MODEL MAS-400 INFRARED

MASK ALIGNMENT

AND EXPOSURE SYSTEM

USER'S MANUAL
RESEARCH DEVICES
MODEL MAS-400 INFRARED MASK ALIGNMENT
AND EXPOSURE SYSTEM

UTILITIES REQUIREMENTS .......................... 1
GENERAL INFORMATION ............................ 1
SPECIAL FEATURES ................................ 3
DESCRIPTION ...................................... 5
KEYBOARD CONTROLS ............................... 5
FRONT PANEL ...................................... 7
SINGLE FIELD SPLIT FIELD OPTIONS ............ 7
COARSE AND FINE VERTICAL STAGE ............... 8
EXPOSURE SYSTEM .................................. 8
OPERATIONAL INSTRUCTIONS ...................... 9
INITIAL SET-UP .................................... 10
ILLUMINATORS ..................................... 12
TROUBLE SHOOTING ................................. 14
FIGURES

ELECTRICAL DIAGRAMS
VIDEO EXPOSURE LAMP MANUALS
PHOTOGRAPHS AND ILLUSTRATIONS
Model MAS-400 Infrared
Mask Alignment System

Utility Requirements:

Power: 110-120 Volts 50-60 CPS
Close voltage control improves exposure
uniformity and lamp life.

Vacuum: 22 inches mercury minimum during entire cycle.

Air: Input pressure 40-100 PSI
Pressure regulated - 35 PSI

Location: For maximum efficiency, locate the aligner in a
clean well-lighted (yellow light), dust-free area.

Physical Dimensions:

Aligner

- Length 37"
- Width 30"
- Height 30"

Keyboard

- Length 24"
- Width 7"
GENERAL INFORMATION

The Research Devices Model MAS-400 Infrared Mask Aligner is a precision instrument designed for operation in the wavelength range from 0.4 - 1.8 microns. The purpose of using the aligner is to align a pattern on an upside down wafer to a second pattern on a mask. Many semiconductor materials such as Silicon, Gallium Arsenide, Cadmium Telluride, and Indium Phosphide are transparent in the near infrared. This makes it possible to see the pattern on the upside down wafer and the mask at the same time, and perform the alignment in the IR Reflection or transmission mode. The contrast in the transmission mode is very high and the alignment is simple and accurate. The MAS-400 infrared aligner operates in the IR reflection mode, and in many applications it may be advantageous to use this mode. For example, iron oxide masks, are almost transparent in the near IR and it is necessary to work in reflection, or transmission reflection combination enhance the mask patterns.

Although this aligner was designed for back side alignment, it is also possible to perform front side alignment by operating it in the visible range.

Wafer diameter and thickness, as well as mask size vary for different devices and it is important to specify these dimensions at the time of ordering the aligner. For wafers
larger than 2" in diameter, a split field is used which shortens the time needed for accurate alignment. The engineers and technicians at Research Devices are experienced with the various applications for mask alignment and are ready to assist you with any technical questions you may have. Our Telephone number is (908) 572-4800, or call your local representative. We will appreciate the opportunity to be of service to you.
SPECIAL FEATURES

The Research Devices Model MAS-400 Infrared Mask Aligner is equipped with special features which make the alignment safe and accurate.

1- The autocollimator is an optical device which aids in bringing the sample to be parallel with the mask in the non-contact position. It uses a special illuminator and lens which are used for this purpose only.

2- A solid state pressure sensor is installed in the chuck assembly and indicates the pressure between the mask and the sample.

3- A safety microswitch, which prevents accidental contact between the mask and the sample at the start of the alignment procedures.

4- When using an iron oxide mask, it is sometimes difficult to see the pattern in the transmission mode. The aligner is supplied with a reflection illuminator to aid in obtaining a better contrast of the mask. This illuminator is equipped with a filter slide marked "visible" and "IR". When using the transmission mode, the filter should be in the "visible" position. The same position is also used for front side alignment.

5- A special automated cycle from aligning to exposure and back to loading is built in. The precise movement will enhance machine accuracy and cycle time.
6- Exposure system for up to 4" wafers with 3% +/- accuracy and feedback control for constant exposure.
7- Fully motorized X,Y,0 stage motions as well as X,Y,Z microscope motions.
8- A Unique transmission illuminator which yields even and collimated illumination over large areas.
DESCRIPTION

Figure 1 shows the general view of the MAS-400 Infrared Aligner. The alignment cycle has three positions. Loading and unloading is performed when the shuttle is in the center position of the aligner. The right side of the aligner is dedicated for alignment and clamping, while the left side contains the exposure system. The wafer and mask are moved from the alignment position to the exposure position on an air bearing cushion which prevents any vibrations or motions between the wafer and the mask.

KEYBOARD CONTROLS

Figure 2 shows the keyboard which controls all the motions of the aligner. The X,Y,O stage motions as well as the X,Y,Z video motions have black push buttons. These motions are controlled with a joystick and are well marked. To operate a particular motion, press on the push button dedicated for it and move the joystick in the desired direction. The joystick has proportional speed control. The higher speeds are achieved as the stick is pushed further away from the middle.

1- CAMERA SCAN— moves the camera in any X or Y direction— 1" motion on X & Y
2- WAFER SCAN— moves the wafer in any X or Y direction for alignment purpose, 1" motion on X & Y
3- WAFER ROTATION— rotates the wafer +/- 8 degrees
4- FOCUS— moves the camera in the Z direction for focusing, 1" travel
5- FINE VERTICAL— moves the stage in the Z direction
6- PITCH & YAW— will change the angle between the mask and the wafer (used with the autocollimator)
The right hand side of the keyboard is dedicated for shuttle movement. When the Auto-Manual switch is in the auto position, and the expose switch is pushed, the shuttle will move automatically from the alignment position to the exposure position, expose the wafer and the move back to the loading position. In the manual mode the shuttle can be moved by pressing the buttons corresponding to the cycle, ALIGN will bring the shuttle under the optical limb, LOAD will bring the shuttle to the center and EXPOSE will move it under UV light source. To move the camera head from single to split field use the appropriate buttons.

Wafer vacuum and mask vacuum are located on the top left of the keyboard. The red light in the button will indicate if the vacuum is on or off. MASK CLAMP RISER- brings the wafer to a proximity position with the mask prior to alignment. The motion is achieved by activating a pneumatic cylinder in the vertical stage structure. A second pneumatic cylinder will lock the mask holder in place at the same time. The fine vertical button when pressed will close remaining gap between mask and wafer and will create contact between the two which will be observed by the pressure sensor reading. PURGE- supplies nitrogen between the wafer and the mask if necessary. There are three more blue push buttons which are used for special purposes only and normally will be disconnected on plugged. Their applications are described in Appendix A.
FRONT PANEL

Figure 3 shows the view of the front panel. The main ON/OFF switch is located on the top left side. Under the ON/OFF switch are three double shaft potentiometers which are used for transmission, reflection, and autocollimator illuminators. They are clearly marked and work in combination with the multiple switch located on the bottom left side. This switch controls the various light sources. The positions are off, autocollimator, single field reflection, single field transmission and split field reflection transmission combination. By proper adjustment of the potentiometers, uniform illumination can be achieved for all the positions.

On the right side of the ON/OFF switch is the timer control for the exposure system. The timer is adjustable from 0 - 99 seconds depending upon customer needs. A force indicator sensor is located on the right hand side of the panel. The pressure indication shows the point of contact between the mask and the wafer and is read in kg. Zero adjustment is possible by using a jeweler screwdriver.

SINGLE FIELD SPLIT FIELD OPTIONS

Figure 4 shows the single field split field optics arrangement. The single field contains three objectives and the autocollimator objective. This objective is used for autocollimation only, and contains an iris which is adjusted to obtain the sharpest cross image on the screen. The reflection illuminator is shown on the right side and the autocollimator illuminator is located on the
back of the assembly. The illuminators for the split field are mounted directly on the two lenses. When using wafers larger than 2" in diameter is important to be able to move the split field objectives to the proper spacings for various alignment marks. The spacing between the split field objectives is changed by pulling the wands on either side of the lens holder block.

COARSE AND FINE VERTICAL STAGE ADJUSTMENT

Figure 5 shows the coarse and fine adjustment of the vertical stage. The coarse motion is a manual one and is used for preadjustment of the spacing between the wafer and the mask when the riser is in the up position. Turning it clockwise will move the stage down, and counterclockwise will move it up. Spacing set up is described later in the manual and is done everytime wafer or mask thickness is changed. The fine Z motion is motorized and is controlled from the front panel as marked. It is used to bring the wafer in contact with the mask by monitoring the pressure sensor mounted on the front panel.

EXPOSURE SYSTEM

Figure 6 shows the exposure lamp which is mounted on the left hand side of the aligner. Exposure uniformity is 3% for wafers up to 4" diameter and light intensity is maintained constant via feedback loop. The manual for the exposure system is enclosed.
OPERATIONAL INSTRUCTIONS

The MAS-400 Infrared Aligner will be installed by Research Devices personnel. Do not attempt to unpack.

1. Make sure all utilities to the aligner are turned on.
2. Press ON the ON/OFF switch, turn on the U.V. power supply system and let it warm up for 15 minutes.
3. Bring the shuttle to the center position of the aligner.
4. Mount the proper mask onto the mask holder and turn on mask vacuum. Make sure emulsion side is facing down. Place holder on the stage.
5. Place sample on the chuck and turn on wafer vacuum. Be aware of orientation.
6. Bring the shuttle into the alignment position by pressing on the button marked ALIGN.
7. Make sure that the camera is in single field position.
8. Turn main selector to autocollimator position and turn the autocollimator lens in place. (Marked) Adjust light level and lens iris to the sharpest image.
9. If the wafer is not parallel to the mask, two crosses will appear on the screen. (see autocollimator section).
10. By pressing on the pitch and yaw button, and moving the joystick, bring one cross on top of the other. There may be more than one fixed cross on the screen, and only one will be the "true" one. The "true" one will be determined experimentally. Ways to do so will be described in training.
Assuming that your process is under control, this procedure will be done only once for the entire lot.

11. For wafer 2" in diameter and smaller, remain in the single field mode. Rotate the proper magnification lens into place and turn on transmission or reflection source as desired. Adjust light for proper illumination.

12. INITIAL LOT SET-UP

On the right side of the shuttle is a coarse micrometer adjustment. This micrometer should be adjusted before "real" samples are used.

a) Place a "dummy" samples of the proper thickness on the chuck, press WAFER VACUUM switch and bring the mask over the sample.

b) Rotate the micrometer all the way clockwise.

c) Press on WAFER CLAMP-RISER button and the stage will move up. If the stage does not move up, make sure that the fine vertical position motor is all the way down. The MAS-400 is equipped with a safety microswitch which will prevent the riser from moving up unless the fine vertical motor is all the way down.

d) When the riser moves up, start rotating the coarse micrometer counterclockwise until a change in the pressure sensor reading is observed.

e) Turn the micrometer back half a turn (clockwise). This will set a proper spacing between the sample and the mask.

f) Depress the WAFER CLAMP-RISER button, move the shuttle back to the center by pressing the LOAD button and remove the dummy sample.
13. With the shuttle in the center position place the "real" sample on the chuck and turn on WAFER VACUUM.
14. Bring the mask over the sample and move the shuttle to the right (alignment position), by pressing the ALIGN button.
15. Turn on the proper illuminator (if reflection, make sure that the filter slide is in the IR position).
16. Press on WAFER CLAMP-RISER.
17. Using the wafer scan and rotation, align the sample to the mask.
18. When alignment is achieved, press on FINE VERTICAL button and with the joystick bring the stage up until a slight change in pressure is observed the sample is now in contact with the mask.
19. With the switch in the AUTOMATIC MODE, press EXPOSE and the shuttle will move from right to left to the exposure location, the shutter will open for the designated time duration, close, and the shuttle will move back to the load-unload center position. With the switch in the manual mode - sequencing will be determined by the operator by pressing the proper buttons for movements and exposure.
20. Split field operation - for wafers larger than 2" in diameter - press SPLIT FIELD button and the camera will move to the split field mode.
21. Turn the main selector switch to the proper illuminator position and adjust the light level for the best image on the screen.
22. Repeat instruction 13 - 20.
ILLUMINATORS

The MAS-400 INFRARED MASK ALIGNER IS EQUIPPED WITH VARIOUS ILLUMINATORS FOR TRANSMISSION AND REFLECTION OPERATION.

SINGLE FIELD REFLECTION

The single field reflection illuminator is located on the right side of the alignment tower. The illuminator is equipped with a filter slide which makes it possible to operate the aligner with normal reflected light for top side alignment, or with IR filter for infrared reflection back side alignment. In many cases the operator will find it easier to work with IR reflection rather than with transmission illumination. When using Iron Oxide masks it is necessary to use reflection illumination in conjunction with transmission illumination controlled with the marked potentiometer on the front panel. A field diaphragm is also available on the illuminator for contrast purposes. In some cases it may be necessary to center the bulb in the reflection illuminator. In the rear part of the illuminator you will find two knurled screws which are used for centering the bulb. An easy way to center the bulb is by illuminating a sample through a mask and making sure there are no shadows imposed by the mask on the sample as viewed on the monitor.

SPLIT FIELD REFLECTION

The illuminators for the split field reflection mode are located on the objective mounts of the split field structures. Their intensity is controlled with the marked potentiometer on the front panel. Each illuminator is equipped with a yellow filter so
the light can be seen on the mask. A filter slide is located in the body of the split field structure. This slide contains two IR cut off filters for top side alignment and two IR pass filters for back side alignment operation. The separation of the split field objectives can be changed by pulling the wands on each side of the objective mounts.

TRANSMISSION ILLUMINATOR

Operation in the transmission mode requires collimated light. For this purpose, an innovative optical design unique to RD is being used. When the aligner is equipped with the split field option, there will be several chuck options. These mainly allow you to switch to different size samples.

AUTOCOLLIMATOR ILLUMINATOR

The autocollimator is used for levelling the wafer to the mask in a non-contact position. It is equipped with a cross which is projected on the mask and on the sample. Reflectivity of the sample is very important in order to obtain sharp images on the monitor. As in the case of the reflection illuminator, two knurled screws are used to center the bulb. An even cross should appear on the monitor when properly adjusted. The sample will be parallel to the mask only if the two crosses are overlapped. This is done by pushing the PITCH and YAW button and using the joystick, change the tilt of the chuck. For samples of the same nature, this procedure is done only once.
TROUBLESHOOTING

The Model MAS-400 Infrared Mask Aligner system has been thoroughly inspected before shipping. The following are some procedures for trouble shooting for this machine.

1. Vertical motion (wafer clamp-riser) does not occur – check air pressure to be at least 30 PSI. Check if fine vertical is all the way down. The motion is protected by the safety microswitch connected to the fine vertical position, and will be activated only when the stage is all the way down. When red signal light is not on in the wafer clamp-riser switch, the riser is disabled. Pull back fine vertical motor till the red indicator light above switch will come on.

2. No picture on screen (reflection illumination)
   a. sliding filter on illuminators is in mid-position
   b. 20% reflecting mirrors are not in the right position

3. Autocollimator cross is not on.
   a. Adjust autocollimator illumination by centering light bulb
   b. Adjust 20% mirror to create a clear visible image

4. Mask Vacuum of wafer vacuum is not working
   a. Check whether you have at least 25 inches Hg off vacuum
   b. See if your vacuum lines are not broken or bent

5. Shuttle does not move when switches are activated
   a. Check if air pressure is on
   b. See if teflon gear is connected to brass rack in the rear of the shuttle
Figure 2.

58 - S19 Momentary Switches
51 - 7 ON/OFF Switchesプル with Ight

Research devices
POWER SUPPLY
CONTROL CIRCUIT
ILLUMINATION

MAS-400
29 April 1984 6.5

[Diagram of a control circuit with various components and connections marked with numbers and symbols.]