Canon Stepper Reticle Guide

Guide for preparing reticle files for the Canon FPA-3000 EX4

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Content

1. Introduction

This document contains an introduction to how to prepare design files for the CANON FPA-3000 EX4 stepper (1). The stepper is equipped with a KrF laser from CYMER (ELS-530) providing light having a wavelength of 248 nm with an illumination intensity of larger than 2800W/cm^2 measured on the wafer (2). The maximum resolution is 200 nm depending on the shape of the structures. E.g. patterns with line-widths down to 160 nm l/s could be generated for line patterns.

The stepper is specified to process 6-inch and 8-inch wafers. The throughput is 95 wafers or more per hour for 6-inch and 73 or more wafers per hour for 8-inch (2). With the help of specially designed inlet trays also 4-inch wafers can be processed with some restrictions. When using 4-inch wafers the wafers should not be equipped with minor flats that are positioned 90° left to the major flat. Minor flats that are positioned 180° from the major flat or that are positioned 90° right to the major flat can be processed. The specified crystal alignment or flat alignment accuracy of $3\sigma = 0{,}06^\circ$ cannot be guaranteed for 4-inch wafers.

2. Mask file format

Mask designs should be submitted in GDSII file format. At the moment we are running the stepper with two different positive chemically-amplified deep-UV photo resists (3). Please notice that the particular layer in the design that should be printed on the reticle – i.e. the “data layer” - will be the chromium layer on the reticle blocking the light to generate a not exposed region on the wafer that will not be removed during development.

Please inform us about the names of the cell (“top cell”) and the layer that should be printed on the reticle (“data layer”), and additionally about the GDSII number of this layer.

2.1 The coordinate system

The pattern on the reticle is printed on the wafer as shown in Fig. 1. Here, the origin of the coordinate corresponds to the centre of the pattern. The projection lens is scaling down the dimensions of the pattern on the reticle by a factor 5. Thus, the dimensions of the patterns on the wafer are reduced by a factor 5 compared to those on the reticle.

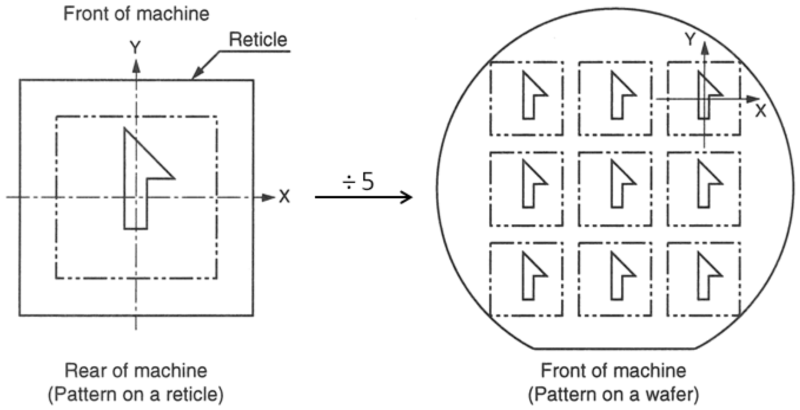


Figure 1: *Definition of the Coordinate system.*

The measurement system used in this guide is based on reticle dimensions. However, sub –clause 2.3, Fig. 4 depicts mark positions on the wafer. Here, the system is based on wafer scale.

Please note: When designing a reticle, be sure to magnify the dimensions of the structures by a factor 5 compared to those that are desired to achieve on the wafer.

It has been turned out that it is a very cost-efficient and suitable way to apply reticles in the stepper that are manufactured with the help of a high end laser mask writer (4). With this lithography a minimum feature size of 0,7 µm can be guaranteed on a grid of 0,005 µm. In the particular design please do not use features with dimensions or grids smaller than these dimensions. Otherwise the applied reticles should be fabricated with the help of e-beam lithography. Nevertheless, feature sizes of 0,7 µm (divided by 5) are much smaller than the specified resolution of the stepper of 200 nm.

2.2 Reticle dimensions

The reticle dimensions are displayed in Fig. 2. The chip area on the reticle - i.e. the exposure area or the effective patterning area - has commonly a size of 110 000 x 110 000 μm^2. In the respective design it is advised to draw first a square with the help of a “cell outline layer” having a high GDSII number of maybe “20” or “50”. The size of this square should be 110 000 x 110 000 μm^2, i.e. the size of the effective patterning area. The zero point of the design should be positioned at the centre of this area. Thus the square is extended both in x and y direction from -55 000 µm to +55 000 µm. Then place all structures that should be printed on the reticle inside this square, using a “data layer” having a low GDSII number of maybe “1”, “2” or “5”. Please do not use a grid size that is much smaller than the smallest size that is required from your design.

The centre of the effective patterning area will be the centre of the particular chip on the wafer. The masking band (see Fig. 2) has not to be plotted; it will be added from the reticle manufacturer (4). The projection lens has the best performance in its centre. So place patterns with high demands concerning resolution near the centre of the design.

Alternatively, if larger chips are required on the wafer it is also possible to design a larger effective patterning area on the reticle with a dimension of x = 110 000 µm and y = 130 000 µm. However, all features have to be placed within a circle having a diameter of 155 560 µm. The centre of this circle must be the centre of the pattern (see Fig. 2). Also here it is advised to draw a grid layer first having the dimensions of the effective patterning area.

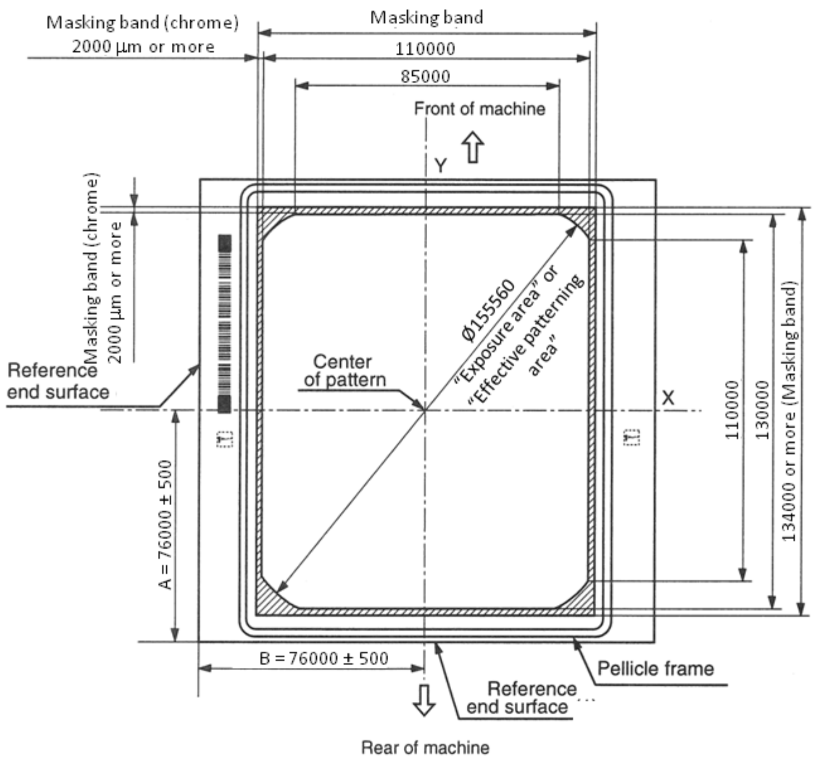


Figure 2: *Reticle dimension (dimensions in µm)*

It is also possible to place different chips onto the reticle and to print them individually on the wafer. The stepper is equipped with four different blades. This leads to the option to expose one particular chip and to shadow out the rest of the reticle. In the design every individual chip has to be surrounded by a frame having a line width of at least 1000 µm. The centre point of individual chips should be at well-defined coordinates. Please place the different chips as near to the centre of the design as possible. If it is not possible to place an individual chip at the centre of the reticle design, place it into a position on the reticle that corresponds to the position on the wafer. E.g. if a chip should be printed on the upper left side of the wafer, place the chip also into the upper left corner on the reticle.

2.3 Alignment marks

The reticle has to be equipped with several focus check and alignment marks as displayed in Fig. 3. The most of them will be placed by the reticle manufacturer (4). Other marks are depending on the individual design so they have to be included into the reticle design. Table 1 comprises marks supplied by the manufacturer (4).

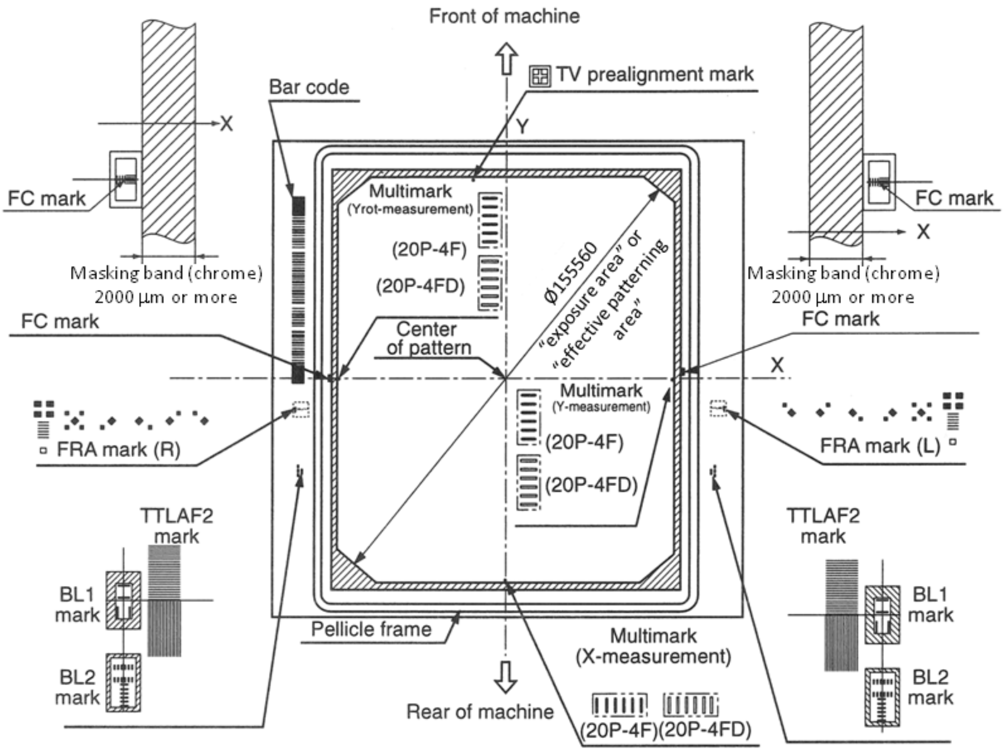


Figure 3: *Reticle focus check and alignment marks (dimensions in μm)*

Table 1: *Marks supplied by the reticle manufacturer*

Marks on Reticle	Measurement	Purpose
FC	Focus check	Aligns reticle to wafer stage in the ALFC (advanced lens focus check) measurement; performs focus check
TTLAF	Through the lens auto focus	Aligns reticle to wafer stage in the TTLAF (Through the lens auto focus) measurement; performs focus check
FRA	Fine reticle alignment	Aligns reticle to reticle stage
BL1, BL2	Baseline correction	Compensates the shift between the optical axis of the projection lens and the optical axis of the OA scope (off-axis alignment scope). This shift is referred to as the Baseline (BL). The OA scope is used to align the pattern on the reticle with that on the wafer (also called as the first layer)

Marks that have to be included into the design are those marks needed for alignment purposes, i.e. when one pattern should be aligned to another which is already located on the wafer surface. The pattern that is located on the wafer will be referred to as “the first layer”. These alignment marks need to be included into every chip on the reticle that is used for printing the first layer on the wafer. After development and etching of the exposed wafer a second layer can be printed on the top of the first layer and aligned to the alignment marks included in the pattern of the first layer. For the second layer no alignment marks are needed on the reticle, because the reticle used for the second layer will just be aligned to the reticle stage with the help of the FRA marks but not to marks that are provided on the wafer. The wafer alignment takes place between alignment marks on the wafer and marks provided within the off-axis alignment scope of the stepper.

The particular alignment marks - listed in Table 2 – have to be placed on correct positions in the reticle design used for the first layer and to be printed in well-defined positions onto the wafer. Both TVPA and Multimarks are available at Danchip in GDSII format.

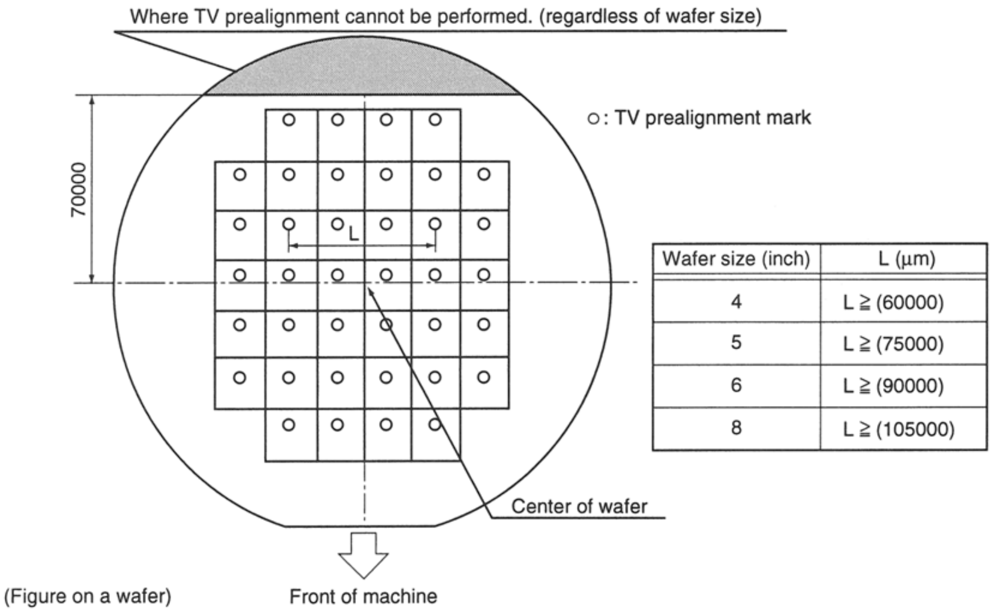
Table 2: *Marks that need to be included into the design*

Marks on Reticle	Measurement	Purpose
TVPA	TV pre-alignment marks	TV pre-alignment calculates a feeding offset between the wafer and the wafer chuck.
Multimarks, AA marks or Off-axis AA marks	Off axis auto alignment	Aligns the wafer pattern with the reticle pattern with the help of the “high-magnification off axis alignment scope”; two different kinds of marks can be used: “20P-4F” and the “20P-4FD” marks.

TVPA marks:

It is recommended to equip every chip of the first layer on the wafer with one TVPA mark on a well defined position with respect to the centre of the chip. There are no positional restrictions where to place the particular mark. Two of these marks will be selected from the marks on the wafer for TV pre-alignment. However, the following conditions must be satisfied on the wafer, as shown in Fig. 4:

1) The separation between two marks - not necessarily next neighbours - has to be ≥ L, whereas L depends on the wafer size (see Fig. 4)
2) Figure 4 shows an area where the TV pre-alignment cannot be performed.
3) It is beneficial to separate adjacent TV pre-alignment marks at least 4000 μm from each other (measured from centre to centre). For smaller mark separations the TV pre-alignment might be manually assisted. Adjacent marks located nearer than 1000 μm to each other cannot be used for TV pre-alignment.



Wafer size (inch)	L (µm)
4	L ≧ (60000)
5	L ≧ (75000)
6	L ≧ (90000)
8	L ≧ (105000)

Figure 4: *Positions of TV pre-alignment marks on the wafer (dimensions in μm). Please note: the measurement system is based on wafer scale*

Multimarks, AA or off-axis AA marks:

Multimarks, AA or off-axis AA marks are synonyms for marks used for aligning the wafer with the help of “high magnification off-axis alignment scope” of the stepper. Fig. 5 displays in a) the outline of the multimarks, in b) their position on the reticle and in c) their position on the wafer. Two kinds of multimarks are available: the “20P-4F” and the “20P-4FD” marks. Since the mark positions are detected both in X- and Y-direction measurements, the multimarks must be placed in both X and Y directions.

The mulimarks has to be placed on the reticle in a way as described hereunder:

1) Place the multimarks on the horizontal and vertical scribe lines. The scribe line is a virtual frame around a chip on the reticle having a width of at least of 250 µm, preferably 350 µm (reticle dimension).
2) Place the Y-direction measurement mark on the vertical scribe line on the right side of the chip of the reticle and the X-direction measurement mark on the horizontal scribe line on the bottom side (see Fig. 5b).
3) If chip rotation error compensation is needed to be performed (5), Y-direction measurement marks for chip rotation error measurements are required (see Fig 5a). Place the chip rotation error measurement mark on the vertical scribe line on the left side of the chip of the reticle (see Fig. 5b). The chip rotation error measurement mark must be placed on positions where it does not interfere with the Y-direction measurement mark. It should not be placed on the same Y-coordinate.
4) Both kind of multimarks “20P-4F” and the “20P-4FD” should be patterned. If both marks cannot be placed the “20P-4F” marks are recommended for the FPA-3000EX4 stepper.

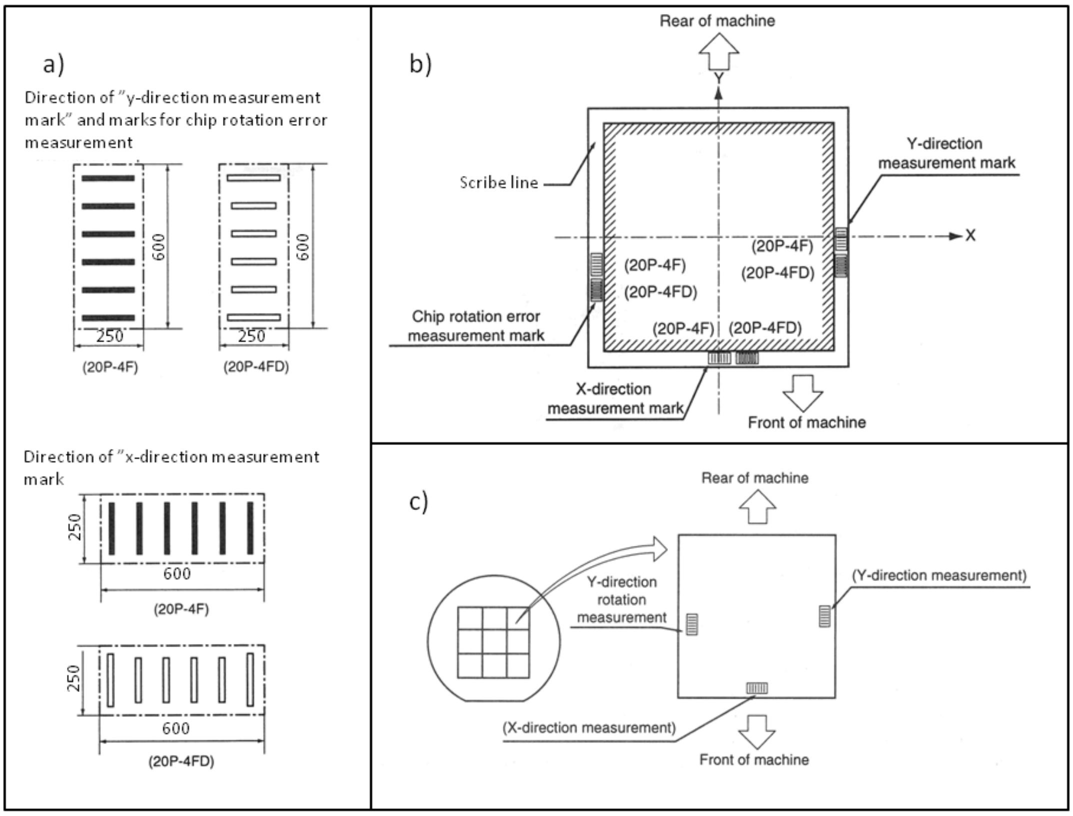


Figure 5: *a) Outline of the multimarks, b) their position on the reticle and c) their position on the wafer*

2.4 Different marks

Veneer patterns - that can be applied as stitching marks - are available in GDSII format from Danchip and can be added to the design. Within the design the Veneer pattern should be connected to a block having a width of at least 500 µm on that side on that the stitching should to be evaluated.

The bar code as shown in Fig. 3 doesn't have to be included into the design because the stepper is not equipped with a bar code reader. Nevertheless, the reticle manufacture will include the bar code anyway.

Please note: The stepper is not equipped B and C scopes used for "phase detection alignment". Thus the marks used for phase detection alignment (G8P-4) do not need to be added to the reticle design. These marks are also not included in Fig. 3. However, an update of the stepper to enable phase detection alignment is possible.

3. Conclusion

The purpose of this guide is to assist customers using the Canon FPA-3000 EX4 stepper to prepare reticle designs. It was not the intention to supply the complete design specifications. The particular design might be quite challenging. The most appropriate pattern profiles are usually not straightforward to achieve especially when the demand concerning the fidelity of the pattern, optical proximity corrections and resolution of the stepper is high. Then the individual design interferes with both process parameters and the choice of the applied material. In the most cases a discussion with the photolith team at Danchip is advised, necessary to avoid misunderstandings, to achieve the best feasible results and to exploit full potential of the stepper.

4. References and Endnotes

1. *FPA-3000 EX4 Reticle Guide Operation Manual - Part I, 6-Inch reticle,* Canon, 1997.
2. *CANON FPA-3000 EX4 operation manual,* Canon, 1997.
3. Hiroshi Ito*, Chemical Amplification Resists for Microlithography,* Advanced Polymer Science **172** (2005) 37-245.
4. *Currently our main reticle supplier is "Compugraphics photomask solutions". It is recommended to send the mask design to the photolith group of Danchip, so that they can order the mask.*
5. *Chip rotation error compensation is required when (a) a reticle manufaturing error may cause a problem or (b) when a wafer was processed with reticle alignment other than FRA.*