1.0 Title
Canon 4X Projection Mask Aligner

2.0 Purpose
The Canon Fine Pattern Projection Mask Aligner (FPA-141F) is a high precision wafer stepper capable of stepping 9 patterns on a two-inch wafer or on pieces of wafer using the special disk (see the Appendix). This is an expensive and high precision machine, so make sure you are familiar with the operating procedures before you use it.

3.0 Scope
This document describes the general operation of the Canon 4X Projection Mask Aligner. It is a 4X projection printer capable of step exposing 1, 4 or 9 exposure fields on a two-inch wafer or on small pieces of wafer using the special disk. It has an effective format area of 43 mm X 43 mm and reproduces images with a 4 times reduction in size. The minimum resolution is rated at 0.8 micron for 5000 A thick positive photoresists on oxide wafer or pieces. Alignment accuracy is rated at ± 0.125 micron.

4.0 Applicable Documents
Refer to Canon 4X Projection Mask Aligner operational manual in the Microlab office for more detailed instructions.

5.0 Definitions & Process Terminology
5.1 Standard or Original Wafer Disk: The optical disk where the wafer comes in contact. It has a ~2" square cut on its stainless steel disk.
5.2 New Wafer Disk: The optical disk where the wafer comes in contact. It contains a 4" sheet glass.
5.3 Standard or Original Wafer Chuck: The stainless steel chuck where the wafer sits. It is a complete stainless steel chuck.
5.4 New Wafer Chuck: The rubber chuck where the wafer sits. It has black grooved rubber on the center of the chuck.

6.0 Safety
Follow general safety guidelines in the lab as well as the specific safety rules as per follows:
6.1 Take good care of the vacuum seal gasket on the wafer disks. We only have limited supplies in stock. The Canon Company does not make them anymore.
6.2 Do not leave the wafer chucks in the up position after each session. This will tend to deform the vacuum seal (rubber) gasket on the wafer disk.
6.3 Always replace a dummy wafer on the stainless steel wafer chuck after each session or else vacuum will keep the stainless steel wafer chuck up.
6.4 Do not touch the lens of the illumination system when loading the photomask.
6.5 Always replace the dummy mask after each session. This is used to protect the projection lens from dust and particles.
6.6 Always clean the photoresist on the new wafer disc when you are through.
6.7 Return the focus to the established setting.
6.8 In principle, the X mm and Y mm settings should not be changed unless the wafer chucks are down. However, these settings may be changed if the XY stage is at address 1.
6.9 Do not press WAFER LOAD button while the XY stage is moving from one step to the next step.
6.10 Do not use the mask COARSE ALIGNMENT LEVER or the FINE ALIGNMENT GRIP unless the wafer has been loaded and the wafer chuck is up.
6.11 Do not restart the mercury arc lamp while it is still warm.
6.12 Never put both the X mm and Y mm switches in the SET position at the same time. As described on step 8.1.6, they should be used one at a time.

7.0 Statistical/Process Data
7.1 Problem and comments section under equipment section of the wand.
7.2 Enable message for canon.

8.0 Available Processes, Gases, Process Notes
8.1 Functions of Switches and Pilot Lamps
8.1.1 LIGHT INTEGRATOR/MANUAL EXPOSURE Switch
In the LIGHT INTEGRATOR position, the exposure is started when the alignment scope is shifted off the optical axis, and ends when the light integrator registers the required level. In the MANUAL mode, the EXPOSURE button can be used to start and end the exposure by successive depressions.

8.1.2 COARSE/FINE Dial for the Light Integrator
Select exposure desired with the COARSE and FINE knobs of the LIGHT INTEGRATOR. Exposure will be doubled if the COARSE knob is set to the next higher level, whereas it is increased by approximately 6% by setting the FINE knob to the next higher level.

8.1.3 MASK LOAD Switch and LAMP
When the MASK LOAD switch is in the upper position, the photomask will be attracted to the photomask chuck, and the pilot lamp will be lit.

8.1.4 WITH ALIGNMENT/WITHOUT ALIGNMENT Switch
If you start with a blank wafer, set the switch to WITHOUT ALIGNMENT. When the wafer is exposed in this mode, the aligner will automatically step through all the steps required without a break. The alignment scope can be pushed back to the optical axis to stop the exposure at any time. If your wafer already has patterns on it, set the switch to WITH ALIGNMENT. This will expose only one step at a time so that you can align the wafer for each step.

8.1.5 PRINT/STROKE SETTING
In the PRINT mode, exposure will be effected through the selected number of steps. In the STROKE SETTING position, the functions of the STEP FEED button and the SET/RESET selector switch will be effective.
8.1.6 SET/RESET Selector Switch
The wafer XY stage can be advanced to the next step without effecting exposure in order to check the stepping amount and the rotational alignment of the mask in the STROKE setting mode. With the X mm or Y mm switch in the SET position, the XY stage will move toward address 2 or 4 respectively to the preset extent of travel. In the RESET position, the XY stage will move back to address 1. Only one of the two switches should be in the SET position at any time, and they should be used only when the XY stage is at address 1.

8.1.7 STEP FEED Button
This button is used for moving the XY stage to subsequent steps without exposing the wafer, when the chuck is raised and the aligner is in the STROKE SETTING mode. After address 9, the XY stage will move back to 1 to complete the cycle.

8.1.8 STEP Dial
Set this to the required number of exposures when the chuck is down. Correct stepping cannot be performed if the number of steps is changed after the exposing action is started.

8.1.9 START Button
Rotates the turntable to activate the aligner.

8.1.10 EXP. Button and Lamp
For use with the MANUAL EXPOSURE mode as described above.

8.1.11 WAFER RELOAD Button and Lamp
When the chuck is up and this button is pressed, the XY stage will move to address 1 and the chuck will lower. When the CHUCK is rotating and this button is pressed, the rotation will stop. Press the START button to restart the rotation.

8.1.12 WAFER ROTATIONAL ALIGNMENT Switch
The wafer can be rotated during alignment within plus or minus 3 degrees.

8.1.13 COARSE/FINE Selector Switch
Selects high or low speed for the wafer rotational alignment switch.

8.1.14 F- STOP Lever
Located on the side of the instrument, for setting the aperture \( f = 1.4 \) to \( 4 \).

9.0 Operating Procedure
The following is a detailed outline of the general procedure to follow in using the canon. Make sure that you are familiar with all the controls and knobs mentioned in Section 8 before you use the instrument. You should also be familiar with the precautions listed in Section 6 and with the wafer disk changing procedure listed in the Appendix.

9.1 Set Switches & Controllers for Proper Operation
9.1.1 Enable the system on the computer (canon).
9.1.2 Check the status of the mercury lamp. If the lamp is off, make sure it is cold, turn off the main electronics power switch, then press the START button on the lighting unit until the
lamp comes on. The lighting unit is directly under the Canon aligner isolation table. Allow the lamp to warm up for 20 minutes. Turn the main electronics power switch back on.

9.1.3 Check to see if the wafer disk you need is installed. If not, go ahead and change the disk. Follow the instructions in the Appendix. In general, 2” wafers can use either disk, while chips should use the “new” wafer disk.

9.1.4 Set the PRINT/STROKE SETTING switch on the right control panel to PRINT.

9.1.5 Set the Xmm and Ymm SET/RESET switches to RESET.

9.1.6 Set the helicoid at the bottom of the projection lens to the proper focus setting posted on the machine. If it is not already set to the value you need, change it by moving it from below to the required value to avoid errors due to hysteresis. If focus setting is off by a great amount, please contact previous user to find out which way the helicoid should be changed (turned).

Note: The focal plane is determined by the wafer disk’s glass surface against which the sample is pressed. Once the focus for this focusing ring has been set, it does not need to be adjusted for different sample thickness. The best focus for the new wafer disk with the rubber platen wafer chuck combination has been determined to be around 848 microns. For 2” whole wafer applications, use 680 um focus on the standard wafer disk and the stainless steel chuck combination. These focus settings are only valid when the wafer disk sits properly and the vacuum is good. The focus values are updated by the staff periodically.

9.1.7 Set the F-stop to the proper setting.

Note: All settings, including the X mm and Y mm settings, can be reset by the user to the desired values after making sure that the wafer chuck is in the down position. The maximum values on the X mm and Y mm settings are 11.00 mm.

9.1.8 Check whether the following gauge readings are correct after loading a wafer:

► N2 gas about 2 kg/cm²
► Vacuum over 50 cm Hg
► N2 gas about 0.5 kg/cm²

Note: If any of the above readings is not right, do not proceed. Report problem on fault.

9.1.9 Select the number of steps desired on the STEP DIAL. The Canon can make 1, 4 or 9 step exposures on your wafer.

9.1.10 Set the LIGHT INTEGRATOR/ MANUAL EXPOSURE switch to LIGHT INTEGRATOR for auto exposure.

9.1.11 Select the desired exposure with the COARSE and FINE knobs of the LIGHT INTEGRATOR.

9.1.12 Set the WITH ALIGNMENT/ WITHOUT ALIGNMENT switch as desired.

9.2 Loading Photomask

9.2.1 Check if both wafer chucks are down. If not, press the WAFER RELOAD button to set them down.

9.2.2 Pull the alignment scope out using the white handle. It should be noted that if the wafer chucks are not down and the scope is pulled out, the illumination system could automatically expose whatever is on the wafer chuck.

9.2.3 Push the spring lever on the illumination system and swing the illumination system to the right.
9.2.4 Flip MASK LOAD switch to the down position, the pilot lamp will go off. The dummy photomask is no longer attracted to the photomask chuck and can be removed. Blow off dust particles on photomask before loading on mask platen. Replace it with your photomask, emulsion/chrome side down. When placing or removing the photomask, always do it from the left. This is to avoid touching the lens of the illumination system, which is now swung to the right.

9.2.5 Flip MASK LOAD switch up, your photomask is now under vacuum on the photomask chuck.

9.2.6 Swing the illumination system back to its lock position and push the alignment scope back to its original position.

9.3 Aligning Rotation of Mask

9.3.1 Turn the VIEWING FIELD SELECTOR knob to split field. This will allow seeing both the left and right fields through the eyepieces simultaneously.

9.3.2 Turn the MAGNIFICATION SELECTION RING to the desired (7X, 14X, 20X) magnification.

9.3.3 Use FOCUSING knobs to focus the objectives. First, focus the right field with the large FOCUSING knob on the alignment scope. This will adjust the focus on both the left and right fields at the same time. Next, focus the left field with the small FOCUSING knob for the left objective. This will only adjust the focus on the left field of the scope.

9.3.4 Adjust contrast for the split field with the center lever on the alignment microscope.

9.3.5 View through the eyepieces and adjust the X-ADJUSTMENT knobs for the left and right objectives fields. You might have to change the magnification and adjust the X-, Y-ADJUSTMENT knobs for the alignment scope as well.

9.3.6 Rotate the photomask by means of the PHOTOMASK ROTATION ADJUSTMENT knob until the photomask pattern in both left and right fields line up.

9.3.7 At this point, if you need to align your wafer (WITH ALIGNMENT), continue with Section 9.4. If you do not need to align (WITHOUT ALIGNMENT), follow step 9.4.1, then go directly to Section 9.5.

9.4 Aligning Wafer with Photomask

9.4.1 Load the wafer onto the wafer chuck. Position the major and minor flats against the guiding pins. Press the START button and the chuck will automatically load.

9.4.2 View through the eyepieces and adjust the X-ALIGNMENT knobs for the left and right objectives until you can see the same wafer pattern on both left and right fields. You might have to change the magnification and adjust the X-, Y-ADJUSTMENT knobs of the alignment scope.

9.4.3 Rotate the wafer by pushing or pulling the WAFER ROTATION ALIGNMENT switch until the wafer pattern in both left and right fields line up. There is a COARSE/FINE selector switch working together with the WAFER ROTATION ALIGNMENT switch. Set to COARSE or FINE as required.

9.4.4 Using COARSE mask adjustment lever, coarsely align the photomask in the X and Y directions with the wafer while pressing its stage lock release button.

9.4.5 Using the FINE MASK ALIGNMENT Grip, do a fine alignment adjustment while pressing its stage lock release button.

9.4.6 Repeat fine wafer rotation alignment and fine mask alignment adjustment until alignment is satisfactory.
Note: Machine accuracy is rarely achieved because of wafer warpage and patterns on the wafer itself. Nevertheless, the fact that the Canon is a projection wafer stepper greatly increases its alignment accuracy.

9.5 Exposing Wafer

9.5.1 Expose the wafer by pulling the alignment scope out with the white handle. If you are using WITH ALIGNMENT, this will only expose one step and automatically move onto the next step. Then you will have to align again by following the procedure on Section 9.4 before you expose the next step. If you are using WITHOUT ALIGNMENT, the aligner will automatically step through the required steps while exposing the steps at the same time.

9.5.2 After all steps are exposed, the wafer chuck will automatically unload. Push the alignment scope in and press the START button to rotate the chuck around so that it will be easier to take the wafer out. Press WAFER RELOAD button to lower the other wafer chuck.

9.5.3 When all of your wafers are done, use N2 gun to blow off the dust particles on the dummy wafer and replace the dummy wafer on the stainless steel chuck.

9.5.4 Use N2 gun to blow off the dust particles on the dummy mask and replace your mask with the dummy photomask by following the procedure in Section 9.2.

9.6 Shut Down Procedure

9.6.1 The alignment scope is in.

9.6.2 Both wafer chucks are down.

9.6.3 The focus is set to the posted value corresponding to the disk on the canon.

9.6.4 The X mm and Y mm settings are 11 mm.

9.6.5 The WITH ALIGNMENT/WITHOUT ALIGNMENT switch is set to WITH ALIGNMENT to prevent accidental exposure of all fields by the next user.

9.6.6 The 2” dummy wafer is on the stainless steel wafer chuck. It should be rotated in (under the column with wafer chuck down).

9.6.7 Replace dummy mask on the mask chuck (platen) after blowing off dust particles.

9.6.8 Log out on the wand.

Note: Ensure that the canon is in the above state before you log out.

10.0 Troubleshooting Guidelines

10.1 If the wafer image seems blurry, check to see if the vacuum is 50 cm Hg or higher.

10.2 If the vacuum is below 50 cm Hg, check the thumbscrews to make sure they are seated tight enough against the wafer disk. But do not over tighten the thumbscrews. Over tighten the thumbscrews will bend the pins.

10.3 If the vacuum is below 50 cm Hg, make sure your sample covers the vacuum groves on the wafer chuck when it is up against wafer disk attached to the lens column.

11.0 Figures & Schematics

12.0 Appendix

12.1 Change the Wafer Disk

12.1.1 There is a stainless steel chuck for whole 2” (standard) silicon wafers and there is a new chuck with a rubber platen for smaller or irregular samples. Make sure that a dummy wafer is in place on the stainless steel wafer chuck at all times when it is not in use.
12.1.2 Lower the wafer chuck by pressing the reload button.
12.1.3 Loosen the thumbscrews that hold the wafer disk in place and swing them up out of the way.
12.1.4 Gently pull out the wafer disk with your hand supporting it to remove it. Please store it in the special stand provided.
12.1.5 Blow off the particles on the new wafer disk with the N2 gun and carefully slide it into the machine. Make sure it seats against the back stop, then swing down the thumb screws and seat them on the tapered surfaces of the wafer disk so that tightening them pushes the wafer disk up into place. Do not use excessive force on these screws. Over tighten the thumbscrews will bend the pins.
12.1.6 Load the rubber platen wafer chuck so that it pushes onto the wafer disk. Tighten the thumbscrews again if they are loose. While they are in place, confirm that the vacuum is at 50 cm Hg or higher.
12.1.7 If the vacuum is poor or the wafer image seems blurred. It is likely the vacuum is not holding the wafer disk securely. In this case, make sure the wafer chuck is the right one and that it is seated properly to the wafer disk. Recheck the thumbscrews and make sure they are tight and are in the appropriate place.
12.1.8 When reinstalling the original wafer disk, make sure there is a 2” dummy wafer in place. If you try to install the wafer disk without a dummy wafer in place, the vacuum will clamp the disk in place without achieving the proper location. Then, you will have to disable the machine while holding the wafer disk carefully to prevent it from falling.
12.1.9 Shut down as described in Section 9.6. Leave the disk you used in the machine with the corresponding focus setting.

Note:  
1. The standard wafer disk & chuck are more appropriate for the whole 2” wafers. The new wafer disk and wafer chuck may be more appropriate for small and broken samples. Yet these wafer disks and wafer chucks may be interchanged to suit your own purposes.
2. A new wafer disk with a glass plate and an accompanying chuck with a rubber substrate table allow the Canon to be used with samples of any size up to 2” diameter and thickness between 300 and 800 microns.