

SEMI P38-1103 (Withdrawn 0710)

SPECIFICATION FOR ABSORBING FILM STACKS AND MULTILAYERS ON EXTREME ULTRAVIOLET LITHOGRAPHY MASK BLANKS

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NOTICE: This document was balloted and approved for withdrawal in 2010.

1 Purpose

1.1 This specification covers the requirements of the multilayer coating and of the absorbing film stack on Extreme Ultraviolet Lithography (EUVL) masks.

2 Scope

2.1 This standard details the physical characteristics and tolerances required for EUVL mask multilayer coatings. Material composition is not specified to allow for innovation in materials.

2.2 This standard details the physical characteristics and tolerances required for EUVL mask absorbing film stacks. The absorbing film stack comprises two or more layers. Material composition is not specified to allow for innovation in materials.

2.3 For purposes of this standard, the supplier fabricates the mask blank and provides it to the user. In most cases, the user patterns some of the layers on the front side of the mask blank.

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 P37 — Specification for Extreme Ultraviolet Lithography Mask Substrates

3.2 ANSI Standard¹

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

3.3 ISO Standard²

ISO 14644-1 — Cleanrooms and Associated Controlled Environments Part 1: Classification of Air Cleanliness

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

4 Terminology

4.1 Definitions

4.1.1 *absorber layers* — one or more layers of material that absorb EUV radiation and are patterned in the mask fabrication process. These layers are deposited on top of the buffer layer (see Figure 1).

4.1.2 *absorber stack* — stack of film layers that includes the absorber layer or layers and the buffer layer (see Figure 1).

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² International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland; Telephone: 41.22.749.01.11, Fax: 41.22.733.34.30, <http://www.iso.org>

4.1.3 *buffer layer* — layer of material beneath the absorber layer or layers (see Figure 1). This layer is patterned on the final mask.

4.1.4 *capping layer* — layer or layers on top of the multilayers are not patterned (see Figure 1).

4.1.5 *conductive layer* — layer deposited on the backside of the EUV mask substrate that is electrically conductive (see Figure 1).

4.1.6 *defect* — any flaw or imperfection in the opaque coating, reflective multilayer coating, or functional pattern of a mask that will reproduce itself in a photoresist film and impair the proper functioning of the microelectronic device being fabricated.

4.1.7 *EUV* — extreme ultraviolet radiation with wavelength in the range of 4 to 20 nm.

4.1.8 *multilayer stack* — stack of film layers that includes layers deposited on the mask blank to provide high EUV reflectivity, any capping layers and any underlayers (see Figure 1).

4.1.9 *multilayers* — film stack with layer materials and thickness values selected to produce high reflectivity of incident EUV radiation (see Figure 1).

4.1.10 *resist* — layer of radiation-sensitive material patterned in the lithography process for fabricating the mask (see Figure 1).

4.1.11 *underlayers* — layer or layers between the multilayers and the EUV mask substrate, which is described by SEMI P37-1101 (see Figure 1).

5 Ordering Information

5.1 Purchase orders must include the type of mask blank. Table 1 shows the layers that are included in each mask type.

5.2 Purchase orders for EUVL masks furnished to this specification shall include the items listed in Table 2.

6 Area Covered by Requirements

6.1 *Layer Quality Area* — A layer quality area with width, W_L , and height, D_L , shall be agreed upon between user and supplier. Figure 2 shows the labeling of the dimensions of the layer quality area. The layer quality area may be smaller than the edge length, L , of the mask substrate, which is defined in SEMI P37. The layer quality area is the region where the multilayer stack and absorber stack properties are specified in § 7. The multilayer, capping, absorber layer(s) and buffer layer properties are also specified only in the layer quality area.

6.1.1 Specifications for the layers and layer stacks outside the layer quality area are agreed upon between user and supplier.

6.2 *Defect Quality Area* — A defect quality area, with width, W_d , and height, D_d , shall be agreed upon between the user and supplier. Figure 3 shows the labeling of the dimensions of the defect quality area. The defect quality area may or may not be identical to the area described in § 9.1 of SEMI P37. The defect quality area may be smaller than the edge length, L , of the mask substrate, which is defined in SEMI P37. The defect quality area is not necessarily the same as the layer quality area described in § 6.1.

6.2.1 Specifications for defects outside the defect quality area are agreed upon between user and supplier.

7 Layer Properties

7.1 The multilayer stack attributes and properties are defined in Table 3. The EUV reflectivity requirements are defined in Tables 4 and 5, and the EUV reflectivity uniformity requirements are defined in Table 6. Figure 4 illustrates the EUV reflectivity parameters. The median wavelength is defined as shown, and the peak reflectivity might not occur at the median wavelength. The optical properties of the multilayer stack at wavelengths besides EUV wavelengths are defined in Table 10.

7.2 The buffer layer requirements are shown in Table 7. The optical properties of the buffer layer at wavelengths besides EUV wavelengths are defined in Table 10. The reflectivity requirements in Table 10 apply to the buffer layer as deposited on top of the multilayer stack. By mutual agreement between the user and supplier, the range of wavelengths for mean reflectivity requirement may be reduced to a subset of the range shown in Table 10.

7.3 The absorber layer requirements are defined in Table 8.

7.4 The requirements for the absorber stack are defined in Table 9. The optical properties of the absorber stack at wavelengths besides EUV wavelengths are shown in Table 11. The reflectivity requirements in Tables 9 and 11 apply to the absorber stack as deposited on top of the multilayer stack. By mutual agreement between the user and supplier, the range of wavelengths for mean reflectivity requirement may be reduced to a subset of the range shown in Table 11.

7.5 At all points on the backside of the mask blank, the sheet resistance should be ≤ 100 Ohms/square. The requirements for the conductive layer on the backside of the substrate are shown in Table 12.

8 Defects

8.1 The multilayer stack must be inspected for defects before deposition of the buffer layer and absorber layer(s). The multilayer stack must meet the defect requirements shown in Table 13.

8.2 The absorber stack must meet the defect requirements shown in Table 14. For Type 3 mask blanks, the resist and absorber stack must meet the defect requirements shown in Table 14.

8.3 The location and size of all defects in the multilayer or absorber stacks that were located by the supplier will be provided to the user. The required accuracy and reference point(s) for these locations will be negotiated between user and supplier.

8.4 Mask blanks must meet the backside defect requirements in § 9.3 of SEMI P37.

9 Flatness Specifications

9.1 The flatness of the mask blank shall be agreed upon between user and supplier.

10 Sampling

10.1 Unless otherwise specified, appropriate sample sizes shall be selected from each lot in accordance with ANSI/ASQ Z1.4. Each quality characteristic shall be assigned an acceptable quality level (AQL) in accordance with ANSI/ASQ 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. The method of certification shall be agreed upon between user and supplier.

11 Test Methods

11.1 *Thickness* — Method of measuring layer thickness values to be agreed upon between user and supplier.

11.2 *Reflectivity* — Method of measuring reflectivity at specified wavelengths to be agreed upon between user and supplier with these exceptions:

11.2.1 Each individual reflectivity measurement should represent reflectivity over an area having rectangular dimensions < 1 mm.

11.2.2 EUV reflectivity must be measured at 6 degrees with respect to the normal to the plane of the mask blank surface.

11.3 *Stress* — Method of measuring stress is to be agreed upon between user and supplier.

11.4 *Outgassing* — Method of measuring outgassing rate is to be agreed upon between user and supplier.

11.5 *Etch Rates* — Method of measuring etch rates and etch selectivity is to be agreed upon between user and supplier.

11.6 *Defects* — Method of inspection for defects is to be agreed upon between user and supplier.

11.7 *Flatness* — Method of measuring flatness is to be agreed upon between user and supplier.

11.8 *Backside Sheet Resistance* — Method of measuring sheet resistance is to be agreed upon between user and supplier.

11.9 *Electrical Resistance* — Method of measuring electrical resistance is to be agreed upon between user and supplier.