

SEMI P37-1109

SPECIFICATION FOR EXTREME ULTRAVIOLET LITHOGRAPHY SUBSTRATES AND BLANKS

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NOTICE: This document was completely rewritten in 2009.

1 Purpose

1.1 There are two main purposes of this standard:

- To define key specifications for EUV substrates that ensure physical dimensional compatibility with EUV carriers, process equipment, and EUV scanners;
- To identify and define key properties of EUV substrates and blanks which should be specified in the purchase order between users and suppliers.

2 Scope

2.1 This standard details the physical characteristics and tolerances required for EUV substrates.

2.2 This standard details select film definitions and specifications required for EUV Blanks.

2.3 This standard details additional specifications which should be included in purchase orders for substrates and blanks.

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 Referenced Standards and Documents

3.1 SEMI Standard

SEMI P1 — Specification for Hard Surface Photomask Substrates

3.2 ANSI Standard¹

ANSI/ASQC-Z1.4 — Sampling Procedures and Tables for Inspection by Attributes

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

4 Terminology

4.1 Abbreviations and Acronyms

4.1.1 *EUV* — Extreme Ultraviolet Light radiation

4.2 Definitions

4.2.1 *Absorber Film Stack* — stack of film layers deposited on top of the multilayer film stack to block reflection of the light, with optional buffer layer for use in some absorber repair operations (see Figure 1).

4.2.2 *Backside Conductive Film Stack* — conductive film(s) deposited on the backside of the substrate to enable electrostatic chucking of the substrate during multilayer film and absorber film deposition and electrostatic chucking of the final mask during EUV scanner exposures.

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4.2.3 *Blank Bow* — any curvature (second order) of the blank, which can arise from the films deposited upon the backside and frontside of the substrate.

4.2.4 *EUV Mask* — the final result of patterning the EUV Blank. The EUV Mask is shipped from the Mask Shop to the customer for EUV exposures (see Figure 1).

4.2.5 *EUV (Mask) Blank* — an EUV substrate which has had deposited upon it a backside conductive layer (for electrostatic chucking), a multilayer film stack (to provide high reflection of EUV light), and an absorber film stack (to block reflection of light in desired areas). A resist for writing of the pattern must be the top most layer, but this step can be done by the blank supplier or by the mask shop (see Figure 1).

4.2.6 *EUV (Mask) Substrate* — the base glass or ceramic material upon which films are deposited to make EUV blanks and EUV masks.

4.2.7 *Multilayer Film Stack* — stack of film layers deposited on the EUV Substrate to provide high EUV reflectivity, and any capping layers for environmental protection and absorber film etch stops (see Figure 1).

5 Ordering Information

5.1 Purchase orders for EUVL substrates furnished to this standard should include the following specifications in addition to those identified in § 6 *EUV Substrate Definitions and Specifications*:

5.1.1 Material (see ¶ 6.1);

5.1.2 Flatness quality area, maximum flatness error, and maximum backside local slope angle (and the area that the local slope angle is to be calculated within) (see ¶ 6.3);

5.1.3 Maximum dimension of smallest unacceptable defect, defect quality area and maximum number of defects detected during substrate inspection;

5.1.4 Lot acceptance criteria for the EUV (Mask) Substrate (see ¶ 10).

5.2 Purchase orders for EUVL blanks furnished to this standard should include the above items for the substrate along with the following blank specifications in addition to those identified § 7 *EUV Blank Film Layer Definitions and Specifications*:

5.2.1 The material of the backside conductive layer, and the maximum area of the coating;

5.2.2 The material of the reflective multilayer film stack;

5.2.3 The quality area for the multilayer film EUV reflectivity and for absorber film inspection wavelength reflectivity;

5.2.4 The allowed deviation of the measured median reflected EUV wavelength at the center of the mask from the incident median wavelength (to be defined by users and material suppliers) of the multilayer film stack, and the range of variation of the median reflected wavelength across the multilayer film stack (see ¶ 7.2, Figure 7 and Table R1-3);

5.2.5 The minimum value for the median EUV reflectance of the multilayer film stack and the uniformity of the reflectance across the quality area (see ¶ 7.2 and Table R1-3);

5.2.6 The material(s) of the absorber film stack;

5.2.7 The maximum value for the median EUV reflectance of the absorber film stack and the uniformity of the reflectance across the quality area;

5.2.8 The absorber film inspection wavelength(s), the maximum value of the absorber reflectivity at that inspection wavelength(s), and the uniformity of the absorber reflectivity across the quality area; Typical inspection wavelengths are 257 nm or 199 nm/193 nm.

5.2.9 The maximum non-flatness with bow and wedge removed;

5.2.10 The maximum bow of the EUVL blank with the combined backside and frontside films;

5.2.11 Maximum dimension of smallest unacceptable defects (multilayer and/or absorber), defect quality area (multilayer and/or absorber) and maximum number of defects detected during multilayer inspection and during absorber inspection;

5.2.12 Lot acceptance criteria EUV (Mask) Blank (see § 10).

6 EUV Substrate Definitions and Specifications

6.1 EUV Substrate Materials

6.1.1 Substrate materials shall be identified as Low Thermal Expansion Material (LTEM). The properties of the LTEM are described in Table 1. Examples of LTEM materials are titanium-doped silica glass or two phase glass ceramics.

6.2 EUV Substrate Physical Dimensions

6.2.1 The square substrates shall conform to the dimensional tolerances for nominal edge length and thickness as listed in Table 2. Dimensions are illustrated in Figure 2.

6.2.2 Substrate corners shall be rounded as illustrated in Figure 3. The corners shall conform to the dimensional tolerances listed in Table 3.

6.2.3 Substrate edges shall be chamfered as illustrated in Figure 3. The edges shall conform to the dimensional tolerances listed in Table 3.

6.2.4 Substrates shall be identified with notches of the required dimensions at three corners on the backside of the substrate as defined in Figure 4. There is no implied or preferred orientation of the notches.

6.3 EUV Substrate Flatness Components

6.3.1 Flatness errors are defined as the deviation of the surface in question from the plane that is defined by a least squares fit to the flatness data (see Figure 5). Tilts are effectively removed from the error since it is relative to the fit plane, however any residual substrate bow will contribute to the flatness error.

6.3.2 The backside local slope angle is defined as the angle between the local slope and the least squares fit plane of the backside flatness data from ¶ 6.3.1 (see Figure 5).

6.3.3 The wedge error is defined as the relative angle between the two least squares fit planes for frontside and backside flatness (see Figure 6). The maximum value of the substrate wedge error is specified in Table 4.

7 EUV Blank Film Layer Definitions and Specifications

7.1 Backside Conductive Layer

7.1.1 The backside conductive layer must coat a minimum area of at least 146 mm × 146 mm. Actual area will be decided between suppliers and users.

7.1.2 The sheet resistance should be ≤100 ohms/square at all points on the backside conductive layer.

7.2 Frontside Multilayer Stack

7.2.1 The multilayer film stack should be optimized for EUV light at a median wavelength (as shown in Figure 7) to be defined by users and material suppliers incident at an angle of 6° to the surface normal.

7.2.2 The reflectivity properties of the multilayer film stack are to be specified in terms of the median EUV reflected wavelength λ_m , which is defined as shown in Figure 7 as the wavelength at the center of the Full-Width-Half-Maximum (FWHM) range of the measured reflectivity data, and this median wavelength might not occur at the measured peak reflectivity.

8 Sampling

8.1 Unless otherwise specified, appropriate sample sizes shall be selected from each lot in accordance with ANSI/ASQC Z1.4. Each quality characteristic shall be assigned an acceptable quality level (AQL) in accordance with ANSI/ASQC Z1.4 definitions for critical, major, and minor classifications. If desired, and so specified in the contract or order, each of these classifications may alternatively be assigned cumulative AQL values. Inspection levels shall be agreed upon between user and supplier.