

SEMI PV29-1018

SPECIFICATION FOR FRONT SURFACE MARKING OF PHOTOVOLTAIC (PV) SILICON WAFERS WITH TWO-DIMENSIONAL MATRIX SYMBOLS

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1 Purpose

- 1.1 This Specification defines the position and size of the two-dimensional matrix symbols excludes the occluding possibility of gridlines to increase the success probability of reading.
- 1.2 This Specification defines the position of the two-dimensional matrix symbols supplements serial alphanumeric marking to improve the chance of artificial reading and success possibility. If the fingers block the two-dimensional code, as substitute the alphanumeric code will work, which can make applicability of the standards more widely.
- 1.3 Position change of the two-dimensional and alphanumeric code can reduce negative effect of the code in the wafer center, on the cell capability.
- 1.4 This Specification defines the reading window to increase the success probability of reading.
- 1.5 A prerequisite for quality and process control in manufacturing of silicon wafers and solar cells is the traceability and track ability of the individual wafers.
- 1.6 The current specification defines a mark containing a data matrix code (DMC) that will allow to uniquely identifying wafers throughout the manufacturing process chain of solar cells and solar modules and their complete life cycle.
- 1.7 The specified mark can be easily applied and read, and is designed for stability throughout all solar cell and module manufacturing steps. Negative effects for this type of laser mark, such as increase of wafer breakage or reduction solar cell efficiency, have not been found in careful investigations performed on a large number of wafers and solar cells. This mark is independent of the positional orientation of the wafer.
- 1.8 Marks are widely used for identifying tracking and tracing wafers in the semiconductor industry. Therefore, equipment for applying and reading marks is easily available.
- 1.9 An additional advantage of a unique wafer mark is product security for producers and users of wafers and solar cells with respect to fraud, theft and counterfeiting.

2 Scope

- 2.1 This Specification covers an identification code, the geometric and spatial relationship and content (serial alphanumeric codes supplemented) of identification codes. This specification requires that identification code to be machine-readable (especially two-dimensional matrix codes) and human-readable (especially serial alphanumeric codes), for marking of square or pseudo-square mono- and multicrystalline silicon wafers for photovoltaic application.
- 2.2 The format and algorithms of these codes are based on two-dimensional symbols as specified in ISO/IEC 16022 and serial alphanumeric codes as specified in SEMI M12.
- 2.3 The mark is applied to one as-cut surface of a wafer on the later-to-be front surface of the solar cell.
- 2.4 One up to four identical marks—with the exception of their orientation—may be applied to one single wafer.
- 2.5 Although this Specification does not specify the marking techniques that may be employed when complying with its requirements, it is assumed that the symbol will be obtained by laser scribing of the individual dots.
- 2.6 The mark is applicable to all wafers sizes.

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 M12 — Specification for Serial Alphanumeric Marking of the Front Surface of Wafers

SEMI MF728 — Practice for Preparing an Optical Microscope for Dimensional Measurements

3.2 ISO/IEC Standard¹

ISO/IEC 16022 — Information Technology – Automatic Identification and Data Capture Techniques – Data Matrix Bar Code Symbology Specification

3.3 Other Documents

SEMI AUX001 — List of Wafer Supplier Identification Codes

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

4 Terminology

4.1 Abbreviations and Acronyms

4.1.1 DMC — data matrix code

4.2 Definitions

4.2.1 *alignment bar, of a data matrix code symbol* — a solid line of contiguous filled cells abutting a line of alternately filled and empty cells. [ISO/IEC 16022]

4.2.2 *binary values* — a dot in the wafer surface indicates the binary value 1. The absence of a dot, or a smooth surface surrounding a cell center point indicates the binary value 0.

4.2.3 *border column* — the outermost column of a data matrix code symbol. This column is a portion of the finder pattern.

4.2.4 *border row* — the outermost row of a data matrix code symbol. This row is a portion of the finder pattern.

4.2.5 *cell center point, of an array* — the point at which the centerline of a row intersects the centerline of a column.

4.2.6 *cell of a data matrix code symbol* — the area within which a dot may be placed to indicate a binary value.

4.2.7 *cell spacing, of an array* — the (equal) vertical or horizontal distance between the cell center points of contiguous cells.

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

4.2.9 *central area, of a cell* — the area enclosed by a circle centered at the cell center point; used by code readers to sense the binary value of the cell.

4.2.10 *character baseline* — a straight line connecting center points of characters with equal size.

4.2.11 *data matrix code symbol* — a two-dimensional array of square cells arranged in contiguous rows and columns. The data region is surrounded by a finder pattern. [ISO/IEC 16022]

4.2.12 *dot* — a localized region with a reflectance which differs from that of the surrounding surface.

NOTE 1: To assure reading efficiency, a minimum contrast of 30% is required between the reflectance value of a dot and the surrounding wafer surface. Various densitometers can provide such measurements nondestructively.

¹ International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland; Telephone: +41.22.749.01.11, <http://www.iso.org>

4.2.13 *dot misalignment, within a cell* — the distance between the physical center point of a dot and the cell center point.

4.2.14 *finder pattern, of a data matrix code symbol* — a perimeter to the data region. Two adjacent sides contain dots in every cell; these are used primarily to define physical size, orientation and symbol distortion. The two opposite sides are made up of cells containing dots in alternate cells. [ISO/IEC 16022]

4.2.15 *reading window* — an area on a wafer in which the dot matrix symbol(s) have to be placed, in order to be read by a reader.

4.2.16 *reference point, of a data matrix code symbol* — the physical center point of cell used to identify the physical location of the symbol on the object being marked with the symbol.

4.2.17 *wafer center point* — a point on a square or rectangular wafer surface defined by the intersection of the diagonals of the square or rectangle.

5 Ordering Information

5.1 *Checklist* — Purchase orders for wafers furnished to this Specification shall include the following items:

- Number of data matrix symbols per wafer

6 Requirements

6.1 Data Matrix Code Layout

6.1.1 Each data matrix shall consist of a square array of cells of 14 rows and 14 columns with alignment bars as defined in ISO/IEC 16022.

6.1.2 One border row and one border column shall contain a dot in each cell. These are identified as the primary border row and the primary border column. These are used by the code reader to determine the orientation of the matrix. They are also referenced to as ‘finder pattern,’ as shown in Figure 2.

6.1.3 The opposing (secondary) border row and column shall contain dots in alternating cells, also referenced to as ‘alignment pattern,’ as shown in Figure 2.

6.1.4 For these square matrix code symbols, the reference point of the symbol shall be the center point of the dot matrix symbol.

6.1.5 The layout of alphanumeric marking is based on SEMI M12-0706.

6.2 Content of the Data Matrix Code Symbol

6.2.1 Each square data matrix code symbol shall contain twelve message characters, together with the error checking and correcting (ECC200) code characters, encoded in accordance with ISO/IEC 16022. Degree of vacuum accuracy: within ± 300 Pa.

6.2.2 The message characters may include the following: A–Z, 0–9. These characters constitute the SEMI OCR Character Set except for the period (.) and dash (-); this is the similar character set as specified in SEMI M12. These characters are also included in the set designated as “primarily upper case alphanumeric” in ISO/IEC 16022, in Table 5 and Annex J. The twelve message characters shall contain following elements, as detailed in Figure 3:

6.2.2.1 A vendor-assigned numeric two-character code identifying the year of manufacturing,

6.2.2.2 A switch code to C40 encoding,

6.2.2.3 A alphanumeric two-character vendor identification code (according to SEMI AUX001),

6.2.2.4 A 7-character code identifying and distinguishing the individual wafer within a yearly production of a specific vendor.

6.2.2.4.1 These 7 characters can be designed to be a unique, serial number or could include information about ingot, brick and the respective wafer position in it.