Guide to making Nikon i-stepper alignment marks.

This document is to aid the mask designer in the placement and dimensioning of reference marks used for wafer alignment on the Nikon stepper.

This information is taken from the Advanced System Training Manual and the Nikon Reticle Design Guide. Both manuals are available upon request. A reticle is the mask used in stepper systems.

In general, there are two types of alignment marks:

Reticle alignment marks are used to position the XY axis of the reticlein parallel to the XY axis of the wafer stage. These marks are outside of the exposure area and can be added to the design data file by the mask fabricator.

Wafer alignment marks establish the precise position of the wafer on the XY stage and guide placement of the reticle pattern onto an existing wafer pattern. These marks should be placed on all permanent levels of a multi –level device.

This SOP includes design details for the several types of wafer marks :

search marks Wx, Wy, Wθ
fine alignment marks LSAx , LSAy
fine alignment marks FIAx , FIAy
fine alignment marks LIAx , LIAy
step alignment marks Sx, Sy

Nikon uses multiple alignment systems to read and measure these marks. Discussion of the theory of operation of these LSA, FIA and LIA systems is taken up in the machine operation SOP and during training rather than in this procedure.

The following outlines the reticle and wafer alignment sequences:

Reticle alignment sequence	description
o reticle loading	o mechanical placement of mask
o mark search	o scans mask under 3 sensors
o Ret. microscopes setup.	o aligns optical axis to stage fiducial alignment
o alignment check	o checks rotation. Fiducial beam → PEM's
o baseline measurements	o reference beam systems: LSA, FIA, LIA to stage fiducial , thus to reticle XY axis

Baseline measurements
Once the reticle is aligned, the ISS beam (from the wafer stage fiducial), will measure its position in the X and Y axis. At this time the wafer alignment systems LSA, FIA and LIA positions must also be measured with respect to the reticle position. Each has it's own marks at the fiducial.

These relative positions become "baseline measurements" which are used in the wafer alignment process.

Wafer alignment sequence	description
o wafer prealignment	o orientation of wafer flat
o wafer search	o leveling, auto-focus, scan marks w/LSA
o wafer global alignment (WGA)	o LSA scans Wy,Wθ, corrects θ. Scans Wx Wafer center coordinates calculated.
o wafer fine alignment	o uses LSA or FIA marks in either mode:
EGA (enhanced global al.)	samples preset die, gets correction value.
D/D (die-by-die)	uses LSA or FIA values directly for each
o wafer exposure	o shoots entire program, unloads to carrier

Wafer Alignment marks Wx, Wy, Wθ. Also called Search marks or WGA marks.

These are used to establish wafer position on the stage and orients the X and Y alignment marks on wafer, making them parallel to the Y stage mirror. This is called Wafer Global Alignment (WGA). Wy and Wθ were once separate marks. Now the LSA system picks up the single horizontal global Wy mark

You must place these marks within the design somewhere (position is arbitrary.)

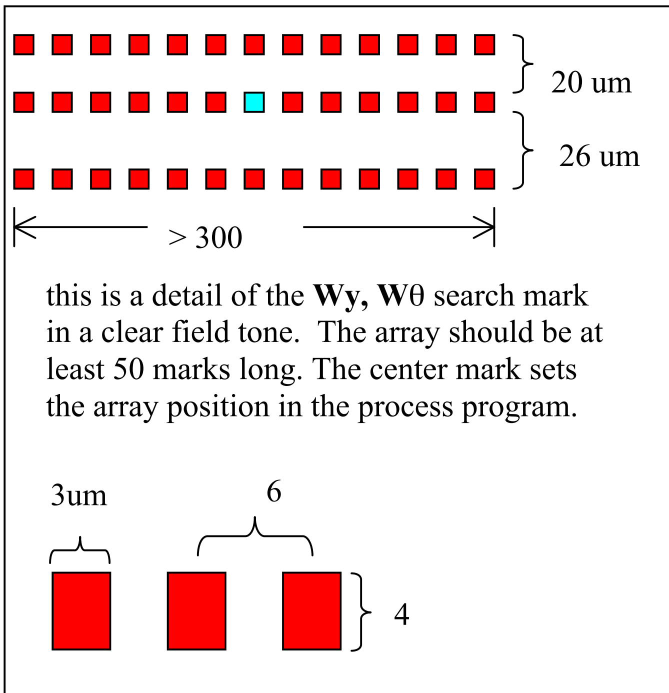
Certain design specifications must be followed:

Wx

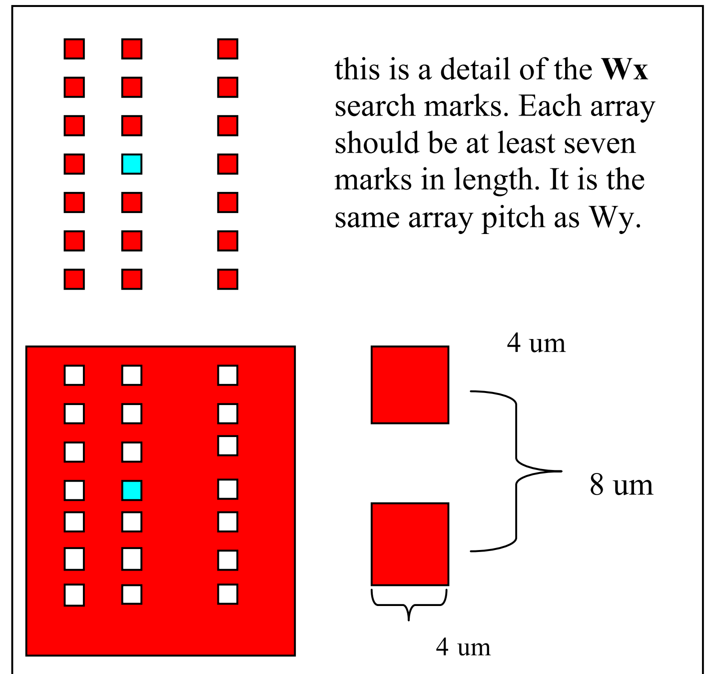
- mark unit size = 4.0 x 4.0 um
- mark unit pitch = 8.0 um
- arrays with both field tones should be made
- array design should be as shown below
- no foreign patterns/edges within 12 um

Wy = Wθ

- mark unit size = 3.0 um (horiz) x 4.0 um (vert.)
- mark unit pitch = 6.0 um (horizontal spacing)
- both dark and clear field tones
- array designs as shown below
- no other patterns within 20 um



this is a detail of the **Wy, W**θ search mark in a clear field tone. The array should be at least 50 marks long. The center mark sets the array position in the process program.



this is a detail of the **Wx** search marks. Each array should be at least seven marks in length. It is the same array pitch as Wy.

The center mark in the array defines the position of the mark in the process program.

Wx & Wy (WGA) marks should be placed on every permanent level that you wish to align to.

LSA marks LSAx , LSAy. Also referred to as fine alignment marks.

These are used to measure and align each exposure position on the wafer.
These are used for overlay, or registration of the reticle pattern to a previous layer.

The mask designer must place these within the design somewhere (position is arbitrary.)

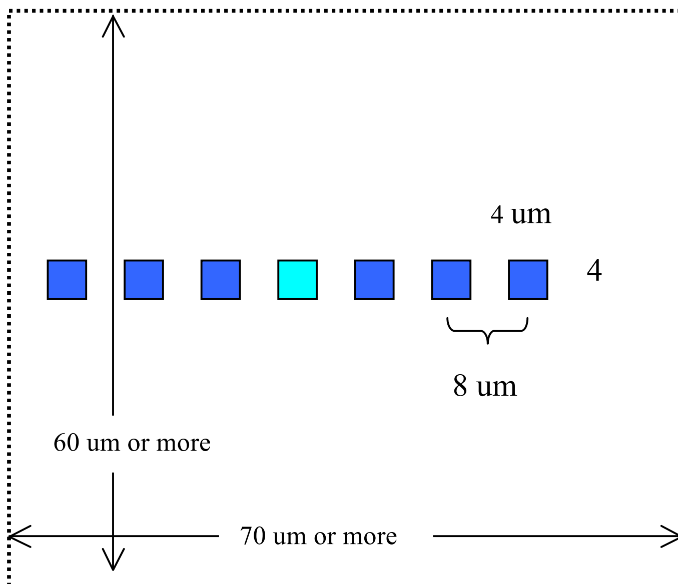
Certain design specifications apply:

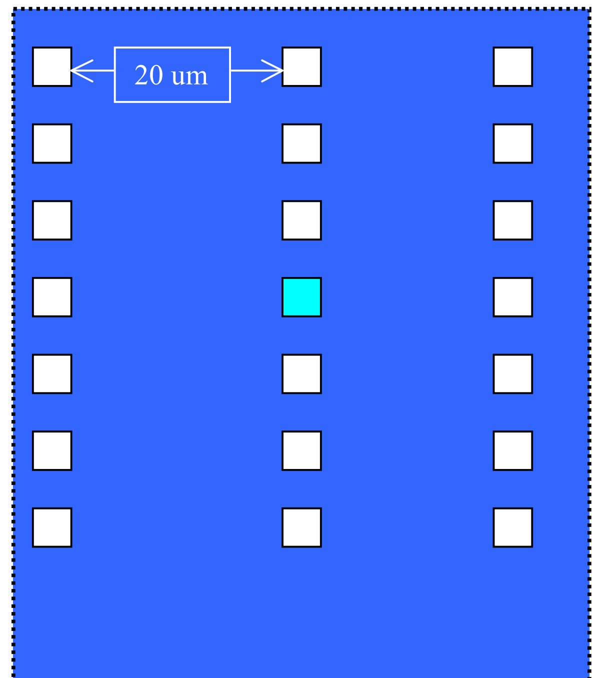
- mark unit size = 4.0 x 4.0 um
- mark unit pitch = 8.0 um
- array design should be as shown below
- no foreign pattern/edges within 30 um

- both dark and clear field tones should be made.
- you may then select the tone that gives the best waveform signal or the best ITV image.

Multiple marks, as shown below in the right side array, may improve accuracy. In this case the LSA system measures and averages the multiple mark positions.

This example shows 3 rows, up to 7 are acceptable. In every case the lines must be separated by 20 um on the wafer . The area forbidden to foreign edges and patterns is increased to 50 um on either side of the array of rows.





Arrays should be a minimum of seven marks long. The center mark defines the array position in the process program. Either array tone's center mark may serve as LSA target.

These marks should be placed on every permanent masking level that you will align to.(i.e not implants)

- Placing the LSA marks on the reticle's center lines (LSAx on Y axis, LSAy on X axis) minimizes the effects on lens distortion (including magnification error.)
- When the LSA marks are placed on the reticle center lines **at the outermost pattern edge**, alignment time is minimized , particularly with die-by-die alignment

FIAx Sy
LSAx

FIAy
LSAy
Sx

Rx1y

Rx2θ

Center to center distance between

Rx1y and Rx2θ crosses = 130.0 mm(+/-.2um)

Wx
Wy

Rx distance to reticle center point is 70.75 mm (+/- 0.5 um)

Rx