SEMI T10-0701 (Reapproved 0923)
TEST METHOD FOR THE ASSESSMENT OF 2D DATA MATRIX DIRECT MARK QUALITY

This Standard was technically approved by the Traceability Global Technical Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on August 21, 2023. Available at www.semiviews.org and www.semi.org in September 2023; originally published July 2001; previously published June 2018.

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NOTICE: Paragraphs entitled 'NOTE:' are not an official part of this Standard or Safety Guideline and are not intended to modify or supersede the official Standard or Safety Guideline. These have been supplied by the global technical committee to enhance the usage of the Standard or Safety Guideline.

1 Purpose

1.1 This Standard is intended to define the methodology for the assessment of 2D Data Matrix direct mark quality.

2 Scope

2.1 This Standard defines assessment criteria, metrology methods, and assessment reporting procedures as applied to 2D Data Matrix code direct marks on semiconductor related materials. Application specifications, which refer to this Standard, may further limit its scope to more specific requirements of a particular application.

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 Limitations

3.1 This Standard will not specifically address the quality assessment of paper-printed labels and will be limited to the usage of the Data Matrix symbology as defined by the AIMI Uniform Symbology Specification.

3.2 This Standard will not specify the resulting minimum, maximum or nominal values of any direct mark assessment method which would be considered acceptable for a 2D Data Matrix direct mark application. Application specifications may define these values with reference to this Standard.

4 Referenced Standards and Documents

4.1 *AIM Standards*[1]

AIMI Uniform Symbology Specification — Data Matrix

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

5 Terminology

5.1 *Definitions*

5.1.1 *alternating pattern of a Data Matrix code symbol* — a line of alternately filled and unfilled cells indicative of the cell spacing along one of the major axes of the Data Matrix symbol. (Refer to Figure 1.)

5.1.2 *binary value* — a mark in the substrate surface indicates the binary value of one. The absence of a mark, or a smooth surface surrounding a cell center point, indicates the binary value of zero.

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5.1.3 *cell, of a Data Matrix symbol* — the area within which a marking may be placed to indicate a binary value. The cell is the smallest element of a two-dimensional Data Matrix symbol. The cell shape is generally quadrilateral, typically rectangular and ideally square.

5.1.4 *cell center point, of a Data Matrix symbol* — the point at which the centerline of a matrix row intersects the centerline of a column.

5.1.5 *cell size, of a Data Matrix symbol* — the number of image pixels within a Data Matrix symbol cell. Since the cell is generally rectangular in shape, the resolution is specified in both the horizontal and vertical directions of the cell.

5.1.6 *cell spacing, of a Data Matrix symbol* — the vertical or horizontal distance between the cell center points of contiguous cells.

5.1.7 *centerline, of a row or a column* — the line positioned parallel to, and spaced equally between, the boundary lines of the row or column.

5.1.8 *edge* — the location of a significant change in pixel brightness values between regions. It is the point(s) that has the greatest amount of contrast difference (change in intensity values) between pixels.

5.1.9 *edge detection method* — a method whereby the location of an edge in an image is determined.

5.1.10 *error correction* — mathematical techniques, which reconstruct the original information, based upon the remaining data in a damaged or poorly marked code. Reed Solomon and convolution are two such techniques.

NOTE 1: Error correction techniques are described extensively in AIMI Uniform Symbology Specification — Data Matrix.

5.1.11 *finder pattern, of a Data Matrix symbol* — a perimeter to the data region. Two adjacent sides contain marks in every cell: these are used primarily to define physical size, orientation and symbol distortion. This is often referred to as the L finder pattern. The two opposite sides are made up of cells containing marks in alternate cells. (Refer to Figure 1.)

5.1.12 *grayscale value* — the assignment of a digital value to a degree of light intensity. The shades of gray are used by a computer to reconstruct an image. A common scale is 256 shades of gray, with 0 being black and 255 being white.

5.1.13 *histogram* — a graphic representation of a frequency distribution of pixel values within an area of interest in a two-dimensional grayscale digital image. The horizontal axis of the graph represents the range of possible grayscale values in the image. The vertical axis of the graph represents the frequency of occurrence of each grayscale value in the area of interest. (Refer to Figure 2.)

5.1.14 *image coordinates* — locations in a two-dimensional digital image are referenced by a two-dimensional orthogonal coordinate system. The datum for the coordinate system is in the upper-left corner of the image. The horizontal axis or *x*-axis is located along the top of the image, with increasing positive values from left to right in the image. The vertical axis or *y*-axis is located along the left side of the image, with increasing positive values from top to bottom in the image.

5.1.15 *mark* — a cell or area of a Data Matrix symbol, which has been marked, meaning the substrate has been altered by the marking process so as to significantly alter its contrast when imaged. Also can refer to an entire Data Matrix symbol that has been applied in rows and columns on a substrate by a marking process.

5.1.16 *pixel resolution* — the precision in pixels at which all measurements are performed. The maximum pixel resolution shall be one pixel.

5.1.17 *pixels* — picture elements. In a two-dimensional digital image, pixels are individual elements to which a grayscale value is associated. The combination of grayscale values for each pixel and its respective location in a two-dimensional plane form a digital representation of a real scene.

5.1.18 *quiet zone* — areas of space surrounding the machine-readable symbol. Quiet zone requirements may be found in application and symbology specifications. Sometimes called ‘Clear Area’ or ‘Margin’.

5.1.19 *space* — an unmarked cell or area of a Data Matrix Symbol.

5.1.20 *symbol* — a machine-readable pattern comprised of a quiet zone, finder pattern, symbology characters (which include special functions and error detection and/or correction characters) required by a particular symbology.

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5.1.21 *symbol contrast* — the difference in grayscale values between the marked and unmarked areas of a Data Matrix symbol.

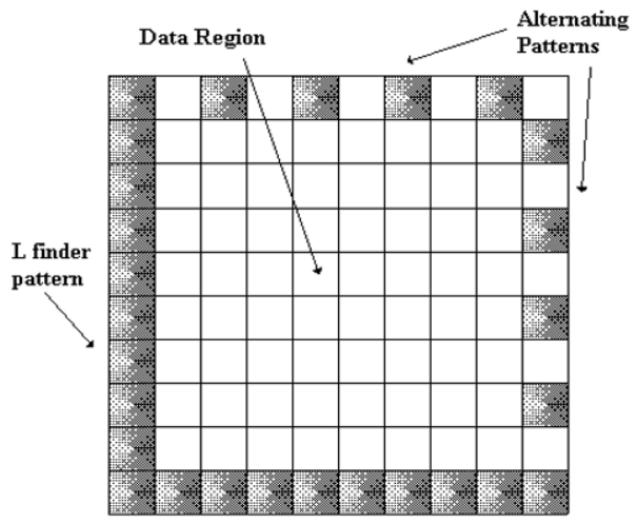

Figure 1
Data Matrix Symbol

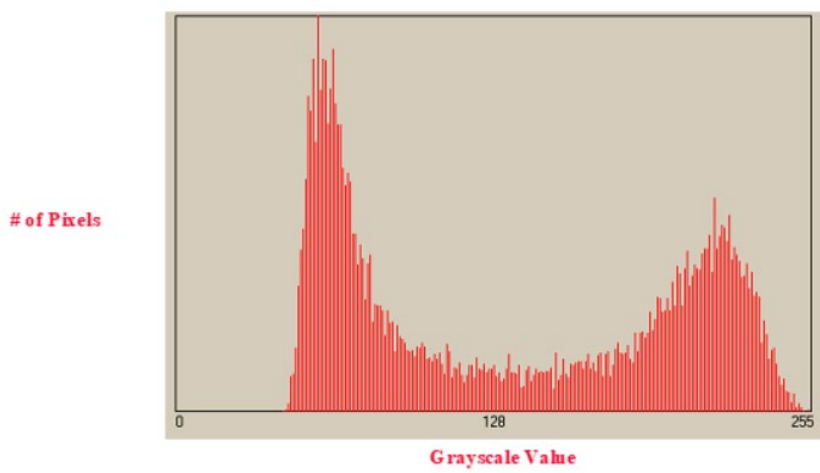

Figure 2
Pixel Histogram

6 Summary of Method and Requirements

6.1 *Test Image*

6.1.1 A test image of the mark shall be obtained in a configuration that mimics the typical reading configuration for that mark, at substantially the same resolution, illumination, optical focus, image exposure, gain or other image signal preprocessing settings that are used during reading. Individual applications may dictate a specific wavelength or color temperature and spatial construction of illumination, image resolution, optical focus, image exposure, etc. The mark/reader configuration shall be consistent to the extent that repeatable results can be obtained from a single sample over many instances of one mark/reader configuration.

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