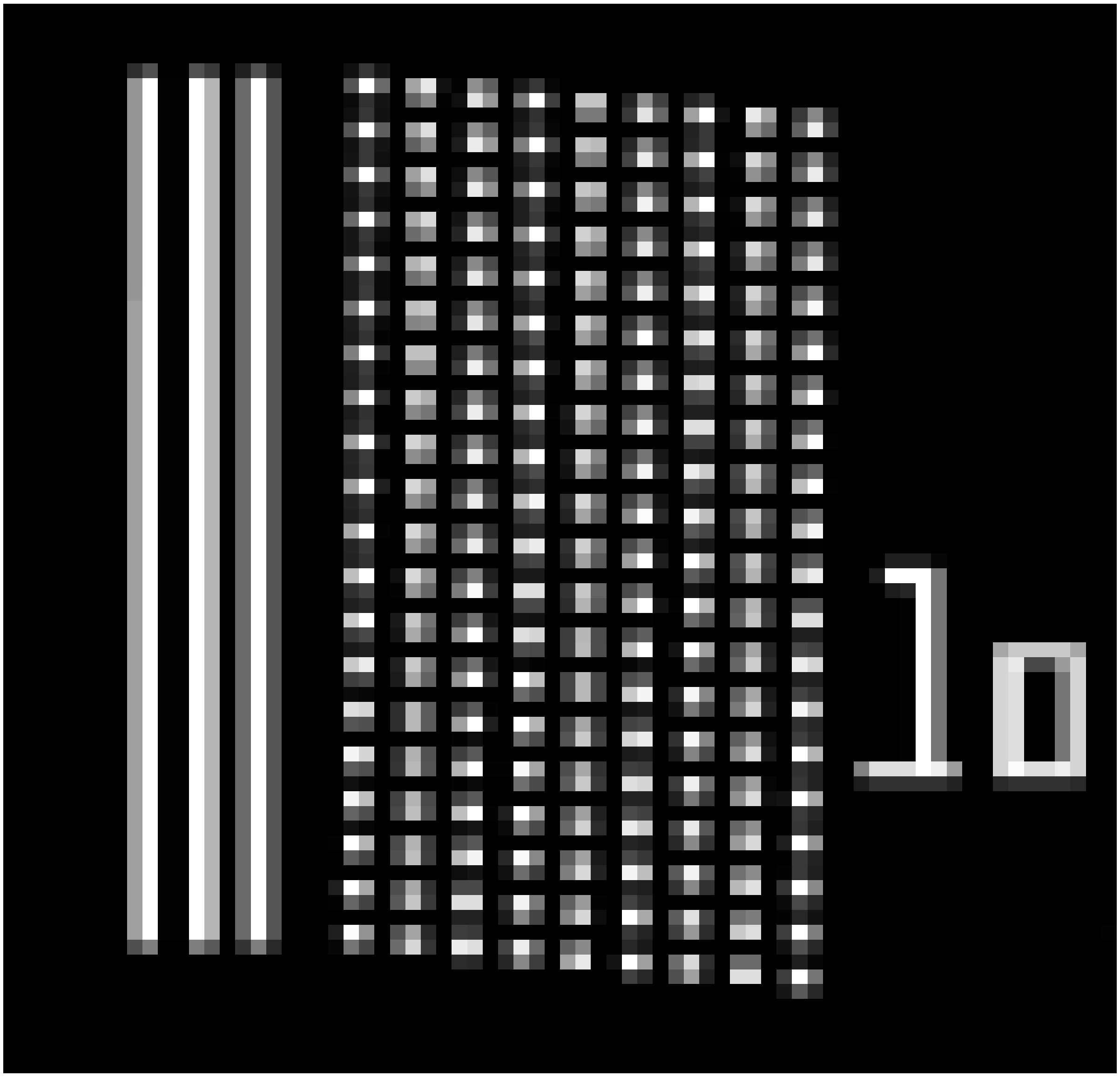


Figure 10
Staggered Contact Array

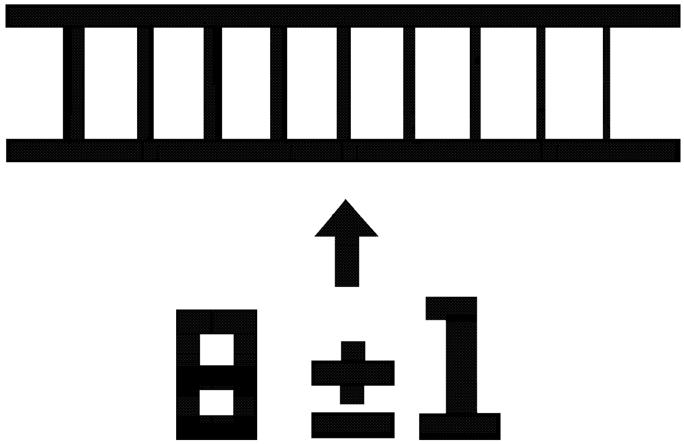


Figure 11
Linearity Cell

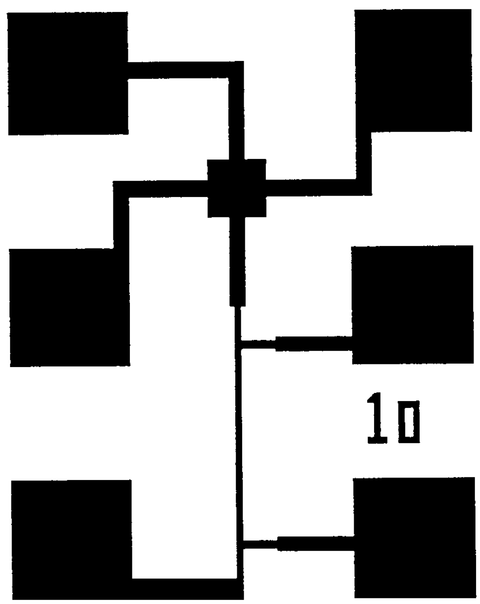


Figure 12
Electrical Cell, 2 × n Configuration

NOTICE: These standards do not purport to address safety issues, if any, associated with their use. It is the responsibility of the user of these standards to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. SEMI makes no warranties or representations as to the suitability of the standards set forth herein for any particular application. The determination of the suitability of the standard is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These standards are subject to change without notice.

The user's attention is called to the possibility that compliance with this standard may require use of copyrighted material or of an invention covered by patent rights. By publication of this standard, SEMI takes no position respecting the validity of any patent rights or copyrights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of any such patent rights or copyrights, and the risk of infringement of such rights, are entirely their own responsibility.

SEMI P20-0703
GUIDELINE FOR CATALOG PUBLICATION OF EB RESIST PARAMETERS (PROPOSAL)

This guideline was technically approved by the Global Micropatterning Committee and is the direct responsibility of the Japanese Micropatterning Committee. Current edition approved by the Japanese Regional Standards Committee on April 28, 2003. Initially available at www.semi.org June 2003; to be published July 2003. Originally published in 1992.

1 Purpose

1.1 The purpose of this guideline is to provide a baseline for publications of EB resist parameters. It can also be used as a guide to evaluate resist process parameters. This guideline is intended to be applicable for electron beam processes.

1.2 The parameters for EB Resist publication are discussed below.

2 Scope

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 Resist Commercial Name

3.1 Describe resist commercial name.

4 Resist Properties

4.1 *Polymer Properties*

4.1.1 *Components* — Describe resist components. Chemical structure is not necessarily required.

4.1.2 *Molecular Weight* — Describe M_w, Mn and M_w/Mn if known.

4.1.3 *Thermal Characteristics* — Describe Tg and Tm.

4.2 *Resist Solution Properties*

4.2.1 *Solvent* — Specify chemical names.

4.2.2 *Viscosity* — Solution viscosity, mPa·s, 25°C.

4.2.3 *Solid Content* — Weight %.

5 Film Forming Properties

5.1 *Thickness Curves* — Plot film thickness T (µm or nm) after prebake versus spinning speed R (rpm). Here, x axis is log (R) and y axis is log (T).

5.2 *Conditions* — Specify following conditions.

5.2.1 *Substrate* — Silicon wafer or chrome mask blank. Specify its structure.

5.2.2 *Spinning Conditions* — Specify spinning conditions including coating sequence.

5.2.3 *Environmental Conditions* — Temperature (°C), relative humidity (%).

5.2.4 *Prebake Conditions* — Prebaking temperature (°C), time (sec), heating and cooling method and apparatus. Specify heating rate and cooling rate if monitored.

5.2.5 *Thickness Measurement Methods* — Thickness measurement instruments and measurement method. In case of a light interferance thickness measurement apparatus, specify the refractive index as a parameter used in the measurement.

6 Film Thicknesses

6.1 Defines resist thicknesses and measurement conditions for resist parameter descriptions in and after Section 10. Unit is µm or nm.

6.1.1 *Film Thickness Definitions*

6.1.1.1 *Ti* — Initial thickness after prebake prior to exposure.

6.1.1.2 *Te* — Exposed region thickness after development.

6.1.1.3 *Tu* — Unexposed region thickness after development, and after postbake if required.

6.1.1.4 *NTe* — Te/Ti. Normalized exposed region thickness.

6.1.1.5 *NTu* — Tu/Ti. Normalized unexposed region thickness.

6.1.2 *Thickness Measurement Conditions* — Thickness measurement conditions should be the same as described in Section 5.2.5. In case of measurements of exposed region thickness, exposed region area should be larger than 20 µm on all sides.

7 Sample Preparation

7.1 Defines sample preparation methods for resist parameter descriptions in and after Section 10.

7.1.1 *Film Thickness* — Ti. 0.50 ± 0.02 µm (500 ± 20 nm) is recommended for a standard thickness.

7.1.2 *Conditions* — Specify conditions described in Sections 5.2.1 to 5.2.4.

8 Exposure

8.1 Defines exposure condition description methods for resist parameter descriptions in and after Section 10.

8.1.1 *Exposure Dosage Definition* — Quantity of electrical charge per unit area, $\mu C/cm^2$. Describe as D.

8.1.2 *Exposure Dosage Calculation* — Calculate as follows.

$$D = I \times t/S \times 10^6$$

Here, I is current (A), t is exposure time (s), S is exposure area (cm^2).

Specify these parameters.

8.1.3 *Acceleration Voltage* — In a range from 10 to 50 kV.

8.1.4 *Exposure System* — Specify exposure methods.

8.1.4.1 *Beam Scanning Methods* — For example, raster scanning or vector scanning. Specify beam scanning pitch if defined.

8.1.4.2 *Beam Shape* — Describe beam shape.

8.1.4.3 *Beam Conditions* — Specify beam size (µm or nm) and current density (A/cm^2), if possible.

8.1.4.4 *Exposure Tool Manufacturer and System Name* — Specify exposure tool manufacturer and system name, if possible.

9 Processing and Developing Parameters

9.1 This section defines process condition descriptions in and after Section 10.

9.1.1 *Post Exposure Treatments* — Describe if any treatment is processed after exposure before development.

9.1.1.1 *Methods* — For example, post exposure bake.

9.1.1.2 *Conditions* — For example, treatment conditions such as temperature (°C), time (s), atmosphere, heating method, cooling method and apparatus. Specify heating rate and cooling rate if monitored.

9.1.2 Developing Parameters

9.1.2.1 *Methods* — Specify spray, dip, or puddle.

9.1.2.2 *Solution Components* — Specify name of developer and rinse. (Chemical names and weight percent if possible.)

9.1.2.3 *Temperature* — °C

- For spray, bulk temperature. Processing chamber atmospheric temperature if monitored.
- For dip, solution temperature.
- For puddle, bulk temperature. Processing chamber atmospheric temperature and substrate temperature if monitored.

9.1.2.4 *Time* — sec.

9.1.2.5 *Relative Humidity* — %.

9.1.2.6 *Additional Processes* — Specify if applied.

9.1.3 *Post bake*

9.1.3.1 *Conditions* — Temperature (°C), time (s), heating method, cooling method, and apparatus. Specify heating rate and cooling rate if monitored.

9.1.3.2 Describe treatment conditions before or after post baking, if applied.

10 Sensitivity Curves

10.1 *Curve Plotting* — Plot NTe as a function of D. Here, x axis is log (D), y axis is NTe.

10.2 *Exposure Dosage Range*

10.2.1 *Positive Resist* — Include dosages larger than a dose gives NTe of 0.

10.2.2 *Negative Resist* — Include dosages larger than a dose gives NTe of 0.7.

11 Sensitivity

11.1 A dose required to form a pattern larger than 20 µm on all sides.

11.1.1 *Positive Resist* — Describe as Dp^0. It gives NTe of 0.

11.1.2 *Negative Resist* — Describe as $Dn^{0.5}$. It gives NTe of 0.5.

12 Contrast

12.1 *Contrast Definition* — Describe as γ. Calculate from a slope of resist sensitivity curve.

12.2 *Positive Resist (Figure 1)* — Calculate using an angle given from a solid line between NTe of 0 and NTe of 0.8 and a solid line parallel to x axis. Here, NTu should be larger than 0.9.

$$\gamma_p^{\,0-0.8} = \tan\theta = y/x = 0.8/\log\,(Dp^0/Dp^{0.8})$$

12.3 *Negative Resist (Figure 2)* — Calculate using an angle given from a solid line between NTe of 0.5 and NTe of 0.7 and a solid line parallel to x axis.

$$\gamma_p^{0.5-0.7} = \tan\theta = y/x = 0.2/\log(Dn^{0.7}/Dn^{0.5})$$

13 Resolution

13.1 *Pattern Type and Feature Size* — Lines and spaces. Ratio of lines and spaces should be 1:1. Add hole pattern and isolated pattern if possible.

13.2 *Conditions* — Specify conditions in Sections 7, 8, and 9.

13.3 *Measurement Method* — Measure resolutions using a scanning electron microscope.

14 Nominal Exposure Dosage

14.1 *Nominal Exposure Dosage Definition* — A dose which gives lines and spaces of 3 µm at a ratio of 1:1 under conditions described in Sections 7, 8, and 9.

15 Others

15.1 Describe following items if known.

15.1.1 *Durability* — Wet etching, dry etching.

15.1.2 *Stability* — Shelf stability, spun film stability, post exposure stability, and post processing stability.

15.1.3 *Removability* — Describe resist removing method after processing.

15.1.4 *Remarks* — Describe special characteristics of the EB resist.

15.1.5 *Cautions* — Describe cautions for safety.

(Reference) G.N. Taylor, Solid State Technology, June (1984) 105.

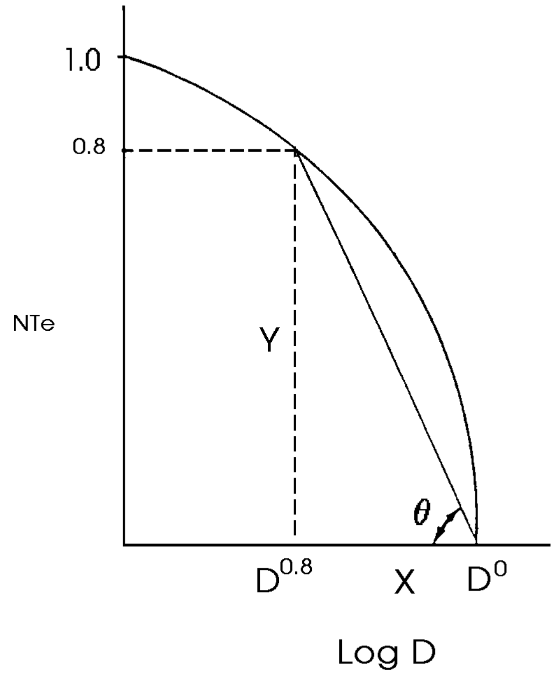


Figure 1
Positive Sensitivity Curve

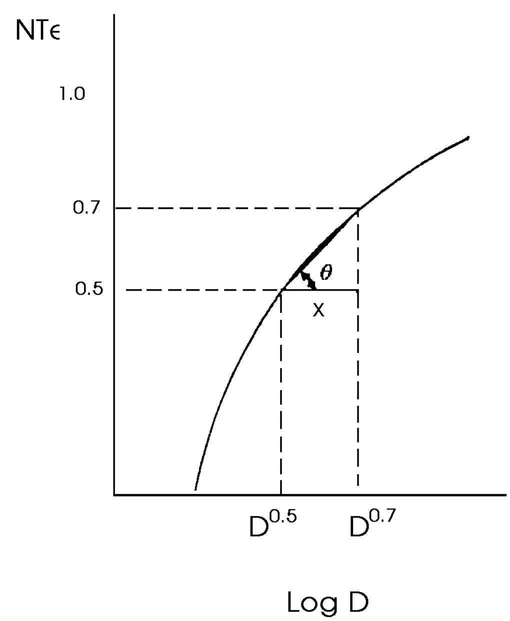


Figure 2
Negative Sensitivity Curve

NOTICE: SEMI makes no warranties or representations as to the suitability of the standards set forth herein for any particular application. The determination of the suitability of the standard is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These standards are subject to change without notice.

The user's attention is called to the possibility that compliance with this standard may require use of copyrighted material or of an invention covered by patent rights. By publication of this standard, SEMI takes no position respecting the validity of any patent rights or copyrights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of any such patent rights or copyrights, and the risk of infringement of such rights, are entirely their own responsibility.

SEMI P21-92 (Reapproved 0703)
GUIDELINES FOR PRECISION AND ACCURACY EXPRESSION FOR MASK WRITING EQUIPMENT

This guideline was technically approved by the Global Micropatterning Committee and is the direct responsibility of the Japanese Micropatterning Committee. Current edition approved by the Japanese Regional Standards Committee on April 28, 2003. Initially available at www.semi.org June 2003; to be published July 2003. Originally published in 1992.

1 Purpose

1.1 This guideline describes general requirements concerning precision and accuracy expression of mask writing equipment. Writing accuracy of the mask writing equipment is evaluated by measuring a written mask and is affected greatly by process conditions to be carried out. Therefore, the writing conditions are to be agreed upon by the user and supplier.

2 Scope

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 Precision and Accuracy Expression Items, Definitions, Measurement, and Requirements

3.1 *Minimum Pattern*

3.1.1 *Definition*

- The minimum line and space pattern and minimum pattern which is possible to be separated.

3.1.2 *Expression*

- SEM photograph

3.1.3 *Measurement*

- SEM photograph of the resist pattern or the chrome pattern.

3.2 *Pattern Dimension Precision and Accuracy*

3.2.1 *Definition*

- Critical Dimension (CD) variation and deviation of written pattern from designed value.

3.2.2 *Expression*

- Deviation of measured mean value to design value (Δl:µm) and variations (3 σ:µm).
- Measured area and number of sampling point should be clearly described.

3.2.3 *Measurement*

- Optical CD measurement
- Electron beam CD measurement
- CD measurement done by self-diagnostic feature of writing equipment.

3.2.4 *Requirement*

- Width of a long line pattern in X and Y direction should be measured.
- Pattern types are isolated pattern; 1:1 line and space pattern or 1:2 line and space pattern.
- The line width to be measured is not specified, but at least three different line widths should be measured.
- Examples of patterns are shown in Figures 1 and 2.

3.3 *Overlay Accuracy*

3.3.1 *Definition*

- Relative deviation of pattern position between two masks.

3.3.2 *Expression*

- 3σ:µm (X and Y direction separately)
- Measured area and number of sampling points should be clearly described.

3.3.3 *Measurement*

- Optical coordinates measurement
- Electron beam coordinates measurement
- Coordinates measurement done by self-diagnostic feature of writing equipment.

3.3.4 *Requirement*

- The pattern should be cross or L mark. Uniform rotation error in measurement should be subtracted from the measurement result.
- Overlay accuracy between different cassette should be clearly described. An example of a pattern is shown in Figure 3.

3.4 *Pattern Stitching Accuracy*

3.4.1 *Definition*

- Position errors at the stitching boundary of writing fields, stripes, and shots.

3.4.2 *Expression*

- |average value| 1 + 3 σμm (X and Y direction separately) measured area and number of sampling points should be clearly described.

3.4.3 *Measurement*

- Optical coordinates measurement
- Electron beam coordinate measurement
- Coordinates measurement done by self-diagnostic feature of writing equipment.
- Vernier measurement
- Boundary measurement by SEM image

3.4.4 *Requirement*

- The pattern should be cross or L marks in both sides adjacent to the stitching boundary for coordinate measurement.
- When the optical microscope is used for measurement, the vernier pattern should be used.

4 Notice

4.1 The following subjects should be agreed upon beforehand between users and makers in order to evaluate the above-mentioned writing precision and accuracy item.

4.1.1 Process Requirements

- Resist Materials
- Coating Condition
- Development Condition
- Process Sequence
- Mask Substrate and Chrome Thin Film Materials

4.1.2 Test Pattern

4.1.3 Measurement Procedure

5 Others

5.1 The following items are not specified in these guidelines, still it is preferable that these items are agreed upon beforehand between user and supplier.

5.1.1 Pattern coordinates

5.1.2 Pattern position accuracy

5.1.3 Long-term stability of accuracy

5.1.4 Particles

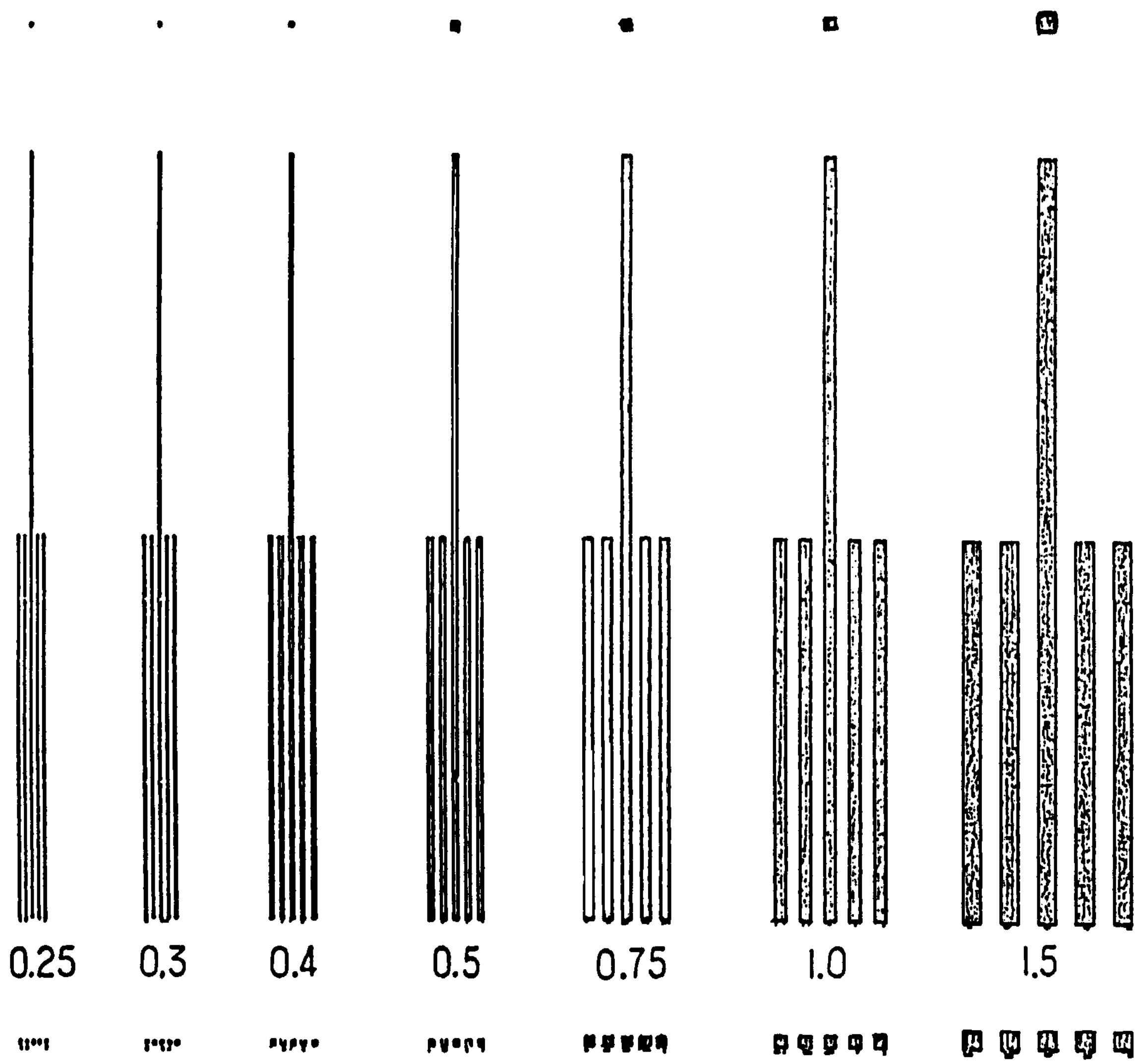


Figure 1

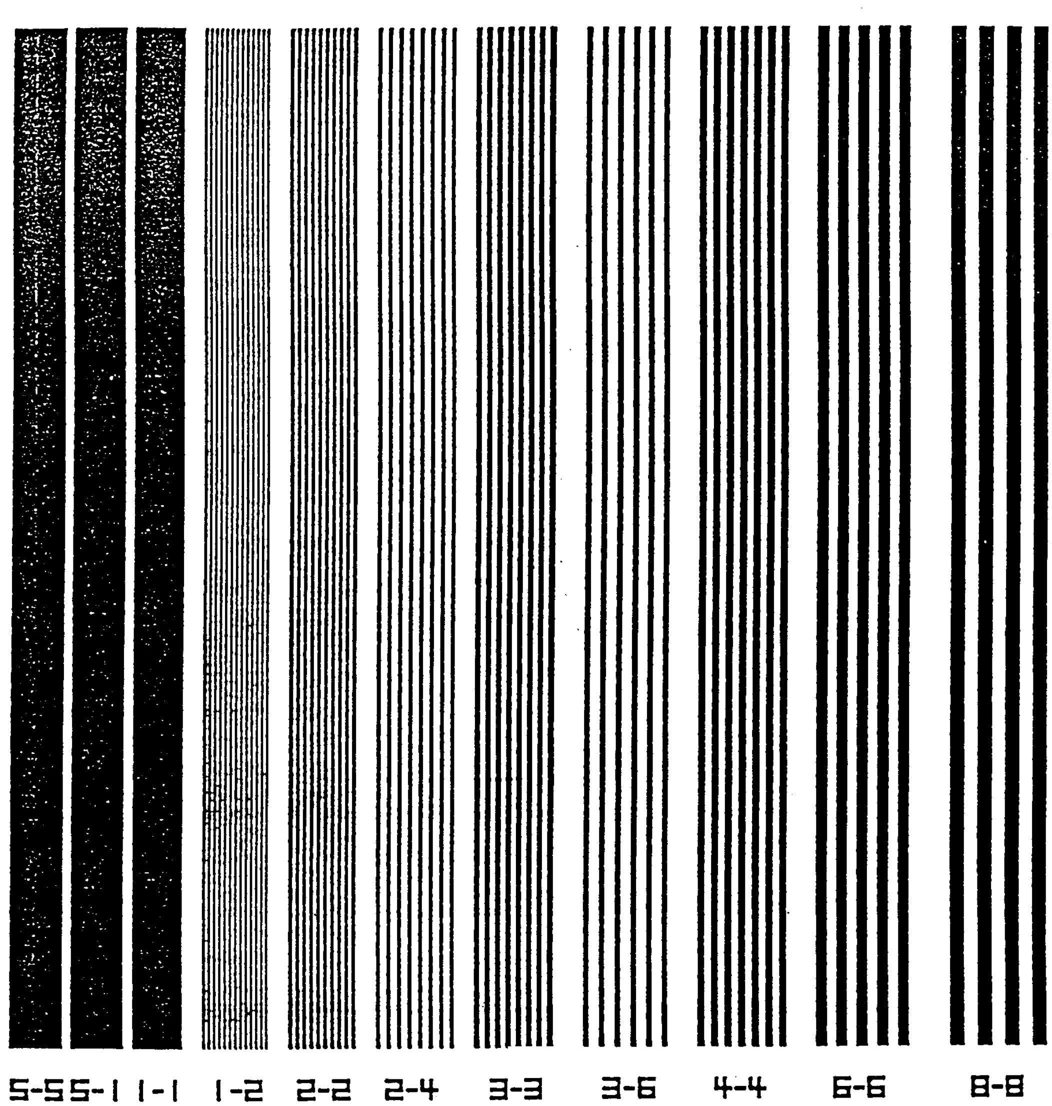


Figure 2

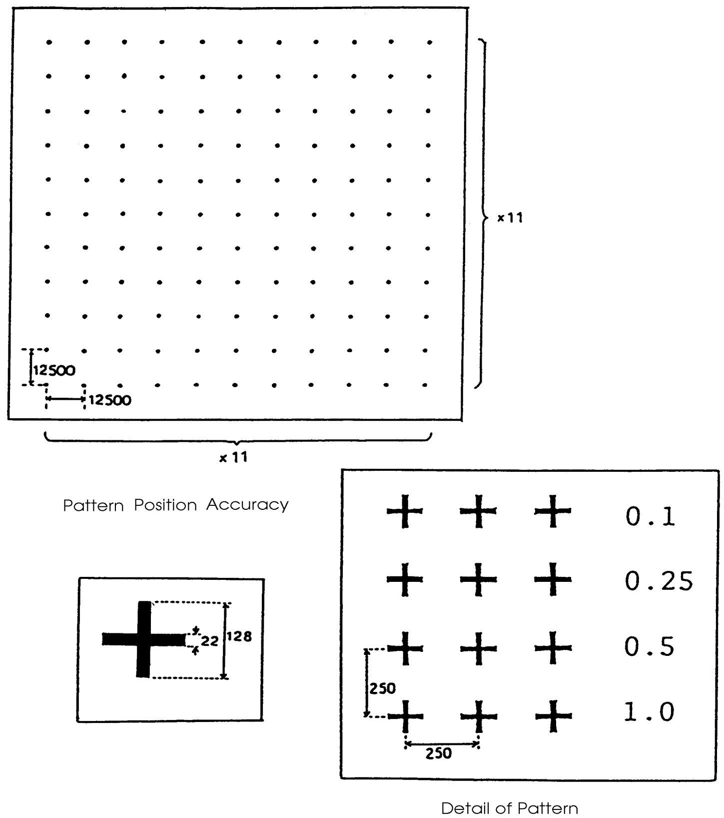


Figure 3

NOTICE: SEMI makes no warranties or representations as to the suitability of the standards set forth herein for any particular application. The determination of the suitability of the standard is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These standards are subject to change without notice.

The user's attention is called to the possibility that compliance with this standard may require use of copyrighted material or of an invention covered by patent rights. By publication of this standard, SEMI takes no position respecting the validity of any patent rights or copyrights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of any such patent rights or copyrights, and the risk of infringement of such rights, are entirely their own responsibility.

SEMI P22-0699
GUIDELINE FOR PHOTOMASK DEFECT CLASSIFICATION AND SIZE DEFINITION

This guideline was technically approved by the Global Mask & Mask Equipment Committee and is the direct responsibility of the Japanese Mask & Mask Equipment Committee. Current edition approved by the Japanese Regional Standards Committee on March 17, 1999. Initially available at www.semi.org April 1999; to be published June 1999. Originally published in 1993.

1 Purpose

1.1 The purpose of this guideline is to establish standard nomenclature for photomask defect classifications, and to define defect sizing methods.

2 Scope

2.1 It is desirable to follow this guideline when discussing classification, nomenclature, and size of the photomask defects.

3 References

3.1 *SEMI Standard*

SEMI P33 — Provisional Specification For Developmental 230 mm Square Hard Surface Photomask Substrates.

4 Terminology

4.1 *design pattern* — pattern of intended design data.

4.2 *photomask pattern* — pattern on photomask surface.

4.3 Many terms relating to photomask technology can be found in SEMI P33.

5 Classification of the Mask Defect

5.1 *Mask Pattern Defects*

5.1.1 *Shape Defect* — a photomask pattern whose shape is different from its intended design pattern.

5.1.1.1 *Isolated Defect* — shape defects which are isolated from pattern.

1) Dot (See Figures 1, 23)

2) Hole (See Figure 2)

5.1.1.2 *Edge Defect* — shape defects which are adjacent to straight pattern edge.

1) Edge Extension (See Figures 3, 24)

2) Edge Intrusion (See Figure 4)

5.1.1.3 *Corner Defect* — shape defects which are adjacent to corners.

1) Corner Extension (See Figures 5, 27, 29)

2) Corner Intrusion (See Figures 6, 28, 30)

5.1.1.4 *Bridge* — shape defects which are adjacent to more than two edges.

1) Opaque Bridge (See Figures 7, 26)

2) Clear Bridge (See Figure 8)

5.1.2 *Size Defect* — a photomask pattern whose size is different from its intended design pattern.

1) Oversize (on opaque pattern) (See Figure 9)

2) Oversize (on clear pattern) (See Figure 10)

3) Undersize (on opaque pattern) (See Figure 11)

4) Undersize (on clear pattern) (See Figure 12)

5) Elongation (on opaque pattern) (See Figure 13)

6) Elongation (on clear pattern) (See Figure 14)

7) Truncation (on opaque pattern) (See Figure 15)

8) Truncation (on clear pattern) (See Figure 16)

5.1.3 *Misplacement Defect* — a photomask pattern whose placement is different from its intended design. (See Figures 17, 18, 25)

5.1.4 *Transmission Defect* — a photomask pattern whose transmission is different from its intended design.

1) Transmission Defect (on clear pattern) (See Figure 19)

2) Transmission Defect (on opaque pattern) (See Figure 20)

5.1.5 *Missing pattern defect* — a photomask pattern which is absent.

1) Missing opaque pattern (See Figure 21)

2) Missing clear pattern (See Figure 22)

5.2 *Glass Defect* — unwanted defect in (or on) a glass created by various undefined causes (e.g. sleek, pit, scratch, chip, striation, polishing mark, discolor, bubbles, etc.).

5.3 *Miscellaneous Defect* — unwanted clear or opaque spot created by various undefined causes (e.g., crystal growth, electrostatic damage, organic material deposit, Phase shift defect).

6 Definition of Size for Photomask Defects

6.1 The tools and conditions used to measure defect size should be clearly specified.

6.2 *Pattern Defects*

6.2.1 Shape Defects

6.2.1.1 *Isolated Defect* — defect size is expressed as two dimensions (S1 and S2) of the smallest rectangle that encloses the defect. (See Figures 1, 2, 23)

6.2.1.2 *Edge Defect* — defect size is expressed as two dimensions (S1 and S2) of the smallest rectangle that encloses the defect. (See Figures 3, 4, 24)

6.2.1.3 *Corner Defect* — defect size is expressed as the distance (S1) between the intersection point, formed by the bisection of the corner angle and the pattern, and the point designed. (See Figures 5, 6)

6.2.1.4 *Bridge* — defect size is expressed as two dimensions (S1 and S2) of the smallest rectangle that encloses the defect. (See Figures 7, 8, 26)

6.2.2 *Size Defects*

6.2.2.1 *Oversize and Undersize* — defect size is expressed as two dimensions (S1 and S2) representing the absolute value of the deviation from the intended design pattern.

$S1 = | b - a |$

$S2 = | d - c |$

"a" and "c" are intended value; "b" and "d" are actual measured value. (See Figures 9, 10, 11, 12)

6.2.2.2 *Elongation and Truncation* — defect size is expressed as two dimensions (S1 and S2) of the smallest rectangle that encloses the deviation from the intended design pattern. (See Figures 13, 14, 15, 16)

6.2.3 *Misplacement Defect* — defect size is expressed as the absolute value of X and Y displacement from its intended position. (See Figures 17, 18, 25)

6.2.4 *Transmission Defect* — transmission defects are evaluated by their transmissivity in addition to the size. The wavelength used for measurement should be clearly specified, as well as the transmissivity error (Te). Defect dimensions should be consistent with other definitions. (See Figures 19, 20)

$Te = Td - Ti$

where

Td = transmissivity of defect

Ti = intended transmissivity of design

6.2.5 *Missing Pattern Defect* — defect size is expressed as two dimensions (S1 and S2) of the smallest rectangle that encloses the intended design pattern. (See Figures 21, 22)

6.3 *Randomly Shaped Defects* — for the defects which all of above sizing method cannot be applied, defect size is expressed as two dimensions (S1 and S2) of the smallest rectangle that encloses the defect. (See Figures 23, 24, 27, 28, 29, 30)

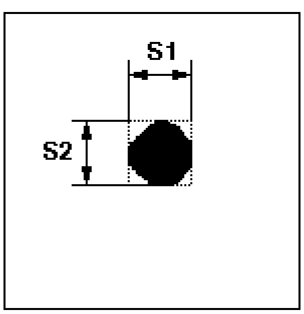


Figure 1

Dot

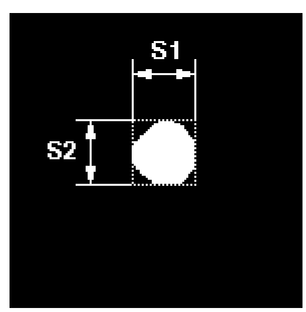


Figure 2

Hole

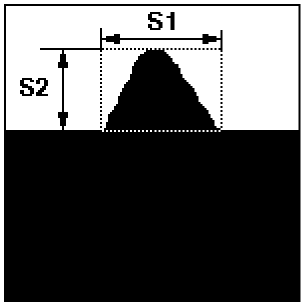


Figure 3

Edge Extension

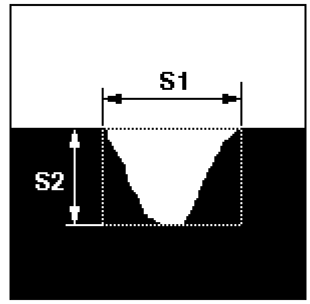


Figure 4

Edge Intrusion

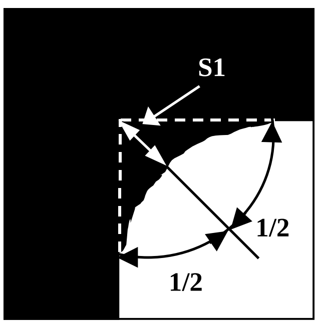


Figure 5

Corner Extension

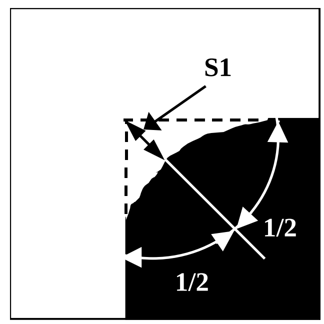


Figure 6

Corner Intrusion

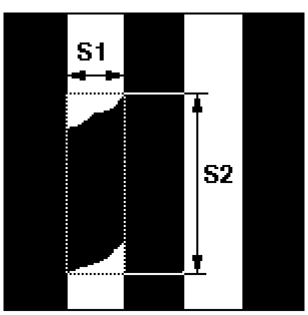


Figure 7

Opaque Bridge

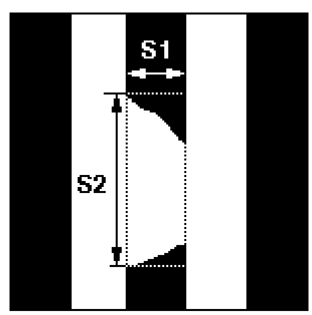


Figure 8

Clear Bridge

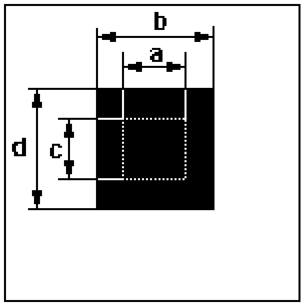


Figure 9

Oversize On Opaque Pattern

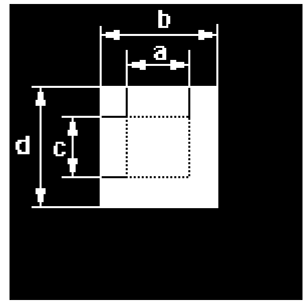


Figure 10

Oversize On Clear Pattern

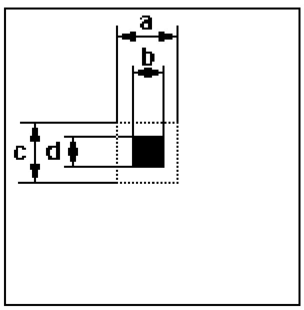


Figure 11

Undersize On Opaque Pattern

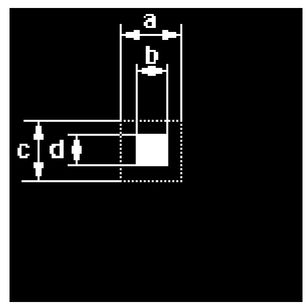


Figure 12

Undersize On Clear Pattern

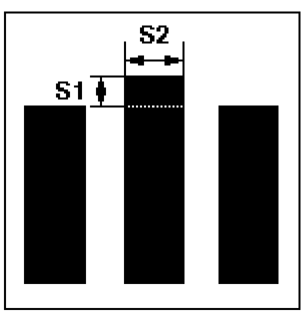


Figure 13

Elongation On Opaque Pattern

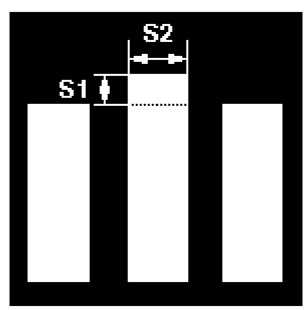


Figure 14

Elongation On Clear Pattern

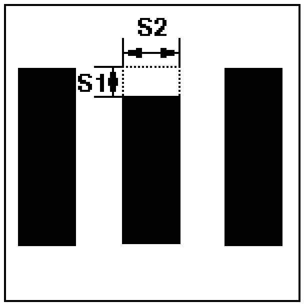


Figure 15

Truncation On Opaque Pattern

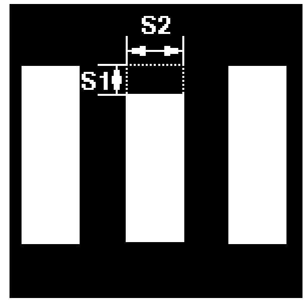


Figure 16

Truncation On Clear Pattern

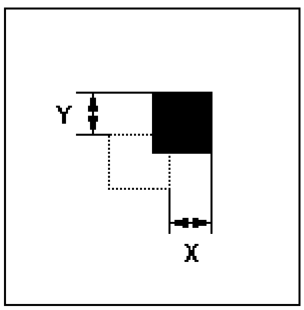


Figure 17

Misplacement On Opaque Pattern

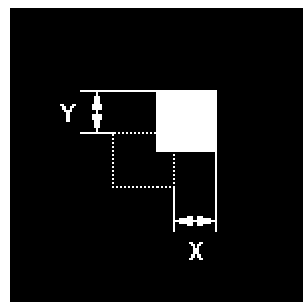


Figure 18

Misplacement On Clear Pattern

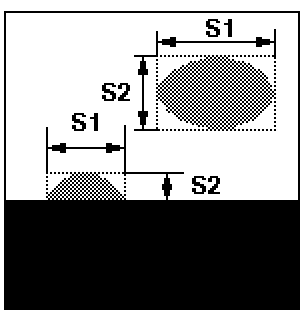


Figure 19

Transmission Defect On Clear Pattern

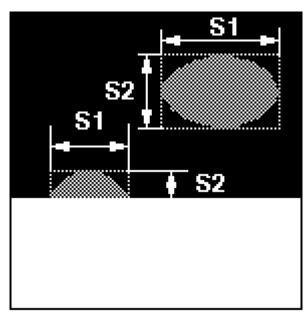


Figure 20

Transmission Defect On Opaque Pattern

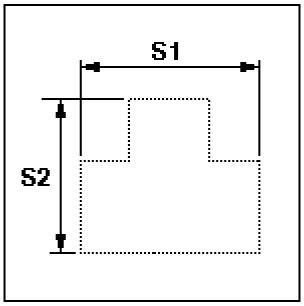


Figure 21

Missing Opaque Pattern

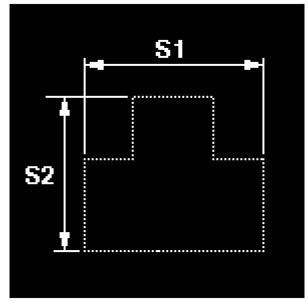


Figure 22

Missing Clear Pattern

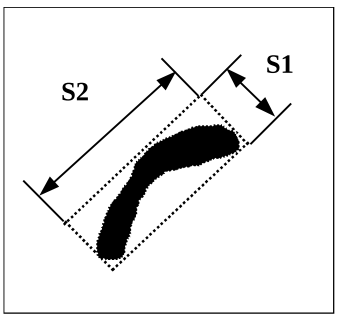


Figure 23

Dot Randomly Shaped

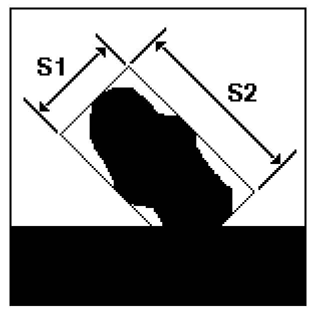


Figure 24

Edge Extension Randomly Shaped

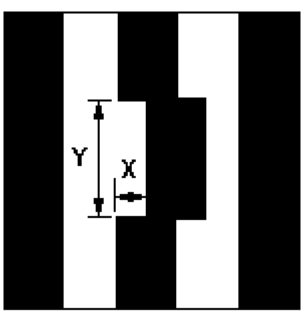


Figure 25

Misplacement On Opaque Pattern

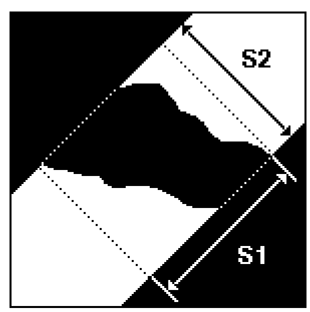


Figure 26

Opaque Bridge

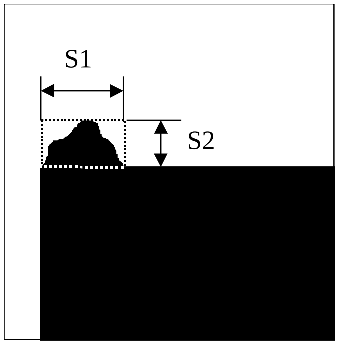


Figure 27

Corner Extension Randomly Shaped

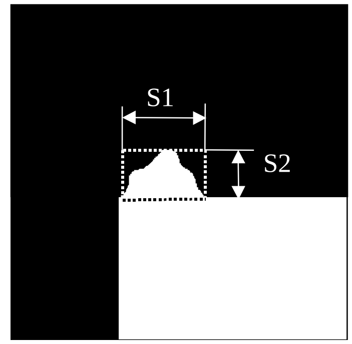


Figure 28

Corner Intrusion Randomly Shaped

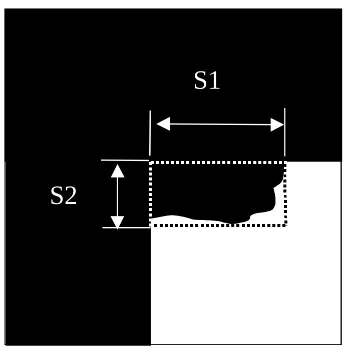


Figure 29

Corner Extension Randomly Shaped

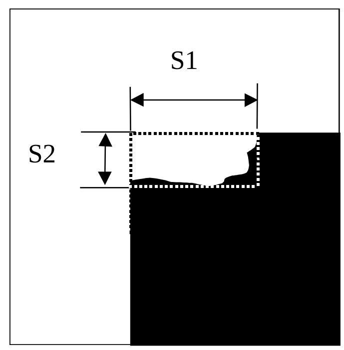


Figure 30

Corner Intrusion Randomly Shaped

SEMI P23-0200
GUIDELINES FOR PROGRAMMED DEFECT MASKS AND BENCHMARK PROCEDURES FOR SENSITIVITY ANALYSIS OF MASK DEFECT INSPECTION SYSTEMS

These guidelines were technically approved by the Global Mask and Mask Equipment Committee and are the direct responsibility of the Japanese Mask and Mask Equipment Committee. Current edition approved by the Japanese Regional Standards Committee on September 10, 1999. Initially available at www.semi.org February 2000; to be published February 2000. Originally published in 1993; previously published in 1996.

NOTE: These guidelines were rewritten in their entirety in February 2000.

1 Purpose

1.1 The purpose of this guideline is to propose a test mask to be used for evaluation of the sensitivity of Mask Defect Inspection Systems. This test mask consists of test chips including programmed pattern defects and reference test chips without programmed defects. Since the test chip is an assembly of cells, the test chips are defined in this guideline by cell patterns, programmed defects in cell patterns, and the layout of the cells. Also, the test mask is defined by defining the test chips arrangement. Furthermore, the use of this mask is described. It is desirable that these test masks and benchmark procedures be used when the sensitivity of a Mask Defect Inspection System is evaluated.

1.2 *Background* — Different masks have been used by many equipment manufacturers and users in the past, and sensitivity has been tested by various methods decided independently by each manufacturer and user. In some cases, no common measurement methods or sensitivity analysis methods have been agreed upon. Therefore, confusion exists concerning the sensitivity comparison of equipment between manufacturers, the definition for specifications between users and suppliers, and the definition for specifications between users. Also, due to the fact that several problems were found when using the previous guideline in actual manufacturing, the document has been reviewed and content has been changed throughout. It was also the goal of this revision, while considering ease of manufacturing of test masks first, to fully cover the evaluation of mask defect inspection systems.

2 Scope

2.1 This guideline defines the content and methods for use of test masks used in the evaluation of mask defect inspection systems. Although it is possible to use this test mask to evaluate transcription of defects etc., this standard does not attempt to define these processes.

2.2 This guideline shall be revised when a new effective measurement technology for defect sizing becomes commonly available in the market.

2.3 This guideline does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this guideline to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Referenced Standards

3.1 *SEMI Standards*

SEMI P1 — Specification for Hard Surface Photomask Substrates

SEMI P22 — Guideline for Photomask Defect Classification and Size Definition.

SEMI P33 — Provisional Specification for Developmental 230 mm Square Hard Surface Photomask Substrates

NOTE 1: As listed or revised, all documents cited shall be the latest publications of adopted standards.

4 Terminology

4.1 *Definitions*

4.1.1 Many terms relating to photomask technology are defined in SEMI P22 and SEMI P33.

4.1.2 *design pattern* — pattern of intended design data.

4.1.3 *photomask pattern* — pattern on photomask surface.

5 Mask (See Figure 1)

5.1 Masks will be either 5" or 6" which meet SEMI P1; both the 5" and 6" will be the same layout.

5.2 Masks will be limited to two types, namely Conventional and Attenuated (Half Tone). Note that Levenson and Optical Proximity Correction (OPC) types will not be included.

5.3 There are two types of patterns: Wiring and Contact Hole pattern.

5.4 In one mask, there will be one type of pattern, either Wiring or Contact Hole.

5.5 One defect chip will be placed in the center of the mask.

5.6 Eight reference chips (non-defective) will be placed at 25,000 micron intervals to make sure that inspection can occur even if the mask is set in the inspection equipment in different directions (e.g., 0º, 90º, 180º, 270º).

5.7 *Mask Naming*

5.7.1 Wiring Pattern Mask is “SEMI STANDARD P23-0200-1500W”.

5.7.2 Contact Hole Pattern Mask is ”SEMI STANDARD P23-0200-1500C”.

5.7.3 “P23-0200” is the registered number of this guideline.

5.7.4 “1500” expressed in nanometers, is the photomask pattern design rule. The following explanations in this guideline are based on a 1,500 nm (1.50 micron) design rule.

5.7.5 The mask naming should be written in characters which can be confirmed by the naked eye, and should be displayed in a place recognized by either the manufacturer or user of the mask.

5.8 Four light intensity adjustment patterns will be placed at 12,500 micron intervals from the center of the mask.

5.9 It is feasible to place stepper alignment marks and other patterns in such a way as not to effect the mask pattern described above.

6 Chip

See Figure 2 for illustration.

6.1 One chip of wiring patterns will be made up of 17 types of defects, each at 20 different defect sizes for a total of 340 cells.

6.2 One chip of contact hole patterns will be made up of 14 types of defects, each at 20 different defect sizes for a total of 280 cells.

6.3 Place defects changing types along the X-axis.

6.3.1 Display the defect type from the left side of the chip, toward the right, in capital English letters.

6.3.1.1 Wiring patterns are listed from A to Q.

6.3.1.2 Contact Hole patters are listed from A to N.

6.4 Place defects changing size along the Y-axis.

6.4.1 Place the defects, from top to bottom, in range of size from 0.05 microns to 1.00 microns at 0.05 micron intervals.

NOTE 2: Display all sizes as they pertain to the mask (on the mask).

7 Cell

7.1 One cell will be 250 microns square. (See Figure 3.)

7.2 Sub-cells will be placed 5 by 5 (Total=25).

7.3 Defects will be placed in the center of the cell (± 5.0 micron).

7.4 Cells will be broken up into 9 types, depending on the content of the pattern and defect.

7.4.1 Seven types are used for Wiring Patterns. (See Figures 4, 15 to 21.)

7.4.2 Two types are used for Contact Hole Patterns. (See Figures 6 and 7.)

8 Sub-cell

8.1 One sub-cell is 50 microns square.

8.2 Place a pattern which shows the boundaries of the cell at the sub-cell coordinates (x1,y1), (x5,y1), (x1,y5) and (x5,y5). (See Figures 8 to 12.)

8.2.1 Figure 13 shows an example of these patterns placed together.

8.2.2 The pattern placed at (x5,y1) should be a pattern from which coordinates can be measured.

8.3 Place the defect type ID (cell coordinates) and the abbreviated pattern for the defect type in sub-cell coordinates (x1,y5). (See Figures 8 and 12.)

8.3.1 Defect type ID (cell coordinates) are written as one capital English letter, representing the defect type and a two-digit number representing defect size. (Example: A01)

Character line width is set at 2.00 micron. (See Figure 14.)

8.3.2 The abbreviated pattern which denotes the defect content should keep the defect shape and direction consistent with the shape and direction of the program defect in the design.

8.4 The recommended values for pattern dimensions under the design rule (dimensions on mask) are as follows:

Dimension on Mask	*Mask Name*
5.00 micron	5000
3.00 micron	3000
2.50 micron	2500
2.00 micron	2000
1.50 micron	1500
1.00 micron	1000
0.80 micron	800
0.50 micron	500

8.4.1 The above list of design rule dimensions are recommended values, and it is feasible to use a different size.

8.4.2 When changing the design rule, chip spacing (25.0 mm) should not change.

8.5 For the Wiring Pattern Chip, place a pattern with uniform sub-cell coordinates: (x2,y1), (x4,y1), (x1,y2), (x2,y2), (x4,y2), (x5,y2), (x1,y4), (x2,y4), (x4,y4), (x5,y4), (x2,y5), (x4,y5). (See Figure 4.)

8.5.1 Patterns in a sub-cell using the uniform Wiring Pattern should be as follows:

Sub-cell Coordinates	*Pattern to Be Used*
(x2,y1) & (x4,y5)	Wiring Type A (Figure 15)
(x4,y1) & (x2,y5)	Wiring Type B (Figure 16)
(x1,y4) & (x5,y2)	Wiring Type A rotated 90º
(x1,y2) & (x5,y4)	Wiring Type B rotated 90º
(x2,y2)	Wiring Type C (Figure 17)
(x4,y2)	Wiring Type D (Figure 18)
(x2,y4)	Wiring Type E (Figure 19)
(x4,y4)	Wiring Type F (Figure 20)

8.5.2 Uniform patterns are placed inside a 50 micron-square sub-cell.

8.5.3 For patterns in the Wiring Pattern which change depending on the defect type ID, the same patterns should be placed, without borders, in sub-cell coordinates (x3,y1), (x3,y2), (x1,y3), (x2,y3), (x3,y3), (x4,y3), (x5,y3), (x3,y4) and (x3,y5).

8.5.4 Pattern content will change as follows, depending on the defect type ID:

Defect Type ID	*Pattern to Be Used*
A, B, C, D	Wiring Type A (Figure 15)
G, H, K, L, Q	Wiring Type C (Figure 17)
I, J	Wiring Type D (Figure 18)
E, F	Wiring Type E (Figure 19)
M, N	Wiring Type F (Figure 20)
O, P	Wiring Type G (Figure 21)

8.5.4.1 Adjust the pattern position so that the defect is placed in the center of sub-cell coordinates (x3,y3). There may be instances where the placement of the uniform patterns and the defect-inserted patterns vary slightly.

8.5.4.2 Figure 5 is an example of placement of a Type A Wiring Pattern.

8.6 For Contact Hole Pattern Chips, contact hole patterns should be placed at all sub-cells except coordinates (x1,y1), (x5,y1), (x1,y5) and (x5,y5). (See Figures 6 and 22.)

8.6.1 For misplacement defects, in order to be evaluated as an isolated field, place just one contact hole pattern in the center of sub-cell coordinates (x3, y3) and only in cells where the contact hole pattern defect type ID is “M”. (See Figure 7.)

8.6.2 Adjust the whole pattern for contact hole patterns so that the defect is placed in the center of sub-cell coordinates (x3,y3).

8.7 Use a common spacing for placement of wiring patterns and contact hole patterns.

8.7.1 For placement of patterns in design rule 1.50 microns (on mask), use a spacing of 14.0 microns in the X-direction and 7.0 microns in the Y-direction.

8.7.2 The values for spacing should change accordingly with a change in the design rule.

9 Defect

See Figures 23 and 24 for illustration.

9.1 *Defect Type*

9.1.1 Dot

9.1.2 Hole

9.1.3 Edge Extension

0 degree

45 degree

arctan (1/2) = 26.565 degree

9.1.4 Edge Intrusion

0 degree

45 degree

arctan (1/2) = 26.565 degree

9.1.5 Corner Extension

9.1.6 Corner Intrusion

9.1.7 Over size

9.1.8 Under size

9.1.9 Elongation

9.1.10 Truncation

9.1.11 Misplacement

9.1.12 Missing Pattern

9.2 *Defect Design Method*

9.2.1 Design the following defects, in squares, for wiring patterns and contact hole patterns. For edge defects on diagonal lines, use a pattern designed in a square and rotated to the angle of the diagonal. (In this case, the shape of the defect may change in the design data.) For corner defects, design using the edge length as a design dimension and not the diagonal.

9.2.1.1 Dot

9.2.1.2 Hole

9.2.1.3 Edge Extension

0 degree

45 degree

arctan (1/2) = 26.565 degree

9.2.1.4 Edge Intrusion

0 degree

45 degree

arctan (1/2) = 26.565 degree

9.2.1.5 Corner Extension

9.2.1.6 Corner Intrusion

9.2.2 The following defects change only in the pattern size along the Y-direction.

9.2.2.1 Wiring Pattern Over Size

9.2.2.2 Wiring Pattern Under Size

9.2.3 The following defects change in pattern size along both X and Y.

9.2.3.1 Contact Hole Pattern Over Size

9.2.3.2 Contact Hole Pattern Under size

9.2.4 The following defects change only in pattern length along the Y-direction in both wiring and contact hole patterns.

9.2.4.1 Elongation

9.2.4.2 Truncation

9.2.5 For the following defects, in both wiring and contact hole patterns, move the right half of the pattern in the Y-direction only to form a step.

9.2.5.1 Misplacement Defect with ID ”K”

9.2.6 In the following defects, the pattern shape and size are the same, with one whole isolated pattern moving only in the Y-direction.

9.2.6.1 Misplacement defects, in both wiring and contact hole patterns, which have the defect ID “L”.

9.2.6.2 Misplacement defects, in contact hole patterns, with the defect ID ”M”.

9.2.7 The following single isolated pattern is completely destroyed in both wiring and contact hole patterns.

9.2.7.1 Missing Pattern

9.3 *Fabricating Position for Program Defect*

9.3.1 Fabricate according to Figure detailed drawing.

10 Program Defect Size

10.1 According to SEMI P22, mainly, two values are to be used in defining size of defects. However, for the following reason, one value will be used to describe program defect size on this SEMI Standard P23 mask.

10.1.1 Defects used in evaluation are all program defects and mainly designed in square shape.

10.1.2 When describing the capabilities of mask defect inspection systems, it has become typical to describe defect size which one value.

10.2 Due to various reasons (influences) in mask manufacturing, it is not always possible to form all program defects with the shape and size described in the design.

10.3 SEMI Standard mask defect size is defined as follows. (See Figures 23 and 24.)

Follow SEMI P22 for the values used below (S1, S2, X, Y, a, b, c, d).

10.3.1 *Dot & Hole*

10.3.1.1 Defect Size is S1 or S2, whichever is larger.

10.3.2 *Edge Extension & Intrusion*

10.3.2.1 Defect Size is S2.

10.3.3 *Corner Extension*

10.3.3.1 Defect Size is the difference between the reference pattern S1[Reference] and the defect pattern S1[Defect]

(| S1[Reference] - S1[Defect] |).

10.3.4 *Corner Intrusion*

10.3.4.1 Wiring Pattern

10.3.4.1.1 Defect Size is the difference between the reference pattern S1[Reference] and the defect pattern S1[Defect]

(| S1[Reference] - S1[Defect] |).

10.3.4.2 Contact Hole Pattern

10.3.4.2.1 As with Edge Intrusion in 10.3.2, Defect Size is S2.

10.3.5 *Over Size*

10.3.5.1 Wiring Pattern

10.3.5.1.1 Since size only changes in the Y-direction, Defect Size is (d-c).

10.3.5.2 Contact Hole Pattern

10.3.5.2.1 With “a” and “c” as the reference pattern size, Defect Size is (b-a) or (d-c), whichever is larger.

10.3.6 *Under Size*

10.3.6.1 Wiring Pattern

10.3.6.1.1 Since size only changes in the Y-direction, Defect Size is (d-c).

10.3.6.2 Contact Hole Pattern

10.3.6.2.1 With “a” and “c” as the reference pattern size, Defect Size is (b-a) or (d-c), whichever is larger.

10.3.7 *Elongation & Truncation*

10.3.7.1 Since, in a program defect, the size only changes in the Y-direction (S1), Defect Size is S1.

10.3.8 *Misplacement*

10.3.8.1 Since the program defect is only moving along the Y-axis, Defect Size is Y.

10.3.9 *Missing Pattern*

10.3.9.1 With S1 and S2 as the reference pattern size, Defect Size is S1 or S2, whichever is larger.

11 Light Intensity Adjustment Pattern

11.1 Light intensity adjustment patterns will be placed in four areas in mask defect inspection systems. (See Figure 1.)

11.2 A glass pattern will be placed in the center.

11.3 Around the circumference of the glass pattern, a line and space pattern will be placed, 1 for 1, with the same line width as the design rule (dimensions on mask).

11.3.1 With 500 by 1,250 microns as one block, place horizontal patterns on the left and right sides, perpendicular patterns on the top and bottom. Also, place a horizontal pattern on the lower left corner. (See Figure 25.)

11.4 The circumference of the glass pattern and line & space pattern should have at least 6,000 microns of shade film.

12 Method for Use of Test Masks in Evaluating Mask Defect Inspection System

12.1 Inspect all defect cells, or a portion of them according to the inspection conditions of the mask defect inspection system to be evaluated.

12.2 Perform at least 20 inspections.

12.3 Perform the inspection at least with a set direction of 0º. It is also preferable that the inspection be performed after rotating the set at 90º, 180º, and 270º.

12.4 When displaying the defect inspection sensitivity for mask defect inspection system, display the defect size of the smallest defect of each type which was detected 100%. (See Figures 26 and 27.)

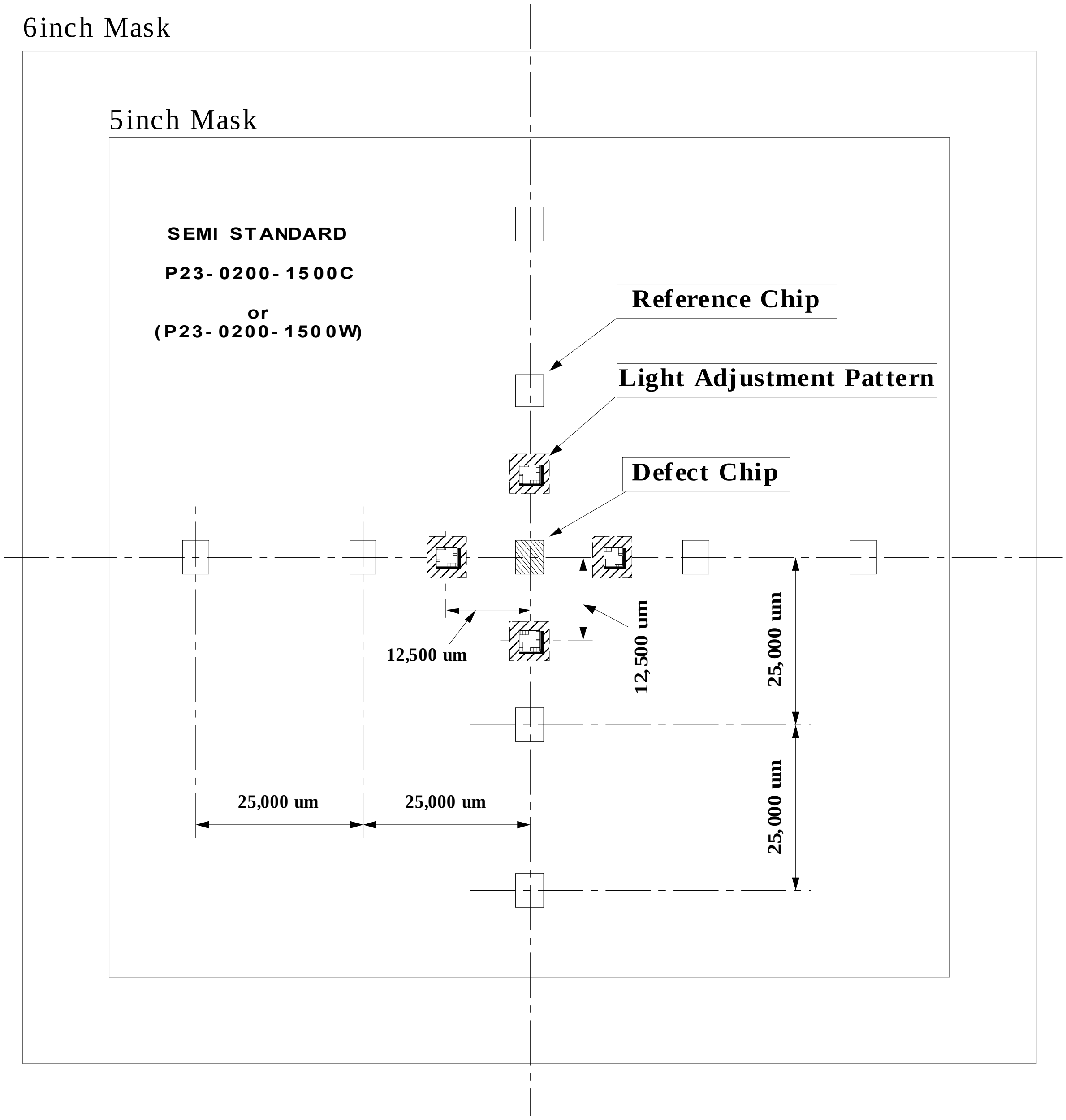


Figure 1
Mask

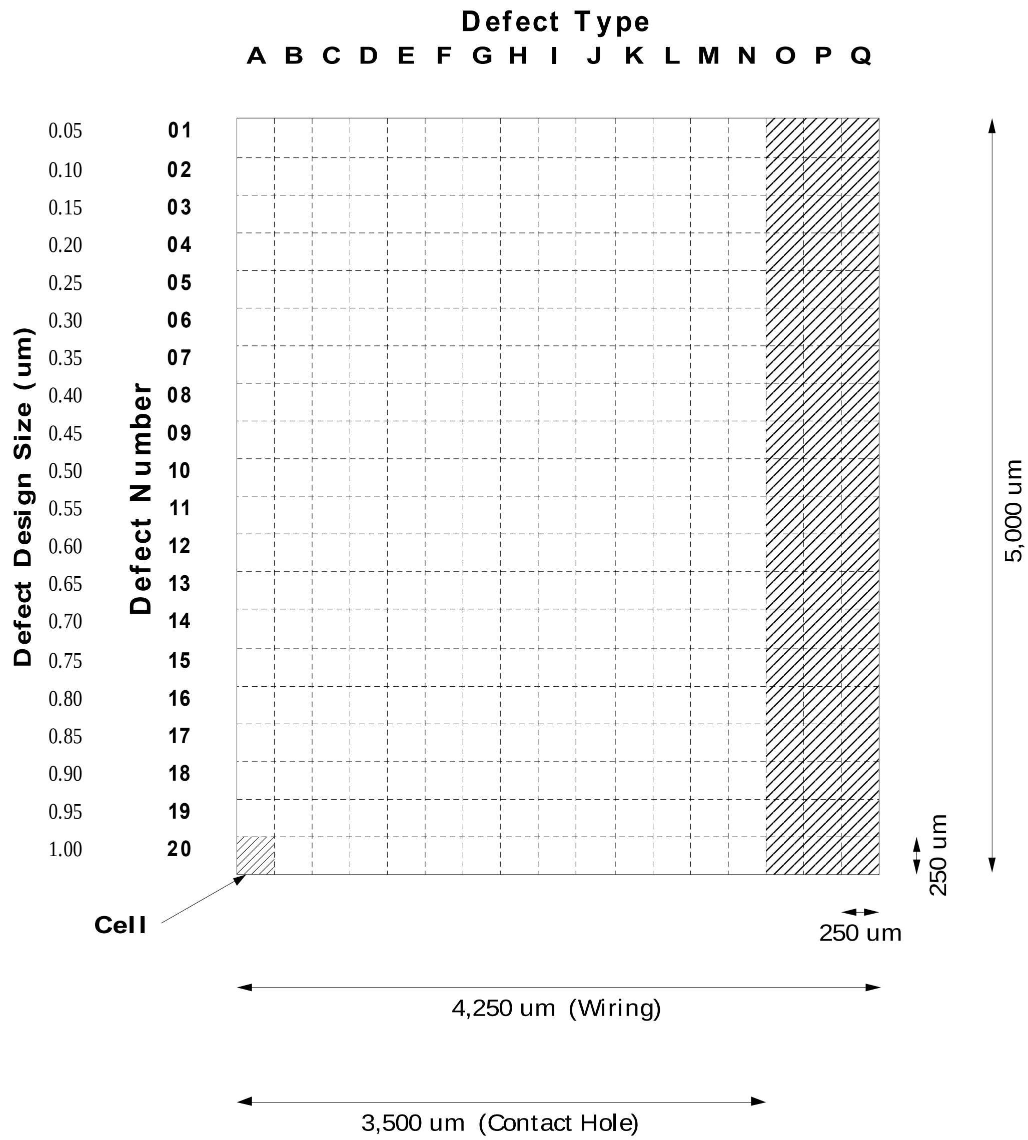


Figure 2
Chip
Wiring Chip; A to Q (#340 cell)
Contact Hole Chip; A to N (#280 cell)

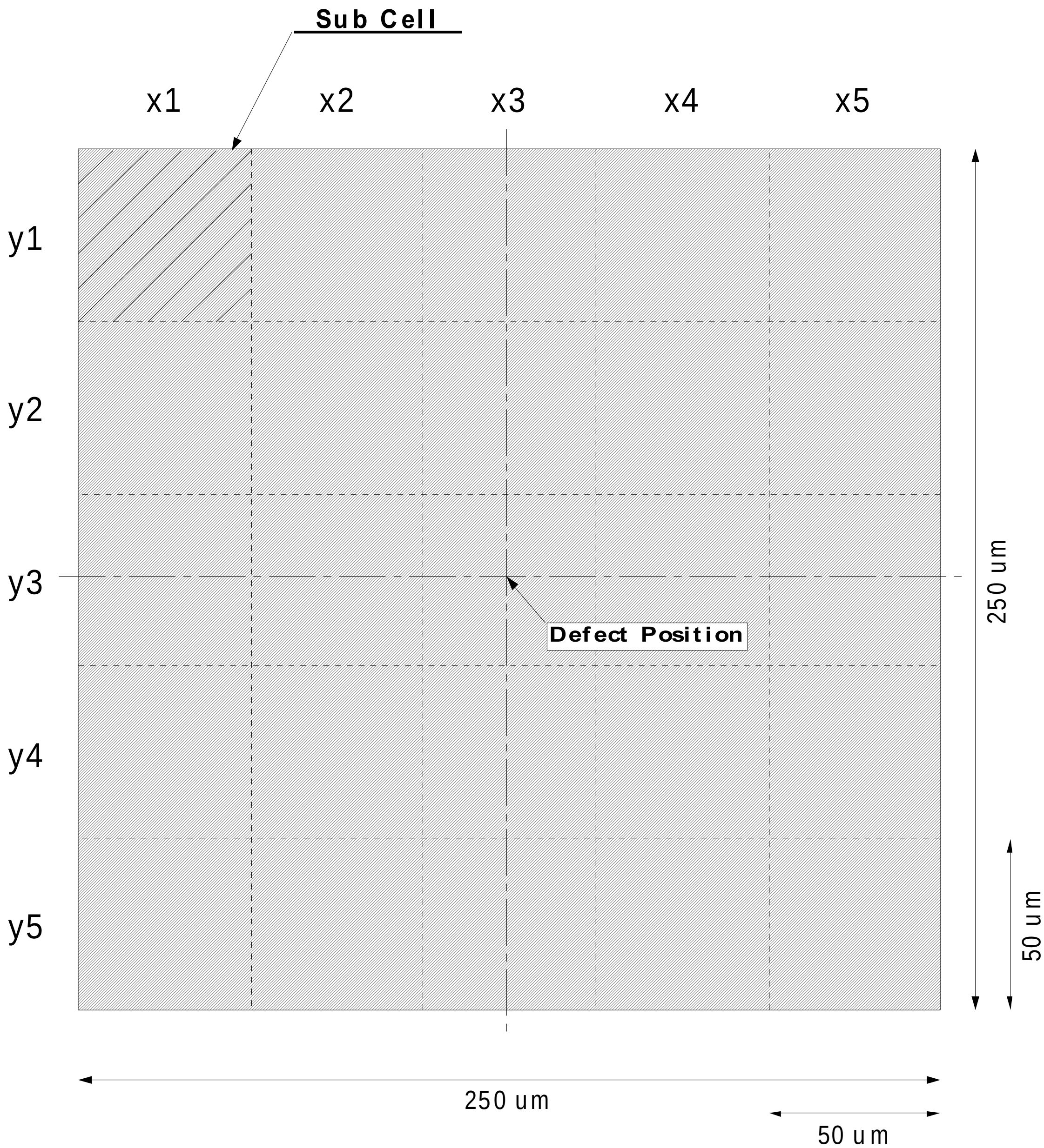


Figure 3
Cell

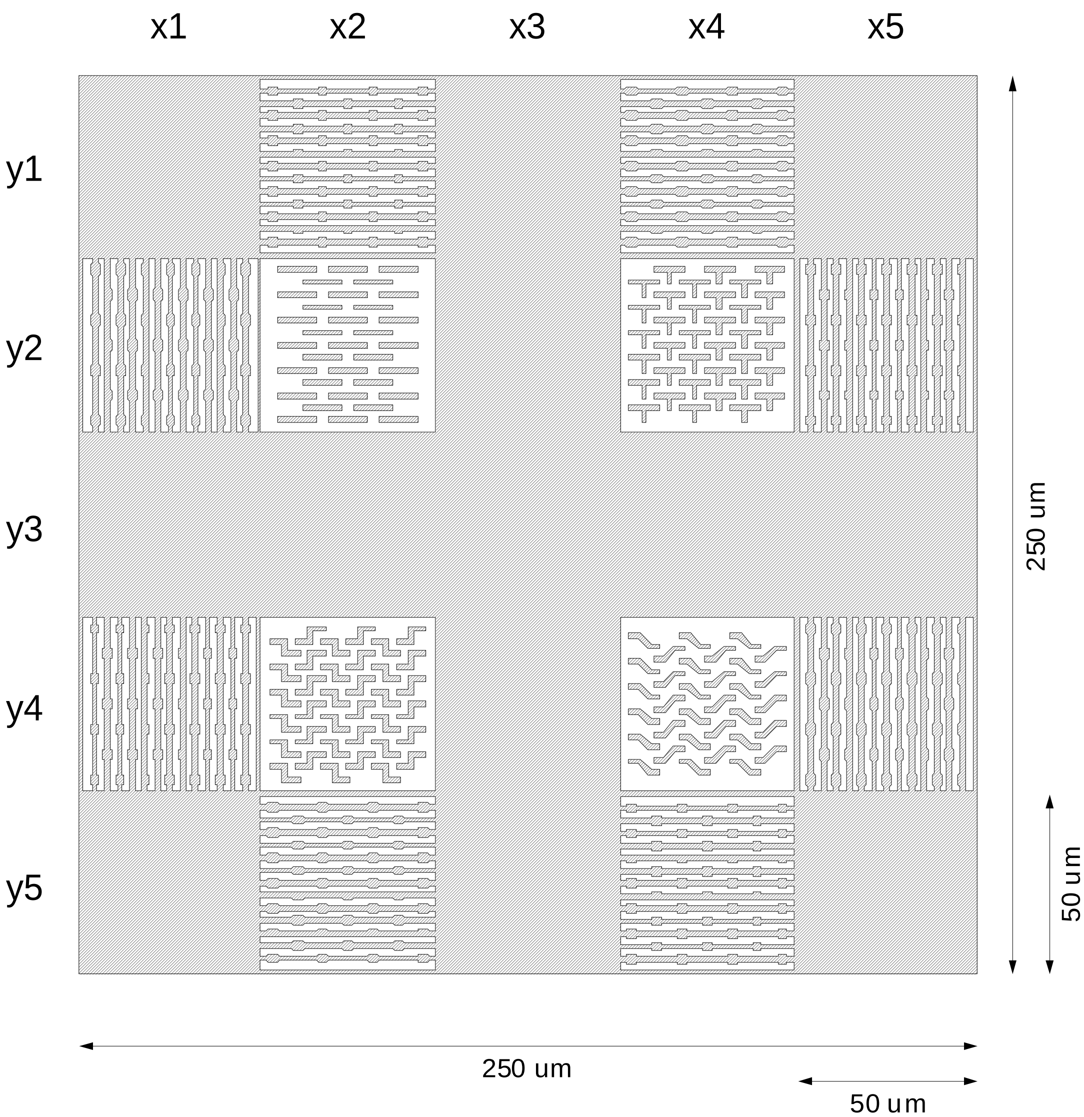


Figure 4
Cell
Wiring Standard Pattern

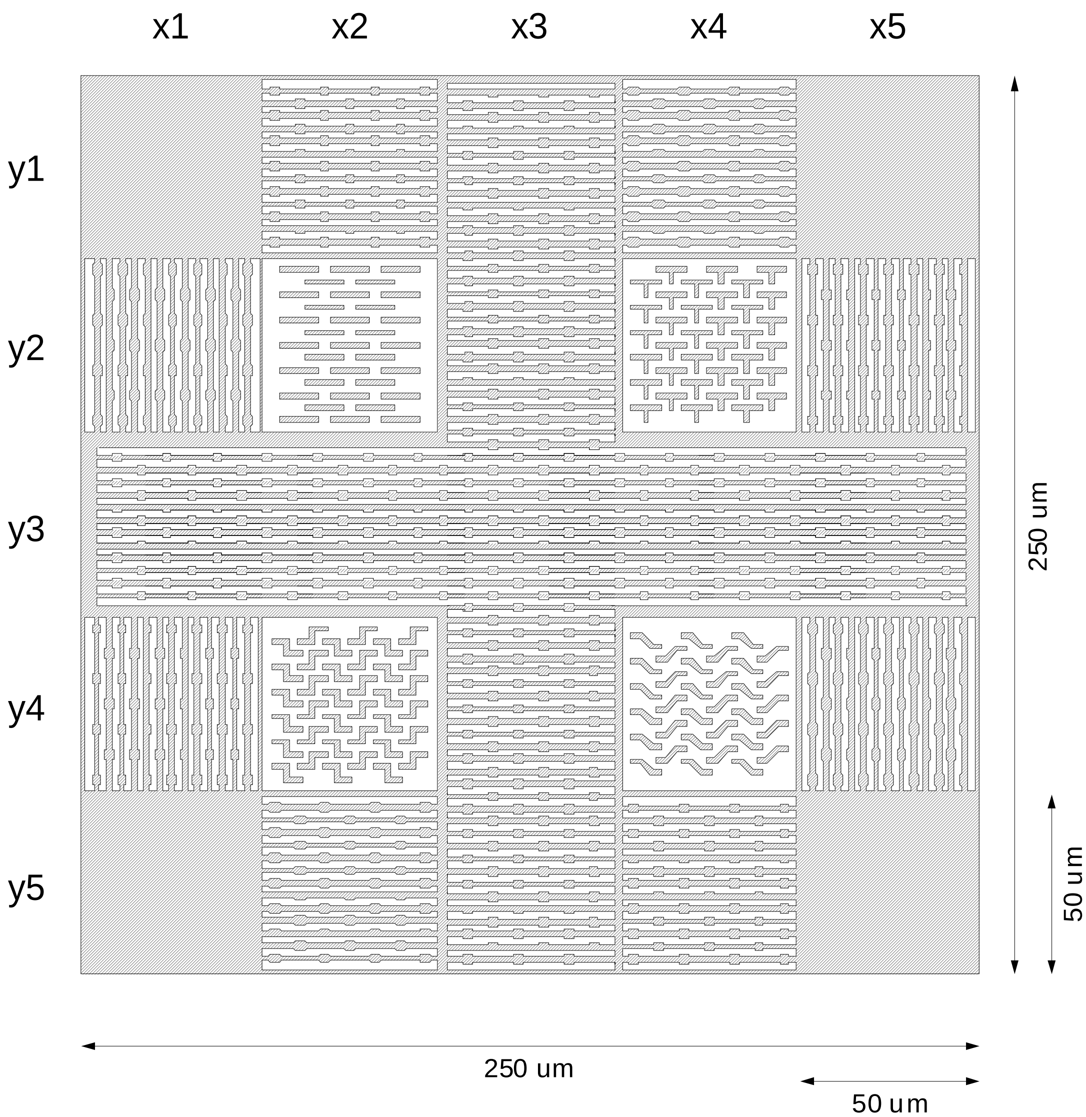


Figure 5
Cell
Sample; Wiring (Type A)
Defect ID; A, B, C, D

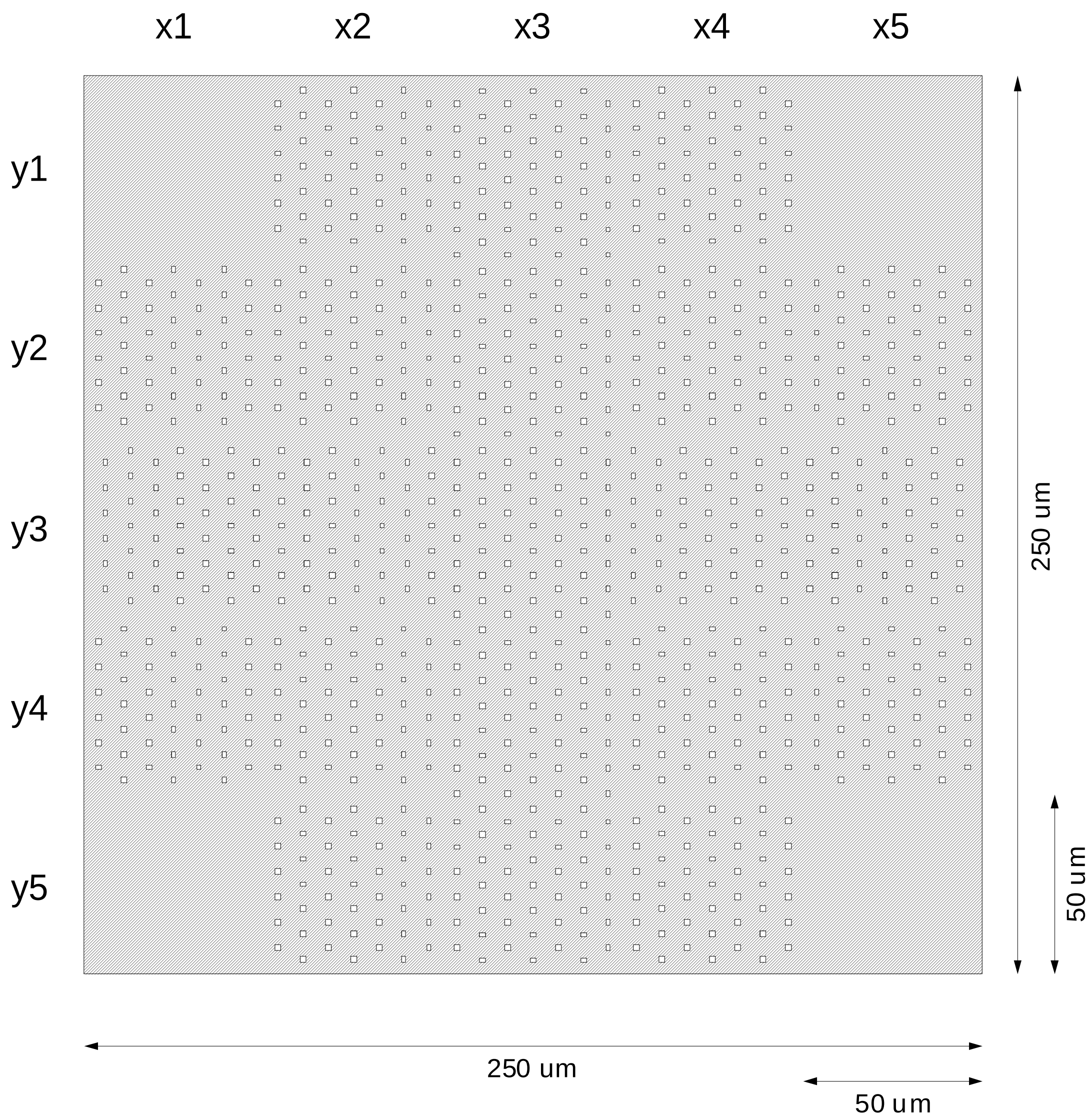


Figure 6
Cell
Contact Hole Pattern (Type A)
Defect ID; A to L, and N

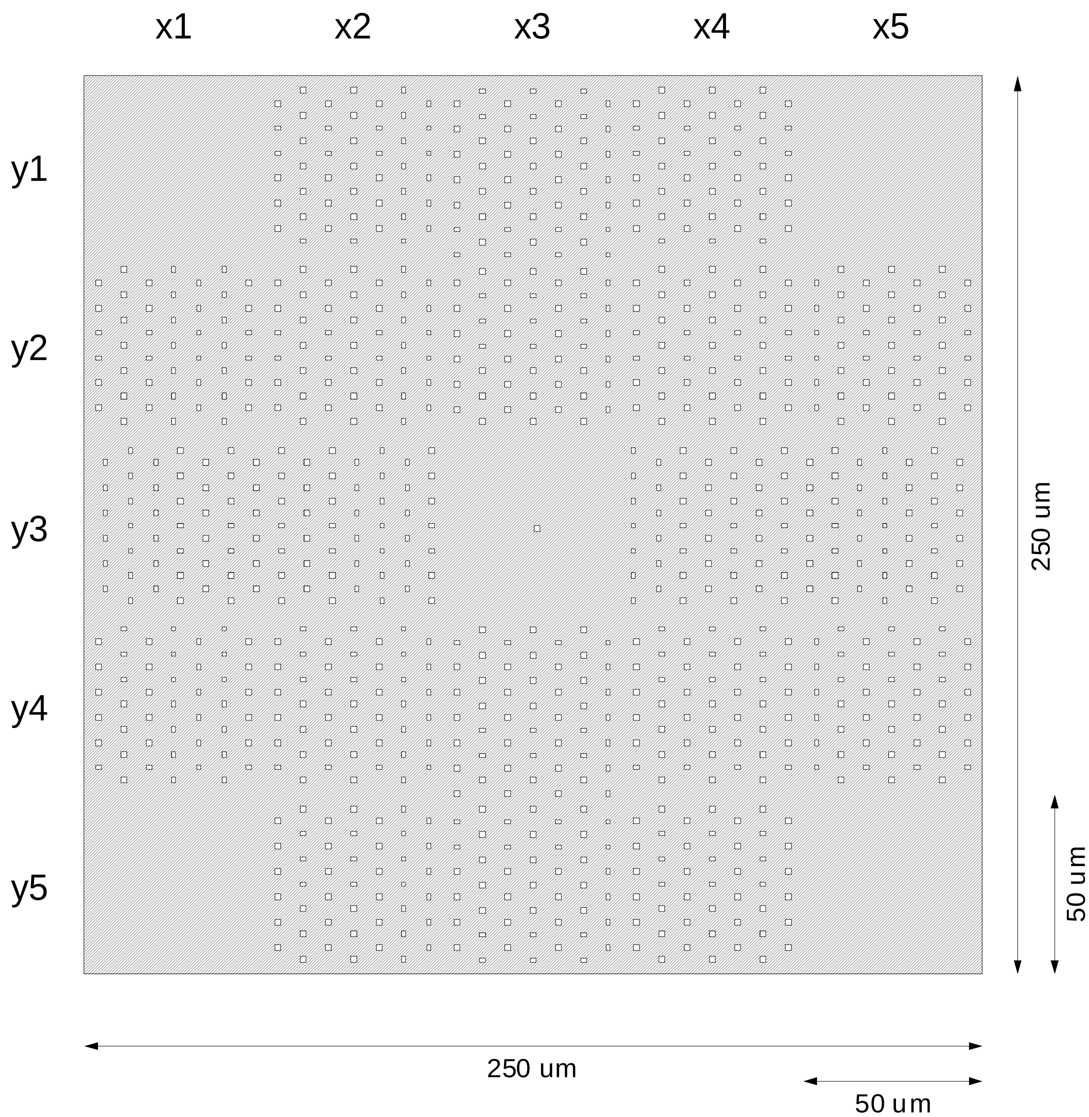


Figure 7
Cell
Contact Hole Pattern (Type B)
Defect ID; M

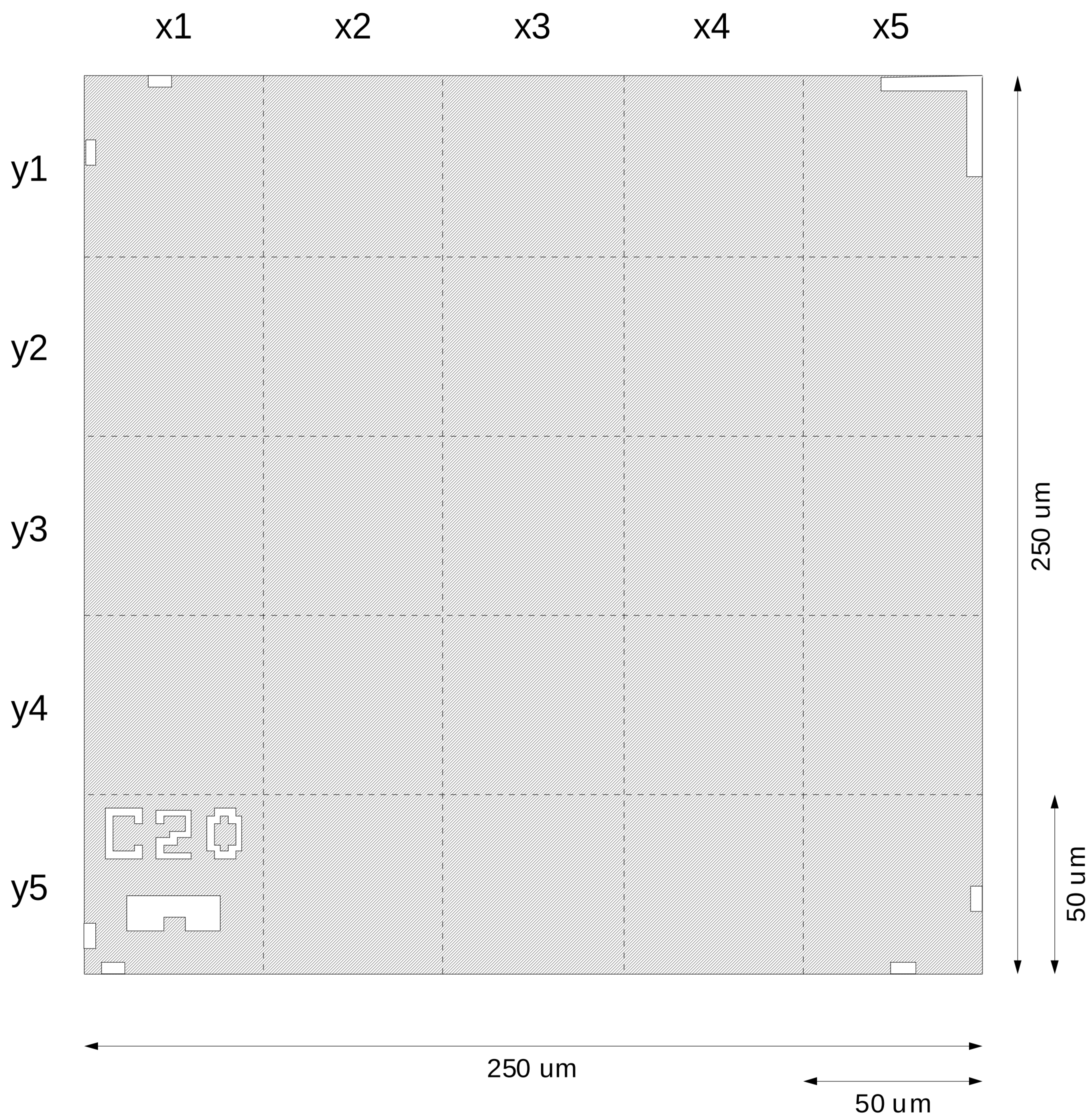
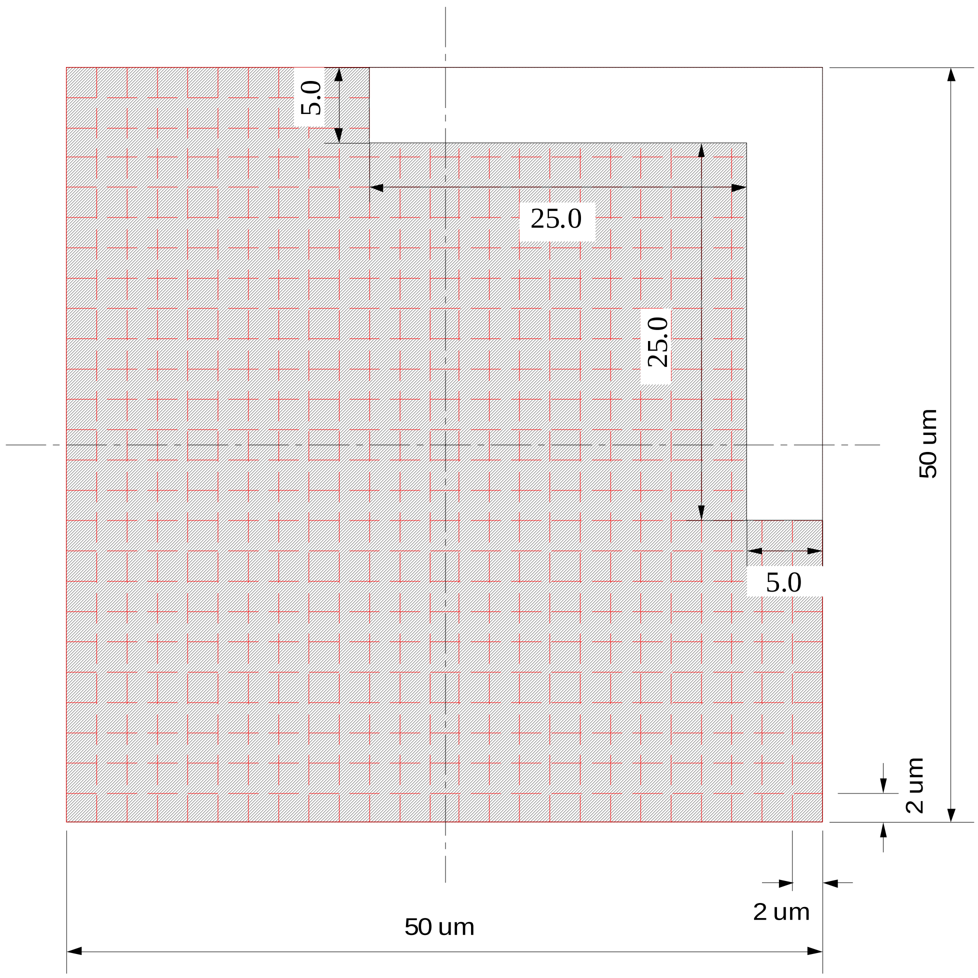


Figure 8
Cell



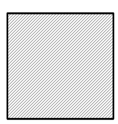


Figure 9
Sub Cell
Right Upper (x5, y1)
(Metrology Measurement Pattern)

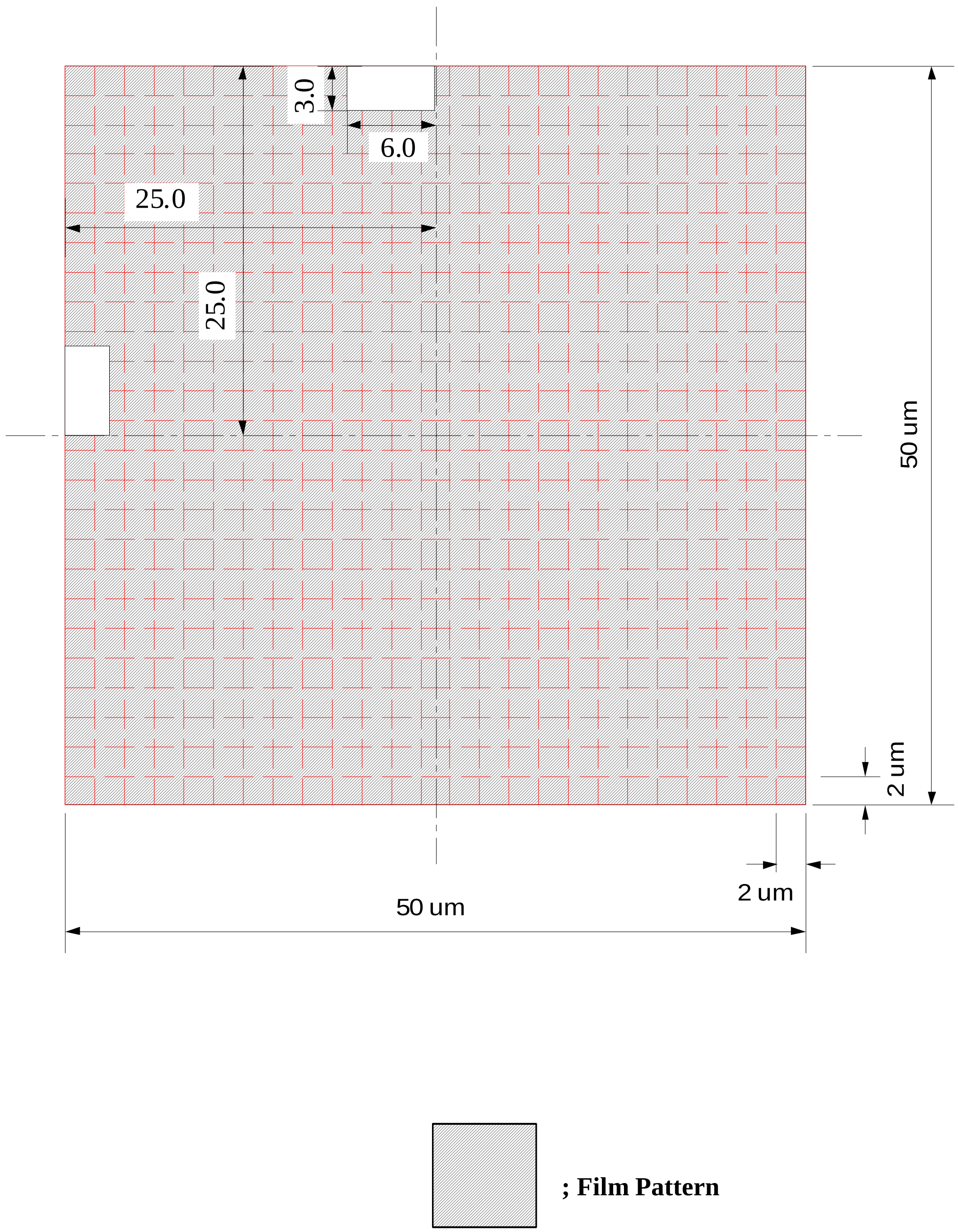
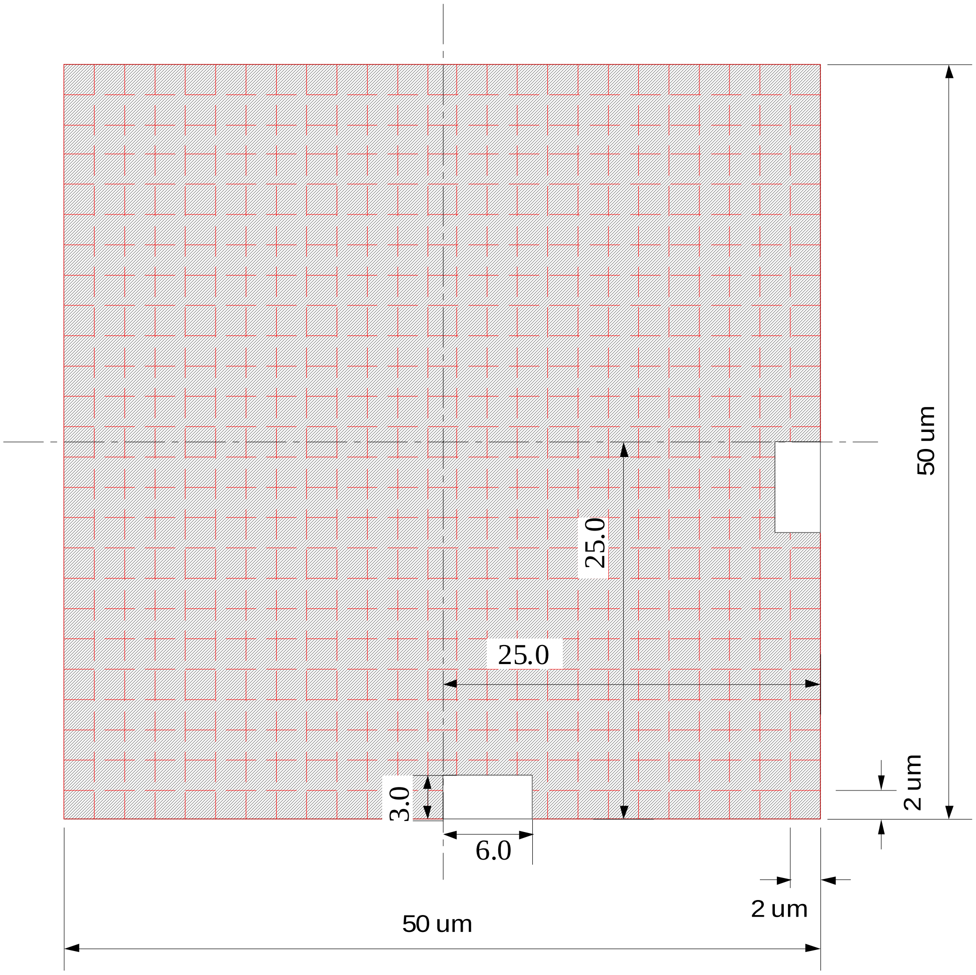


Figure 10
Sub Cell
Left Upper (x1, y1)



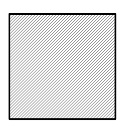
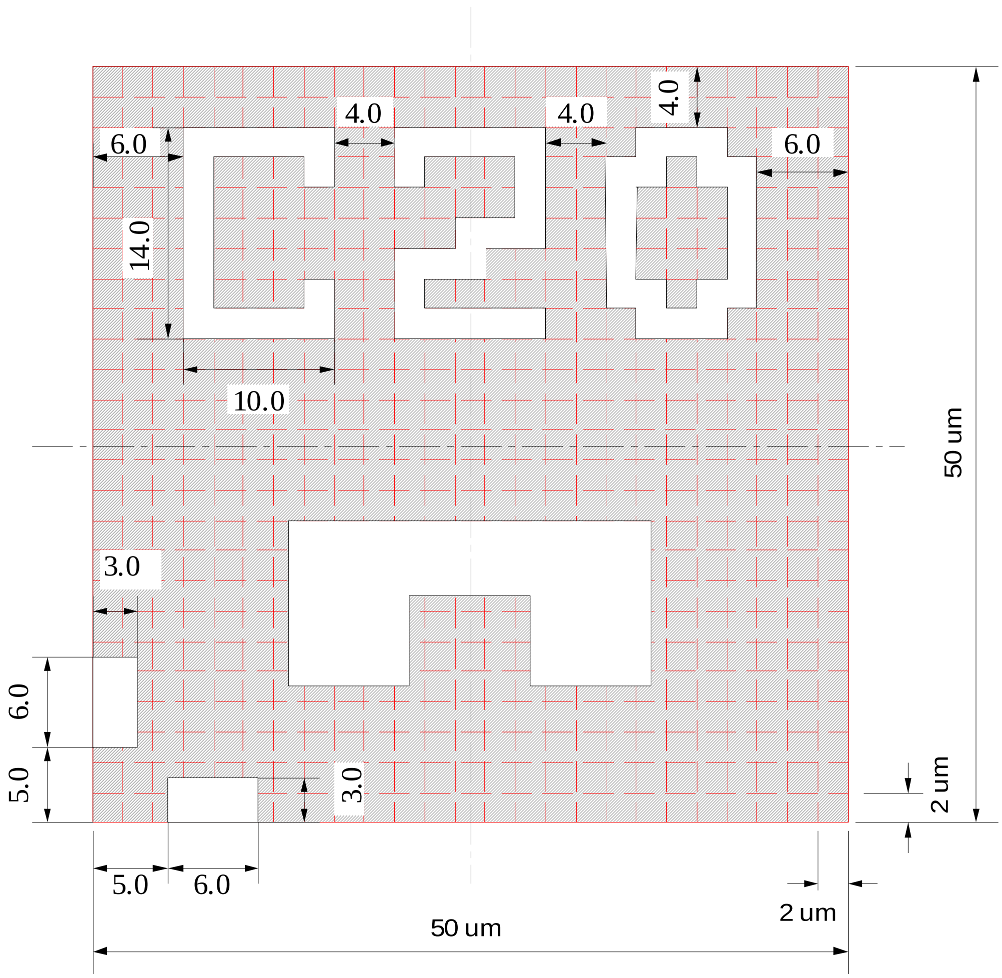


Figure 11
Sub Cell
Right Lower (x5, y5)



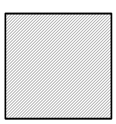
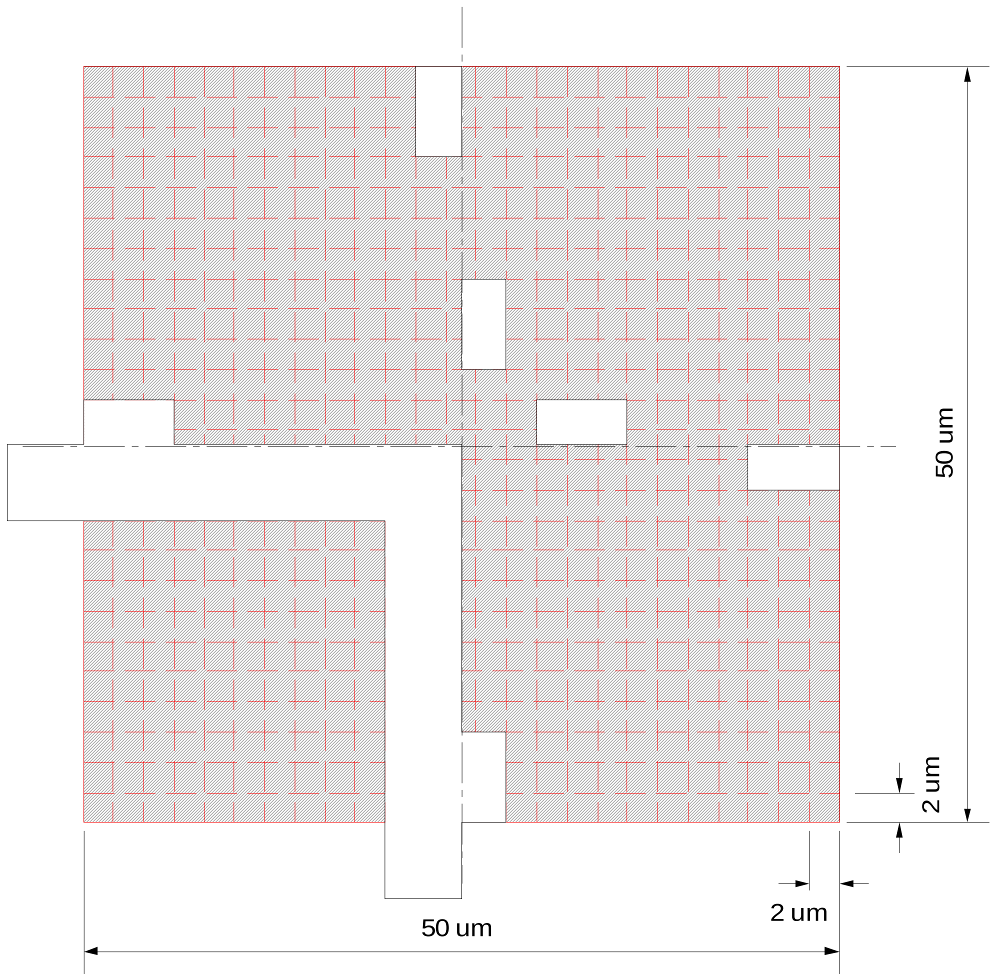


Figure 12
Sub Cell
Left Lower (X1, y5)
Defect ID & Defect Type



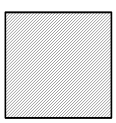


Figure 13
Sub Cell
Cell Corner Sample

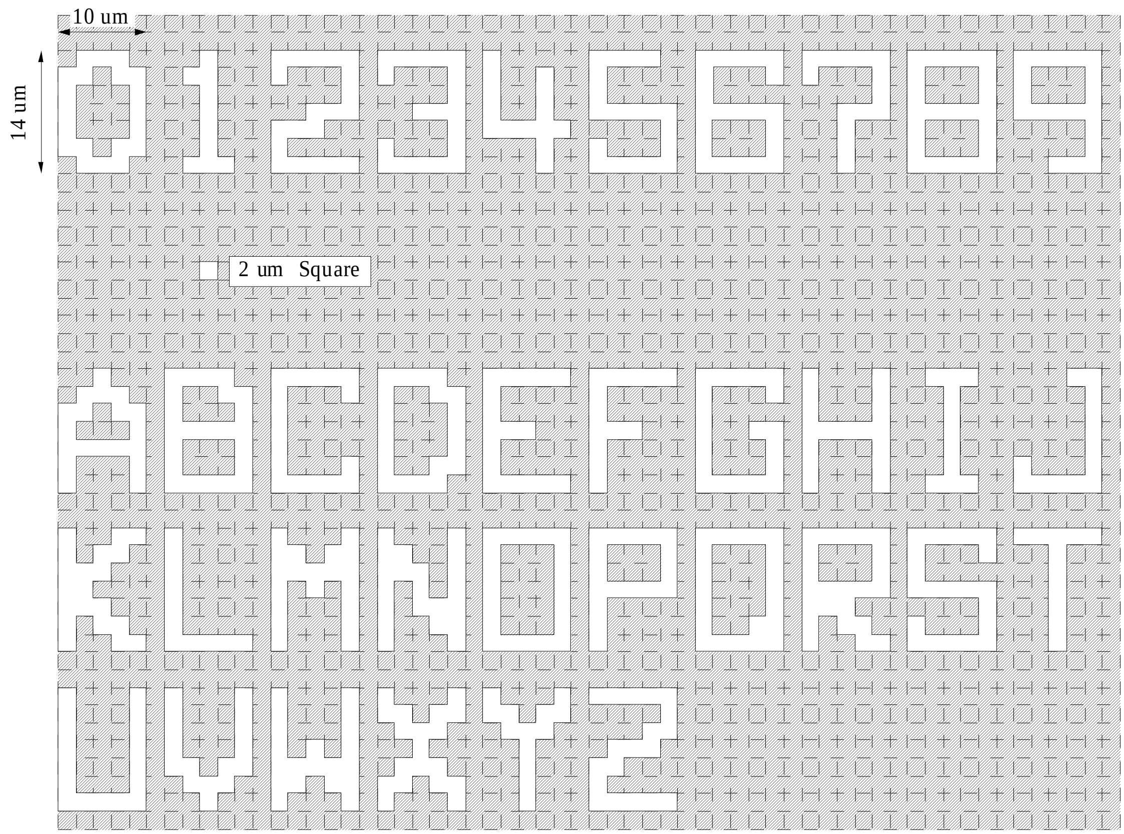
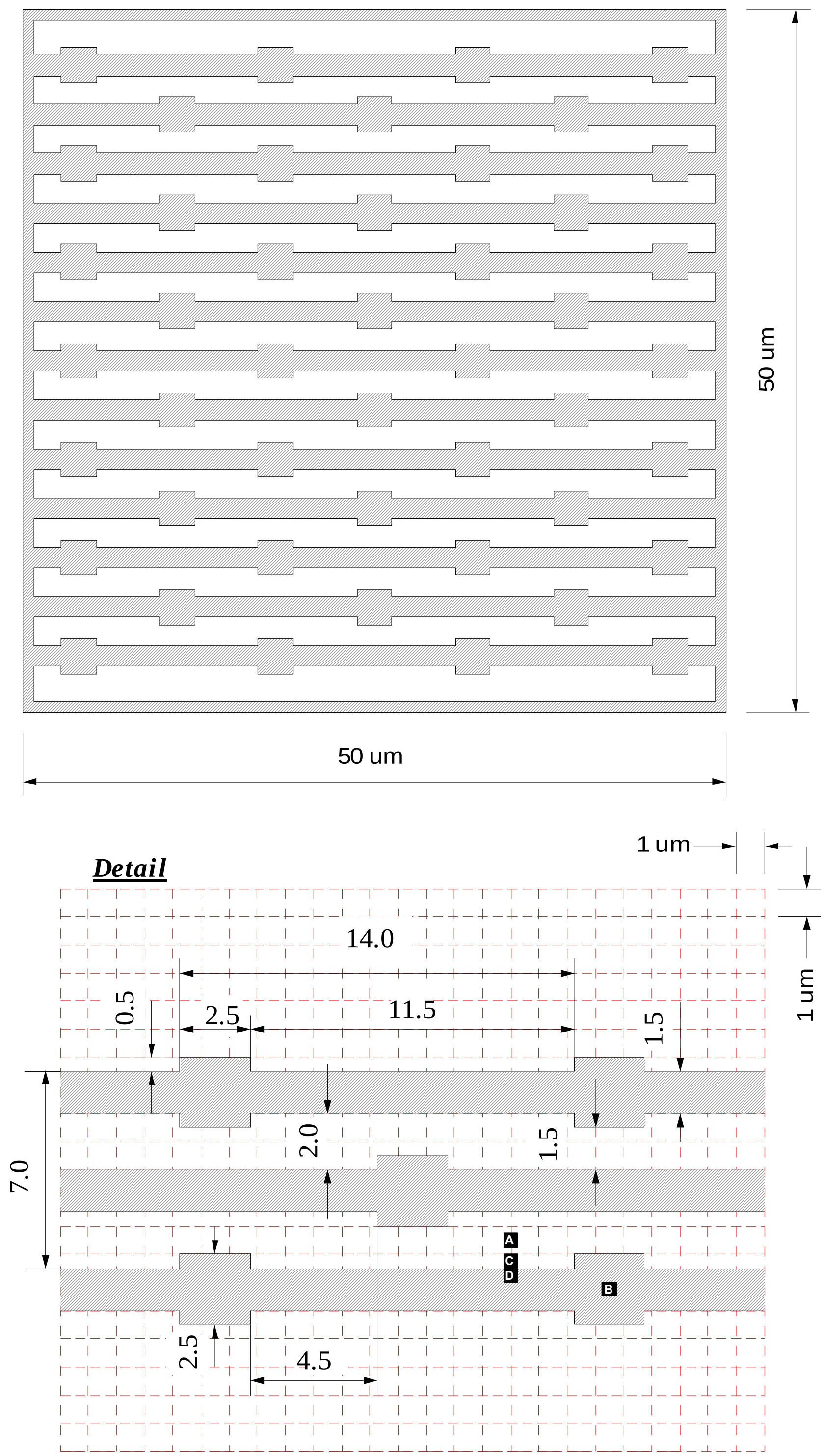


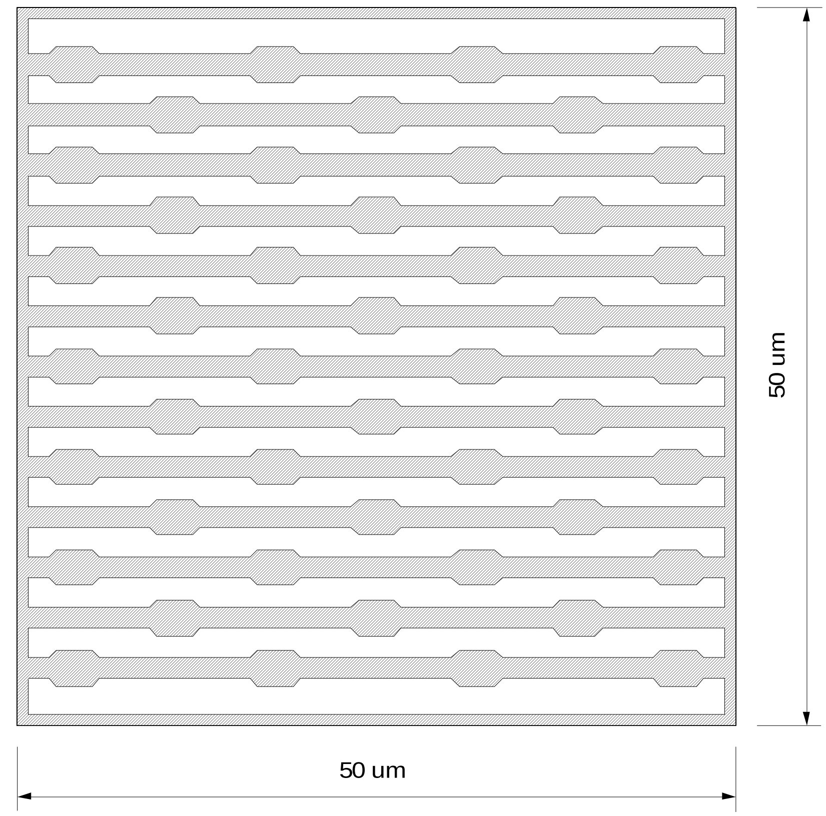
Figure 14
Letter
(Non False Defects Pattern)



; Film Pattern

■ ; Defect Position

Figure 15
Sub Cell
Wiring (Type A)



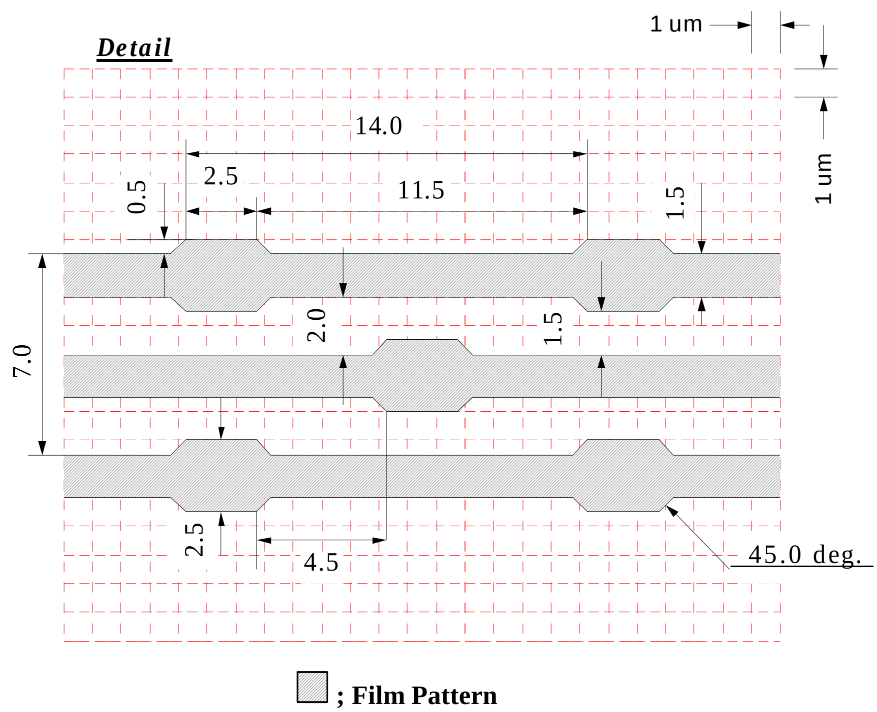


Figure 16
Sub Cell
Wiring (Type B)

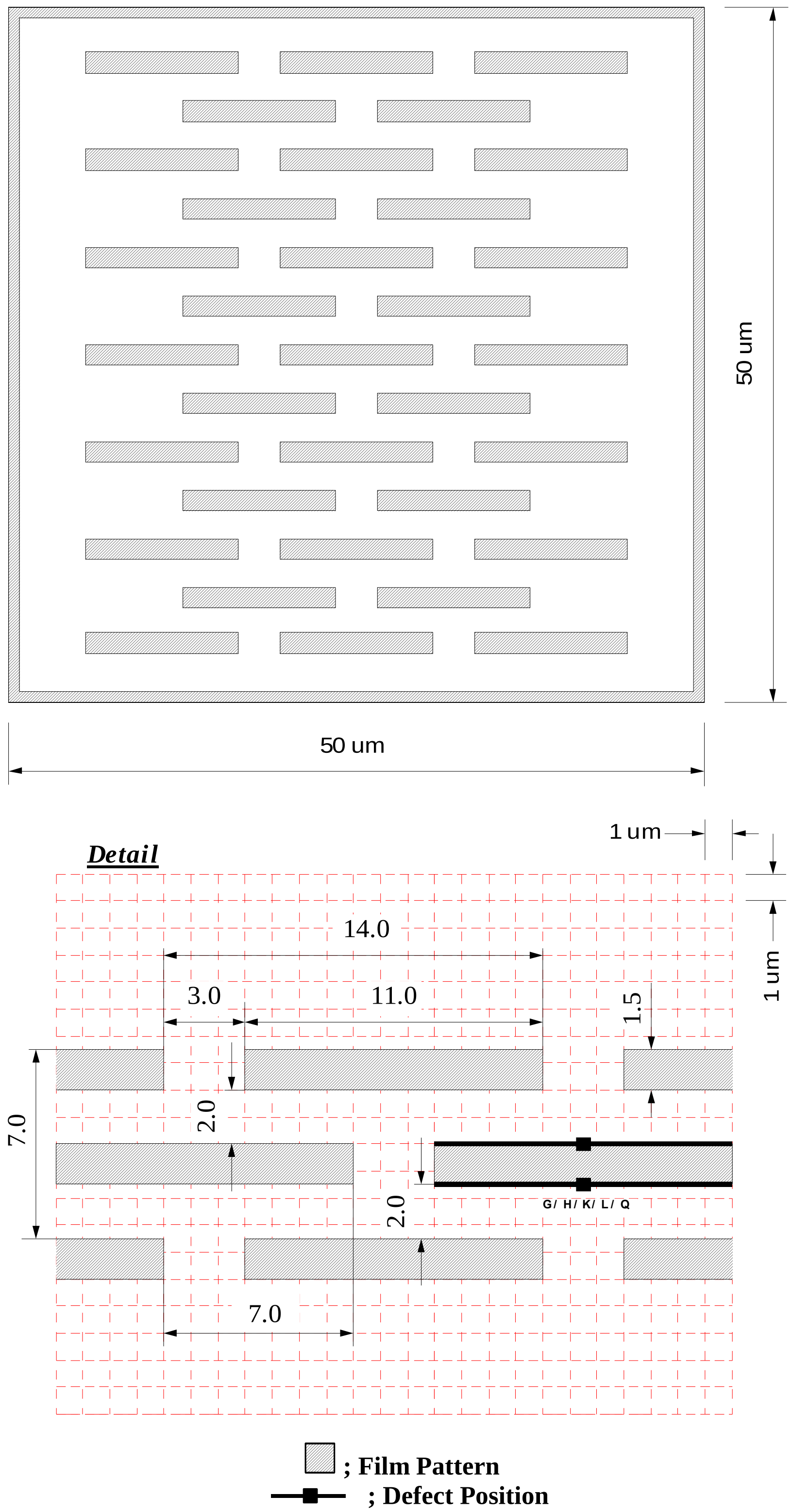
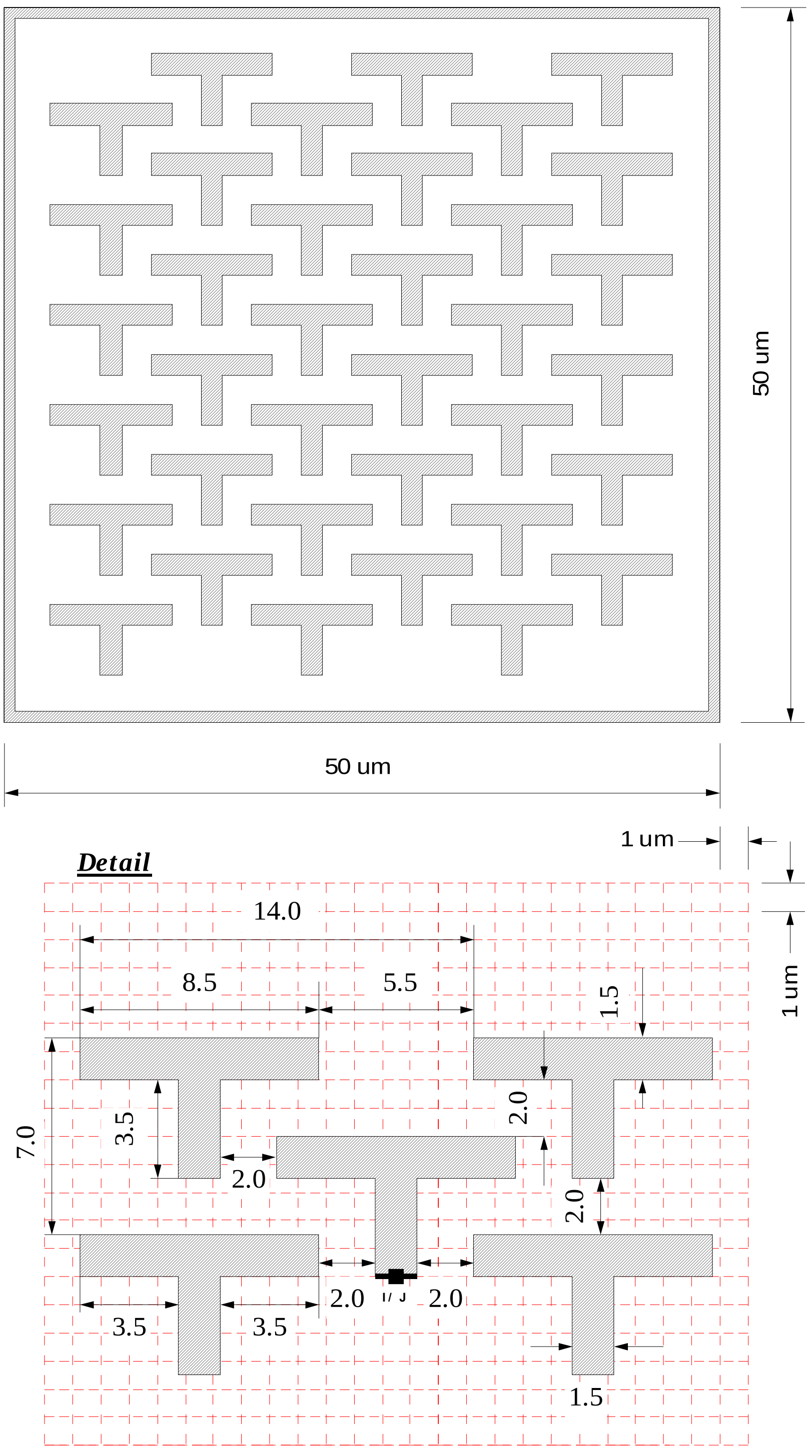


Figure 17
Sub Cell
Wiring (Type C)



; Film Pattern
; Defect Position

Figure 18
Sub Cell
Wiring (Type D)