

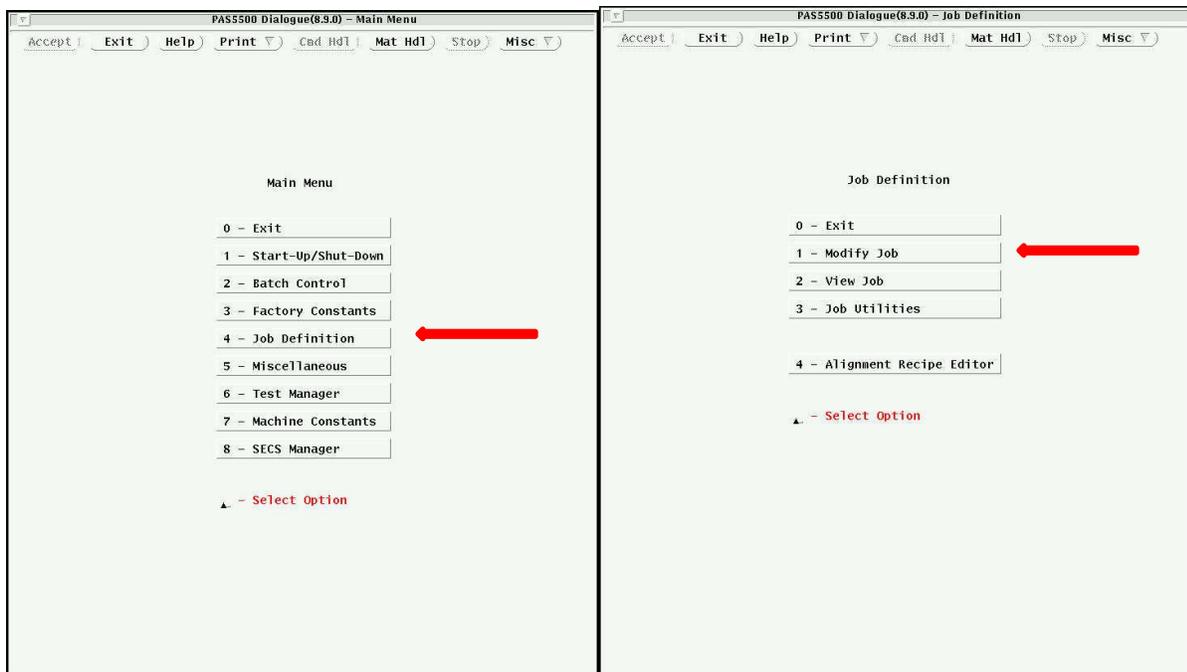
ASML System Programming:

Background:

The ASML job files are complex and have a significant number of features not available on the GCA steppers. The procedure for setting up jobs is therefore more complex. The following guide will help you to set up programs for full 4" wafers and for piece parts (anything smaller than a 4" wafer) mounted to 4" wafer carriers. A separate procedure is written for executing jobs for wafers and/or piece parts on wafers.

Jobs contain all cell layout, process, and mask image information to run your full process. All user created jobs will be saved in your user group directory. Layer 0 is set aside for system alignment mark exposure onto your wafer. These marks, called PM marks, are used for pre-alignment of the wafer and possibly for main alignment depending on how the rest of the layers are set up. In general, you do not need to have alignment marks of any kind in your actual die patterns as the system contains a mask with pre-defined marks that can be placed on your sample for alignment. 2 marks are all that is needed for layer to layer alignment. **Whenever test or numbers are entered into a job screen, you must hit enter for the change to be made and usually you also need to press an apply button to save the change.** Also, you can press the Help button to get information on a particular entry within any menu.

Job Definition:



Main System Menu

Job Definition Menu

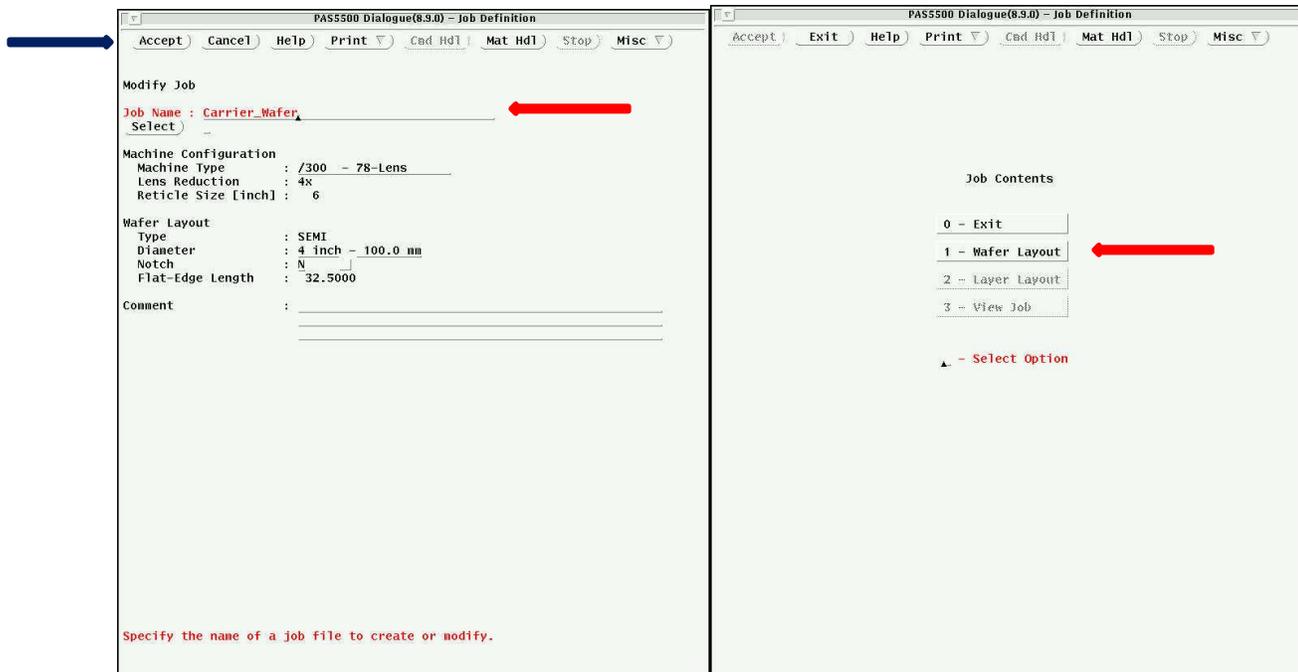
For the job set-up, press the **Job Definition** button in the main menu list. You can copy jobs using the job utilities command. For new jobs or to modify existing jobs, use the following :

From the Job definition menu, press the **Modify Job** button.

In the modify job screen, put in the **Job Name** and press enter. (If you are modifying a job, press the select button and find your job in the file system.) Machine configuration and Wafer Layout information will automatically appear. You can add a job comment at the bottom.

Store recipes in your group user folder: /users/groupname/jobname

Press **Accept** button at top when done. This takes you to the Job Contents Screen.



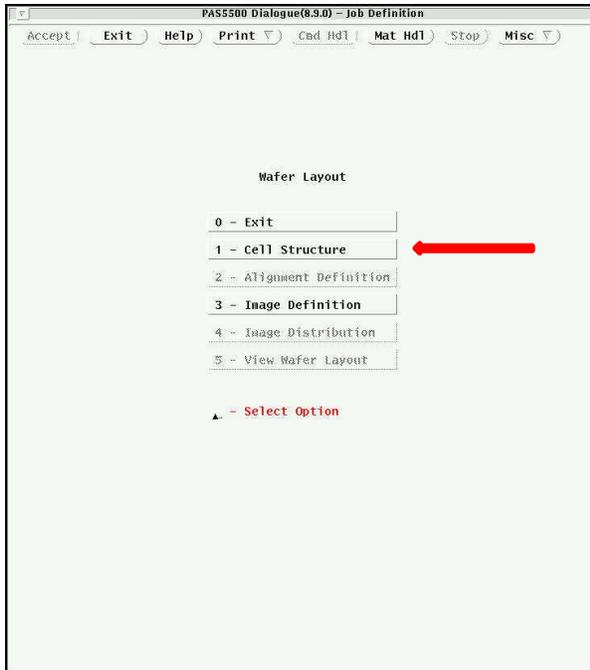
Modify Job Screen

Job Contents Screen

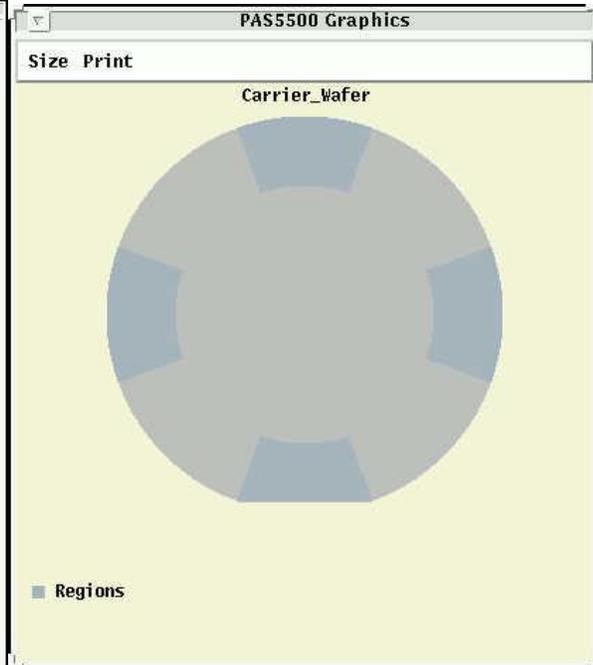
Now, you will set up the job. There are 2 sections. Wafer Layout and Layer Layout. In Wafer layout, you will define where the patterns are on your mask (images), define where the patterns will be placed on the wafer (image distribution), and define the alignment mark use (placement and strategy). In Layer Layout, you will define the process layers, which images will be shot in each layer, what exposure conditions will be used for each image in each layer, and what alignment strategy to use for each layer.

Wafer Layout:

Press the **Wafer Layout** button. You will see the wafer layout screen and a carrier graphics window appear.



Wafer Layout Screen

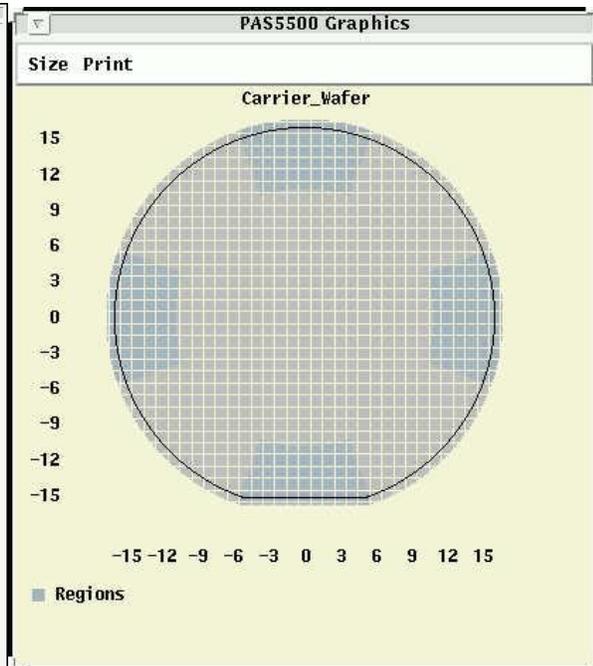


Carrier Graphics Window

Choose **Cell Structure** from the wafer layout menu to get to the cell structure screen. A cell is defined the same as the step size for the wafer stepper.



Cell Structure Screen



Carrier Graphics Window showing Cell Matrix

Dimensions: Enter the cell (step) size for x and y, in mm. (3mm x 3mm is selected for this example) Keep edge clearance at default values. Edge exclusion can be increased for 3 inch or 2 inch wafers to allow for auto-filling of exposures to the wafer edges.

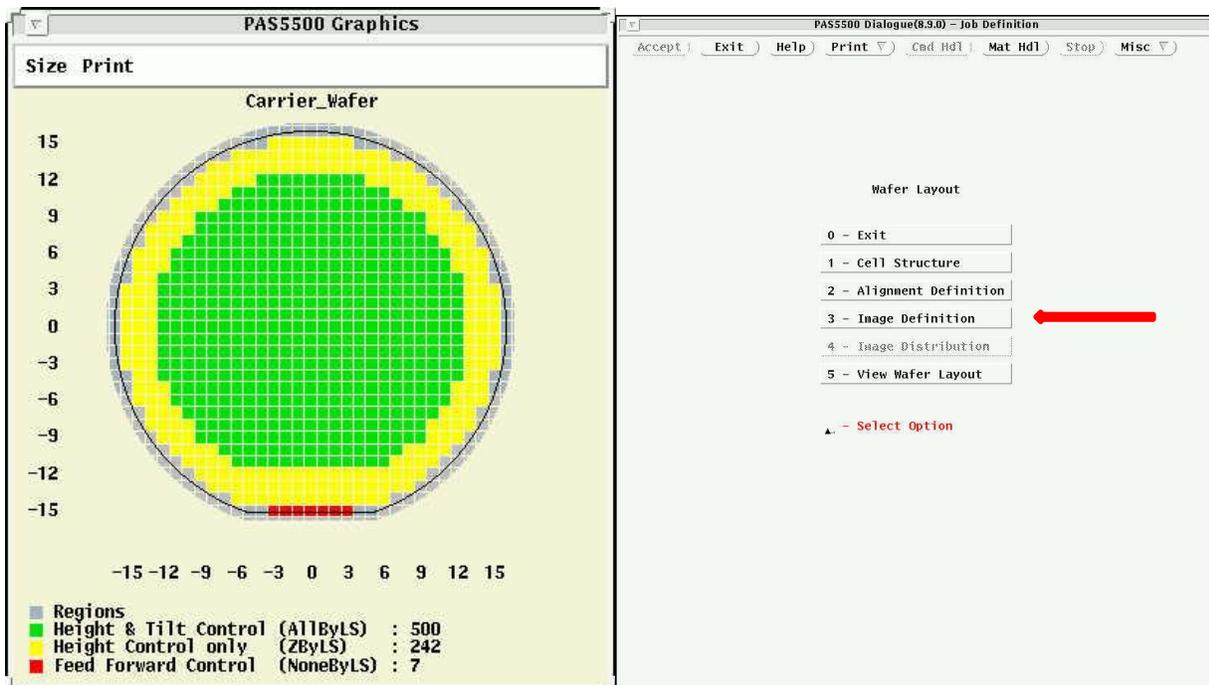
Die Definition: If you want partial shots to be exposed, you can specify more than one die per cell. The system will know to shoot cells where dice (but only partial cells) are present near the edges of the wafer. For smaller and odd-shaped piece parts, leave number of dies at 1.

Cell Matrix: Use this to shift the die matrix to do optimum filling. If O is selected, the operator enters a matrix shift value in mm. There is an auto function option that tells the computer to do this for you (only for round wafers). This option will rarely be used, except of larger wafers.

Press **Preview Results** button to update carrier graphics window with the cell matrix

Select **Focus Modes Stepper** button to see the focus height/tilt control modes for all dice. Note, for small piece parts, height and tilt control will not be possible, but only height control. (no cell leveling).

Press **Accept** at top when done to return to wafer layout screen.



Focus Control Modes on wafer

Wafer Layout Screen (2)

Before defining alignment marks positions, we will define where we want images to be shot on the wafer. Choose **Image Definition** from the menu to get to the image definition screen. In this screen, you will enter information about where and how large the different exposure patterns (images) are on the mask. You can define values at wafer scale or mask scale.

NOTE: An image is not a Layer. It just defines where a given pattern is on the mask. A Layer can have several images printed at the same time and this is defined later in the Layer section.

First, **name the image ID**. Numbers are fine, Names are fine.

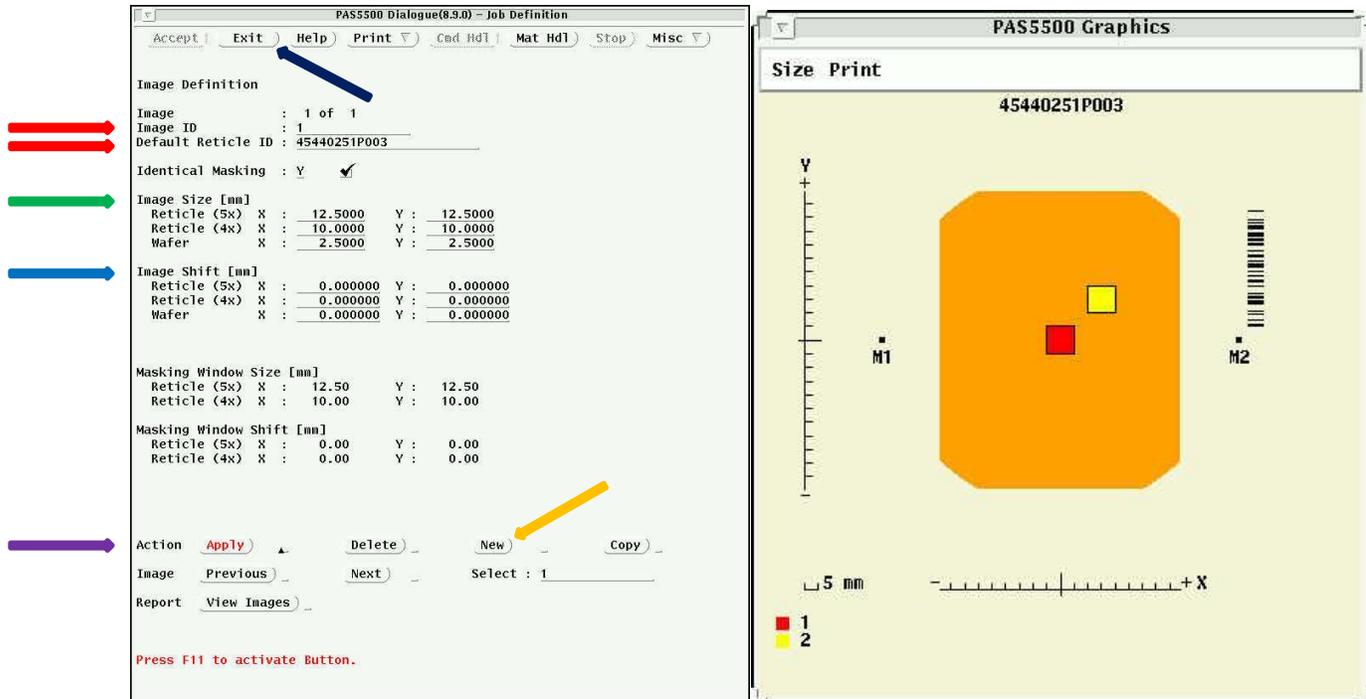


Image Definition Screen

Reticle (Image) Layout

Next, **Input a default reticle ID**. Press enter after typing. This is on the barcode on your mask. The mask maker, Toppan or Photronics, can put this barcode on the mask. You specify the string to them.

Next, **specify an image size** (wafer scale or reticle scale). This will set the blade window size for blanking off parts of the mask not desired in the exposure. This should be slightly larger than your cell size (wafer scale) if you are using dark field masks, or smaller than the cell size if you have light field masks (smaller because of the imprecision of the blade to cut off light).

Next, **specify an image shift** (wafer scale or reticle scale) if the area on the mask is off-center. This is how to have multiple layers on the same mask for different process steps.

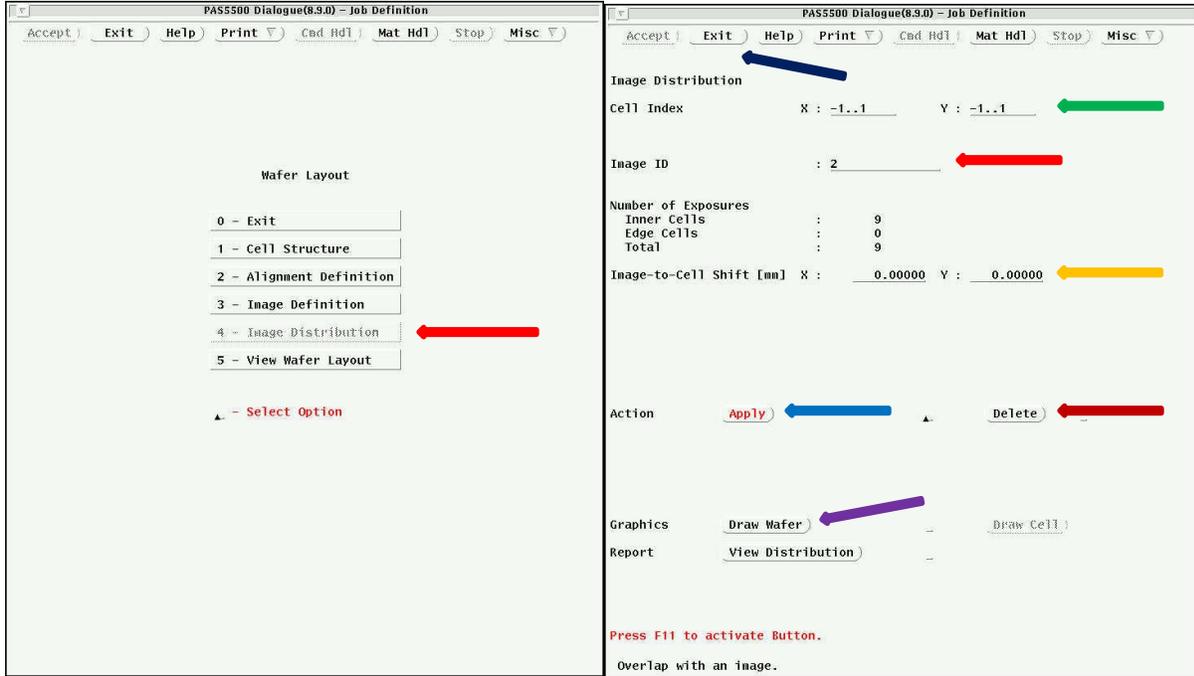
Press **Apply** when done, a window showing the reticle layout with color coded Image IDs will appear.

To **add another image**, press **New**, define all parameters for this image, **Apply** again.

The reticle layout window shown above is defined for 2, 2.5mm square images (wafer scale) separated by 5mm in x and y (wafer scale)

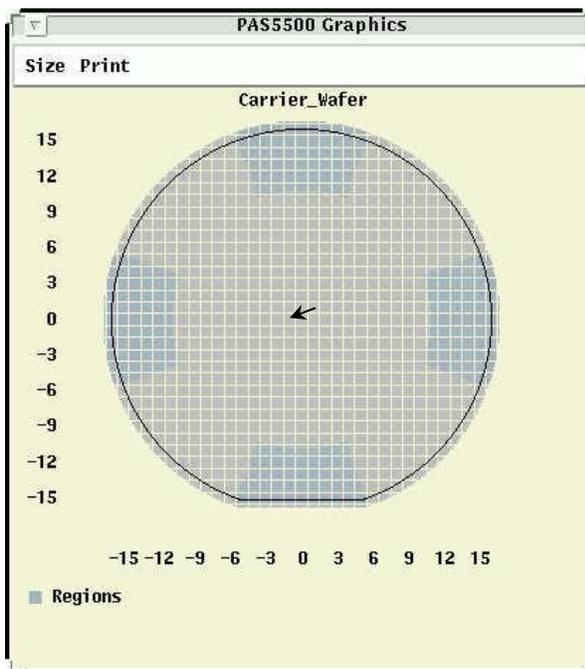
Select **Exit** on top button row when done. This takes you back to the Wafer Layout Menu.

Select **Image Distribution**. In this section you will choose which cells to expose for each image defined in the image definition section. In this way multiple images can be shot in different locations on the wafer in any given layer. Usually, you will have one image per layer, with each layer distributed over the whole wafer. See Image Distribution Page below.

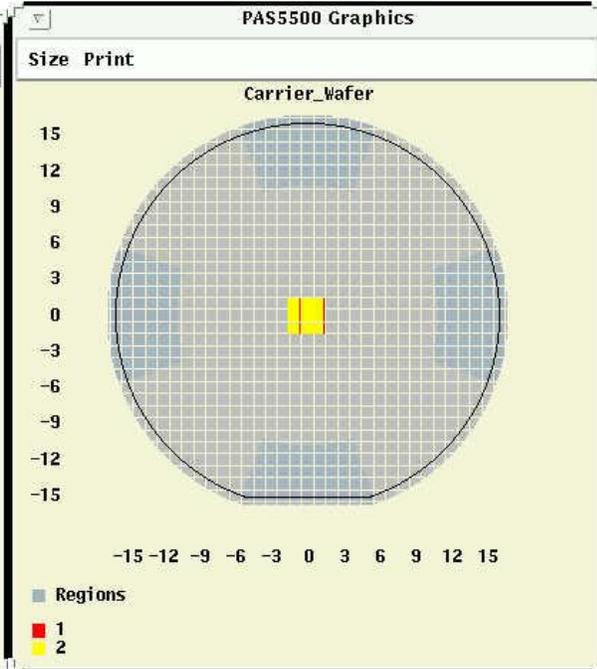


Wafer Layout Screen (2)

Image Distribution



Carrier Graphics - Cursor pointing at 0,0.



Carrier Graphics - Cells to be exposed.

Image ID: Select the image ID you wish to distribute on the wafer.

Press the **Draw Wafer** button to display the carrier graphics screen.

You can select cells to expose in two ways:

1. **Cell Index:** Enter the cell number, where $x=0,y=0$ is the center cell, press **apply**. Enter a range of cells (with format $-3..3$), press **apply**.
2. Use mouse to select cells on carrier graphics screen. Pressing same cell again removes the selection. Press **apply** button.

As you apply the cells, they show up on the carrier with the color assigned to the particular image selected.

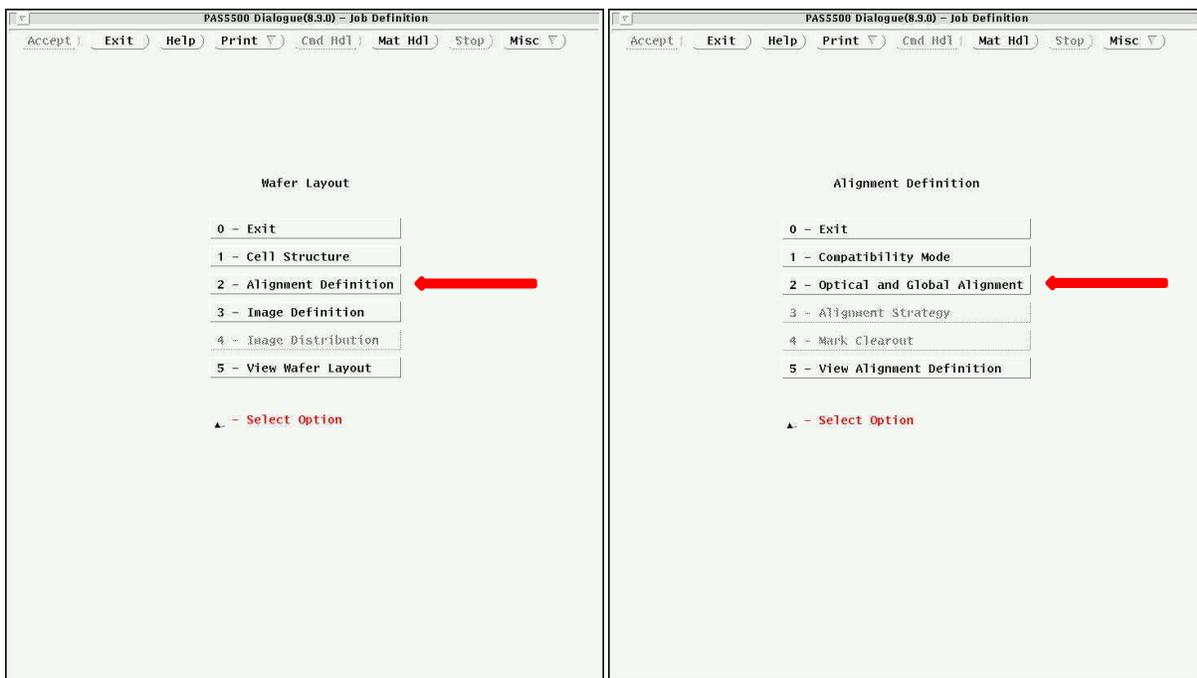
For each exposed cell, you can also specify an **image shift** relative to the cell outline. If you put in a number, remember to hit apply to make it active. This will usually be zero.

You can also delete an image cell by selecting the cell as shown above and pressing the **delete** button.

The picture above (cells to be exposed) shows a 3 x 3 matrix of cells with two images (1 and 2) set to be exposed in each cell.

Select **Exit** on top button row when done. This takes you back to the Wafer Layout Menu.

Select **Alignment Definition** from the menu. This takes you to the Alignment Definition Menu.

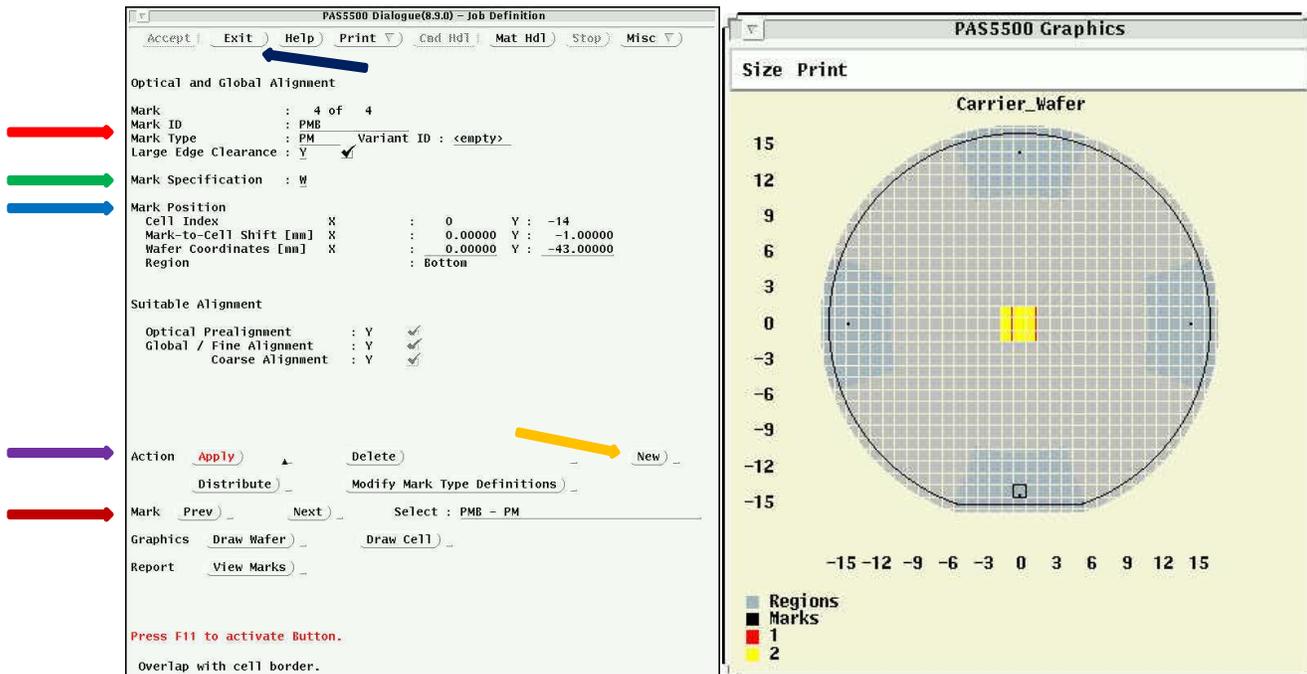


Wafer Layout Screen

Alignment Definition Screen

From the Alignment Definition menu, select **Optical and Global Alignment**. In this section, you will define where alignment marks will be placed on the carrier and/or your wafer. Wafers requiring alignment will always have at least 2 PM marks placed symmetrically on the x-axis within the gray areas on the wafer graphics screen. The PM marks are on a reticle always installed in the system and the machine knows where they are. You do not need to put alignment marks on your mask layers. These are exposed and etched into the wafer during a level 0 exposure step (or put on at the same time as layer one is executed). These marks will be used for alignment of subsequent layers.

Note: Mounting pieces on carrier wafers: Another set of PM alignment marks will be exposed on to your piece during the first layer exposure. This second set of marks is used to align subsequent layers to your first layer. Alignment accuracy is better than 50nm, in general, for this system. For alignment to work with pieces you must have pieces larger than 12mm per side (1/4 of 2" wafers are OK) and must be able to place you piece on the carrier to within +/- 40um of the original placement for the first layer exposure if you will be doing layer to layer alignment. Techniques for this will be discussed in the piece mounting document.



Optical Global Align Screen

Wafer Graphics

Defining the Carrier wafer marks (or marks for full 4" wafers). The 2 marks must appear in the darker gray areas as shown on the wafer graphics screen. It is good to have 2 additional marks in case one mark is damaged during process and you need another one as a replacement.

Mark ID and Type: Enter PML for the left mark and select PM for mark type. Use Large Edge Clearance.

Mark Specification: Choose W to select the mark position in mm from center on the wafer. Choose C to specify the cell index position and offset of the mark relative to cell center. You can place the marks right at the cell edge where the dice streets are.

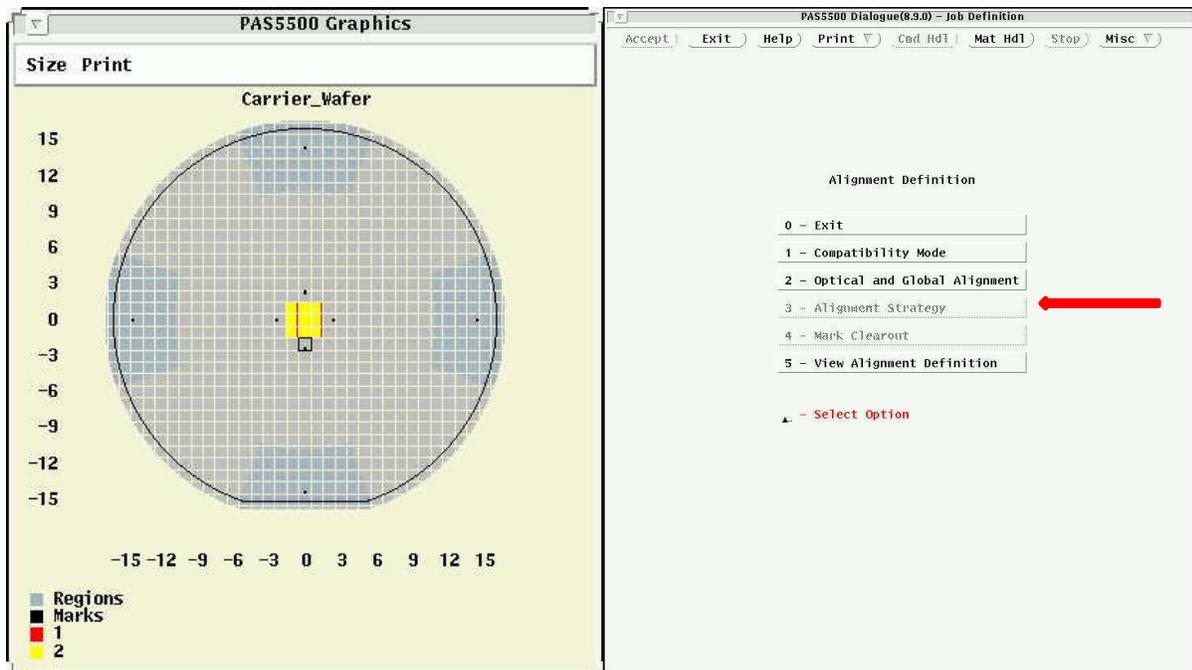
Mark Position: If “W” chosen above, put in the wafer coordinates, relative to center, where you want the left mark. For carrier wafers, the mark will always be at 43mm from center (i.e. x=-43, y=0 for the left mark)

Select **Apply** button to make the mark appear on the graphics screen.

Press the **New** button to make the next mark. Following the same sequence as above, define PMR, PMT, PMB marks for the Right, Top, and Bottom alignment marks. If you want additional marks, you can name them however you want and place them anywhere. Two marks is sufficient for very accurate alignment. More is not necessarily better and leads to more programming. If you made an error and need to change a mark, use the **Prev and Next** buttons to get to the mark you need to change.

Note For Piece parts: Defining the marks that will be placed on your piece. These marks must be a minimum of 5mm away from the center of the carrier wafer. Using the same procedure as above, define 2 to 4 marks that will appear on your piece. The example below shows 4 piece marks placed 8mm from wafer center.

Select **Exit** on top button row when done. This takes you back to the Alignment Definition Menu.



Wafer Graphics

Alignment Definition

Next, select **Alignment Strategy**. This is where you will tell the system which alignment marks will be used together for aligning layers. Multiple strategies can be defined to use different sets of marks for

different layers. For 4" wafers, you will most likely only use one strategy. For pieces, you will have one strategy for aligning the first layer on your piece to the alignment marks on the carrier wafer, then another strategy for aligning subsequent layers of the piece to itself.

First, Name the **strategy ID** and press the **Apply** button. Wafer alignment method is always TTL. Press **New** to add another alignment strategy and give it a **name** and **apply** as well.

Note for Piece parts: For Piece Alignment, you need to press the Modify **Alignment Data** Button to open the alignment data screen. Change **Minimum Mark Dist Coarse (mm) and Fine (%)** to 8.0. Press **Accept** to return.

Next, press the **Marks Selection** button to open the mark selection and mark alignment graphics screens so that you can select the marks that will be used for this alignment strategy.

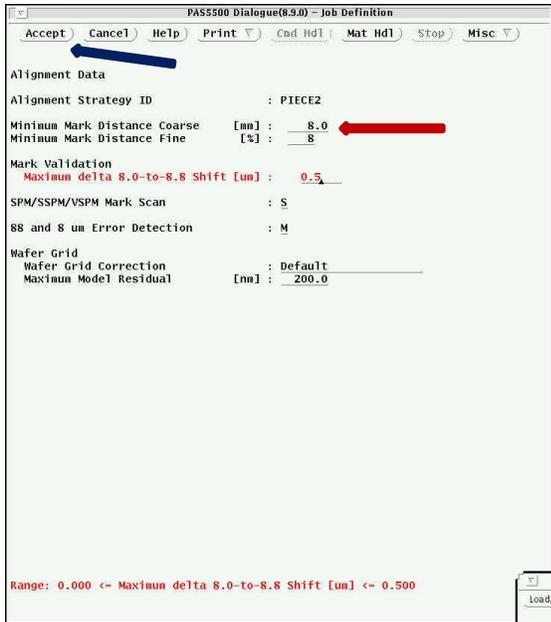
Press **Previous** or **Next** to select which strategy you will add or delete marks from

Enter the **Mark ID** by name (you can use wildcards, for instance you can type P* to select all mark IDs starting with P) or click on the alignment marks you wish to add to the strategy (in the upper graphics screen) Leave the <All> selected for Mark type.

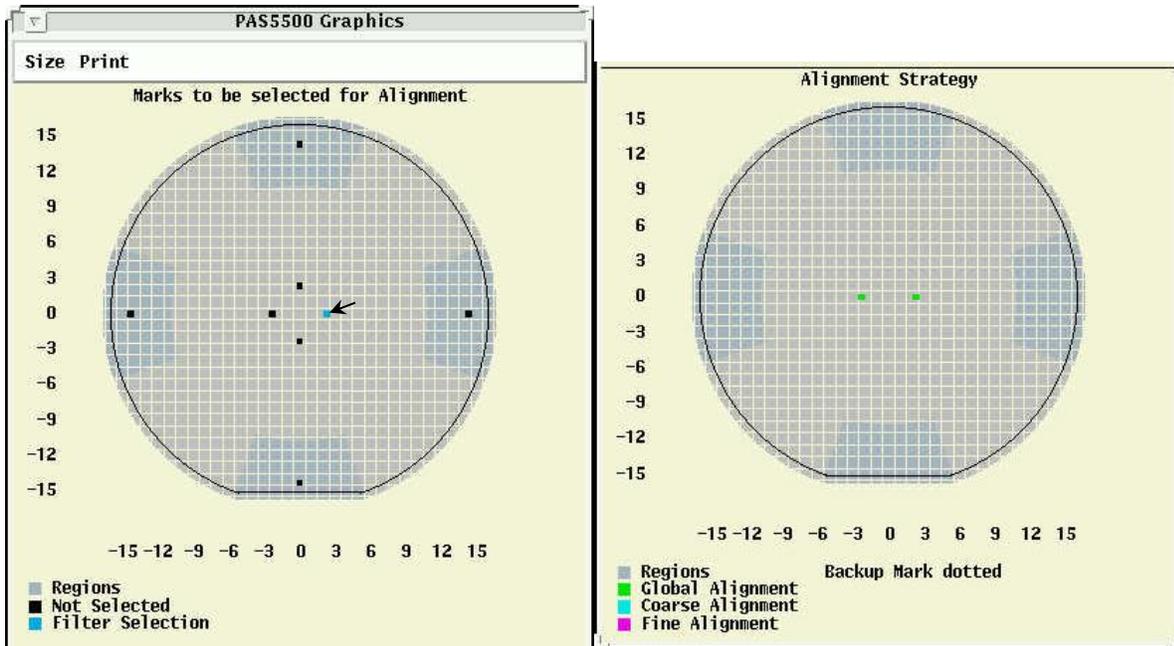


Alignment Strategy Screen

Mark Selection Screen



Alignment Data Screen



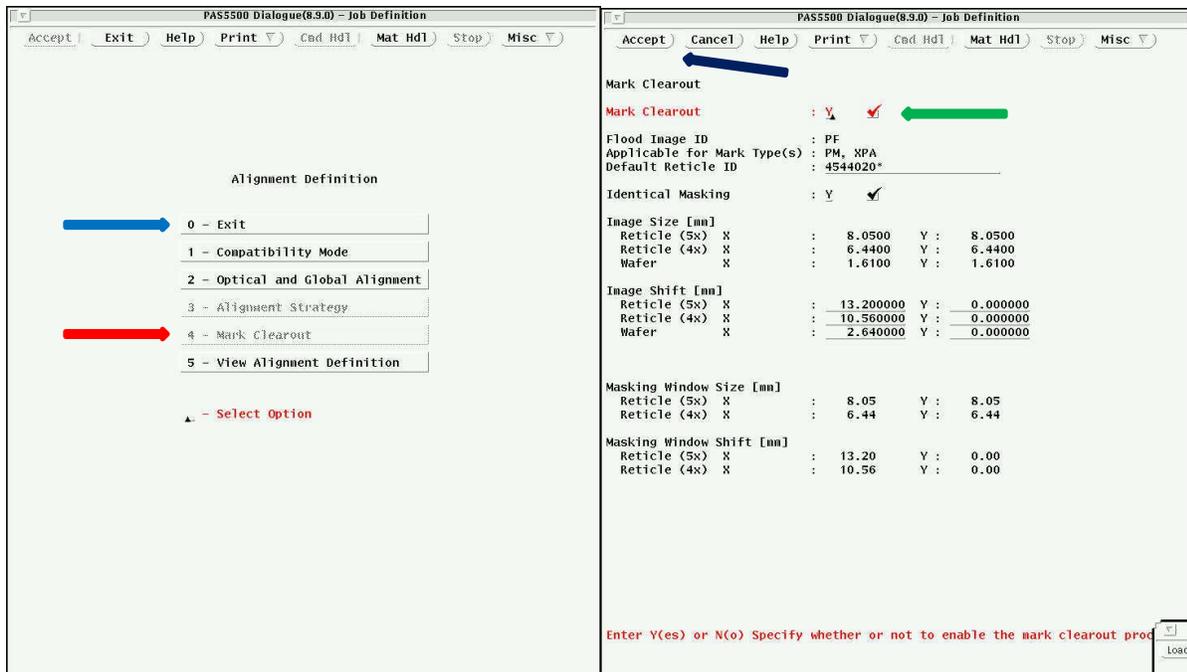
Upper Screen Marks Selection

Lower Screen Mark Selection

Press the **Add** button to add the marks to the strategy or **Delete** to remove them. You will see the added marks turned green on the bottom graphics screen.

Repeat the procedure with the next Strategy until all strategies are defined with marks

Select **Exit** on top button row when done. This takes you back to the Alignment Strategy Screen. Press **Exit** again to get back to Alignment Definition Screen.



Alignment Definition

Mark Clearout Screen

Next, select **Mark Clearout**. This will take you to the Mark Clearout Screen.

Mark Clearout Option: **Check the box if desired**. Checking this box will enable the option (to be enabled in a later step on various layers) to expose a window over the alignment marks during a subsequent process step. This might especially be needed if you are doing a negative resist process to form an etch mask, but want the marks protected from being damaged during the etch step.

Press the **Accept** button when done. You are done with the Wafer Layout section

Layer Layout:

Press the **Exit** option until you reach back to the Job Contents Menu.

Next, go to the **Layer Layout** Menu.

The first step will be **Layer Definition**.

First enter the **number of layers** for your process (2 for this example; 1, and 2, the 0 layer is always included). Press **Apply**.

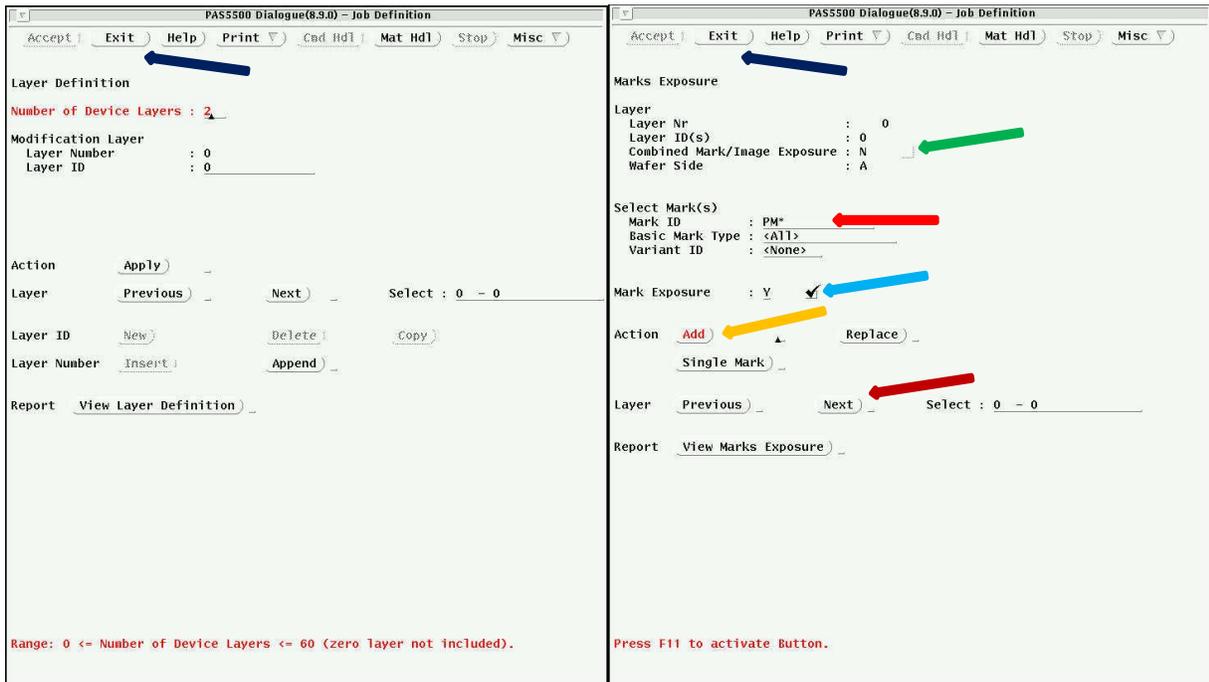
You can enter a **layer ID name** for each layer. Use the **Next and Previous Buttons** to edit the layer IDs for each layer. Remember to hit **Apply** after each name change or addition.

When done defining all layers, **Exit** to Layer Layout menu. First go to startagey selection, set active Alignment strategy to None if you want to shoot zero and first layer. Then go to process data and combine Zero and First. Then go to **Marks Exposure**.



Job Contents Menu

Layer Layout Menu



Layer Definition Screen

Marks Exposure Screen

The Marks exposure page is used to tell what layer the different alignment marks defined earlier will be exposed on.

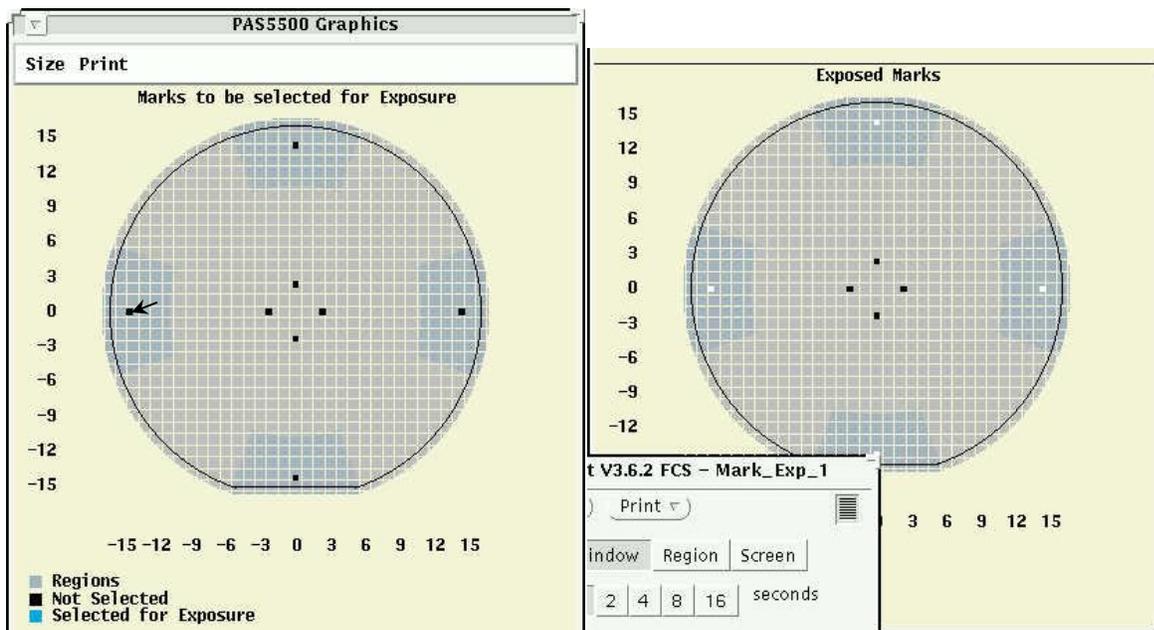
Using the **Previous/Next** buttons scroll to the desired layer where you want to expose marks, then check the box for **Mark Exposure**.

If you also want to expose an image on that layer at the same time as the marks (for example, with a piece, you will shoot alignment marks and your first mask layer on layer 1), check the **combined mark/image exposure box**.

In the upper graphics window use the mouse to click on the marks you want to expose for that layer. Selected marks will turn Blue. You can also select the marks for a layer by typing in the names (wildcards allowed) in the **Select Marks section**.

Press the **Add** button to add those marks to the exposed marks graphics (lower graphic). Marks to be exposed turn white.

When done with all mark exposures, press **Exit** to return to the layer layout menu.



Upper Graphics for Mark Exposure

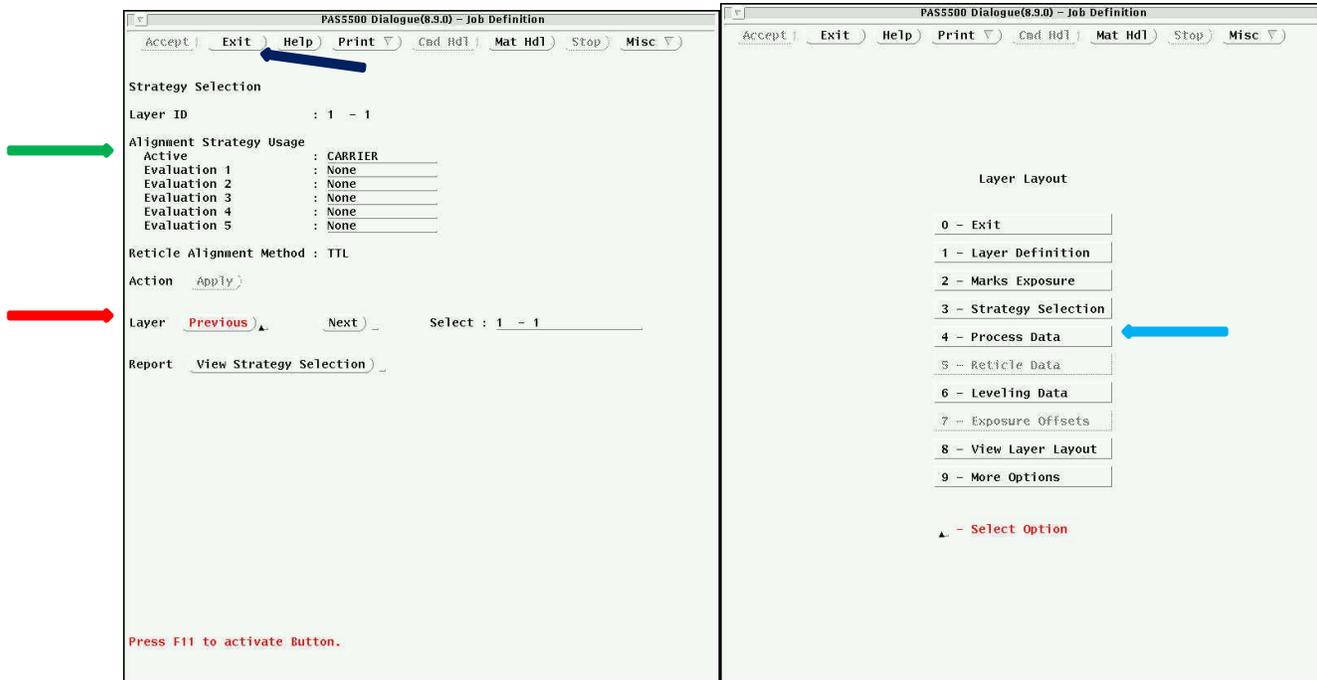
Lower Graphics for Mark Exposure

Next, select **Strategy Selection** from the layer layout menu. In the strategy selection section, you will choose what mark sets to use for alignment for the different layers. Layer 0 does not need a strategy since there is no alignment, except by the system to the wafer flat.

Use the **Previous Next Buttons** to select the layer you want to set the strategy for. For 4 inch wafers, you may need only one strategy for all layers. For pieces, you will need one strategy for layer 1 that uses the carrier wafer alignment marks (for example a strategy named Carrier), then need a second strategy to align layer 2 to marks on the piece exposed during layer 1 (for example a strategy named Piece).

In the Alignment Strategy Usage list, use the **Active line** to enter your primary strategy to use for the selected layer. Use Evaluation 1,2,... etc. to put in alternative strategies to use in case the active one fails due to an unreadable mark. You can always go back and add more strategies later (in the alignment strategy section) so that you can use them here. An example of how this might be set up. Use 4 marks for Active, use left/right marks for Evaluation 1, use top/bottom marks for evaluation 2. Remember: If you are shooting layer 0 and 1 together select NONE for layer 1 alignment strategy.

When done with each layer, select **Exit** to return to the layer layout screen.



Strategy Selection Screen

Layer Layout Menu

Next, select **Process Data**.

Use the **previous/next** buttons to select the layer.

For a 4" wafer, if you want to shoot layer 1 at the same time as you put on the 0-layer alignment marks, check the **combined zero/first layer box**. This saves a process step for full wafers.

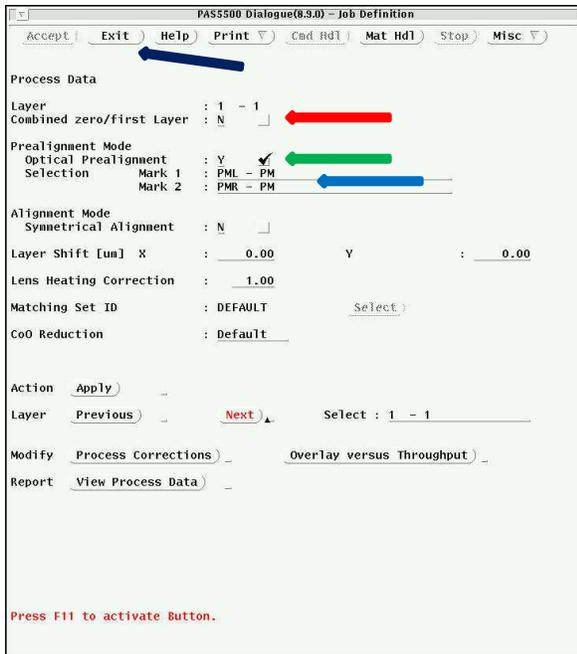
For all layers, check the **optical prealignment box**.

Select the **outer left and right alignment marks** for use in prealignment.

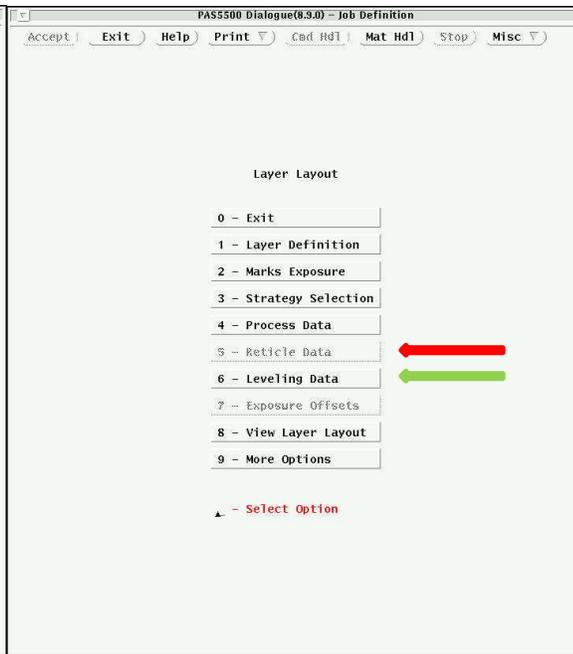
If you want the layer shifted relative to the cell grid, **enter the shift in microns**. This will not be used by most users.

Press **Apply** when done to make changes active. Make changes to the rest of the layers.

Press **Exit** when done to return to the layer layout menu.

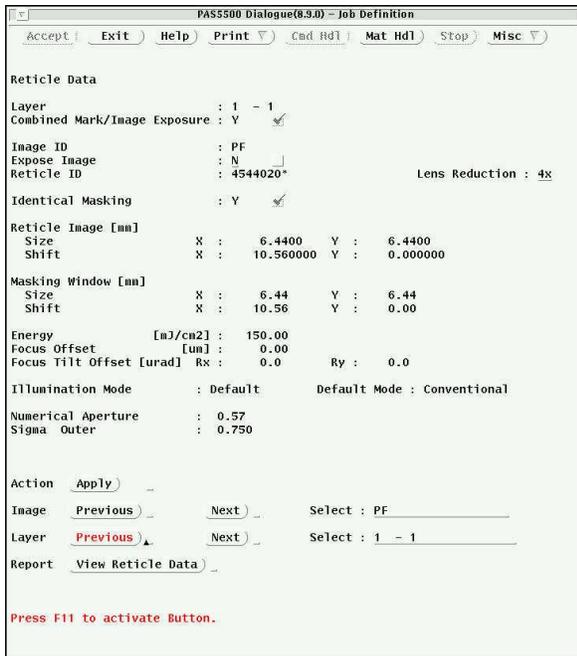


Process Data Screen

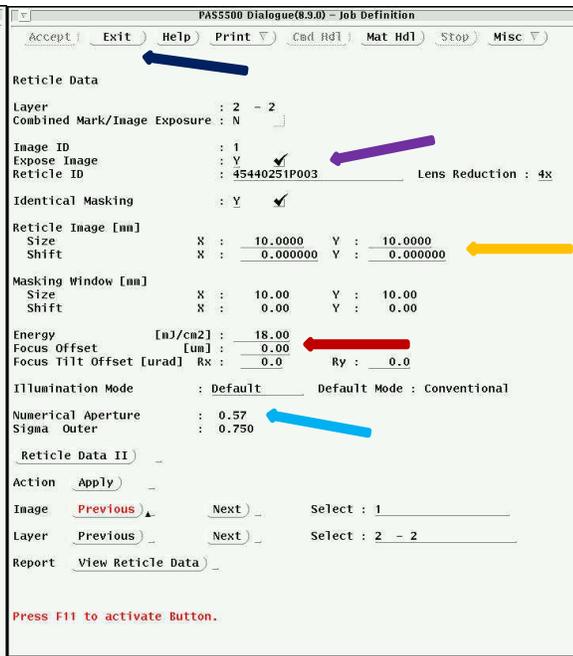


Layer Layout Menu

Next, select **Reticle Data** from the layout menu. In this screen, you will tell the system which images to expose on the layers, energy of the exposure for each image on each layer, focus offsets, NA of the lens.



Reticle Data Screen (1)



Reticle Data Screen(2)

First, go down to **Layer** and select the first layer to adjust using the Previous/Next buttons

Next, go to **Image** and select which image to adjust parameters for using the previous/next buttons. In the example in screen (1) above, the PF image is selected. The PF image is the Mark Clearout Image. Other Images available will be alignment marks (if allowed you will see the combined mark box checked near the top of the screen) and mask images you defined in the wafer layout menu.

Choose to expose the selected image on the selected layer by checking the **expose image box**. In screen (1) the box is left unchecked and no other options can be changed.

In screen (2) layer 2 with image 1 is selected. Expose Image is also selected.

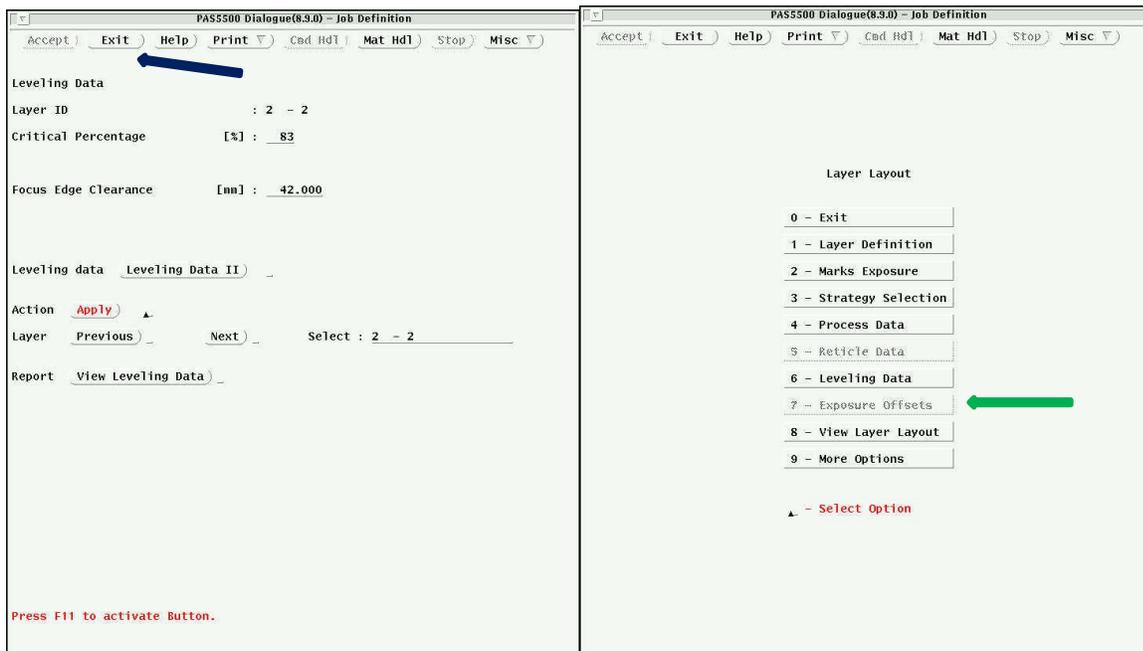
Now, you can change the **Reticle ID** if it is the wrong one and you can change the **Reticle image size and shift** if they are not correct. These parameters were defined by you in earlier menus in the wafer layout section.

Change the **Energy and focus Offset** values. (Use 18mJ/cm² for UV6 on AR2). Best energy and focus should ultimately be determined using a focus exposure matrix, to be described later and in another document.

Change the **illumination mode and NA** for the system. Conventional will be used mostly. Annular is available and can extend fine feature resolution down to smaller numbers. Max NA is 0.63, lowest NA is 0.4. Higher NA is better resolution, but smaller process focus window.

Finish this procedure for all layers/images, then **Exit** to Layer Layout Menu.

Now go to **Leveling Data** from the layout menu.



Leveling Data Screen

Layer Layout Screen

The leveling data screen needs to be used to make piece part leveling work properly on the system. Choose layers using **previous and next**. The **focus edge clearance (FEC)** parameter defines a focus exclusion zone so that the carrier wafer will not play a role in focus, but only your piece will be focused. It is measured from carrier edge inward. For all layers, except layer 0, change the focus edge clearance so that the resulting focus circle lies within your piece as much as possible. Maximum FEC is 43mm so that the resulting focus circle is 14mm.

Press **Exit** when done to return to the Layer Layout Screen.

Press Exit again and Exit again, then save job when prompted. If you do not save, all changes will be discarded.