Wafer Alignment for Canon Stepper

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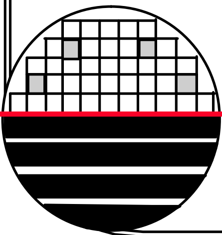

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OUTLINE

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Canon FPA 2000-i1
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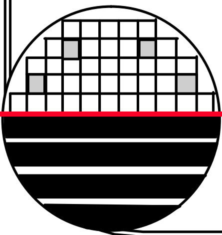
INTRODUCTION

Overlay (alignment) is as important as resolution in lithography. Modern CMOS integrated circuits have ~ 30 layers to be aligned. The RIT CMOS processes use up to 13 layers. Alignment marks are placed on the wafer at the beginning of the process during the first level lithography or in a special zero level lithography. The wafers then undergo many processing steps such as CMP, oxide growth, metal deposition and LOCOS like processes. These processes change the appearance of the alignment marks. Marks that start out as trenches can change to mesas, marks with topology can become flat after CMP, marks can change color and can become buried or even invisible. Thus a strategy for alignment must be devised as part of the process design and chip layout. An example strategy is given at the end of these introduction pages.



INTRODUCTION (cont.)

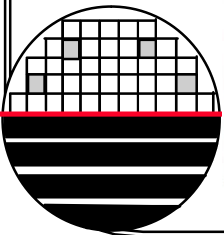
The Canon FPA-2000i1 has four alignment techniques for aligning the wafer to the stepper. It has a separate system for aligning the mask to the stepper (optical column). If the mask is aligned to the stepper and the wafer is aligned to the stepper and the stage accuracy is perfect then overlay will be achieved by moving the wafer to the correct location under the lens.

The wafer is aligned to the stepper using one or more of the following: 1) alignment with TVPA marks and TVPA scope, 2) alignment with the fine alignment x-y or multi-marks using a HeNe Laser, B and C scopes, 3) alignment with the fine alignment x-y or multi-marks using a Halogen Lamp filtered to 612+/-35nm (broadband or BB), B and C scopes 4) alignment with the x-y auto-alignment (AA) marks using i-line illumination through the lens for Die-by-Die alignment and iA scope.

INTRODUCTION (cont.)

Comparison of All Alignment Systems

i-Line Illuminator
TV AA/FRA
Light Output Unit
iA Scope (on-axis)
TV AA/FRA
4
Optical fiber
C Scope
(off-axis)
TV Camera
2,3
B Scope
(off-axis)
TV signal
C
TV signals to
image processors
HeNe(B²)
Illumination Source
B Optical fibers
TV PA
Light Source
Optical fiber
to TV PA
Projection Lens
TV PA Scope
(off-axis)
1



Canon
FPA-2000 i1/FPA-2500 i3

OPi1CP1- O2/40F25

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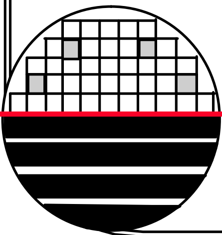
INTRODUCTION (cont.)

Broadband (612+/-35nm) and HeNe illumination are essentially the same except that the laser is single wavelength (612nm). The laser light source can give rise to thin film interference phenomena that could interfere with alignment. The laser light source can be brighter and longer lasting and offer advantages in a manufacturing environment. At RIT we use broadband illumination for most applications because it is more versatile than HeNe and less complicated than the i-line technique. Die-by-Die alignment is useful for large wafer diameters where wafer distortion is expected from high temperature processing. Die-by-Die alignment requires that the i-line alignment technique be used. i-line illumination will expose the wafer during alignment.



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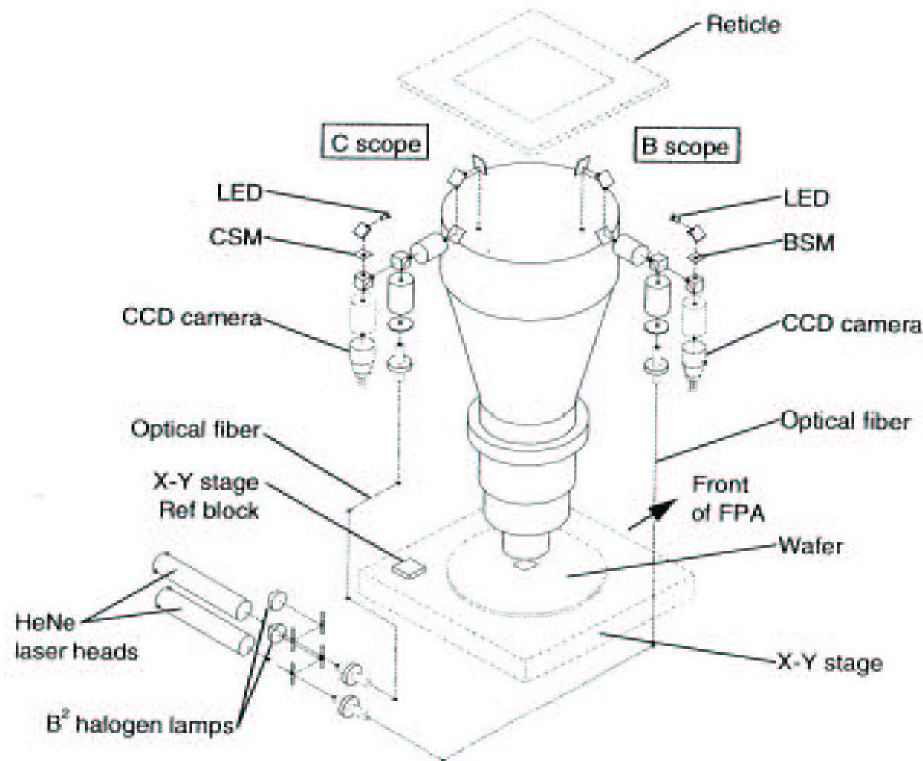
B AND C SCOPES

B and C Scope Alignment Units (AGA)

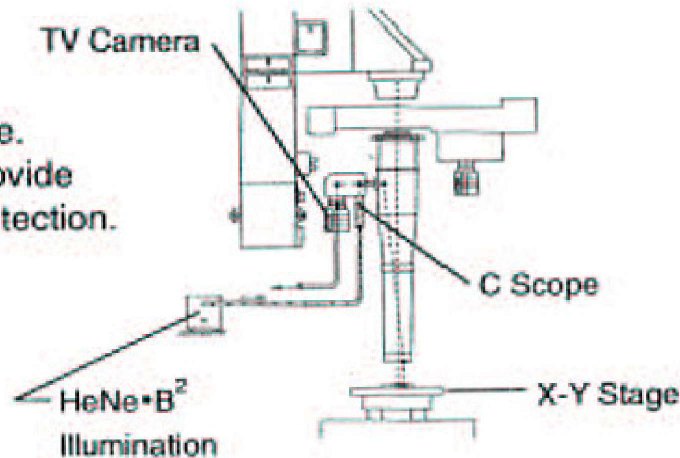


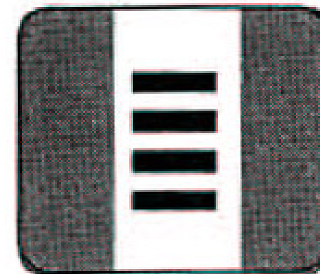
Canon
FPA-2000 i1 / FPA-2500 i3

O16/5F3.69
9511V1.0FST/BOPS68-4

HeNe and BB Alignment

HeNe•B[2] TV AA
aligns the wafer to the reticle using the X-Y stage. The B and/or C scope provide viewing and alignment detection.

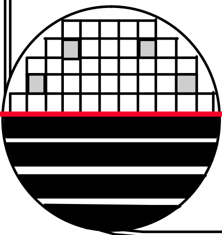




Multimark

Canon
FPA-2000 i1 / FPA-2500 i3

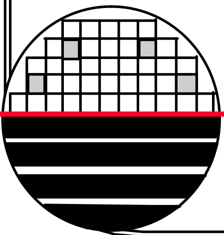
05/17sum2.15
9511V1.0FST/BOPS1E-9



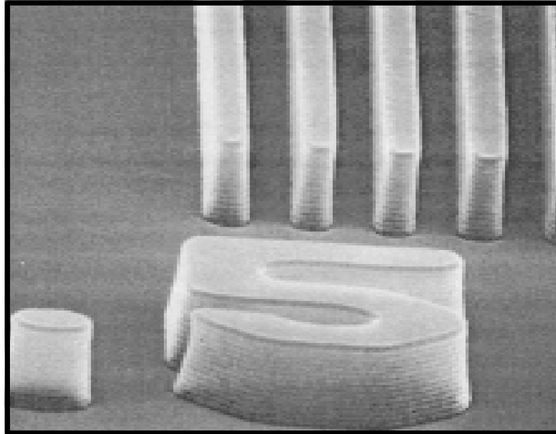
ALIGNMENT STRATEGY

An alignment strategy for a CMOS process might be as follows:

1st mask is the nwell mask shot with no alignment, pre alignment marks and fine alignment marks are on this level for alignment of subsequent layers
2nd mask is active and is aligned using both TVPA and BB fine alignment marks.
3rd mask is channel stop and is a non critical alignment so use TVPA only.
4th mask is pmos VT and is a non critical alignment so use TVPA only.
5th mask is poly and is aligned using both TVPA and BB fine alignment marks.
6th mask NLDD and is a non critical alignment so use TVPA only.
7th mask PLDD and is a non critical alignment so use TVPA only.
8th mask N+DS and is a non critical alignment so use TVPA only.
9th mask P+DS and is a non critical alignment so use TVPA only.
10th mask is contact cut and is aligned using both TVPA and BB fine alignment marks. Also include on this mask another set of alignment marks to be used for metal alignment.
11th mask is metal one and is aligned using both TVPA and BB fine alignment marks on the contact cut level. Include another set of marks for via level alignment.
etc., etc.,



CANON FPA-2000 i1 STEPPER



i-Line Stepper λ = 365 nm

NA = 0.52, σ = 0.6

Resolution = 0.7 λ / NA = ~0.5 µm

20 x 20 mm Field Size

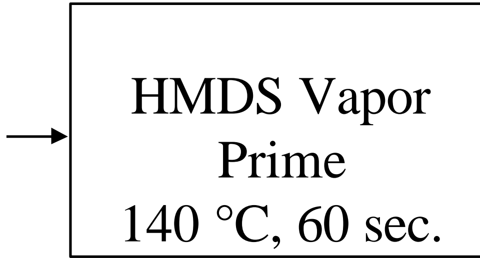
Depth of focus = k_2 $\lambda/(NA)^2$ = 0.8 µm

Overlay ~0.1µm

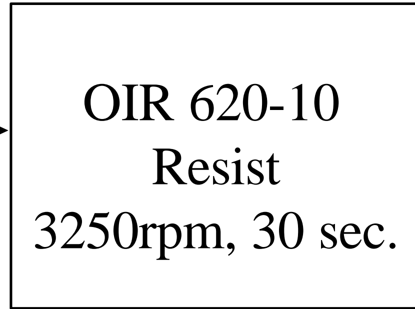
CANON PHOTORESIST PROCESSING

COAT.RCP

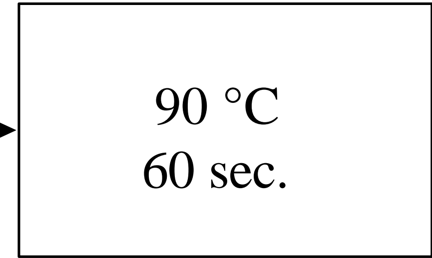
DEHYDRATE BAKE/ HMDS PRIMING



SPIN COAT

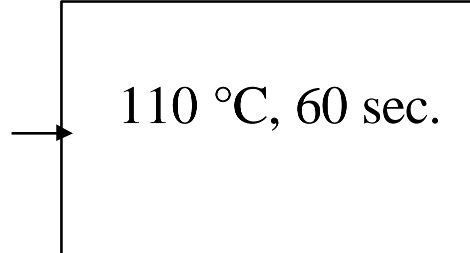


SOFT BAKE

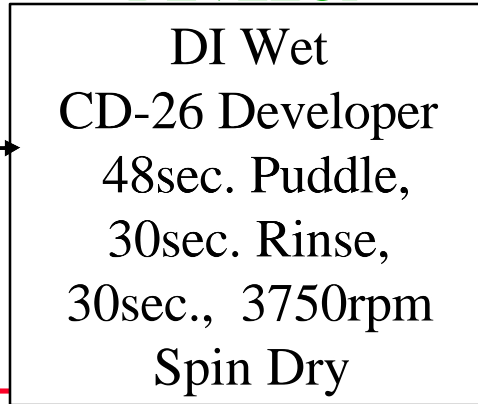


DEVELOP.RCP

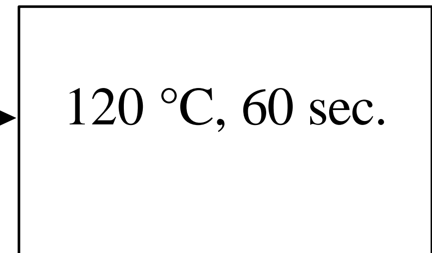
POST EXPOSURE BAKE

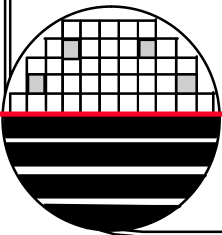


DEVELOP



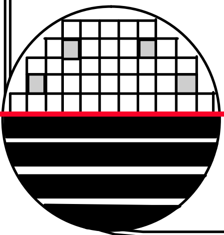
HARD BAKE





STAGE ACCURACY

The stage position is very accurate. Its position is measured using a laser interferometer that has a fundamental accuracy of $\lambda/8$ ~0.08µm. The interferometer measures the position of the mirrors on the x and y stages while the wafer is some distance from the mirrors on the stage. If the temperature inside the environmental chamber is kept constant then the errors caused by the thermal coefficient of expansion for the stage can be minimized. The stage accuracy is monitored periodically to ensure that the interferometer is working correctly. However, in most modes of operation, including alignment, the stepper stage measured position is assumed to be perfect.



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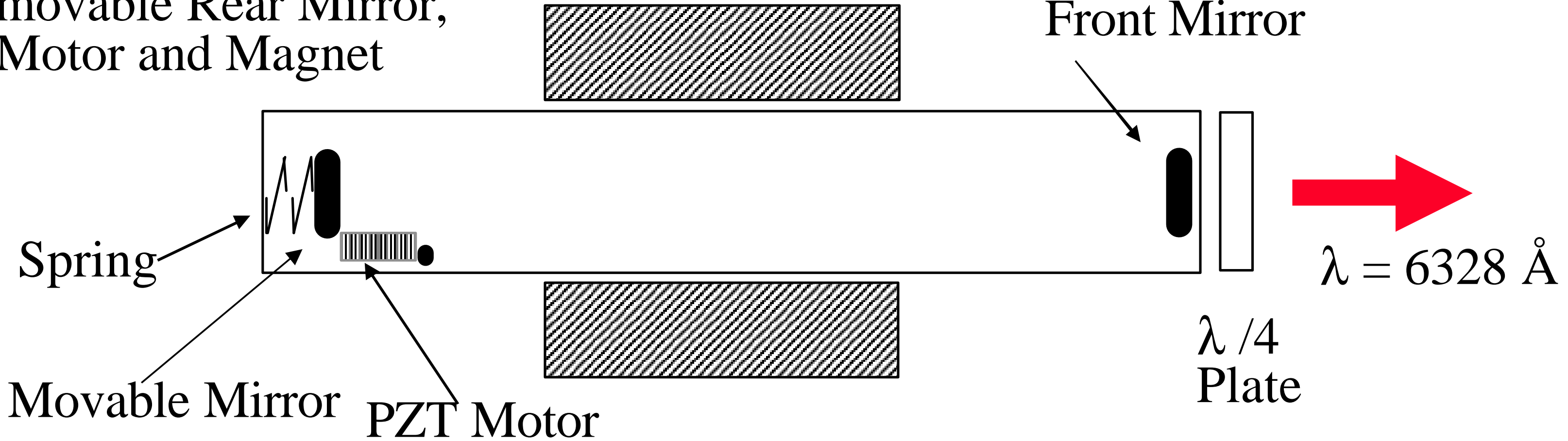
LASER FOR STAGE POSITION MEASUREMENT



The magnet causes Zeeman splitting of the LASER frequency resulting in two circularly polarized frequency components. One left-hand circularly polarized (LHCP) the other RHCP and about 1 M Hz above and below the center frequency, fo. By applying a voltage between 270 and 1800 Volts to the piezoelectric transducer (PZT), the rear mirror can be moved, giving a small amount of resonate cavity length tuning. Tuning makes the strength of LHCP and RHCP components equal. A quarter wave plate makes the output beam have two equal strength, linearly polarized, mutually perpendicular beams.

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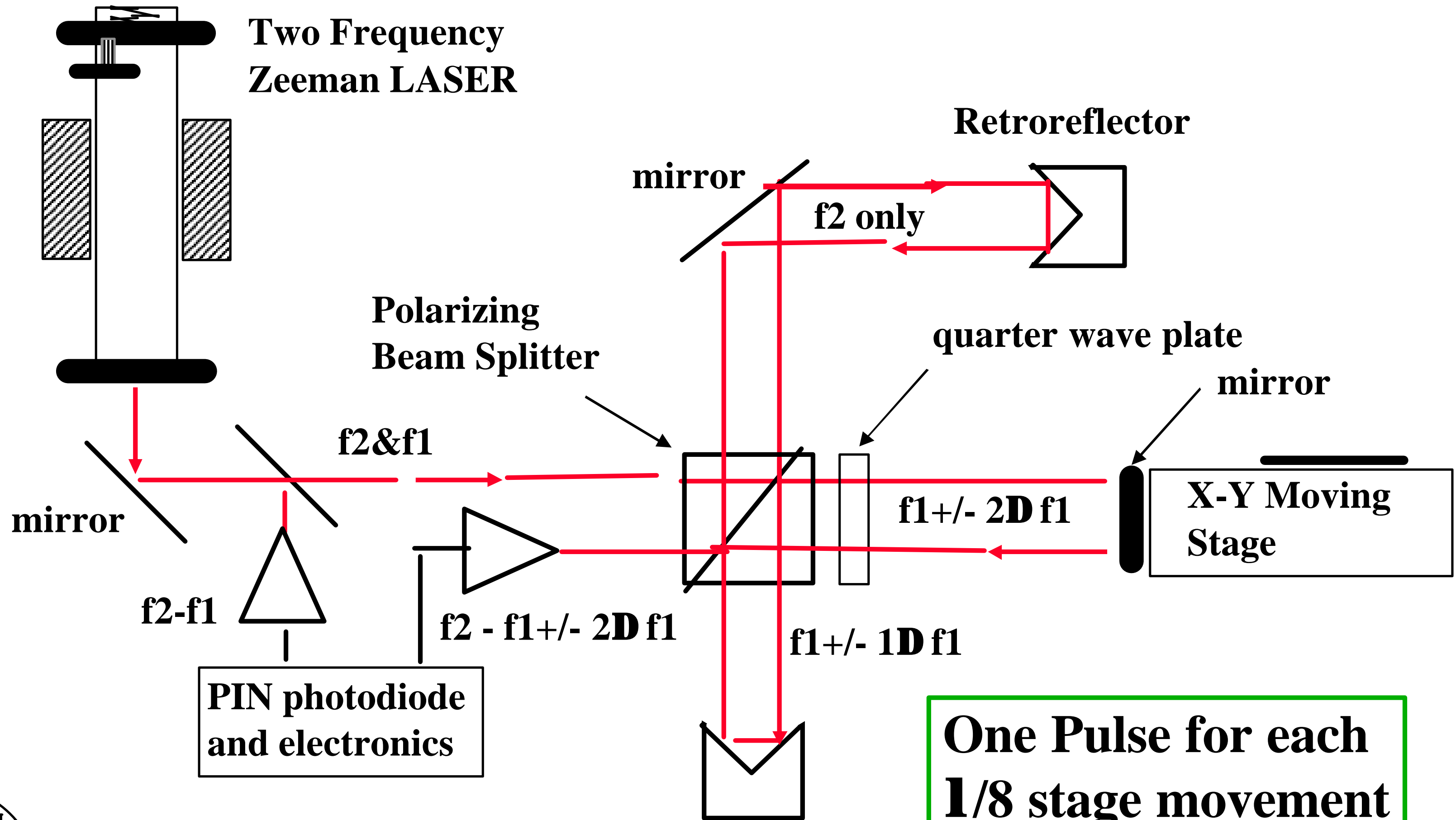
PLANE MIRROR INTERFEROMETR



One Pulse for each
1/8 stage movement
1/8 = 0.08 µm

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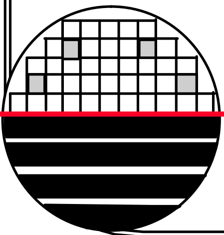
BASELINE CORRECTION

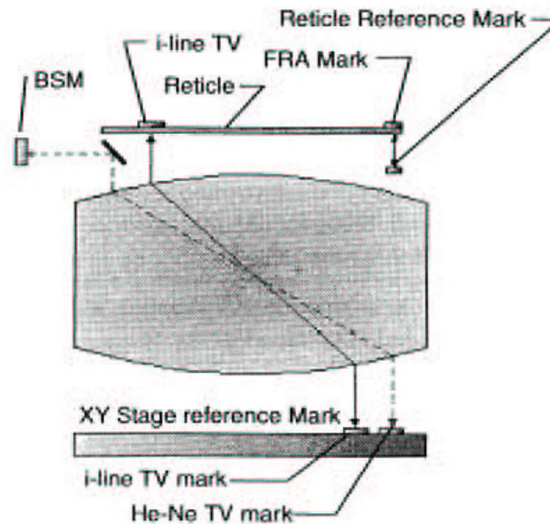
Base Line correction is a precise measurement of the difference between the actual and nominal distance to the center of the optical column from the location of the alignment microscopes. Since the wafers are aligned to the off axis alignment microscopes then moved under the optical column for exposure, this distance must be know to ~ 0.1µm.

To make this measurement a special target that is attached to the stage is moved under one of the alignment microscopes and measured. Any error in alignment is calculated and becomes a correction to the current baseline value. The error in the base line correction is a statistical quantity. Ideally the number is randomly distributed around zero with a small variance.



BASELINE MEASUREMENT

Baseline Measurement Sequence



[1] FRA
Reticle ref. mark vs Reticle

[2] i-Line TV
Reticle vs XY stage ref. mark

[3] He-Ne TV
XY stage ref. mark vs BSM

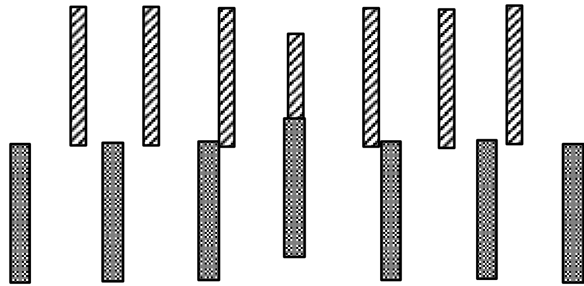
[4] Baseline compensation
Reticle ref. mark vs BSM

Canon
FPA-2000 i1/FPA-2500 i3

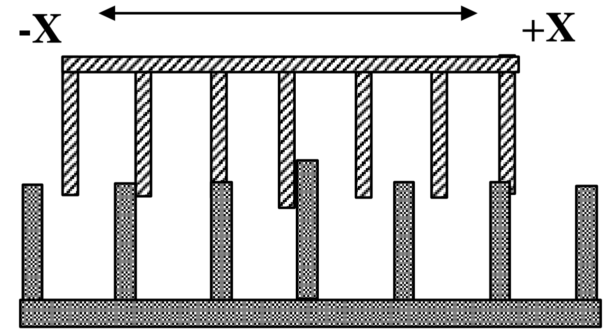
i1UD5/14F3-3
9511V1.0-FST/BOPS1E-14,6B-12

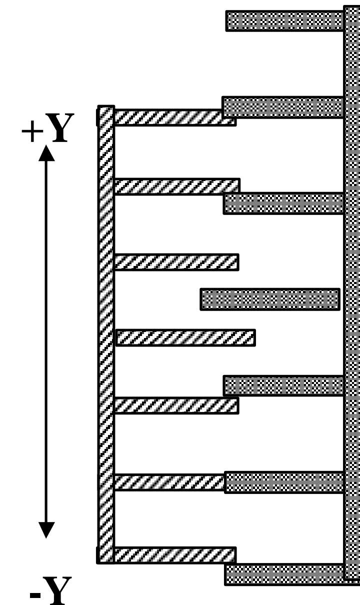
BASIC OVERLAY VERNIERS

Second Level Marks
on 10 µm Spaces

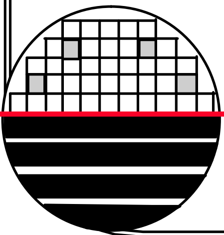


First Level Marks
on 11 µm Spaces





Example shows alignment error of -1 µm in X and -2 µm in Y



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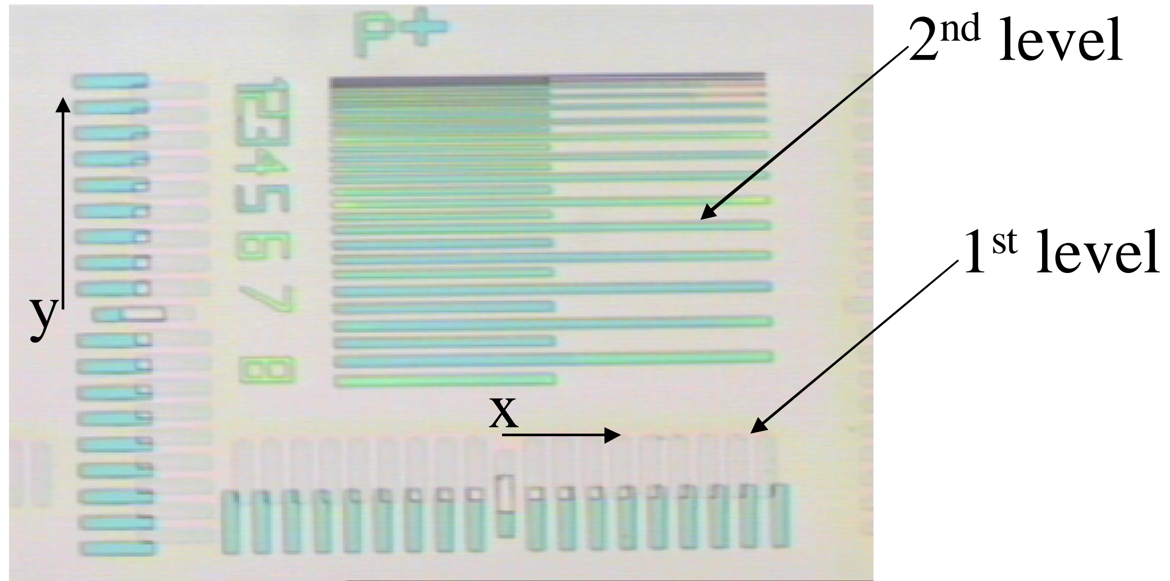
RIT 1 µm OVERLAY VERNIERS

This picture shows perfect alignment in x and y



Note: in this picture the lines and spaces and the outer set of marks for x and y overlay are the result of the most recent photolithography. The inner set of overlay marks are from a previous layer. Some RIT designs use the inner set of bars with the lines and spaces. Be careful when determining and specifying alignment directions. (A precise specification for example is: the 2nd layer pattern needs to shift 1µm in the –y direction (down toward wafer flat) and 0.5µm in +x direction to give correct alignment with the previous layer)

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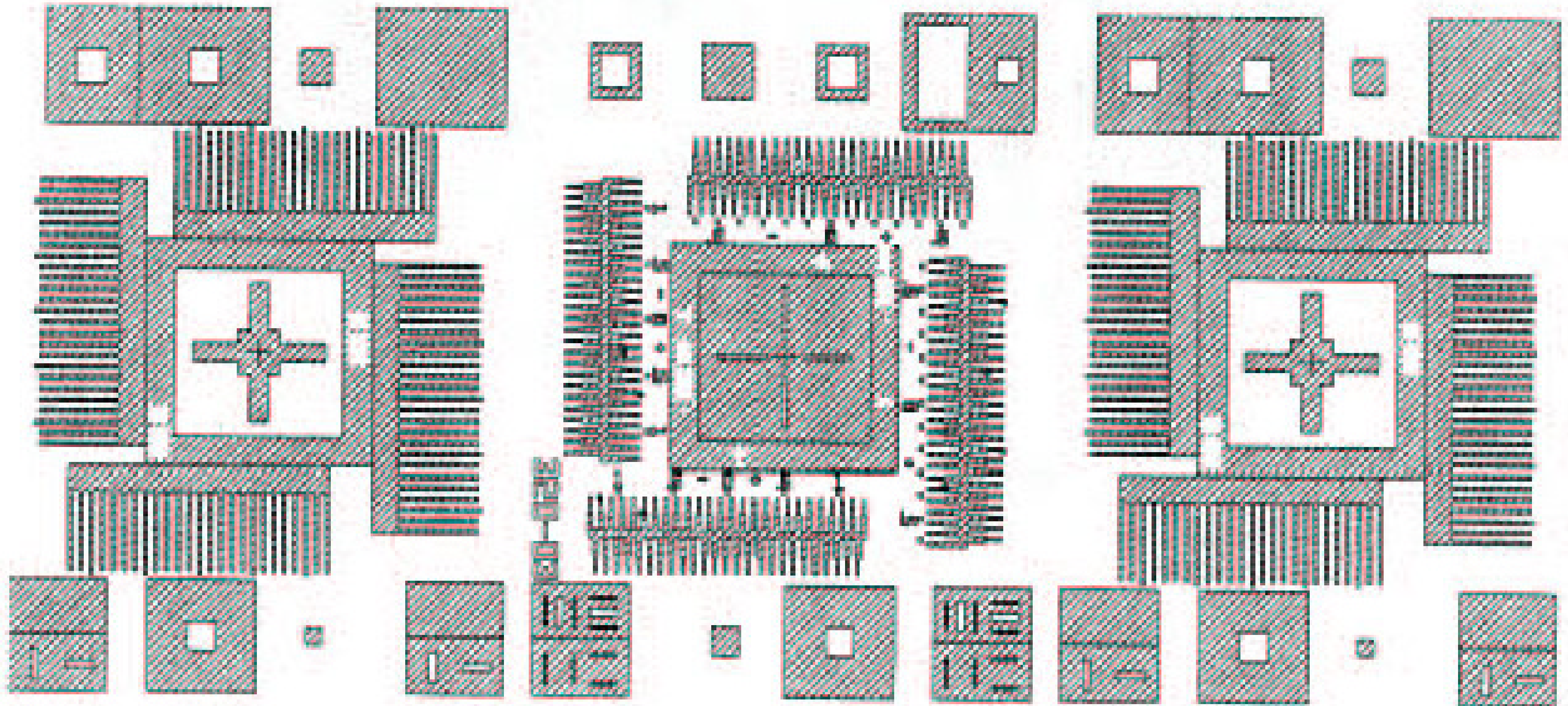
ADVANCED 0.1μM OVERLAY VERNIERS



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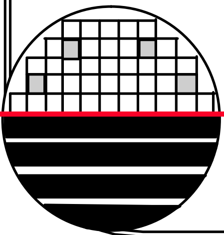
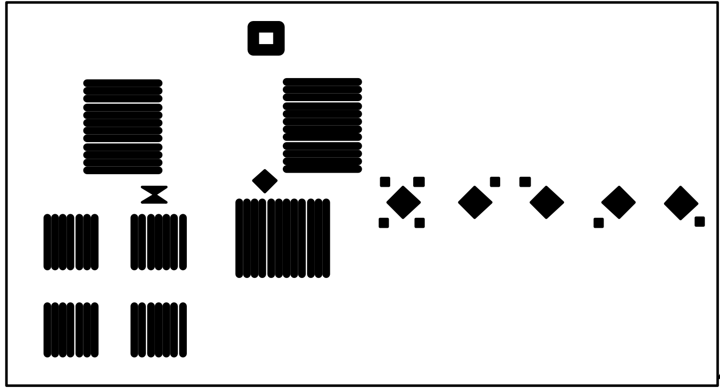
RETICLE ALIGNMENT

In order to align a reticle to the stepper, the reticle must have fiducial marks at given locations near the edge of the mask. The Canon fiducial marks are shown on the following pages. They are automatically included in any stepper job written in the RIT maskshop. If your mask is made outside of RIT you will need to request fiducial marks and specify type (FRA1 and/or FRA2) and possibly the exact location on the mask. The type of mark on your reticle to be used for reticle alignment is one of the inputs required in the stepper job reticle table. You can use reticles with no fiducial marks by specifying no reticle alignment in the stepper job, reticle table, or when alignment fails in a stepper job that calls for reticle alignment, typing the command ROK.

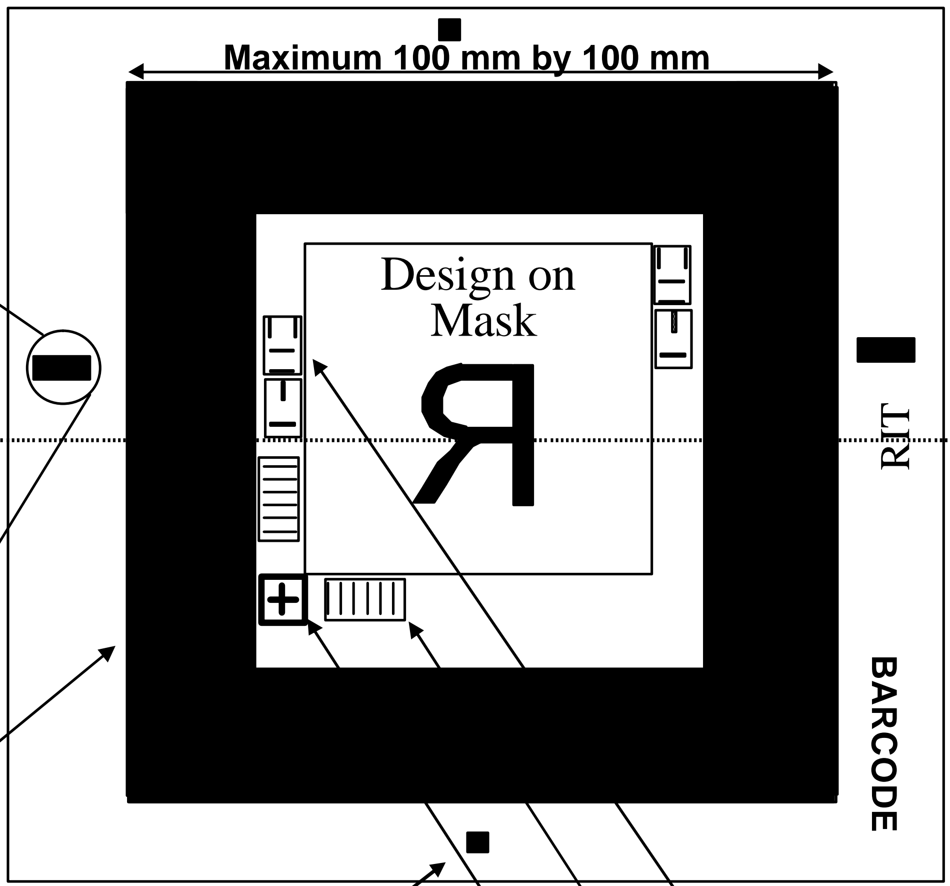


CANON FIDUCIAL MARKS

RIT reads correct from chrome side all other titles read correct from non-chrome side, Chip is wrong reading from chrome side.



Opaque Fiducials marks in clear field



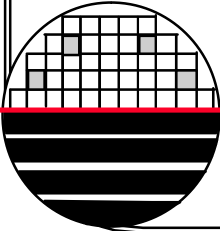
Chrome Side 0.0

GCA marks

i-Line Fine Align

HeNe or B^2 Fine Align

TV Pre Alignment marks



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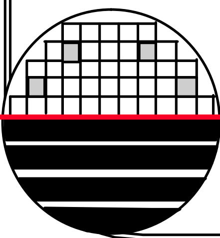
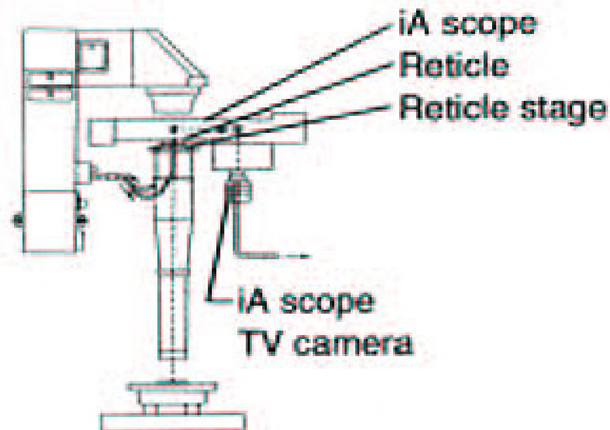
FINE RETICAL ALIGNMENT (FRA) FIDUCIAL MARKS

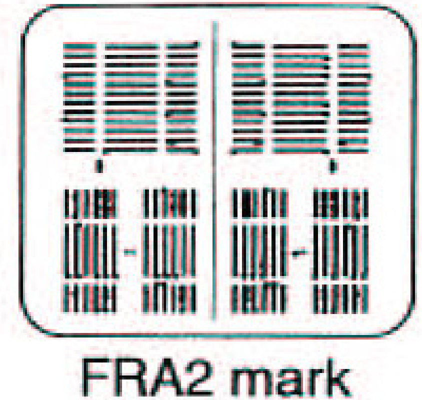


Rochester Institute of Technology
Microelectronic Engineering

FINE RETICLE ALIGNMENT (FRA)

Fine Reticle Alignment (FRA) aligns the reticle to the projection lens to the reticle stage. The iA scope provides viewing and alignment detection.





FRA2 mark

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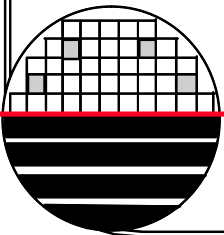
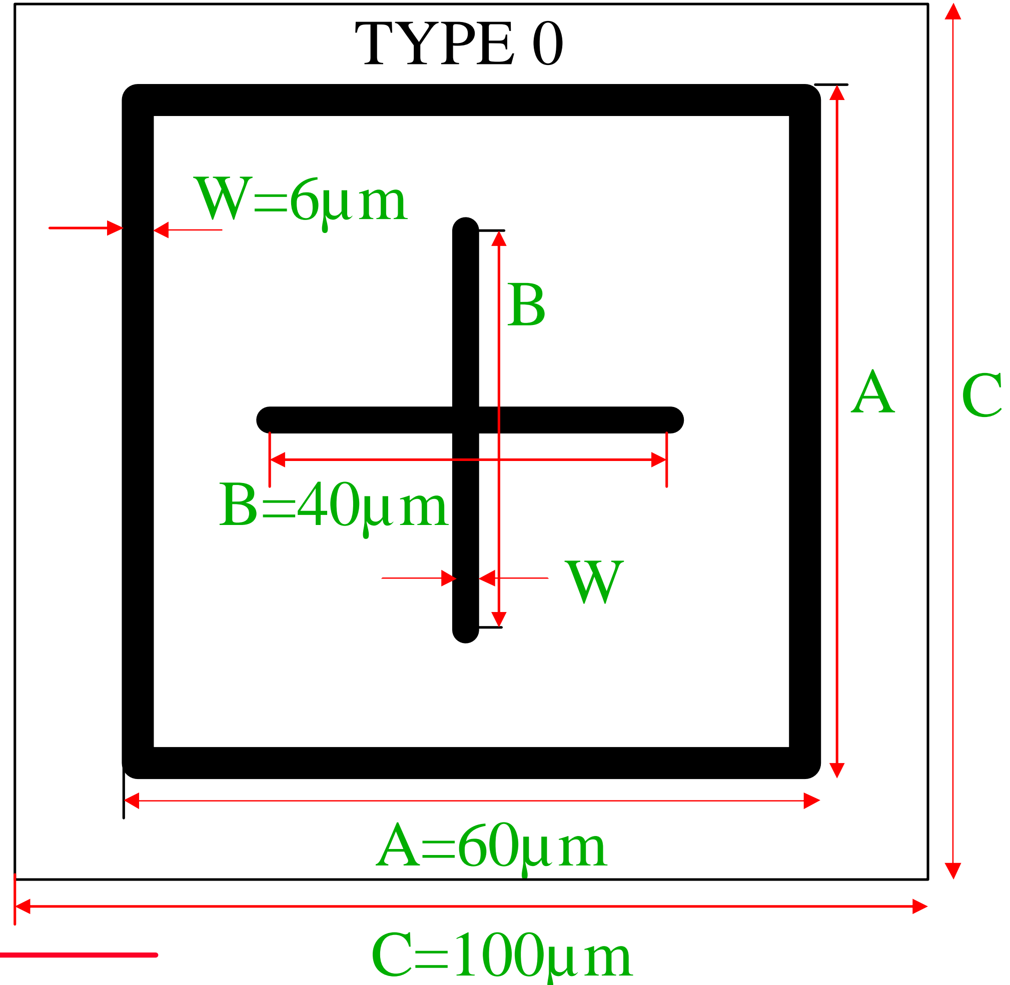
WAFER ALIGNMENT

Wafer alignment involves placing the wafer in a position that can be imaged by one of the alignment scopes (TVPA, B, C or iA scope). The TVPA scope creates a dark field image without using the stepper lens. The B and C scope captures a bright field image through the stepper lens but is off axis and is not at the i-line wavelength. B and C scope is designed for 612nm wavelength (red). iA scope is also through the stepper lens but is on axis and at the i-line wavelength, 365nm. The video images that are captured are analyzed to detect the position of the alignment mark. The exact algorithm used depends on the expected type of mark on the wafer, TVPA, x-y, or multi-mark.



TV PRE ALIGNMENT (TVPA) MARKS

- The TVPA Marks are placed by the designer on design
- TVPA Marks may be copied from the RITPUB directory
- Dimensions are given for sizes on the wafer
- TVPA Marks are used for pre-alignment and to adjust for rotation (theta)
- On 6" wafers TVPA marks should be placed on the wafer > 90mm apart, on the front half of the wafer



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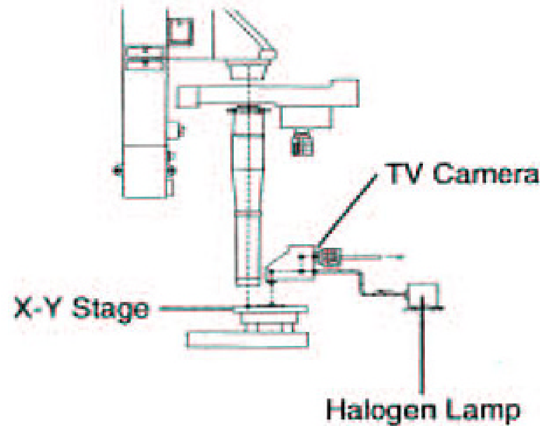
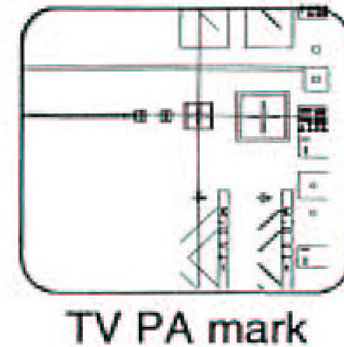
TV PA ALIGNMENT

TV Prealignment (TV PA) locates the TV PA marks on the wafer using the X-Y stage. The TV PA camera provides viewing and alignment detection.





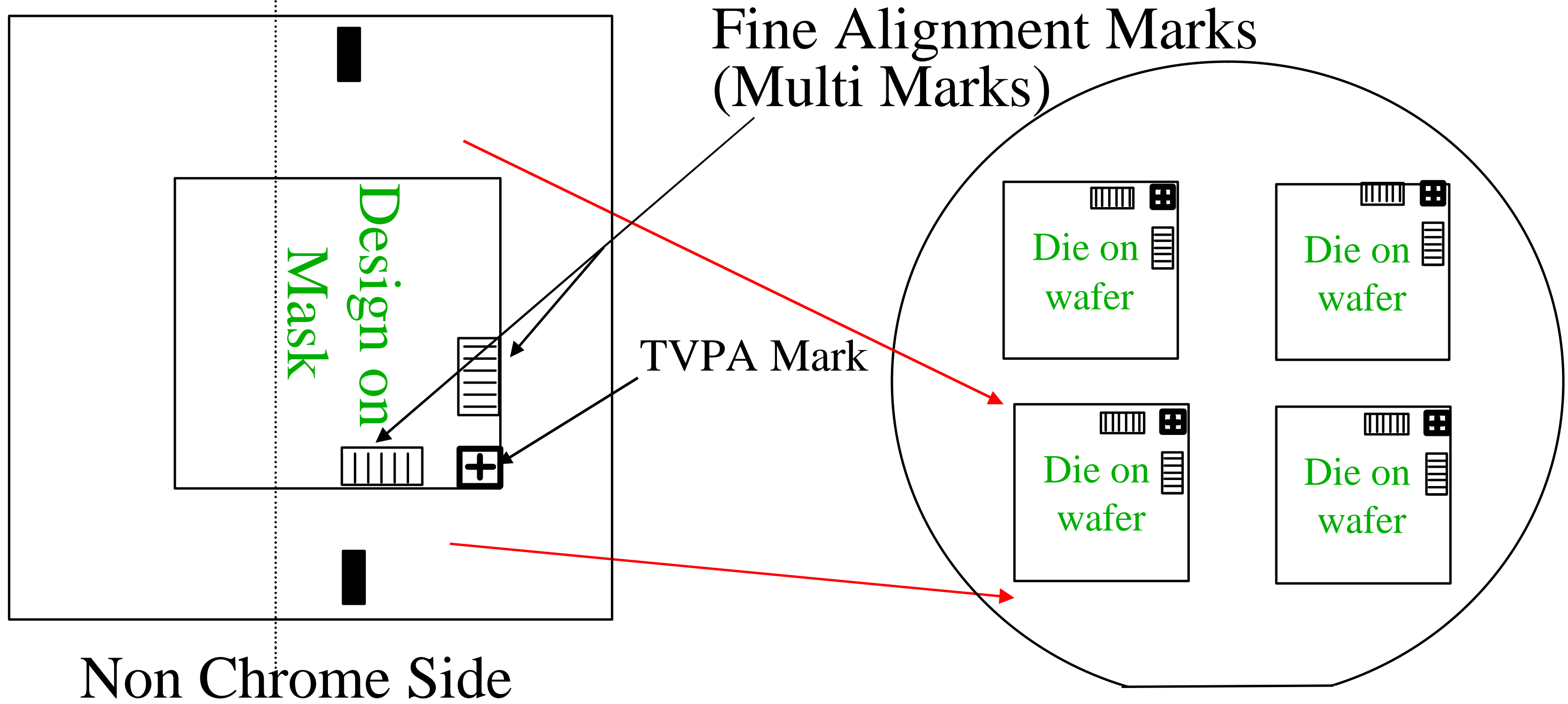
TV PA mark

Canon
FPA-2000 i1/FPA-2500 i3

O5/17sum1.14
9511V1.0FST/BOPS1E8

Alignment using TVPA only is accurate to better than 2 µm.

WAFER FINE ALIGNMENT MARKS for HeNe OR B^2

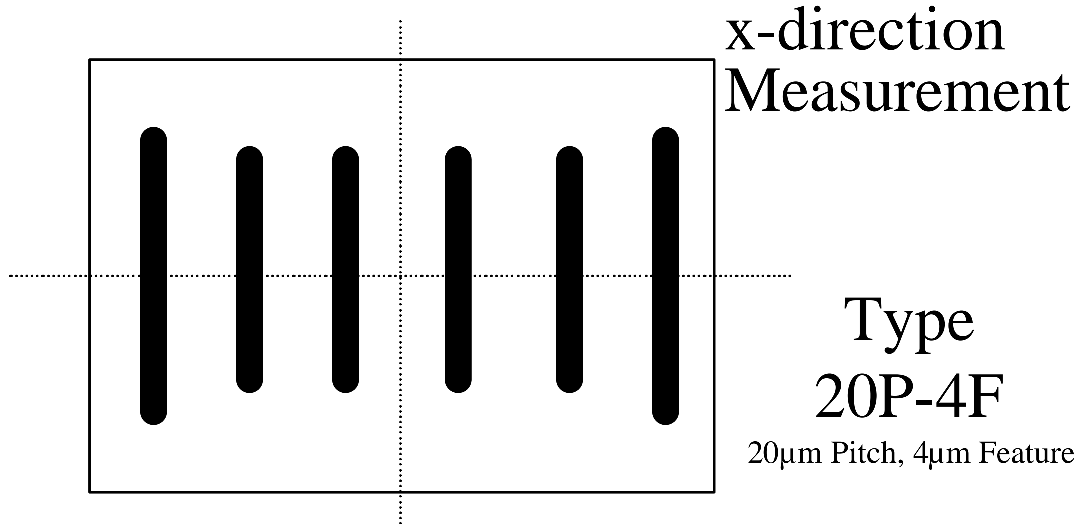


Non Chrome Side

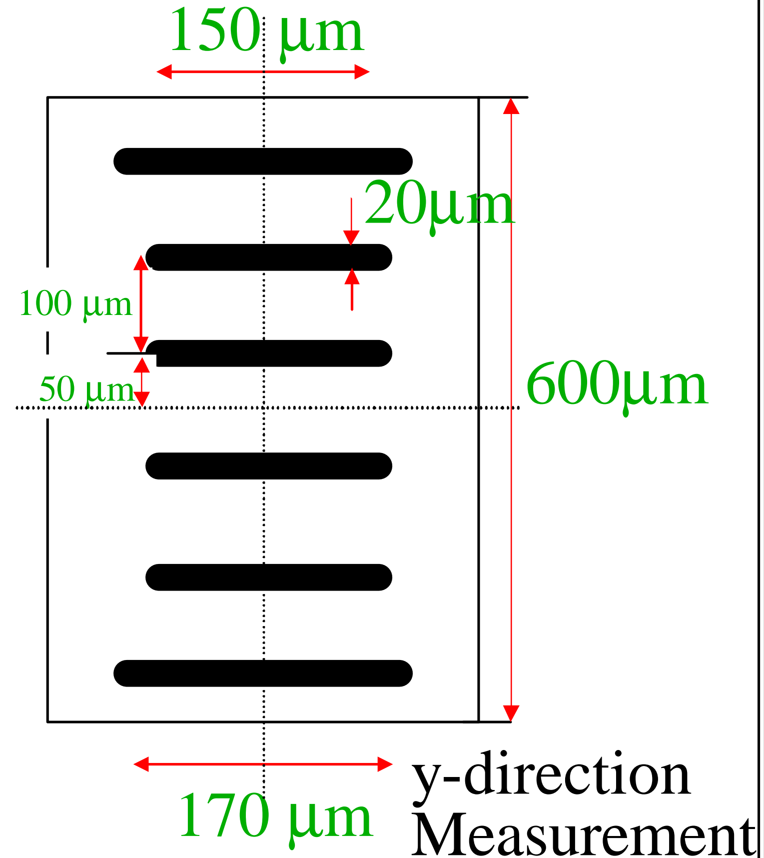
HeNe means marks are illuminated with HeNe Laser
B^2 means broadband (white light source with red filter at 612+/-35nm)

Need at least 2 die for alignment, choose 2,4,6,8,12,or 16. More may be more accurate, less is faster.

WAFER FINE ALIGNMENT MARKS for HeNe OR B^2



Type
20P-4F
20µm Pitch, 4µm Feature



Dimensions are for Sizes on the Reticle. Need both x and y patterns and locations of center for each. These marks are normally in the streets around the edge of the chip. These marks are called multi-marks.

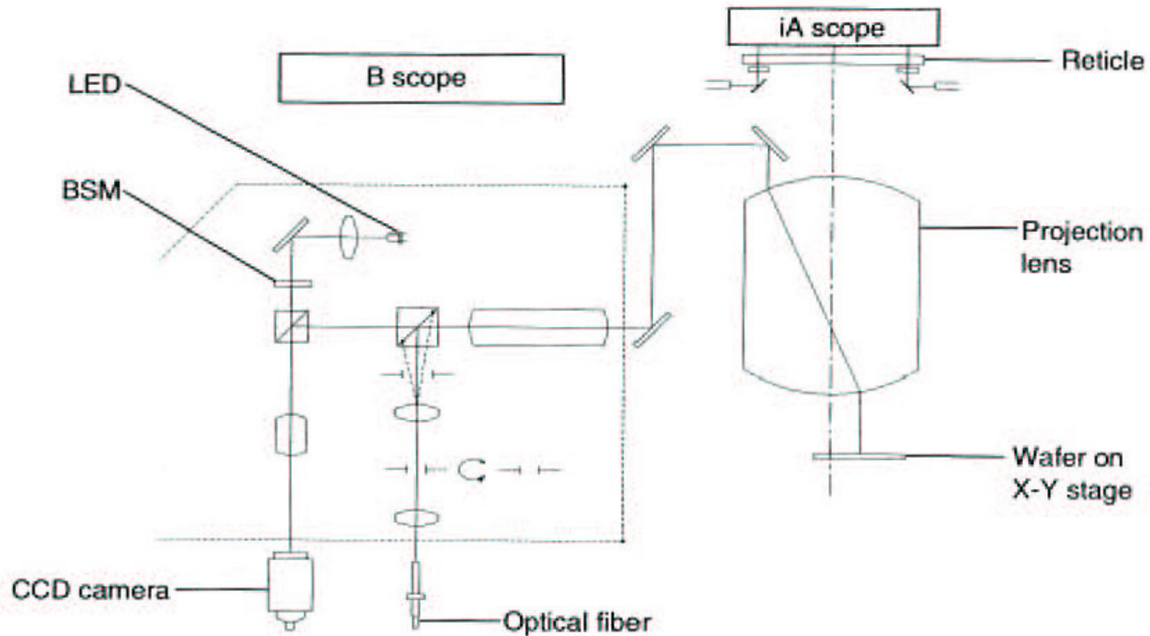
HeNe means marks are illuminated with HeNe Laser
B^2 means broadband (white light source with red filter at 612+/-35nm)

HeNe or B² AGA USING B-SCOPE AND C-SCOPE

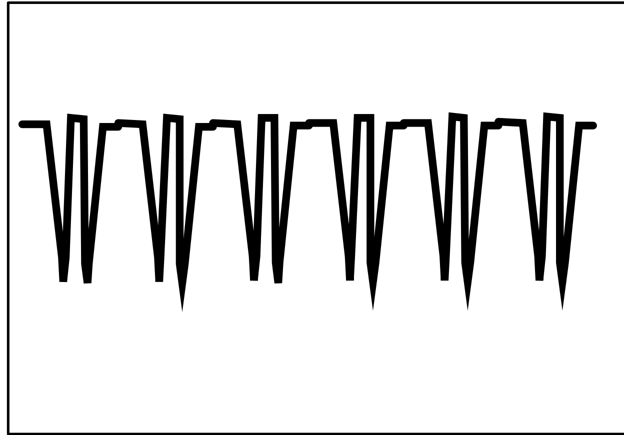
The B and C scopes are alignment microscopes mounted to the right and back of the lens. A video image of the multi-marks is captured and analyzed to determine the fine alignment correction. The illumination is either HeNe laser at 612 nm or Broad-Band filtered to 612+/-35 nm (both are Red in color)

Knowing the location of the y-direction multi-mark on the die, the stage is moved to place the mark under the B-scope (13.0 mm in x-direction). The image of the multi-marks is analyzed to determine the correction in the y alignment. The stage moves the x-direction multi-mark under the C-scope (13.1 mm in y-direction). The image of the multi-marks is analyzed to determine the correction in the y alignment. The stepper then calculates the stage position to center the die under the optical column. The stage moves the die under the optical column. The die is exposed.

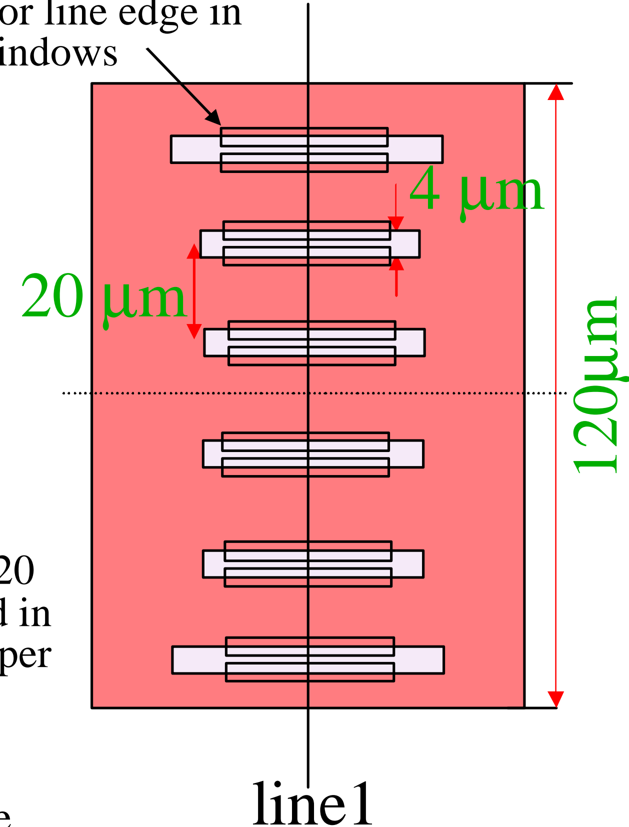
B AND C SCOPE ALIGNMENT



B AND C SCOPE VIDEO SIGNAL



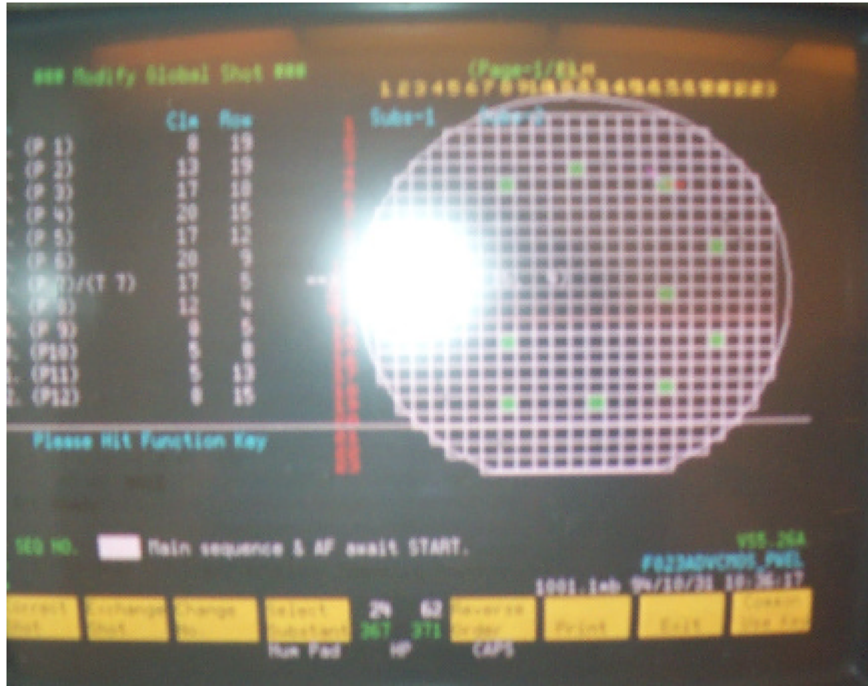
Intensity along line1



The location of the edges of the multi-marks are determined and compared to the expected locations corresponding to 4 µm marks on 20 µm pitch. The number of die to be used for alignment can be selected in the stepper job, 2 to 16 die locations. If the mark is damaged the stepper automatically looks at the marks on an adjacent die and if that fails it looks at another adjacent die. So the stepper could look at up to 16x3=48 die locations to determine alignment. Die that give error readings are ignored. More die locations are better but results in more time per wafer in the stepper (lower throughput).

Note: search window location can be specified in the stepper job, ie wafer surface condition, 0,1,2,3,4,5

AGA (Multimarks) SHOT SELECTION, MEASUREMENT



Shows selected shots and backup shots for fine alignment

Video image of multi-marks

GAUS COMMAND

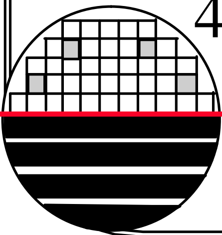
GAUS (AGA – Check Outlier)

Wafer NO.;1

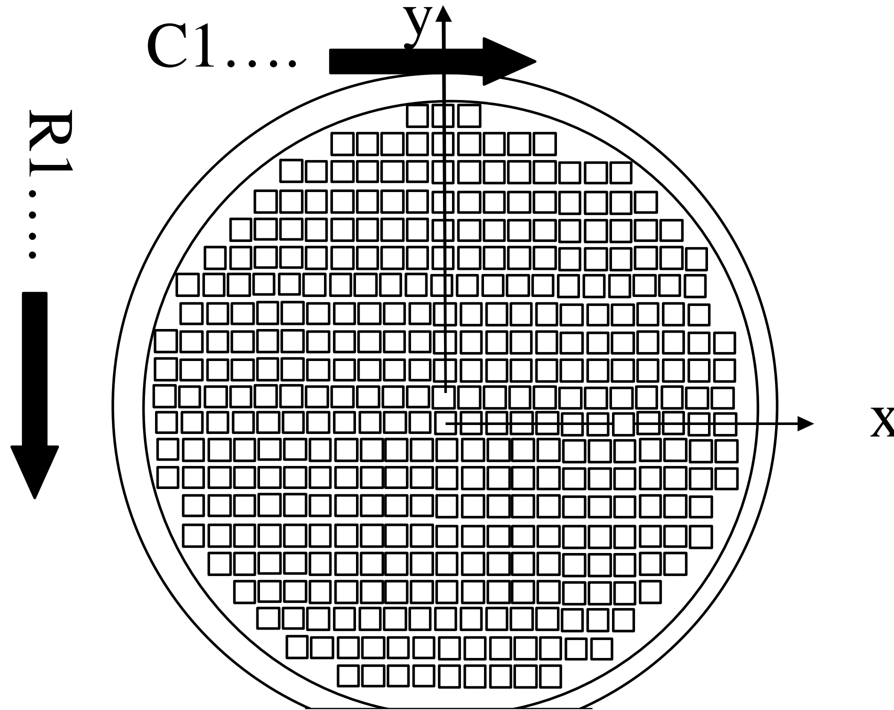
Meas. Sample Shot

Shows fine alignemt measurements for two attempts at alignment with 4 selected shot locations. 1st attempt failed, 2nd attempt all measurements were less than 0.5µm so wafer is exposed. (the 0.5 value is set by the user)

No.	(clm,row)	x	y	x1-xr	y1-yr	Status
1	(11,7)	-.51	-6.44	99.99	99.99	OK
2	(7,2)	-.71	-6.59	99.99	99.99	OK
3	(2,7)	-.45	-6.56	99.99	99.99	OK
4	(7,11)	-.32	-6.28	99.99	99.99	OK
1	(11,7)	.01	-.30	99.99	99.99	OK
2	(7,2)	.02	-.01	99.99	99.99	OK
3	(2,7)	.02	-.21	99.99	99.99	OK
4	(7,11)	.02	-.32	99.99	99.99	OK

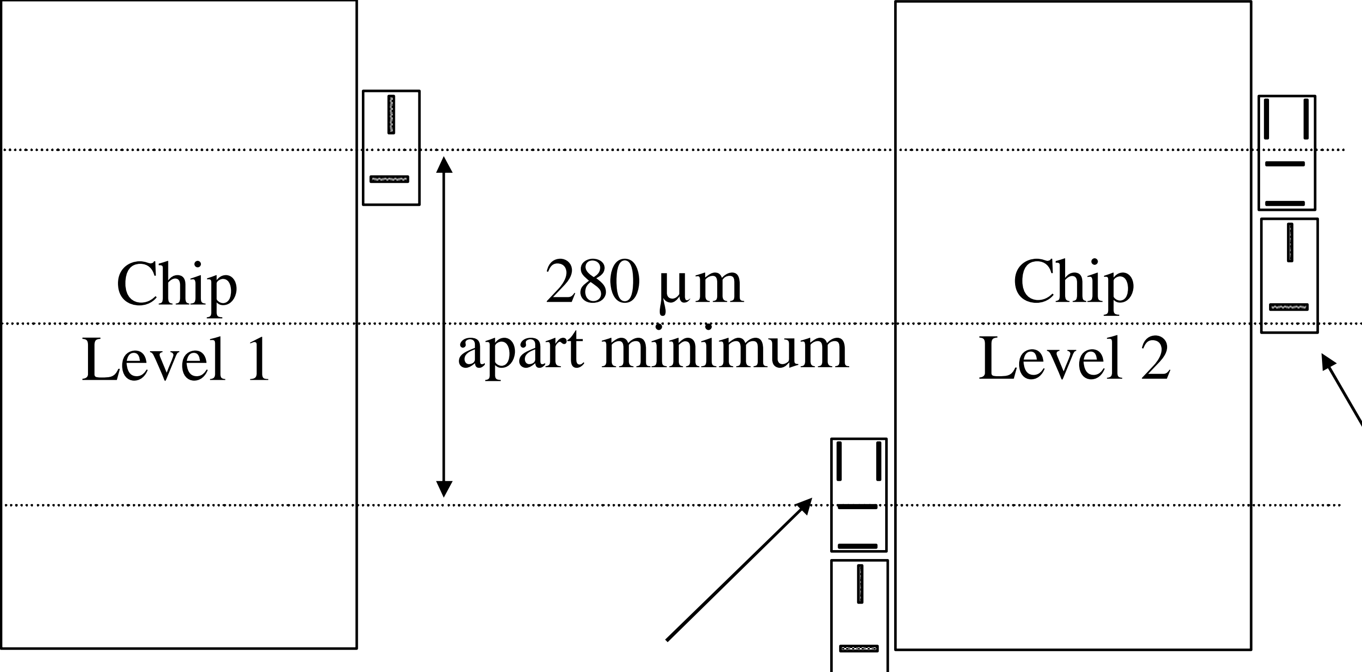


DIRECTIONS ON THE WAFER



Die should be correct reading with bottom of the chip design toward the wafer flat. Some microscopes invert the image so be careful determining directions of alignment errors. (For example: 2nd layer pattern needs to shift 1µm in –y direction and 0.5µm in +x direction to give correct alignment)

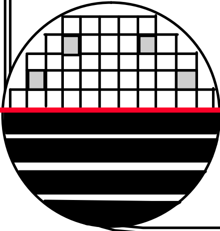
WAFER AUTO ALIGNMENT (AA) MARKS FOR i-LINE



Marks on wafer used to align subsequent levels

Marks on mask used to align to previous level marks on the wafer

Optional marks on mask used to create new wafer marks for subsequent layer alignment



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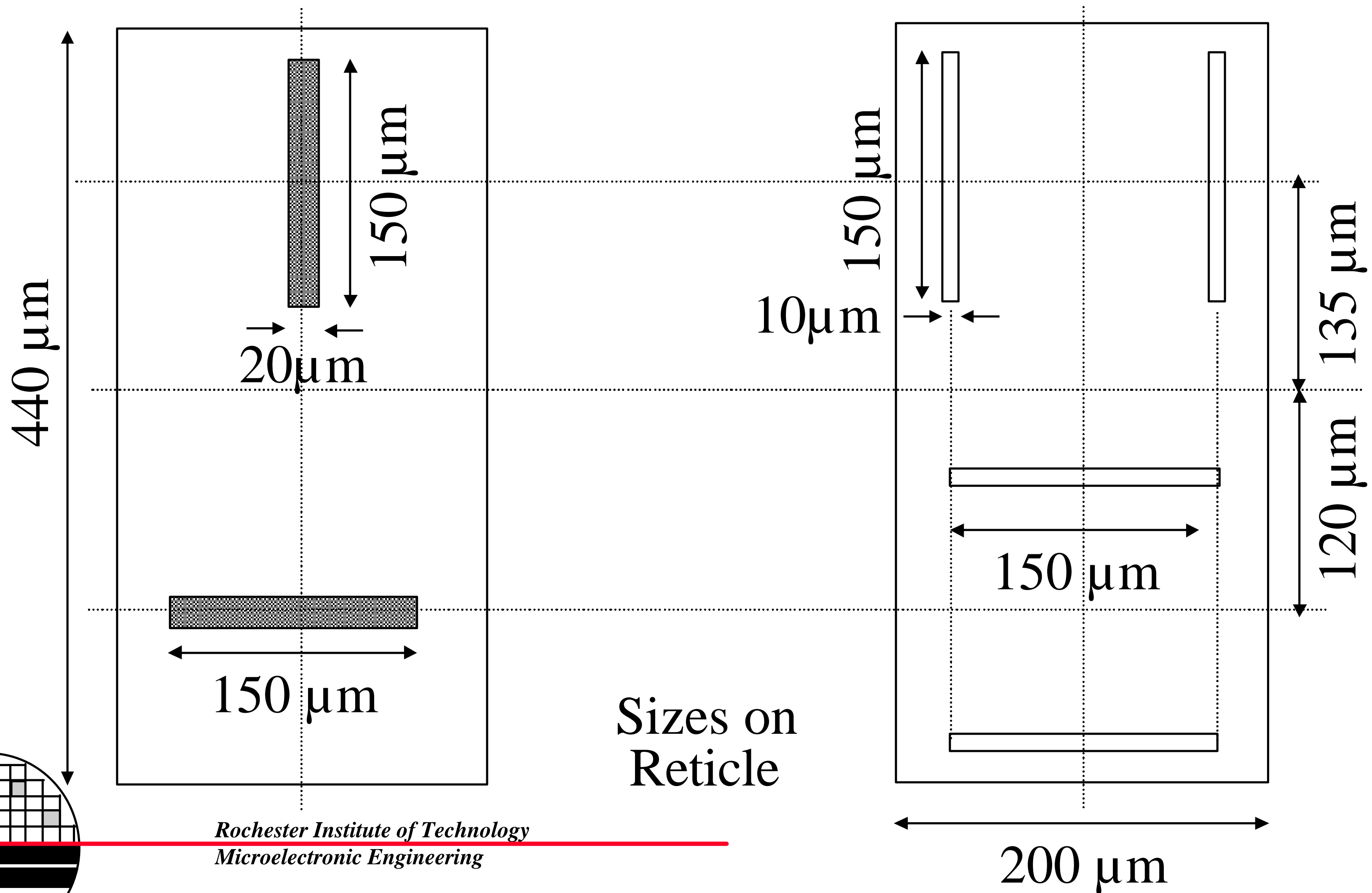
WAFER AUTO ALIGNMENT (AA) MARKS FOR i-LINE



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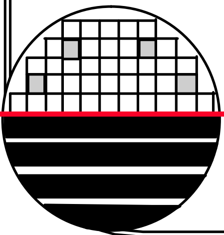
i-LINE TV AA USING A SCOPE

Marks on the wafer from a previous level are illuminated through the lens with a small rectangle of i-line light. The reflected light goes through complementary marks on the reticle and is collected by the A scope. The signal is analyzed as the stage is moved slightly. The best alignment position is found and the adjustment is measured. The correct position to center the die under the optical column is calculated and the stage is moved to that location. The die is exposed.

Use the i-line through the lens alignment method for die-by-die alignment.



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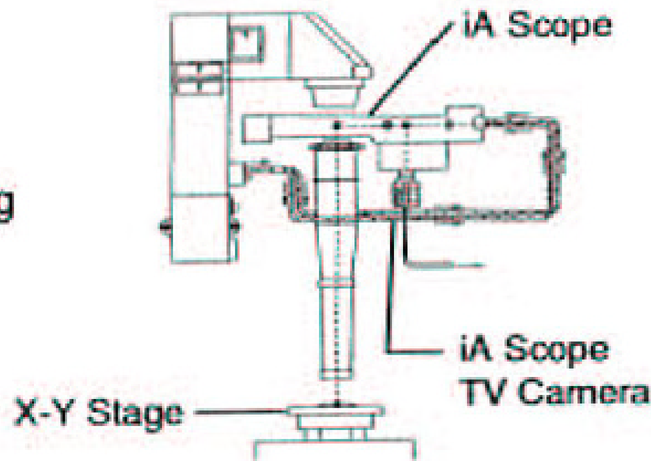
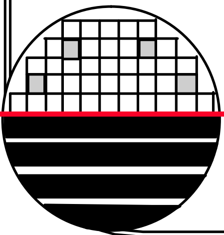
I-Line AA MARKS (XY MARKS)

i-Line TV AA
aligns the wafer to the reticle using the X-Y stage. The iA scope provides viewing and alignment detection.





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STEPPER JOBS AND RELATED FILES/TABLES

(all layers)

Reticle File (Table) - information about all reticles to be used for this product

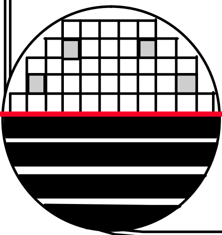
Layout File - information about exposure matrix, rows, columns, step size,

(for each layer)

Job? **File** - Links Layout, Reticle, Shot, Process Files for this layer ?

Shot File Layer ? - exposure dose, focus, blade positions, which locations in matrix are to be exposed or skipped

Process File Layer ? - 1st mask level yes/no, alignment method, compensation



NAMING HIERARCHY

Since these files are all linked together at the end it is convenient to use a naming hierarchy similar to this example for the files needed for the RIT submicron CMOS testchip product (16 characters max):

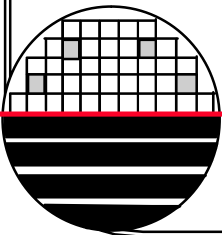
Jobname:	Shot file:	Process file:
F012subcmos_well	SF012subcmos1	Psubcmos1
F012subcmos_act	SF012subcmos2	PF012subcmos2
F012subcmos_stop	SF012subcmos3	PF012subcmos3
F012subcmos_vt	SF012subcmos4	PF012subcmos4
F012subcmos_poly	SF012subcmos5	PF012subcmos5
F012subcmos_lddn	SF012subcmos6	PF012subcmos6
F012subcmos_lddp	SF012subcmos7	PF012subcmos7
F012subcmos_n+ds	SF012subcmos8	PF012subcmos8
F012subcmos_p+ds	SF012subcmos9	PF012subcmos9
F012subcmos_cc	SF012subcmos10	PF012subcmos10
F012subcmos_m1	SF012subcmos11	PF012subcmos11

Layout file: LF012subcmos

Reticle Table: RF012subcmos

Reticle ID:

subcmos012nwell	subcmos012poly	subcmos012p+ds
subcmos012active	subcmos012lddn	subcmos012cc
subcmos012stop	subcmos012lddp	subcmos012m1
subcmos012vt	subcmos012n+ds	



Rochester Institute of Technology
Microelectronic Engineering

An 11 level chip requires up to 46 names for files and reticles

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SUGGESTED NAME CONVENTION FOR RIT JOBS

A991XXXXXXX_YYYY

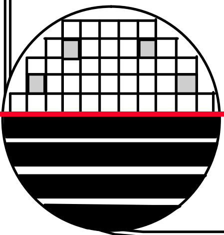
A is the letter **F,L,S** or **R** where **F** is for **F**actory jobs, **L** is **L**aboratory courses jobs, **S** is **S**hort course jobs, **R** is **R**esearch jobs

the number **012** is the quarter code

XXXXXXX is any code like EMCR632 or SUBCMOS or PMOS

YYYY is the name of the level like WELL, CC, M1, M2, OX, DIFF

Shot files start with letter **S**	**SA012XXXXXXX_YYYY**
Process files start with letter **P**	**PA012XXXXXXX_YYYY**
Reticle files start with letter **R**	**RA012XXXXXXX_YYYY**



NAMING HIERARCHY - METAL GATE PMOS SHORTCOURSE EXAMPLE

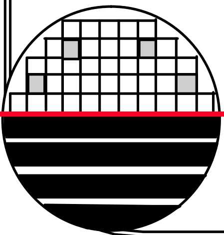
Jobname:		Shot file:		Process file:
	L981short_diff		SL981short_diff	PL981short_diff
	L981short_ox		SL981short_ox	PL981short_ox
	L981short_cc		SL981short_cc	PL981short_cc
	L981short_m1		SL981short_m1	PL981short_m1

Layout file: LL981short

Reticle Table: RL981short

Reticle ID
short981diff
short981ox
short981cc
short981m1

A 4 level chip requires up to 18 names for files and reticles



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FILE EDITOR

The various files are created using the edit (ed RT, ed L, ed P, or ed S) command and then linked together using the link (LNKS) command.

The editor is a "form" with 1 or more pages and entries are made to fill out the "form" (or defaults are used)

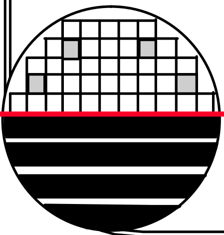
Example entries are indicated by red type in a gray box as shown below

RF012subcmos

Once the four files are created then they are linked using the link command LNKS

Auto

Use the softkeys to save and/or print files



CANON RETICLE TABLE FILE EDITOR

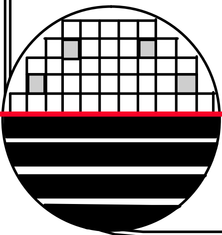
RETICLE TABLE EDITOR (File ID)### (page-1)

File name; RF012subcmos

1. Comment; anything you want

RETICLE TABLE EDITOR (File ID)### (page-2)

1. ID: subcmos012nwell
2. Reticle Alignment Mode (0:No Use,1:FRA1, 2:FRA2) **2** Select **0** slot **12**
3. Setting Offset for FRA; **X=21.6 um Y = -14.25 um Theta = 2415.4 ppm**
4. Bar Code (0:No, 1:Yes) 0 slice select (0-7): **0** type: **0**
5. Type of TTLAF mark (0:MF-mark, 1:TTLAF-mark) 1
6. Throughout Rate: Re= 50% Auto RT (0:off, 1:on) 1
7. ****Reserve****
8. Effective Pattern Area: Bl=-3mm, Br=3mm, Bu=3mm, Bd=-3mm
9. Sampling Pitch X= 0.01 mm Y = 0.01 mm



There is an additional page for each additional reticle

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CANON - LAYOUT FILE EDITOR

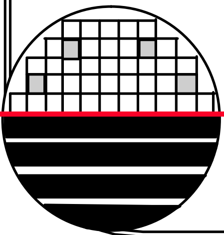
LAYOUT EDITOR (File ID)### (page-1)

File name; LF012subcmos

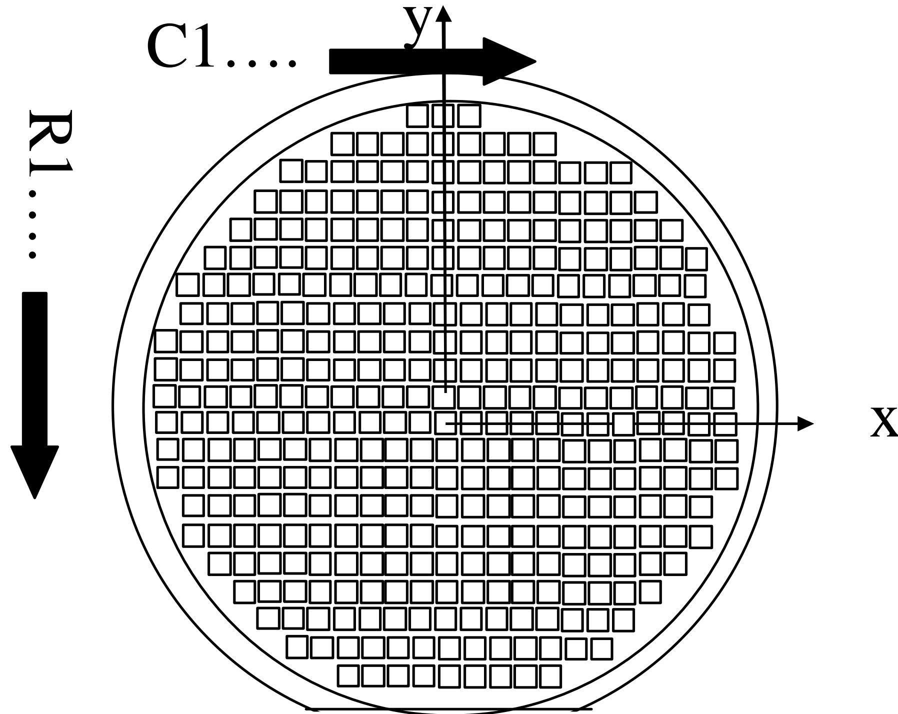
1. Comment; anything you want

LAYOUT EDITOR (File ID)### (page-2)

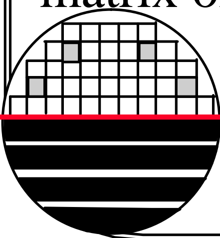
1. Matrix Invalid Area: 5 mm
2. Step Size; Sx = 6 mm Sy = 6 mm
3. Matrix; Clm = 23 Row = 23
4. Origin; X= 0 mm Y= 0 mm
5. Reticle Table Name ; RF012subcmos



CANON – LAYOUT



Assume 5 mm square die, pick 1mm street, pick 5 mm space around wafer edge, that is a Matrix invalid area of 5 mm. Find: step size =6 mm, for 150 mm wafers (6") find matrix of (150-10)/6 or 23 rows and 23 columns.



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CANON STEPPER - SHOT FILE EDITOR

SHOT EDITOR (File ID)### (page-1)

File name; SF012subcmos1

1. Comment; anything you want

SHOT EDITOR (Parameter Set)### (page-2)

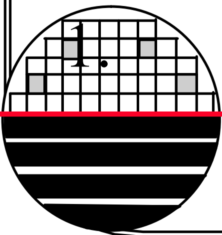
1. Exposure; 160 mj/cm2
2. Focus Offset; 0 µm
3. AA Mark; Auto **Auto**
4. Blade Position; Bl=-3mm, Br=3mm, Bu=3mm, Bd=-3mm
5. Dummy Shot; No
6. Skip shot; No

SHOT EDITOR (Shot Order)### (page-3)

1. Sequential; Auto

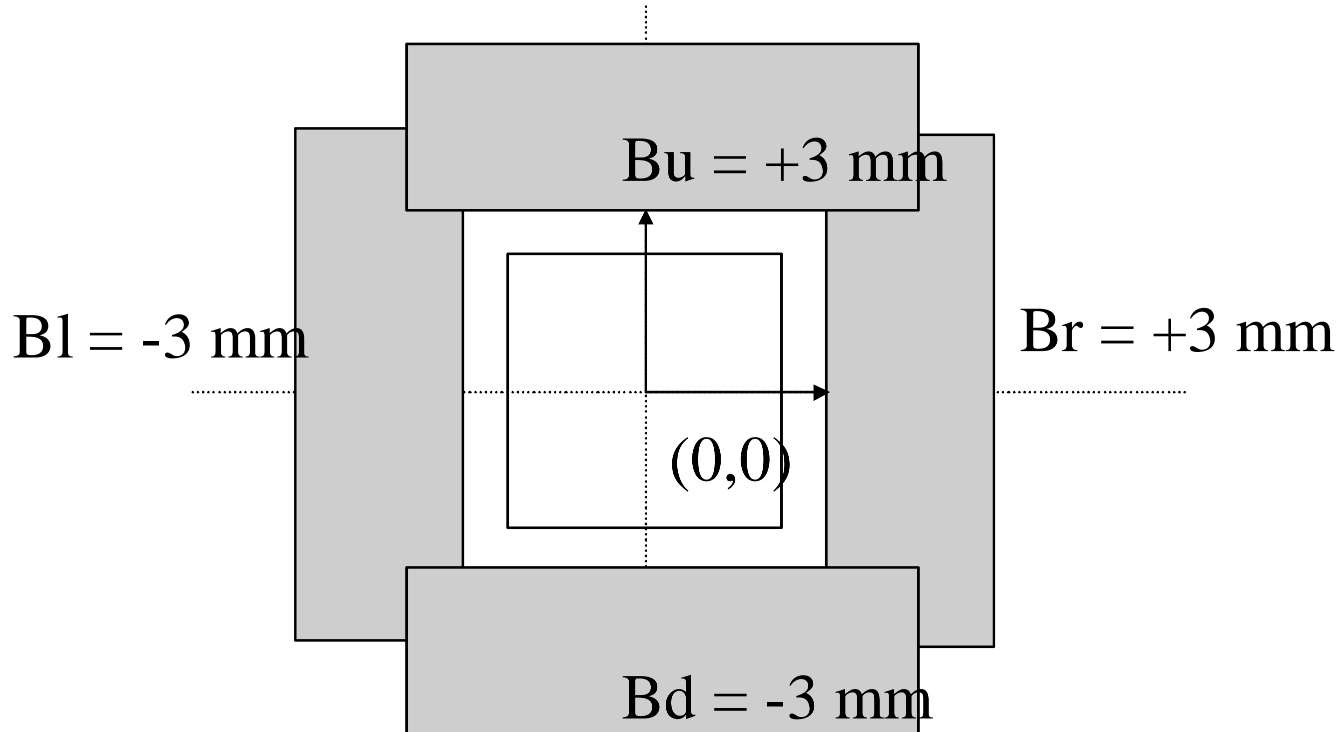
SHOT EDITOR (Parameter Display)### (page-4)

1.



BLADE POSITION CALCULATION

Note: Assume the Reticle is opaque outside the chip area. The blade opening should be a little larger than the chip size so divide by 2. For example a 5mm square chip should have blades open a little more than 2.5 mm in each direction. Pick 3 mm. Blade openings should be less than ½ step size, for 6 mm step size that is 3 mm.



CANON STEPPER - PROCESS FILE EDITOR

PROCESS EDITOR (File ID)### (page-1)

File name; LF012subcmos/PF012subcmos2

1. Comment; anything you want, like: second level active
2. Alignment Sequence: 1st Mask or AGA …. AGA
3. TTL Alignment Mode (none, I-line or HeNe/B^2) HeNe-TV
4. TV PA Measurement Mode; PA

PROCESS EDITOR (Reticle ID)### (page-2)

1. Reticle ID Active

PROCESS EDITOR (Fine Reticle Alignment)### (page-3)

1. Fine Align Tol xy = 0.03 µm Theta = 0.03 µm

The Process file has 36 pages, only highlighted pages can be accessed, if AGA in item 2 page 2 is selected then page 4 is highlighted and gives row and column and x,y location of the prealignment marks. If alignment mode HeNe is selected page 13 gives the x&y coordinates of the fine alignment marks, if I-line was selected then pg 10&11give fine alignment mark locations

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CANON STEPPER - PROCESS FILE EDITOR (cont.)

PROCESS EDITOR (TV Prealignment-1)### (page-4)

1. L) Shot ; clm = 3 row = 12
   PA Mark Position; Xlp = 2.2 mm Ylp= 1.65 mm
2. R) Shot ; clm = 20 row = 12
   PA Mark Position; Xlp= 2.2 mm Ylp= 1.65 mm

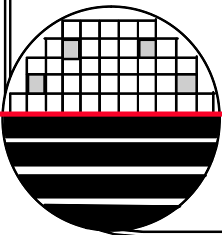
note: this is where the user inputs the **pre alignment (TVPA)** mark locations. X and Y locations are relative to the center of the die

PROCESS EDITOR (HeNe TV Alignment - 1)### (page-12)

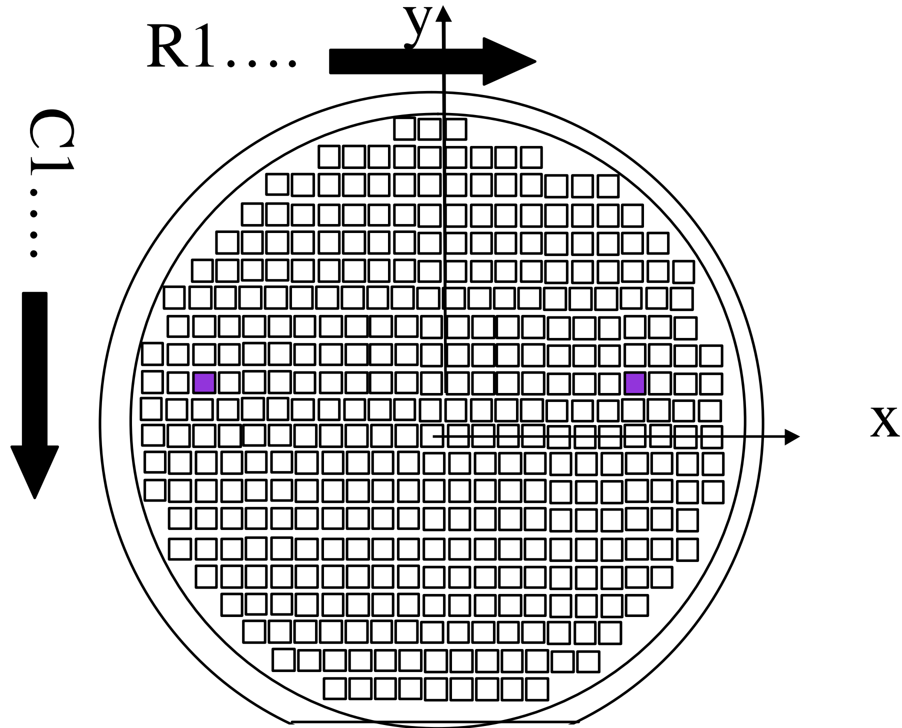
1. all offsets are zero on this page initially

PROCESS EDITOR (HeNe TV Alignment - 2)### (page-13)

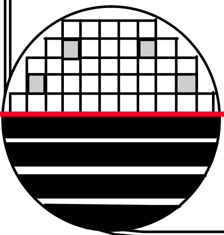
note: this is where the user inputs the **fine alignment** mark locations for HeNe or Broadband (B^2) alignment method. X and Y locations are relative to the center of the die. Page 4 and 13 make it possible to overlay two levels



CANON – LAYOUT



Location, row and column, and distance from center of die to center of TVPA mark.



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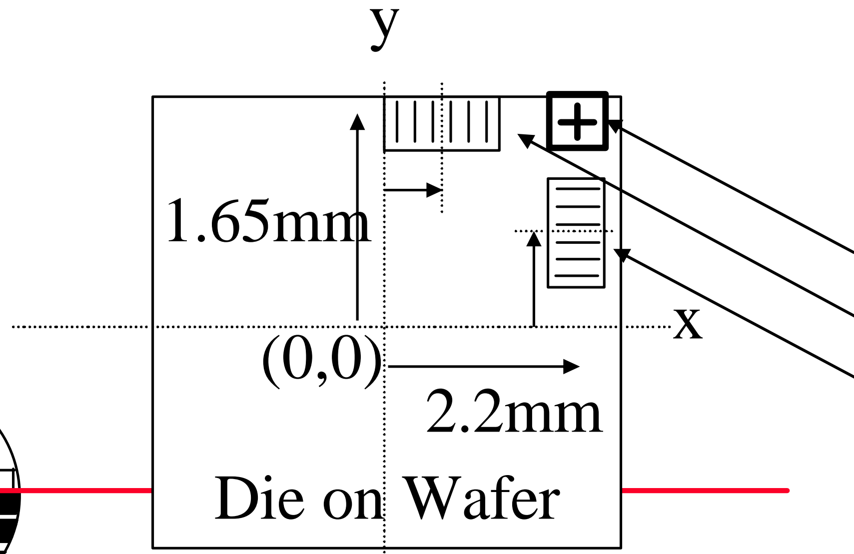
CANON STEPPER - PROCESS FILE EDITOR (cont.)

PROCESS EDITOR (HeNe TV Alignment - 2)### (page-13)

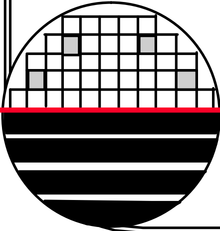
1. AA Mark Position; B X = 2.2 mm Y = 0.8 mm
   C X = 0.7 mm Y = 1.65 mm
   Brot X = 0.00 Y = 0.00
2. AA Mark Pattern: 20P-4F
   XY Mark: Multi
3. Mark Condition (Window or Island) Island
4. Wafer Surface Condition 0

20P means 20um pitch
4F means 4um feature

0 or 1 means default ~4um
2 means 4um marks are ~3.2um
3 means 4um marks are ~1.6um
4 means 4um marks are ~4.8um
5 means 4um marks are ~6.4um

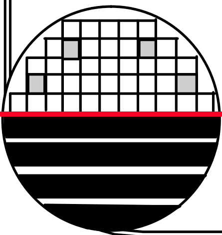


Pre Alignment Mark (2.2,1.65)
C mark is for x alignment
B mark is for y alignment



DEFINITIONS

Island/Window describes the slope of the edge of the multi-marks. If the marks are mesa shaped it is called an island. If the marks are below the surface (as in etched holes) they are windows. Note: marks can change during processing. For example marks made in the active layer might be islands and turn to windows after LOCOS. Marks made in the shallow trench isolation are neither because of the CMP process. Fortunately alignment looks for the edge of the marks and it does not seem to make much difference if marks are called island or window, either work. Mark edges look dark in bright field illumination.



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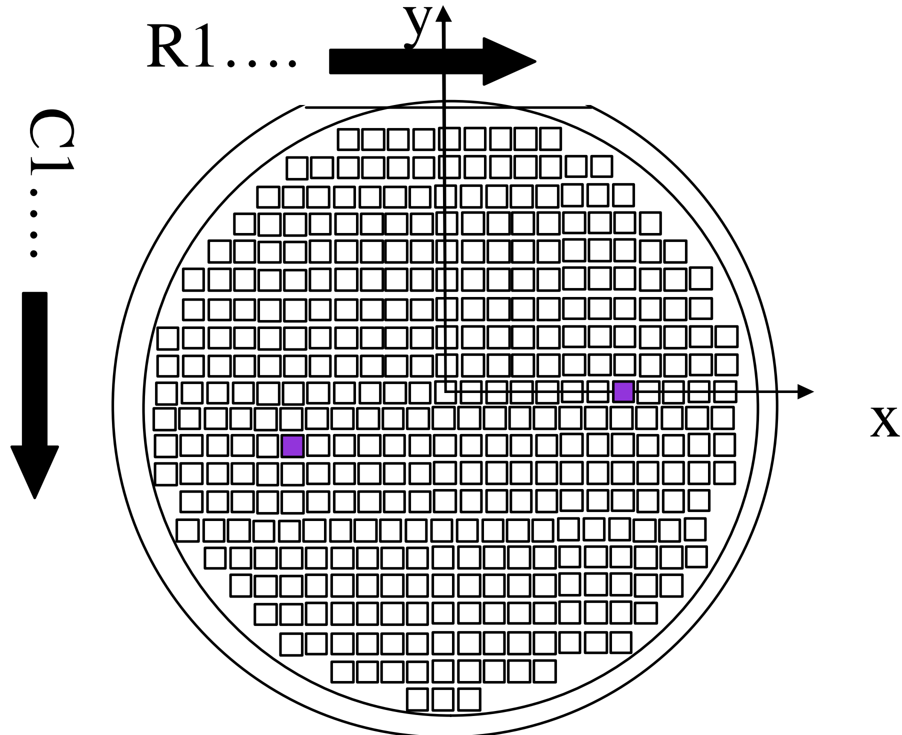
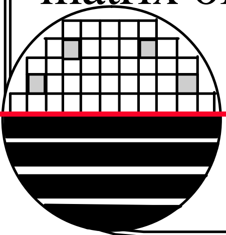
CANON – LAYOUT



Assume 5 mm square die, pick 1mm street, pick 5 mm space around wafer edge, that is a Matrix invalid area of 5 mm. Find: step size =6 mm, for 150 mm wafers (6") find matrix of (150-10)/6 or 23 rows and 23 columns.



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CANON STEPPER - PROCESS FILE EDITOR (cont.)

PROCESS EDITOR (TV Prealignment)### (page-15)

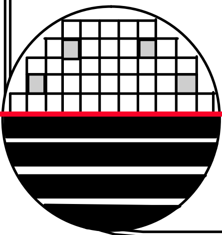
1. AA Illumination Mode [3]
   Mode 1: He-Ne normal
   Mode 2: He-Ne high contrast
   Mode 3: B-B (broadband)

PROCESS EDITOR (AGA Sample Shot) ### (page-17)

1. Number of Sample Shots Main m=(2,4,6,8,12,16) [16]
   preliminary p=2 to (m-2) [8]
2. AGA for 1st wafer (none, AGA, shot only) [AGA]
   AGA for 2nd and more wafers [AGA]

Selecting none for both will result in wafer exposure using PA only

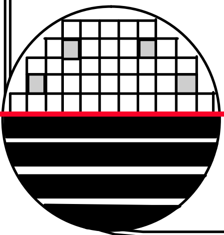
3. Prohibited Shots..row and column of die that do not have alignment marks because those die are blank or have a different chip design, etc.



CANON STEPPER - PROCESS FILE EDITOR (cont.)

PROCESS EDITOR (Tilt Mode)### (page-21-23)
1.Bypass
PROCESS EDITOR (TTL Auto Focus)### (page-24)
1.Bypass

Note: bypass means this information is not used



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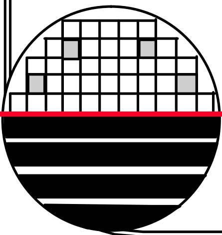
CANON STEPPER - JOB FILE EDITOR

START JOB : PARAMETER CHECK### (page-1)

Parameter		Value
1. Data Acquisition (0:Off; 1:on)		OFF
2. AA Mode (1: 1st, 1=no Use, 2 = No		4
3. Number of processing Wafer	;	1
4. Jobname	;	F012subcmos_act
5. Layout File	;	LF012subcmos2
6. Process File	;	PF012subcmos2
7. Shot File	;	SF012subcmos
8. Focus Offset	;	0 µm
9. Exposure	;	160 mj/cm2
10. Reticle Table	;	RF012subcmos
Reticle ID		subcmos012active
Select No.:		0
Reticle Slot #:		12
11. AA Offset	;	X=0.0, y=0.0, rot=0.0, mag=0.0



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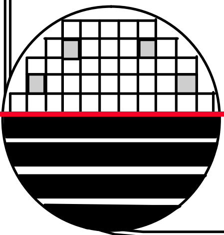
SOME CANON COMMANDS

Category	Command	Description
Operations	st	load up original job name from hard drive
	st ;c	load job from cpu, original or modified
	h	list of commands
	err	shows last 10 errors
	ld	load wafer
	rrld	unload wafer
	rl	reload (takes wafer off stage and puts in output cassette without exposure
	aux fec	turns a normal job into focus/exposure
	qrs	quick reset
	lf	list job files
	cont	restart the current job
job	ed p	edit the process file
	ed s	edit the shot file
	ed rt	edit the reticle file
	ed l	edit the layout file
	lnk s	link the various job files
	pu	purge (delete) selected files

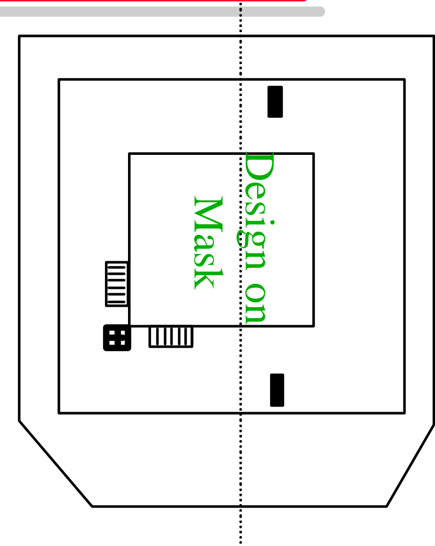
SOME CANON COMMANDS

Category	Command	Description
reticle	rrl	unload reticle from stepper to tray
	rret	return reticle elevator to down position
	ra	align reticle
	rch	prepare reticle library to accept reticle
	roc	align reticle-idle tool
	rok	skip reticle alignment (eg plain glass)
	rmv	prepare reticle library to remove reticle
Alignment	por	pre offset read (read offset of TV PA marks)
	rpa	retry TV pre alignment
	gaus	gives measured alignment errors
	tvws	displays the location of windows in which multimark edges must fall

Note: help “h”gives a list of all commands



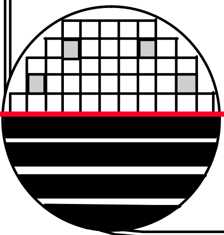
CANON MINI OPERATION MANUAL



1. Load the mask in the reticle tray
   a) Obtain a reticle tray from drawer under white table.
   b) Flip wire latch & remove cover from the tray
   c) Load the mask in the tray chrome side down, with the fiducial marks on top and bottom but closer to the right side of the tray.
   a) The mask has to be in the correct slot. Factory jobs use slot 12.
2. Run a job
   a) Start the stepper job. Type **ST stepper_jobname** <RET>

For example: the ADV CMOS Process, Test Chip Product, 2nd Level, stepper_jobname is: **F023ADVCMOS_NWEL**

The stepper_jobname might be on the mask storage box label



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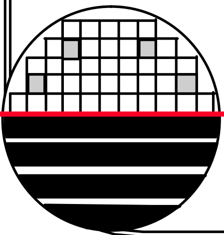
CANON MINI OPERATION MANUAL

b) Check that the mask is in the slot shown in the stepper job.
c) Verify other job details. If any changes are made press enter. If changes are permanent be sure to press F4 (Transmit) so the changes take effect.
d) Load the wafers and press the flashing light to select that cassette.
e) Press F1 (Go)
f) Wait for the mask to be loaded into the stepper and the wafer loaded onto the stage.

3) Reticle Alignment

a) May see an error "Reticle not aligned"… to manually align the reticle press R/A button on console (or type RPA <RET>). Turn on the Ikegami TV monitor. Align fine FRA2 or FRA1 marks using the joystick (right for x-y, left for Theta) The FRA2 aligned marks should look as shown on the next page.*
b) Press CONT button to the right of the right hand joystick.

*Type ROK (ret) to skip reticle alignment.



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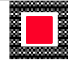
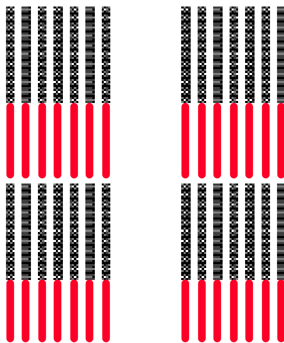
CANON MINI OPERATION MANUAL



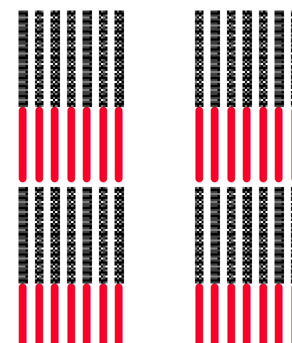
Reticle Coarse Alignment Marks

These Marks on the Stepper

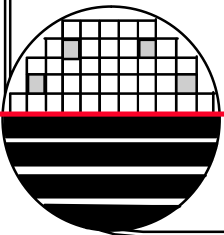
These Marks on the Reticle



Fine Reticle Alignment (FRA2) Marks

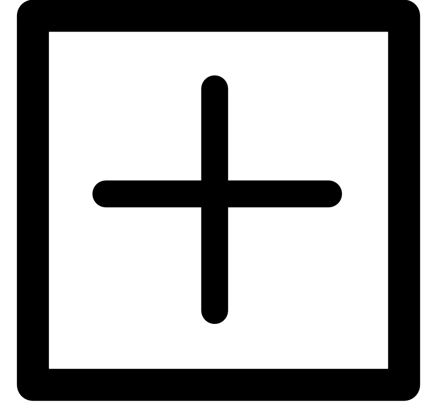


Right Side of Reticle

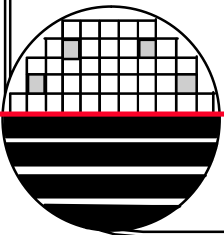


CANON MINI OPERATION MANUAL

4) If this is an alignment job and there is an auto alignment failure do the following.
   a) Press P/A on the console
   b) Press the L button next to the P/A button on console
   c) Using the right joystick, move the alignment TVPA mark to center of the cross hairs on TV monitor

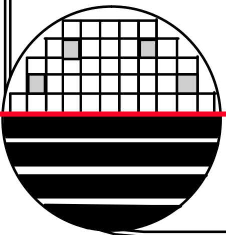


   d) Type **POR** to capture the alignment mark location, repeat as necessary
   e) Press the R button next to the P/A button on console
   f) Using the right Joystick, move the alignment TVPA mark to center of the cross hairs on TV monitor
   g) Type **POR** to capture the alignment mark location, repeat as necessary.
   h) Type **RPA**, retry pre alignment
   i) Press continue
5) Fine Alignment – should be automatic



CANON MINI OPERATION MANUAL

6. Finish Running a Job
   a) Type **RRL**<RET> and wait for the mask to be put back in the tray
   b) Then type **RRET** to return the elevator holding all the masks to the low position.
   c) Press the Cont button on the elevator
   d) Remove your mask.



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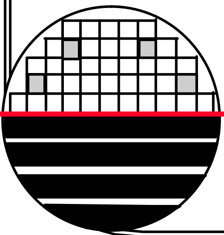
EXAMPLE PROCESS FILE: 1ST LEVEL NO ALIGNMENT

This process file shoots the first level with no alignment. If line 2 on page 1/ is 1st Mask than anything else in the process file is ignored.

Page –1 Alignment Mode

1. Comment ;
2. Alignment Sequence Mode; **1st Mask**



EXAMPLE PROCESS FILE: 2nd LEVEL PA and FINE

This process file does alignment to 2 TVPA marks and then looks at 4 locations for fine alignment. It uses Broad-Band illumination and 20P-4F multi-marks.

Page –1 Alignment Mode
2. Alignment Sequence Mode; **AGA**
3. TTL Alignment mode. ; **HeNe-TV**
4. TV PA Measurement Mode ; **PA**

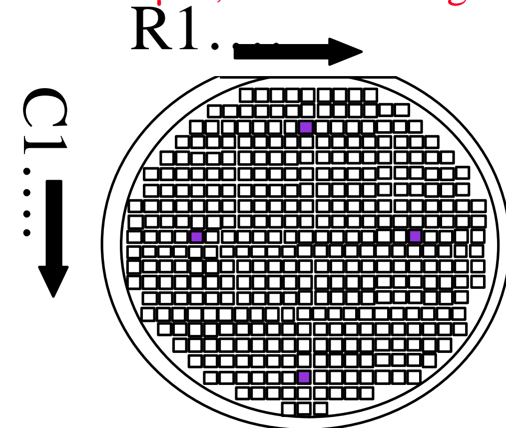
Page –4
1. L) Shot : clm= **3** row= **6**
   PA Mark Position; Xlp=**1.87** mm Ylp= **1.37** mm
2. R) Shot : clm= **17** row= **6**
   PA Mark Position; Xrp=**1.87** mm Yrp= **1.37** mm

Page –13
1. AA Mark Position ; B X=**1.87** mm Y = **1.159** mm
   C X=**1.66** mm Y = **1.37** mm
   Brot X=0 Y=0
2. AA Mark Pattern ; **20P-4F**
3. Mark Condition ; **Island**
4. Wafer Surface Condition ; **0**

Page –15
1. AA illumination Mode ; **Mode-3**

Page –17
1. Number of sample shots (2,4,6,8,12,16)
   Main; 4
   Preliminary ; 4
2. AGA for first wafer ; AGA
   AGA for 2nd and more wafer ; AGA

Page –19
1. Limit of x or y difference ; 0.5µm
   (default=0.2µm, can be as large as 9µm)



On page 17/ select sample shots.

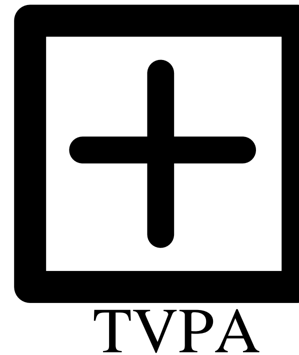
EXAMPLE PROCESS FILE: 2nd LEVEL TVPA ONLY

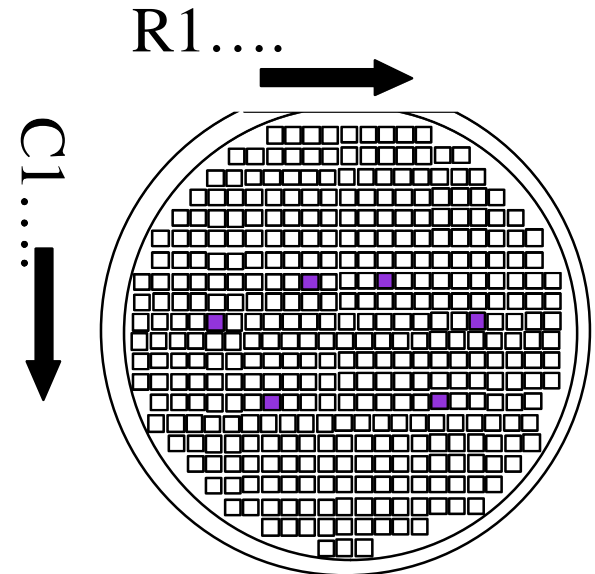
This process file does alignment to 6 TVPA marks and skips fine alignment

Page –1 Alignment Mode
2. Alignment Sequence Mode; **AGA**
3. TTL Alignment mode. ; **HeNe-TV**
4. TV PA Measurement Mode ; **APA**

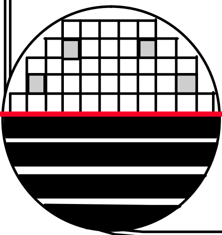
Page –4
1. Number of Sample Shots: **6**
2. APA Mark Position: **X= 1.8**
   Y=1.732

Page –17
2. AGA for 1st wafer; **None**
   AGA for 2nd and more wafer; **None**





On page 4/ select location of 6 shots, all in bottom half of wafer (TVPA scope can not see top half of wafer) It is a good idea to correct the shots to move them to row/column locations a little in from the edge of the wafer.



TROUBLE SHOOTING ALIGNMENT

1. Make sure the first level lithography is good. Inspect the wafers after photo and look for undeveloped resist (scum) especially near the TVPA marks and around/between multi-marks. Also look for missing multi-mark islands (poor adhesion can cause lifting of resist islands)
2. Select shots away from the edge of the wafer. Edge die often look different than center die due to non-uniform film deposition and non-uniform plasma etch. Some die should be at least 90mm apart.
3. Measure the multi-mark lines. The should be 4µm but if they are over etched or under etched they might be 5 µm or 3 µm. Islands and windows will measure differently. An adjustment on page 13/ of the process file (ED P) for wafer surface condition can be used to place the multi-mark edge measurement windows in the proper location over the edge. Use the TVWS command to see the window size and location. (see pictures on the next page)

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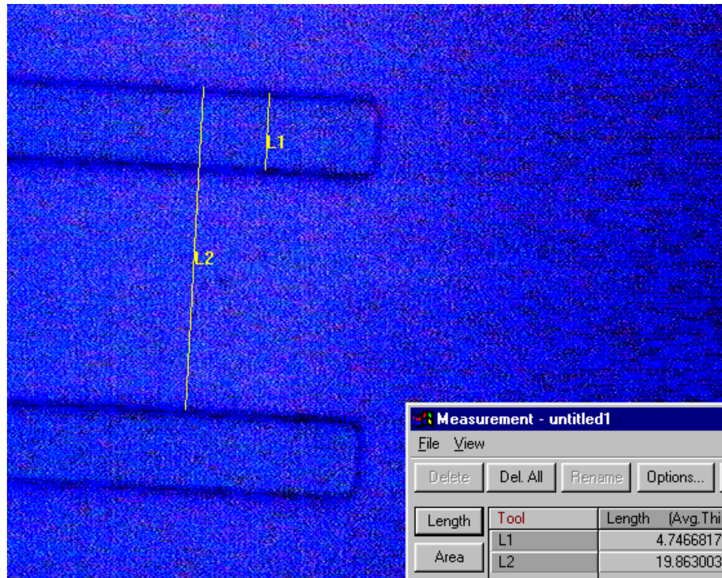
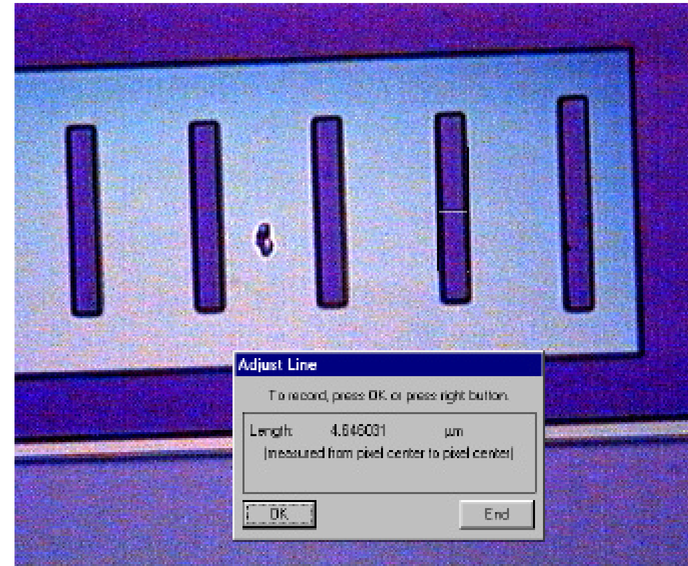
TROUBLE SHOOTING ALIGNMENT



Multi-mark Islands
Measured at ~5 µm



Multi-mark Windows
Measured at 4.6 µm

Wafer Surface Condition on page 13/ of Process File
0 or 1 means default ~4.0um marks
2 means 4um marks are ~3.2um
3 means 4um marks are ~1.6um
4 means 4um marks are ~4.8um
5 means 4um marks are ~6.4um

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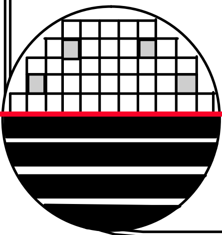
TROUBLE SHOOTING ALIGNMENT

4. Try setting the multi-mark measurement error limit higher, page 17/. Default is 0.2µm but can be set larger. Use the GAUS command to see the measurement error values. In the example below 0.5um would allow the wafer to be exposed.

GAUS (AGA – Check Outlier)
Wafer NO.;1
Meas. Sample Shot

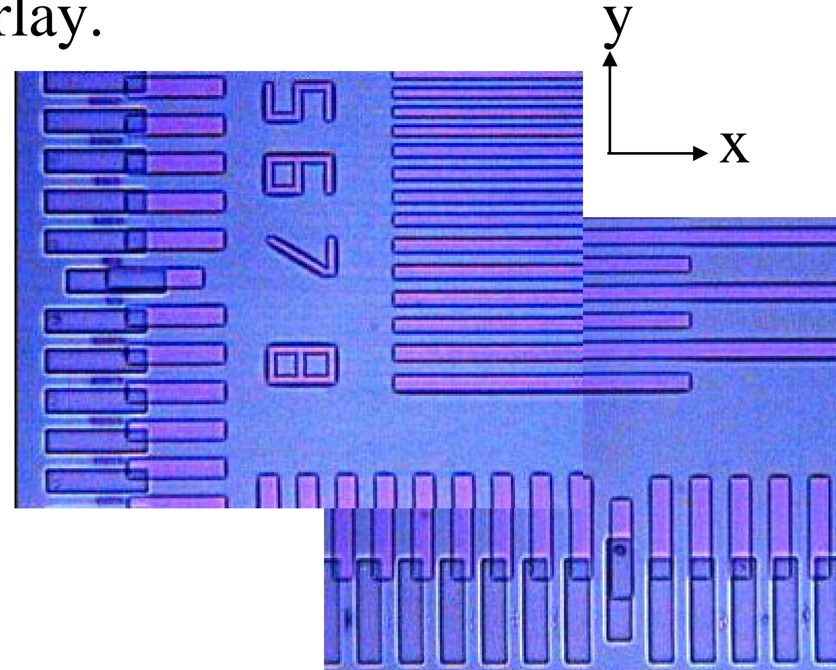
No.	(clm,row)	x	y	x1-xr	y1-yr	Status
1	(11,7)	.01	-.30	99.99	99.99	OK
2	(7,2)	.02	-.01	99.99	99.99	OK
3	(2,7)	.02	-.21	99.99	99.99	OK
4	(7,11)	.02	-.32	99.99	99.99	OK



TROUBLE SHOOTING ALIGNMENT

5. When using the TVPA marks only for alignment. If there is a overlay error and it is the same everywhere on the wafer it can be corrected by adjusting the X and Y mark location on page 4/ of the process file. First look at the overlay target and determine the necessary shift to achieve perfect overlay.

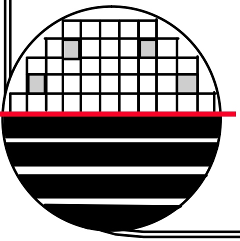
Note: in this picture the lines and spaces and the inner set of marks for x and y overlay are the result of the most recent photolithography. The outer set of overlay marks are from a previous layer. The 2nd layer pattern needs to shift 2µm in the –y direction and 1µm in -x direction to give correct alignment with the previous layer)



So on page 4/ change offset

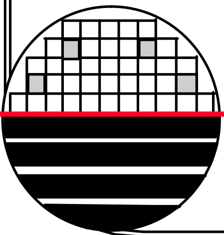
Xnew=Xold + 1µm

Ynew=Yold + 2µm



TROUBLE SHOOTING ALIGNMENT

6. If you want to make a large shift in a pattern and still use the multi-marks for fine alignment you can add or subtract a distance to the TVPA mark location on page 4/, but you must also add or subtract the same amount to the multi-mark locations on page 13/



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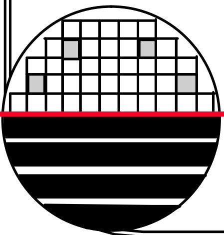
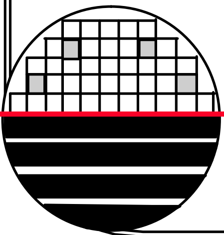
2. "Maskmaking for Canon FPA 2000i", Suraj Bhaskaran, November 30, 1998, RIT internal presentation.
3. Joe Suma, MicroE Alumni, Lithography Engineer at Eastman Kodak Co. 585-722-0559
4. Chuck Smith, MicroE Alumni 1987, Applications Engineer, Canon USA, Inc. 804-328-6620x203, csmith@cusa.canon.com
5. Bill Cooman, Canon Equipment Engineer, Maintains the RIT Canon FPA 2000-i1



HOMEWORK – CANON ALIGNMENT

1. What is the difference between fiducial marks and alignment marks?
2. What is the definition of alignment key offset? How is the alignment key offset, left alignment die and right alignment die (row and column) used in a stepper job?
3. How accurate can a stepper overlay images? What determines this accuracy?
4. What are the 20P-4F marks used by the Canon stepper?
5. Explain how the Canon stepper overlays images accurately.
6. Why are four levels placed on a single mask at RIT? What are the advantages and disadvantages of this approach? Can this be done on the Canon stepper?



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