

INSTRUCTION

Nom de l'Instruction :

QUALITY SPECIFICATIONS FOR MASKS

Référence :

PHO-IG-482

Version de l'Instruction :

J

Objet :

Definition of the quality standards and control methods relating to masks. To be use by all maskshops providing masks for LETI.

Domaine d'application :

This instruction applies to all masks used by CEA-LETI

	Nom / Fonction / Entité	Date	Visa
Rédacteur(s) :	A. BERNADAC / DPFT / SPAT / LPAC	17/03/2026	
Vérificateur(s) :	N. BERNARD-HERNIQUES / DCOS / SCCS/ LMDE		
Approbateur(s) :	A.Fay / CdL / DPFT / SPAT / LPAC		

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J**1. Reference documents**

- SEMI P1-0708 Specification for hard surface photomask substrates
- SEMI P2-0308 Specification for chrome thin films for hard surface photomasks
- SEMI P5-0416 Specification for pellicles
- SEMI P6-88 Specification for registration marks for photomasks
- SEMI P10-1112 Specification of data structures for photomask orders
- SEMI P22-0307 Guideline for photomask defect classification and size definition
- SEMI P23-0200 Guidelines for programmed defect masks and benchmark procedures for sensitivity analysis of mask defect inspection systems
- SEMI P29-1111 Specification for characteristics specific to attenuated phase shift masks and mask blanks
- SEMI P34-0200 Specification for 230 mm square photomask substrates
- SEMI P43-0304 Photomask qualification terminology

2. General definitions

Mask: Transparent substrate selectively covered by an opaque layer. Its purpose is to reproduce patterns on wafers by photolithography.

Mask set: A series of photomask used for the same project

MLR: Multi-Layer reticle.

Mask blank: substrate material use for mask fabrication. Several types:

- **Binary mask:** Quartz mask with opaque chrome layer
- **Embedded Attenuated Phase Shift Mask (EAPSM):** transparent quartz substrate covered by a thin layer of MoSi, which change the phase of the transmitted light by 180°. The transmittance of this layer can vary from 3% to higher values at the exposure wavelength
- **Optical dense MoSi on Glass (OMOG):** Transparent quartz substrate covered by opaque MoSi layer. A thin chrome hard mass cover the opaque MoSi layer for etch purpose.

Transmission (for EAPSM): Percentage of light passing through the attenuated PSM layer with respect to air or quartz.

Phase change: any change in the phase of the optical light when crossing a material interface

Pellicle: thin transparent film, attached to the mask by a metallic frame. It is purposed is to avoid any contaminant to be in contact with the active area of the mask.

Contamination: Particle &/or defectivity removable by a cleaning process

Mask active area: Area supposed to be exposed, should be under pellicle

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Grade: Standardized class of mask quality

Pattern: Any feature written on the mask

Design: Original design before frackling containing all patterns to be reproduced on mask

Database: Original design send to maskshop, can be already fracked (MEBES) or not (GDS/OASIS)

Address grid of the database: Length of the elementary square of the database

Jobdeck: File readable by maskshop lithography equipment

Address size: Pixel size in the Jobdeck

MRC: Mask Design Rule Check

OPC: Optical proximity correction

Assist features: Optical enhancement patterns on mask to correct optical proximity effect on wafer. These patterns are not supposed to be printed on wafer due to their small size (beyond scanner resolution)

SPC: Statistical process control

USL: upper specification limit

LSL: lower specification limit

Cpk: process capability to be in specification. If Cpk < 1.33, it means that the process isn't centered according to the specifications limits

$$Cpk = \min \left(\frac{USL - mean}{3\sigma} ; \frac{mean - LSL}{3\sigma} \right)$$

PTCC: percentage of specification tolerance of a measurement system. Allow to verify if an equipment is capable at 99% to measure a value.

$$PTCC = \left(\frac{5.15 * \sqrt{\sigma_{repeatability}^2 + \sigma_{reproductibility}^2}}{USL - LSL} \right) * 100$$

Critical dimension (CD): dimension of a specified geometry/pattern

Nominal CD (N): CD target value

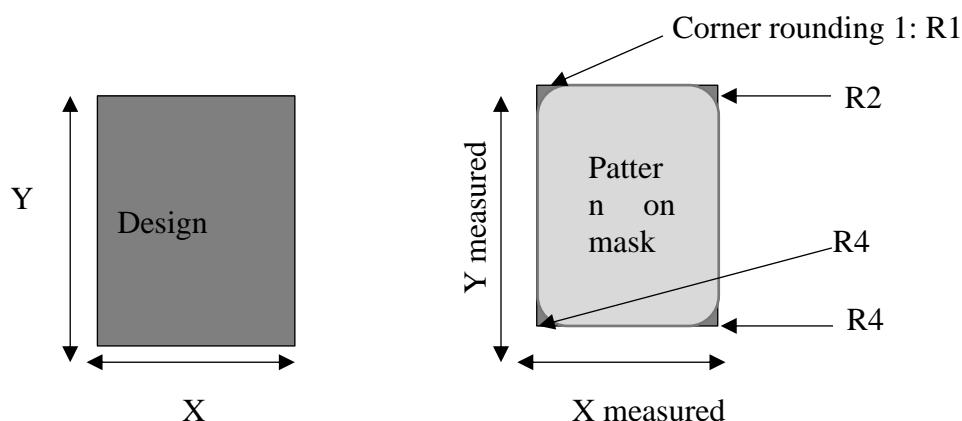
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Database CD: Size of CD feature in the database

Mask CD: size of the critical dimension on the mask

Contact CD measurement:

SRA method: Square root area method used for contact measurement can be used starting grade K.



$$SRA \text{ of design} = \sqrt{X * Y}$$

$$SRA \text{ of pattern on mask} = \sqrt{(X_{measured} * Y_{measured}) - (R1 + R2 + R3 + R4)}$$

As shortcut for contact, use 'CD' instead of SRA

Max CD deviation: For one given nominal CD (N), it's the highest absolute value of the difference among all measured CD values (CD_i) and their nominal (N)

$$Max \text{ CD deviation} = Max|CD_i - N|$$

CD range: For one given nominal CD (N), it is the difference between the maximum and the minimum of all measured CD values at this nominal.

$$CD_{range} = Max(CD_i) - Min(CD_i)$$

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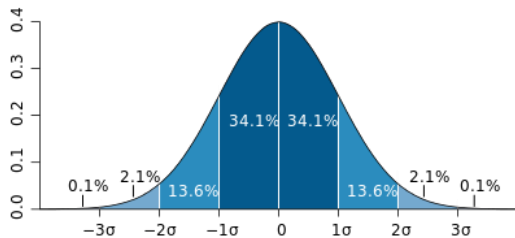
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CD Mean to target (MTT): For one given nominal CD (N), it is the difference between the mean of all (n) measured CD values (CD_i) and their nominal (N).

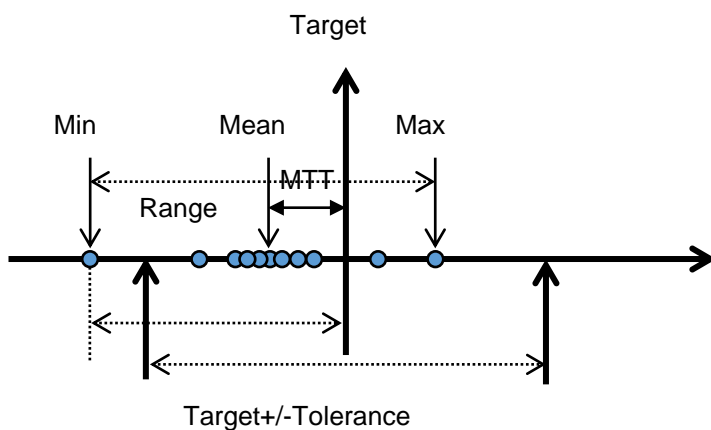
$$CD \text{ Mean to target} = \frac{\sum_i^n CD_i}{n} - N$$

CD 3sigma (3σ (CD)): It is 3 times the standard deviation; it gives the dispersion of CD values to the mean. It means that 99.73% of CD values are included between CD_{mean} - 3σ (CD) & CD_{mean} + 3σ (CD).



$$3\sigma (CD) = 3 * \sqrt{\frac{\sum_i^n (x_i - \bar{x})^2}{(n - 1)}}$$

Where n is the number of CD measurements, \bar{x} the mean of all CD measurements.



Corner rounding: Radius of a curve of any shape is assumed to be $R = 2.16\sqrt{a}$, where 'a' is the area given by the difference between the ideal corner and the real corner.

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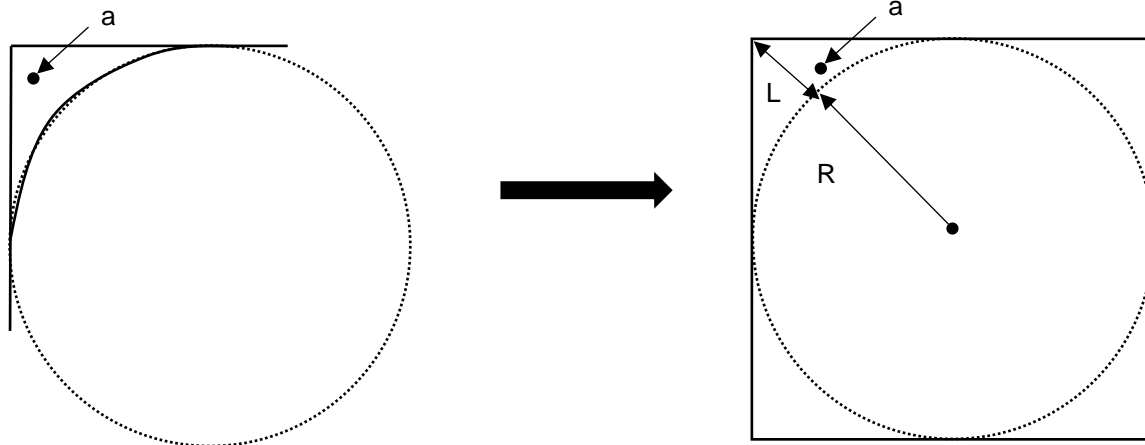
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$$A1 \text{ (area of the square)} = (2R)^2$$

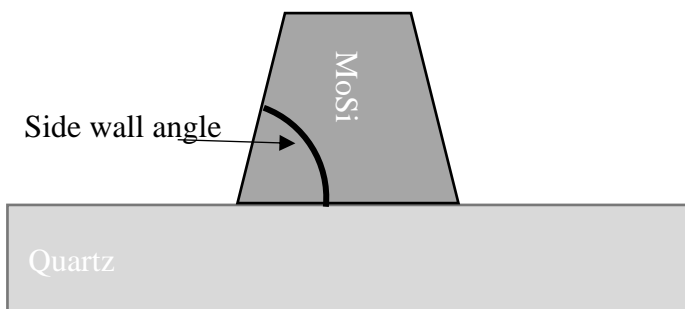
$$A2 \text{ (area of the circle)} = \pi R^2$$

$$a = \frac{A1 - A2}{4}$$

$$R = 2.16\sqrt{a}$$

$$\text{Or } R = \frac{L}{\sqrt{2} - 1}$$

Sidewall angle: Slope of the profile of a pattern expressed in degree. Example for EAPSM mask:



Registration: a vector quantity defined at every point of the mask as the difference between the vectorial position of mask geometry and the vectorial position of the corresponding point on a reference grid.

Registration error: placement error relative to a reference grid.

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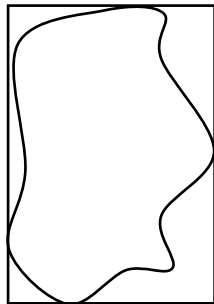
Mask defect: Any non-intended pattern, imperfection on the mask, that can be reproduced on the wafer by photolithography, thus induce a malfunction of the electronic device being produce.

Macro defect: Defect visible by human eye

Micro defect: Defect not visible by human eye. Required inspection or magnification system to be detected

Defect size:

1. The defect size is assumed to be the square root of its area.
2. We define a rectangle that surround the defect. Its length and width must be minimize.



Maximum dimension: the biggest edge of the rectangle

Minimum dimension: the smallest edge of the rectangle

The defect size can be approximated by:

$$defect\ size = \sqrt{defect\ area} = \sqrt{0.8 * maximum\ dimension * minimum\ dimension}$$

Die to die inspection: automatic inspection of mask defectivity based on the comparison by an automatic tool of at least two identical die.

Die to database inspection: Inspection of mask defectivity based on the comparison by an automatic tool of the mask to the original database

Array rotation: Rotational misalignment between the lower side of the substrate and the exposed array

Array translation: Translational misalignment between the blank's center and the exposed array

Centrality error: Error with both array rotation & translation

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Linearity: Difference between max and min 'mask mean to target' for a range of feature (range is generally from min feature to four time the min feature) of the same nature (same feature pattern), same polarity and different design size or different pitches.

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J**3. Order form & Database**

The order form, the database and optional data transfer from LETI to the maskshop must provide all information necessary to maskshop to manufacture the mask.

A Mask design rule check (MRC) has to be validate by both side (maskshop & LETI). It will include all criteria to insure design is writable and inspectable.

Database must follow rules in order to be compliant with grade requirement.

- Address size of database, as written on the mask, must be in adequacy with the require grade. Address size are defined to take into account the lithography tools to write mask (CORE 2564 for lowest grade, ALTA series for medium grade and ebeam tools for highest grade)
- The database must respect MRC rules defined for the chosen grade. It mean that all pattern must respect criteria on size, area, distance between each other, etc...

For each mask, the maskshop is due to respect all constrain concerning pattern placement, additional pattern, reference marks, and mask titles, writing area limits, mask substrate properties and pellicles as written in the corresponding (s) stepper/scanner reticle design guide document:

- NSR-S207D/S307E, Reticle Design Guide;
- TSA-scope Reticle Design Guide for FPA-5500iZa and FPA-5510iZ;
- Reticle Design Manual: 6-inch Reticles for TWINSCAN NXT systems;
- RETICLE DESIGN MANUAL 6-inch Reticles for PAS 5500 systems;

The maskshop is free to add any pattern to check the mask manufacturing process, outside the reserved area for each stepper/scanner specific pattern and outside the area limited by the inner edge of the pellicle frame, if it respect documents cited above.

It is under maskshop responsibility to inverse the database provided by LETI in case of negative process. In general, it is under maskshop responsibility to prepare the database for its process.

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J**4. Equipment**

All equipment used to make a mask must allow to respect the required grade.

The equipment and processes used to manufacture, measure and inspect masks must be kept under control by means of adequate SPC procedures.

Wet etch is allowed until grade E.

4.1. *Lithography tools characteristics*

Two types of lithography tools can be used: laser tools and ebeam tools. Laser are used for "mature" grade (until grade G), ebeam will be used for most advanced grade (grade G and higher).

4.2. *Metrology tool characteristics*

The PTCC of the registration and CD measurement equipment used must be lower than 30% regarding the value of interest.

It is upon maskshop responsibility to have its metrology equipment correlated between them.

4.3. *Inspection tool characteristics*

Mask inspection tool has to be tested on regular bases to verify defect capture rate and classification capabilities. A suitable test vehicle must put in place with relevant mask to validate MDRC.

The equipment chose for the inspection of a mask must be capable to capture all defect as defined by the grade, the pixel inspection and the document relative to MRC rules.

The database use to performed die to database inspection must be the original one send by CEA-LETI. None other database can be use (fracked database for lithography tool for example) to perform the inspection.

4.4. *Repair tool characteristics*

Repair tool has also to be kept under SPC control. SPC is used to validate that a repair tool is able to repair a default on the mask. The tool is considered capable if SPC show that 3sigma CD over last month is less or equal to $0.25 \times \text{defect size}$

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J**5. Control methods**

Number of measurements vs Cpk:

$$Cpk = \min \left(\frac{USL - mean}{3\sigma} ; \frac{mean - LSL}{3\sigma} \right)$$

USL: upper specification limit

LSL: lower specification limit

Must be used for: CD range, CD deviation, and registration.

If $Cpk < 1,33$ it mean that the process is not suitable for the requested mask. Specific agreements between supplier & customer must be find.

Only CD, registration and defectivity control are mandatory for each mask (exception: CD for grade N00). For other specifications, the Maskshop "have just to prove" that its process meet specifications, by SPC controls, or other agreement with CEA-LETI.

5.1. *CD*

1. LETI has to provide all information to perform measurement
2. Maskshop has to make the measurement
3. Maskshop has to provide report upon agreed format

If a correlation factor is establish, CD values must be measured according to this correlation factor. Until grade G (include), CD check should be carried out on the four positions of the field on standard features.

For masks (4'', 5'' & 9'' masks), CD has to be guaranteed either by SPC, or by CD measurement if CEA-LETI provide all information needed to perform measurement.

Starting grade H, in identified cases, CEA-LETI will provide files with all information necessary to perform measurement (coordinates, CD target, polarity, etc...)

The mask will be consider as OK if the following criteria corresponding to the requested grade are met:

- Max CD deviation (until grade K, exclude)
- Max CD range (until grade K, exclude)
- Max CD Mean To Target (from grade K)
- Max CD 3 Sigma (from grade K)

All other CD criteria are to be used as reference for POR selection. They will not be measured and certified on each mask (unless specific request).

For contacts, vias & dots measurement starting grade K (include), DBM and MROI method can be used to certify Mean to Target and 3 Sigma criteria.

Each mask must be measured to respect CD specifications.

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CEA-LETI to give sufficient information to make all measurement in the order form:

- Nominal CDs
- Polarity
- Pattern type
- CD tolerances/specification

Specification to be fulfill for one nominal: all measurement of the nominal must be taken in count.

The maximum Size for nominal must not exceed metrology tools limits:

- Optical measurement : 10µm
- CD SEM measurement : 2.4µm

Local CD error superior to 10% must be consider as defectivity and so be able to be detected by relevant inspection tool, if CD >300nm.

One measurement is one site location in one direction. If two direction measured at same location, it is two measurement.

Max number of measurement that may be requested for certification per grade:

Grade	2	1	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Max measurement	4	4	4	4	4	10	14	20	45	55	80	100	140	180	270	350	500

In case of AIMS metrology, measurement values have to be reported separately of the standard CD measurement.

5.2. **Registration**

1. LETI has to provide all information to perform measurement
2. Maskshop has to make the measurement if point 1 is fulfilled
3. Maskshop has to provide report upon agreed format if point 2 is fulfilled

If a correlation factor is establish, registration values must be measured according to this correlation factor.

Until grade G (include), registration check should be carried out on the 4 corners of the field on standard features or have to be guaranteed by SPC.

Starting grade H, in identified cases, CEA-LETI will provide files with all information necessary to perform measurement (coordinates).

The mask will be consider as OK if the following criteria corresponding to the requested grade are met:

- Max registration deviation
- 3 sigma registration residual error (starting grade M)
- Mask to mask or layer to layer overlay in some cases

Each mask must be measured to respect Registration specifications.

CEA-LETI to provide sufficient information to make all measurement in the order form.

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J**5.2.1. For 4X reticule used on ASML XT and NXT scanners:**

Registration must be measured as max absolute error, either in X or Y directions using multi-point alignment with orthogonality and both components of X and Y magnification independently removed, using methods and algorithms as provided by the measuring tools.

The points to be measured will always include the four L-bars at the corner of the frame

Residual method must be applied:

1. Alignment must be done using the corresponding equipment alignment marks (TIS/RSC mark for NXT or Rxy 1XX marks for Nikon) present in the 'big frame'. Using these marks, translation & rotation should be corrected. Data are defined as 'raw data' at this point
2. Then scale & orthogonality are corrected. The positioning error after all these correction are called 'residual data'

Calculate the residuals for all points, but the certification is done only on the Field points (not on TIS, not on RSC, not on Rxy 1XX). The Field points will include the L corners of the frame, the AIM structures, and all other ongoing features.

CEA LETI provide all relevant measurements instructions for registration measurement.

5.2.2. For 4X & 5X reticule used on steppers (Canon & ASM PAS5500 @ LETI):

Registration has to be measured using the so-called "two points matching" method.

Registration must be measured as max absolute error, either in X or Y directions using multi-point alignment with orthogonality and both components of X and Y magnification independently removed, using methods and algorithms as provided by the measuring tools.

The points to be measured will include:

1. Two reference points :
 - ASM PAS5500:
 - o The 2 reference points are the centre of the 2 ASM marks positioned at $X=\pm 65.5$ mm, $Y=0$ for ASM300 reticules
 - o The 2 reference points are the centre of the 2 ASM marks positioned at $X=\pm 69.5$ mm, $Y=0$ for ASM100 reticules
 - CANON : The 2 reference points are the two alignment marks (FRA)
2. The four L corners
3. TIS marks: if included, the 4 TIS marks

Registration is considered as SPC guaranteed until grade G.

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5.2.3. Max number of measurement requested per grade:

Grade	N00	2	1	A	B	D	E	F	G	H	I	J	K	L	M	N	O
Max measurement	SPC	SPC	SPC	SPC	SPC	SPC	SPC	SPC	11	14	19	22	29	80	115	230	250

5.2.4. Mask to mask or layer to layer overlay requirement

When mask to mask or layer to layer overlay is required (starting grade L), CEA-LETI will provides coordinates of patterns at same positions on the 2 masks concern in order to perform measurement.

The order form will alert that mask to mask overlay or layer to layer measurement should be performed

When mask to mask overlay is required, both masks has to be written on the same litho tool

5.3. *Defectivity*

1. LETI has to provide all information to perform inspection
2. Maskshop has to make the inspection
3. Maskshop has to provide report upon agreed format

Starting grade H, the report of the inspection should be send to CEA-LETI.

The mask will be consider as OK if there is no defect larger than the max defect size set by the requested grade.

It is upon CEA-LETI responsibility to give sufficient information to make the inspection in the order form.

Each mask must be inspected to respect defectivity specifications. Visual inspection using microscope is allowed when max defect size is superior to 2µm.

Die to database inspection is mandatory for pre pellicle inspection. When it is possible die to die inspection is allowed.

All the active zone must be inspect before and after pellicle attachment. A particle inspection (Starlight) is mandatory post pellicle attachment.

5.3.1. Macro Defectivity

Each mask must be free from macro defect on the 2 sides:

- Scratches
- Particles, contamination, dirt
- Glass ships
- Notches, flaking off, fractures
- Error on mask title
- Broken, wrong or defective pellicle
- Error on polarity

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- Error on substrate
- Lacking patterns
- Splintering
- Fingerprint
- Etc.

When any macro defect is found, if the supplier cannot remove it by any process (cleaning, repair, etc...), the mask is rejected. Except special agreement for particular case (mainly default falling in non-active area and which do not touch any pattern). Supplier must ask LETI before sending the mask if the default is acceptable.

For 1X reticules, scratches and dirt are allowed if they are outside of the active area and does not touch any patterns.

The pellicle integrity must be respect: no scratches, fingerprints, damage & particle > 10µm and no more than 10 particles < 10µm.

All specifications (for example pellicle centring, array centring, array rotation etc...) must respected as stated in ASML/Nikon/Canon reticule design manuals.

5.3.2. Micro Defectivity

Any mask can contain defect smaller or equal the "max defect size" define by the requested grade. All defect bigger than this size has to be considered. CEA-LETI's MRC rules must be respected.

CEA-LETI will give the information in the order form if the mask contain curvilinear form &/or do not respect MRC rules according to the grade.

If MRC rules are not respected for high grades (starting grade L), CEA-LETI recognize that inspection may be impossible and so will not request it or set DNIR region, in this case only. However the provider have to make one attempt of inspection.

If relevant inspection tool find any defect whose size is superior to the defect size specified by the grade, it must be repair to the best of supplier's capabilities. If the repair fail or the defect cannot be repair, the mask is rejected.

Random Defectivity:**Edge defect, local edge displacement:**

These defects are located on the edge of lines/spaces or contacts/dots, they induced local CD error. They should not exceed the 'maximum local edge displacement' defined by the mask grade requirement.

Edge displacement must be considered as defect when its length is upper than the CD of the involved pattern for line/space. For contacts/dots, edge displacement is considered as defect is it's change the size of the contact of more than the max CD deviation.

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If inspection tool aren't able to detect this criteria (for small pattern), we can use CD measurement tool to detect them on a very small sample. If any default is detect on these very small sample, agreement has to be met between maskshop & CEA-LETI.

AIMS verification:

Note: AIMS need similar without default pattern in short range of defect pattern to compare signal.

CEA-LETI has to provide the illumination setup in order to perform AIMS. If not, the maskshop is not obliged to perform AIMS measurement.

In case of repair, AIMS should be perform to verify that the repair has corrected the default. No need of AIMS if feature is $>1\mu\text{m}$ at reticule scale.

Report of AIMS data must be provided to CEA-LETI.

In any case the repair is not acceptable if the local predicted CD variation exceed $\pm 10\%$.

In case of assist feature repair: the CD transmission of the main pattern next to it is the only one to be verified

In case of hole/dot repair, both direction (X & Y) must be verified by AIMS

Chrome border inspection :

Pre-pellicle inspection require also the inspection of the chrome border. Reticule design manuals of the corresponding equipment define the chrome border. If the mask is requested to be compliant with 2 or more equipment the border chrome should be the highest border chrome requested for the concerning equipment.

5.4. Other controls**5.4.1. SEM images**

In some case SEM images may be required, for image analysis at CEA-LETI. Information on field size, pixel size, coordinates and number of images requested, will then be transmitted to the supplier.

5.4.2. Dummies

Defect on dummy patterns are tolerated, if the size doesn't exceed the dummy size.

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It will not be taken in count for certification. Nevertheless, Maskshop must show that its writings tools can fulfill the specification.

5.4.4. Corner rounding

Corner rounding specification is the maximum allowed inner radius R for features. I will not be taken in count for certification. Nevertheless, Maskshop must show that its writings tools can fulfill the specification.

5.4.5. Side wall angle

Side wall angle will not be required for mask certification.

5.4.6. Transmission and phase

Transmission and phase for EAPSM has to be measured on at least 4 locations on the mask using adequate marks.

5.4.7. Haze prevention

The supplier must have process and pellicle that prevent haze, especially for 193nm reticules. CEA-LETI have taken measures to prevent haze formation in its cleanroom.

5.4.8. Aging

The supplier must have process and pellicle that prevent aging: change in CD, registration, transmission versus time and versus number of exposures

5.4.9. POR

Whenever a POR is defined by LETI in the order form, the maskshop must applied this exact POR. Any change must be discuss before happening.

5.4.10. Roughness (LER)

The Line edge roughness (LER) can be very important for some devices. Mask LER have direct impact on LER on wafer. CEA-LETI want to put in place methodology to control LER using Power Spectral Density (PSD) method. The parameter σ (RMS roughness value) is considered has directly link to the LER and is so considered. Further development need to be put in place to use this quantity in production qualification.

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Mask must be send in specific box

The box used must follow the reference below or have identic specifications in all domain:

For 9'' mask: box Pozzetta PL900-20012 or GUDENG GL09A

For réticules 6'' : box PozzettaPLS600-31125AU

For 5'' mask: box Pozzetta PL500-20009

For 4'' mask: box Entegris B80 or POZZETTA PM400 ETA 06

Theses box must have two tag: one tag on the box identifying the mask and one blank tag on the edge.

In case of re-filming demand, the mask will be resend in a new box, respecting all specification above.

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Type is referring to SEMI P1-0708E

SPECIFICATION FOR HARD SURFACE PHOTOMASK SUBSTRATES types

7.1. ASML PAS5500 ASM100 (type 6025)

Quartz 6", thickness = 0.250", anti-reflective chrome

7.2. ASML PAS5500 ASM300 (type 6025)

Quartz 6", thickness = 0.250", anti-reflective chrome

7.3. CANON FPA5510iZ (type 6025)

Quartz 6", thickness = 0.250", anti-reflective chrome (double layer)

7.4. ASML TWINSCAN NXT & XT (type 6025)

Quartz 6" (152.4mm), thickness = 0.250" (6.35 ± 0.1mm), anti-reflective chrome

7.5. 4" Mask (type 4006)

Quartz 4", thickness = 0.60", anti-reflective chrome

7.6. 5" Mask (type 5009)

Quartz 5", thickness = 0.90"mils, anti-reflective chrome

7.1. 7.25"R Mask (type 7015)

Quartz 7.25"R, thickness = 0.150"mils, anti-reflective chrome

7.2. 9" Sodalime mask

Sodalime 9", thickness = 0.120", anti-reflective chrome

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J**8. Pellicles**

The pellicle frame must not cover any pattern requested by LETI. And be put on Chrome side only.

The pellicle and the frame type are dependent of the tool or the tools that the reticules will be used on. Here are a recap of main rules to follow for pellicle according the chosen equipment. For all details, please refer to manual design reticule.

8.1. *ASML PAS5500 ASM100*

Standard pellicle for ASML PAS5500 ASM300 should use the following frame dimension:

Outer: 147x126mm

Inner: 143x122 mm

Max height = 5mm

Pellicle wavelength: 365 nm

Allow compatibility with equipments:

- ASML PAS5500 ASM100

Example of part reference numbers: MLI ASM17P 122 1017HFLC

Pellicle Alignment: The outer edges of the frame should be within the specific marks described in the outer file.

8.2. *ASML PAS5500 ASM300***8.2.1. Standard pellicle**

Standard pellicle for ASM300 PAS5500 should use the following frame dimension:

Outer: 147x113mm

Inner: 143x109 mm

Max height = 5mm

Pellicle wavelength: 248 nm.

Allow compatibility with equipments:

- ASML PAS5500 ASM300
- ASML XT1060

Example of part Reference numbers: MLI ASM47 602 1017 HFLC

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Pellicle Alignment:

The outer edges of the frame should be within the specific marks described in the outer file.

8.2.2. Secondary pellicle

In some condition LETI may require this pellicle:

Outer: 147x109mm

Inner: 143x105 mm

Max height = 5mm

Pellicle wavelength: 248 nm.

Allow compatibility with equipments:

- ASML PAS5500 ASM300

Example of part Reference numbers: MLI ASM23 602 1017HFLC

Pellicle Alignment:

The outer edges of the frame should be within the specific marks described in the outer file.

8.3. *CANON FPA5510iZ***8.3.1. Standard pellicle**

Standard pellicle for CANON FPA5510iZ should use the following frame dimension:

Outer: 149x115mm

Inner: 145x111 mm

Max height = 5mm

Pellicle wavelength: 248/365 nm

Allow compatibility with equipments:

- CANON FPA5510iZ
- ASML XT400
- ASML XT1060

Example of part reference numbers: INKO ASM149*115*4.6 DUV A HF IA

Pellicle Alignment:

The outer edges of the frame should be within the specific marks described in the outer file.

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J**8.3.2. Secondary pellicle**

In some condition LETI may require this pellicle:

Outer: 149x122mm

Inner: 145x118 mm

Max height = 6.3mm

Pellicle wavelength: 365 nm.

Allow compatibility with equipments:

- CANON FPA5510iZ

Example of part Reference numbers: MLI NIK49P 122 1017HFLC

Pellicle Alignment:

The outer edges of the frame should be within the specific marks described in the outer file.

8.4. *ASML XT400M*

Standard pellicle for ASML XT400M should use the following frame dimension:

Outer: 149x115mm

Inner: 145x111 mm

Max height = 5mm

Pellicle wavelength: 248/365 nm

Allow compatibility with equipments:

- CANON FPA5510iZ
- ASML XT400
- ASML XT1060

Example of part reference numbers: INKO ASM149*115*4.6 DUV A HF IA

Pellicle Alignment:

The outer edges of the frame should be within the specific marks described in the outer file.

8.5. *ASML XT1060K*

Standard pellicle for ASML XT1060K should use the following frame dimension:

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Outer: 149x115mm

Inner: 145x111 mm

Max height = 5mm

Pellicle wavelength: 193/248 nm

Allow compatibility with equipments:

- ASML XT1060
- ASML NXT2050i

Example of part reference numbers: Mitsui A6FFS AF6A

Pellicle Alignment:

The outer edges of the frame should be within the specific marks described in the outer file.

8.6. **ASML NXT2050i**

Standard pellicle for ASML NXT2050i should use the following frame dimension:

Outer: 149x115mm

Inner: 145x111 mm

Max height = 5mm

Pellicle wavelength: 193nm

Allow compatibility with equipments:

- ASML NXT2050i

Example of part reference numbers: Mitsui A6FFS AF6A

Pellicle Alignment:

The outer edges of the frame should be within the specific marks described in the outer file.

9. **Quality requirement**

The supplier must accept before shipment all reticule and mask. A certificate of conformity should be sent at CEA-LETI.

Any defect/error detect at CEA-LETI will be the object of an 8D report.

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10. Grades quality

Only specification in bold are mandatory. Other speciation (like address size, X-Y bias, radial criteria, etc...) are there for indication.

All value are at reticule/mask scale.

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Grade specification for 4X reticules (N00 to G)									
GRADE	N00	2	1	A	B	D	E	F	G
Min main feature line/space (nm)	2000	2000	1500	1500	1000	750	750	640	600
Min main feature contact/dot (nm)	2000	2000	1500	1500	1500	1000	900	900	900
Min address size (Laser/ebeam writing grid) (nm) *	50	50	25	25	8,33	8,33	8,33	5	5
Min corner to corner distance (nm)	1000	1000	750	750	750	500	500	500	500
DEFECTIVITY									
Min Inspection pixel required								250	186
Max defect size (nm)	1200	1200	800	500	500	400	400	300	200
Max local edge placement error (nm) *		260	215	180	160	130	95	72,5	59
REGISTRATION									
Max error (nm)	80	200	150	120	120	100	70	65	50
CRITICAL DIMENSION									
Max CD deviation (main & assist feature) (nm)		160	140	120	100	80	60	40	34
CD range (main & assist feature)		160	140	120	100	80	60	40	36
Linearity (from min feature size to 4*min feature size) (nm)								80	60
BLANK - PATTERN FIDELITY									
Blank flatness (µm)	2	2	2	2	2	2	1	1	1

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GRADE	H	I	J	K
Min main feature line/space (nm)	400	316	316	230
Min main feature contact/dot (nm)	450	450	360	360
Min address size (Laser/ebeam writing grid) (nm) *	2	2	2	1
Min scatter bar (nm)		170	170	140
Min area of assist polygon (nm)		216	216	140
Min corner to corner distance (nm)	380	324	212	212
DEFECTIVITY				
Min Inspection pixel required	150	125	125 (90 for Dot/Hole)	90
Max defect size (nm)	150	130	110	95
Max local edge placement error (nm) *	50	41	35	26
REGISTRATION				
Max error (nm)	40	30	26	20
CRITICAL DIMENSION				
Max CD deviation (main & assist feature) (nm)	30	26	22	16
CD range (main & assist feature)	30	20	16	11*
Mean to target (for L/S, starting grade K) (nm)				8
Mean to target (for contacts/dots) SRA method (starting grade K) (nm)				12
3 sigma (L/S) (starting grade K) (nm)	15	10	8	6
3 sigma (contact/dot) SRA method (starting grade K) (nm)				7
Linearity (from min feature size to 4*min feature size) (nm)	60	48	30	11
X-Y bias (average) * (nm)				5
Max LER (roughness) * (nm)		12	10	8
Radial criteria *				3
BLANK - PATTERN FIDELITY				
Blank flatness (μm)	1	1	0,5	0,5
Corner rounding *	300	240	200	160
ATTENUATED PSM SPECIFICATION				

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Phase range (deg)	2	2	2	2
Phase mean deviation (deg)	+/-3	+/-3	+/-3	+/-3
Mean transmission @193nm vs Qz (%)	6.3	6.3	6.3	6.3
Transmission accuracy mean to target (%)	0,3	0,3	0,3	0,3

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GRADE	L	M	N	O
Min main feature line/space (nm)	230	160	100	100
Min main feature contact/dot (nm)	310	180	160	120
Min address size (Laser/ebeam writing grid) (nm) *	1	0,5	0,5	0.5
Min scatter bar (nm)	100	80	60	60
Min area of assist polygon (nm)	120	84	80	80
Min corner to corner distance (nm)	180	128	96	80
DEFECTIVITY				
Min Inspection pixel required	90 (72 for Dot/Hole)	72 (55 for Dot/Hole)	55	55
Max defect size (nm)	70	60	50	50
Max local edge placement error (nm) *	19,5	13	8	5.75
REGISTRATION				
Max error (nm)	15	10	4	3.5
3sigma registration residual error (nm)(starting grade M)	12	9	3,5	3
Mask to Mask overlay 3 sigma (nm)	13	10	4.5	4
CRITICAL DIMENSION				
Max CD deviation (main & assist feature) (nm)	12	8	6	4
CD range (main & assist feature)*	8	6	4	2
Mean to target (for L/S, starting grade K) (nm)	6	5	4	2
Mean to target (for contacts/dots) DBM or SRA method (starting grade K) (nm)	8	5,5	4	2
3 sigma (L/S) (starting grade K) (nm)	5	3	2,2	1.5
3 sigma (contact/dot) SRA method (starting grade K) (nm)	5	4	3	2
Linearity (from min feature size to 4*min feature size) (nm)	8	5	4	3
X-Y bias (average) * (nm)	4	2	1,5	1
Max LER (roughness) * (nm)	7	5	4	3
Radial criteria *	2	2	1,5	1
BLANK - PATTERN FIDELITY				
Blank flatness (µm)	0,5	0,5	0,3	0.3
Corner rounding *	90	65	45	35
ATTENUATED PSM SPECIFICATION				
Phase range (deg)	2	2	2	2
Phase mean deviation (deg)	+/-3	+/-2	+/-2	+/-2

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Mean transmission @193nm vs Qz (%)	6.3	6.3	6.3	6.3
Transmission accuracy mean to target (%)	0,3	0,2	0,2	0.2

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Grade specification for 5X reticules									
GRADE	N00	2	1	A	B	C	D	E	F
Subgrade	0	0	0	0	0	0	0	0	0
Min feature size (nm)	2500	2500	2500	1900	1900	1500	1250	1250	940
Min address size (Laser/ebeam writing grid) (nm) *	50	50	25	25	8,33	8,33	8,33	8,33	5
DEFECTIVITY									
Inspection pixel									
Max defect size (nm)	1000	1500	1500	1000	800	700	600	500	400
Max local edge placement error *		500	400	300	275	275	220	160	130
REGISTRATION									
Max error (nm)	100	250	200	150	150	150	120	85	80
CRITICAL DIMENSION									
Max CD deviation (nm)	NA	500	200	150	125	120	100	70	50
CD range (nm)	NA	500	200	150	125	120	100	70	50
Linearity (from min feature size to 4*min feature size)									100
BLANK SPECIFICATION									
Blank flatness (µm)	2	2	2	2	2	2	2	1	1

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Grade specification for 1X 4" & 5" Mask							
GRADE	C4	D4	F4		A5	C5	F5
Min feature size (nm)	2000	2000	800		1000	1000	800
Min address size (Laser/ebeam writing grid) (nm) *	100	100	50		100	100	50
DEFECTIVITY							
Max defect rate (def/cm ²)	0,15	0,15	0,15		0,3	0,15	0,15
Max defect size (nm)	2000	2000	1500		1500	1500	1500
REGISTRATION							
Max error (nm)	NA	NA	NA		NA	NA	NA
CRITICAL DIMENSION							
Max CD deviation (nm)		250	100			250	100
CD range (nm)		250	100			250	100
BLANK SPECIFICATION							
Blank flatness (μm)	NA	NA	NA		NA	NA	NA

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Grade specification for 1X 7.25"R Mask			
GRADE	A7	C7	D7
Min feature size (nm)	2000	2000	1000
Min address size (Laser/ebeam writing grid) (nm) *	50	50	50
DEFECTIVITY			
Max defect rate (def/cm ²)	0,3	0,15	0,15
Max defect size (nm)	2000	1500	1500
REGISTRATION			
Max error (nm)	NA	NA	NA
CRITICAL DIMENSION			
Max CD deviation (nm)	NA	250	100
CD range (nm)	NA	250	100
BLANK SPECIFICATION			
Blank flatness (μm)	NA	NA	NA

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Grade specification for 1X 9" Mask						
GRADE	A9L	A9S	B9L	B9S	C9L	C9S
Min feature size (nm)	3000	1500	3000	1500	3000	1500
Min address size (Laser/ebeam writing grid) (nm) *	100	100	100	100	100	100
DEFECTIVITY						
Max defect rate (def/cm²)	0,3	0,3	0,3	0,3	0,3	0,3
Max defect size (nm)	3000	1500	3000	1500	3000	1500
REGISTRATION						
Max error (µm)	2	2	2	2	2	2
CRITICAL DIMENSION						
Max CD deviation (nm)	NA	NA	500	500	250	250
CD range (nm)	NA	NA	500	500	250	250
BLANK SPECIFICATION						
Blank flatness (µm)	50	50	50	50	50	50

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11. Historic

Version	Auteur	Date	Objet de l'évolution
A	A. BERNADAC	18/02/2020	Création
B	A. BERNADAC	03/04/2020	Ajout pellicule ASM1100 Méthode SRA peut être utilisé à partir du grade K (pas obligatoire)
C	A. BERNADAC	11/02/2021	Modification CDmin Line/Space grade N AIMS : not necessary for feature size >1µm
D	A. BERNADAC	28/04/2021	Spec CD, feature repair verified by AIMS : +/- 10%
E	A. BERNADAC	18/01/2023	Add mask to mask and layer to layer registration spec
F	A.Bernadac	14/06/2023	Allow wet etch until grade E
G	A.Bernadac	14/12/2023	Allow using SPC for CD specification for mask 4'', 5'', 9''
H	A.Bernadac	26/09/2024	Add grade O Add a 2 nd pellicle for ASM300
I	A.bernadac	04/09/2025	Add 7.25''R mask description and grade specification Update authorized box for 4'' & 9'' mask Update Mean transmission @193nm vs Qz (%) ofr eaPSM Update CDmin grade O Update measurement method for contact & dot (grade K and above) CDrange spec : only or info starting grade K
J	A.Bernadac	17/02/2026	Update §7 & §8. Nikon erase. Add XT400M and XT1060K. Rework pellicle paragraph for clearness

Vous pouvez consulter l'instruction via la page « instructions » du site intranet qualité plateformes :

https://gre-wikis.intra.cea.fr/sites/Qualite_plateformes/Pages/Instructions%20Accueil.aspx