

SEMI P19-92 (Reapproved 0707) SPECIFICATION FOR METROLOGY PATTERN CELLS FOR INTEGRATED CIRCUIT MANUFACTURE

This standard was technically approved by the global Micropatterning Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on April 25, 2007. It was available at www.semi.org in June 2007. Originally published in 1992; previously published in 1996.

NOTICE: This Standard or Safety Guideline has an Inactive Status because the conditions to maintain Current Status have not been met. Inactive Standards or Safety Guidelines are available from SEMI and continue to be valid for use.

1 Purpose

1.1 This document defines several standard test patterns to provide consistent industrywide evaluation and testing of micropatterning equipment, metrology instruments, and processes used in integrated circuit manufacturing.

2 Scope

2.1 This specification defines the shape, general size, and recommended placement and design rules (where appropriate) of several basic pattern cells for linewidth metrology, resolution testing, and proximity testing. These standard patterns include cells that can be used for optical microscopy, electron microscopy, and electrical probe testing.

2.2 This document does not attempt to specify the measurement techniques to be used in verifying critical dimensions for these test patterns on the reticle. Similarly, this document does not attempt to specify how the printed patterns are to be measured on the wafer. This document specifies only what the patterns are supposed to be; it is left to the user to ensure that the actual pattern conforms to this specification, subject to all other applicable SEMI specifications. A separate SEMI document will specify CD measurement conditions (see § 3).

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Referenced Standards and Documents

3.1 SEMI Standards and Safety Guidelines

SEMI P24 — CD Metrology Procedures

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

4 Terminology

4.1 Definitions

4.1.1 *linewidth* — in semiconductor technology, at a given cross-section of the line, the distance between the airline material boundaries at some specified height above the interface between the patterned layer in which the line is formed and the underlying layer (see Figure 1).

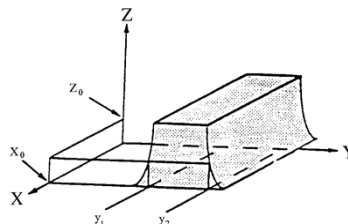


Figure 1
Linewidth (X_0, Z_0) = $Y_2 - Y_1$

NOTE 1: The physical basis for various methods of measuring linewidth may result in the measurements being carried out at differing heights for the same line at the same cross-section. For this reason, substantial method-dependent differences in measurement results may be expected and it is convenient to identify the method used in expressions such as “SEM linewidth,” “optical linewidth,” or “electrical linewidth” (ASTM F127). Furthermore, the height at which the measurement is taken shall be qualitatively stated, even if it cannot be quantitatively determined.

4.1.2 *feature* — areas within a single, continuous boundary (e.g., an aggregate image) that have an optical-density value (gray-level range), that is distinct from the background area outside the feature (ASTM D3849, ASTM D24) (e.g., the simplest element of a pattern, such as a single line, space, or L-bar).

4.1.3 *feature group* — a small assembly of one or more similar features arranged together, such as three nested L-bars.

4.1.4 *nominal feature dimension* — the linear dimension of interest, such as the linewidth or contact hole width.

4.1.5 *basic cell* — an arrangement of features or groups, as defined by this document, based upon a specific, nominal-feature dimension.

4.1.6 *composite cell* — an arrangement of several basic cells.

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



Figure 2
Isolated Line

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



Figure 3
Isolated Space

5 Detail Specification

5.1 Introduction

5.1.1 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.

5.1.2 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.

5.1.3 All critical dimensions given in this document are the actual CAD values at 1×. 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.

5.2 Applications

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

5.2.1.1 *In-Line Process Monitoring* — To establish patterns to determine if the layer has been processed to design specifications.

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

5.2.1.3 *Equipment Evaluation* — To standardize the patterns used to evaluate semiconductor equipment.

5.2.1.4 *Equipment Characterization* — To standardize the patterns for the characterization process of different metrology equipment.

6 Guidelines for Applications

6.1 General

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

6.1.2 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.

6.1.3 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.

6.1.4 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.

6.1.5 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.

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

6.1.7 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).

6.1.8 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).

6.2 Specific

6.2.1 L-Bar Cell (see Figure 4)

6.2.1.1 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.

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

6.2.1.3 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)

The center L-bar of each group shall extend beyond the ends of the other L-bars by at least $10\text{ }\mu\text{m}$. 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.

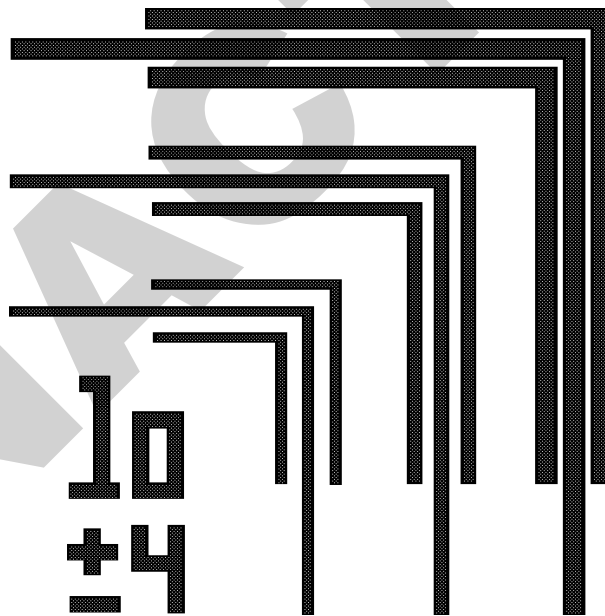


Figure 4
L-Bar Cell