ABM, Inc.

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Operation Manual For ABM
Mask Alignment & Exposure System

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1.0 SYSTEM DESCRIPTION

1.1 General System Description

The ABM, high performance Mask Alignment and Exposure System is designed to provide precise, repeatable mask alignment and exposure of photoresist-coated substrates. These systems can be manufactured in a variety of configurations each designed to provide the user with the level of performance desired. Modular in design, the system incorporates all the functions necessary to produce high-quality patterning on materials that can have a wide range of physical size, and photolithographic properties.

Major subsystems (modules) are integrated in a typical system which include:

a. Mask alignment tooling module
b. Operator's control module
c. Alignment optics
d. Proximity-type, collimated UV or DUV lightsource system
e. Lamp power supply/controller

All of these (sub) systems are integrated within a laboratory grade console that produces a fully operational, table top, high performance mask aligner system with outstanding capabilities and exceptional reliability.

Before attempting to operate this system, spend time reviewing this and the other associated appendices which describe in greater detail the functions of the system's major components. Also included in this (operator's) manual, there are sections covering the UV/DUV lightsource system, and lamp power supply controller.

Contact ABM, Inc., or it's local representative, if there are any questions regarding this or any other ABM equipment you may have. Failure to operate this equipment properly can cause damage in addition to negating the warranty.

1.2 Basic Subsystem Description

The aligner has been designed to provide the versatility needed for R & D, Pilot Production and Production.

1.3 Mask-to-Wafer Alignment Modules

ABM features the choice of two types of Vacuum Chucks. Technical descriptions are listed below, the basic difference being the leveling operation of the chuck.

1.3.1 Fixed Level Wafer-to-Mask Vacuum Chucks / Alignment Module

A high precision mask alignment tooling module (proximity and contact adjustable) incorporates functions necessary to produce precise, repeatable sub-micron features. X,Y and O motions are precise, backlash-free micrometer movements capable of resolving 0.1 micron increments (optional differential micrometers). Rotation of the Z axis knob allows the user to set the chuck assembly for mask-to-wafer separation to a precision of better than 2.5 microns for substrate thickness compensation, proximity gap adjustments and alignment separation.

The tooling module includes one (1) set of interchangeable mask holders and substrate chucks (with pre-alignment). The wafer chuck is precision lapped to ensure wafer flatness and to ensure a good wafer-to-mask seal, both important especially when using previously processed wafers. The chuck seal is designed in close proximity to the edge of the wafer chuck so that the contact sealing is made directly on the mask creating minimal leverage and resulting in negligible mask bow. The chuck also incorporates a nitrogen (N2) purge to minimize outgasing which effects the printing quality when some negative resists are used. The mask assembly is pneumatically actuated up and down for operator convenience and to safeguard against the operator accidentally dropping the mask assembly and damaging the mask or other components. The alignment module is capable of accommodating proximity, soft contact and hard contact (vacuum) printing requirements.

Fixed Level Vacuum Chucks are primarily used with flat wafers & substrates.

1.3.2 Planarizing Wafer-to-Mask Vacuum Chucks / Alignment Module

The semiconductor-grade mask alignment tooling module (proximity and contact adjustable) incorporates functions necessary to produce precise, repeatable sub-micron features. X,Y and O motions are precise, backlash-free micrometer movements capable of resolving .1 micron increments (optional differential micrometers). The chuck mechanism utilizes an air bearing which is needed to planarize previously processed wafers. The chuck seal is designed in close proximity to the edge of the wafer chuck so that the contact sealing is made directly on the mask, creating minimal leverage and resulting in negligible mask bow. The mask assembly is pneumatically actuated up and down for operator convenience and to safeguard against the operator accidentally dropping the mask assembly and damaging the mask or other components. The alignment module is capable of accommodating proximity, soft contact and hard contact (vacuum) printing requirements.

Planarizing Vacuum Chucks are primarily designed for high resolution, precise registration and proximity printing requirements.

1.3.3 Specification for Alignment Module adjustments

Z Motion (Fixed Level Chuck)	.250" Motion, in 2.5 micron increments with Z knob adjustment
Z Motion (Planarizing Chuck)	.250" Motion, in 2.5 micron increments with Z knob adjustment air bearing planarizing (wedge compensation)
Theta	Chuck rotates approximately ±5°
Mask rotation (O)	Mask holder rotates approx. ±45° may be rotated 360° if necessary
Fine Theta (O)	Chuck mask ±5° - micrometer driven
X Motion	Micrometer driven ±0.5
Y Motion	Micrometer driven ±0.5
Optional:	Micrometer, coarse/fine. Fine, <1 micron

NOTE: Differential micrometers may also be fitted to theta (O).

1.3.4 Mask Holding Options (all types)

Vacuum clamp, Top Load (one & two piece)	Mask is loaded from the top, allowing for almost full utilization of mask surface for contact printing
Vacuum Clamp, Bottom Load	Mask is loaded from the bottom, allowing full utilization of mask surface for contact
Special	Different types * Mechanical Clamp * Multiple mask holder * Custom
Mask Assembly	Pneumatically Actuated for Load/ Unload of Wafers & Substrates

1.3.5 Mask Holding Options

There are two different methods available for holding the mask in (or against) the mask holder assembly:

a. Top Load

b. Bottom Load

The Top Load (drop-in) type provides greater mask position control and mask safety while the vacuum clamped for quick-change capability. Top load mask holders are used when substrates are at least 1.0" smaller (length/width) than masks.

Bottom Load Vacuum clamping is generally used for applications where substrates are almost the same size as masks. Rotation of mask-to-substrate is greater because more mask area is exposed to the vacuum chuck contact seal.

Both mask holders are rotational. These mask holders are designed to allow the operator to align the mask to the row and column layout and to handle patterns which are not parallel to the sides. Mask sizes up to 9" X 9" can be accommodated with this rotatable mask feature.

1.3.6 Vacuum Chuck Assemblies

Fixed level vacuum chucks are designed as one piece (multiple pieces in planarizing vacuum chucks) assemblies consisting of an insert and a chuck mount. This arrangement produces a readily changeable chuck system that can handle a variety of sizes, shapes, and thickness'.. Chuck assemblies are available that can handle substrates from 1.0" X 1.0" to 6.0" X 6.0". Chucks can be furnished with pre-alignment aids capable of repeatable material orientation to typically better than 7 microns.

1.4 Alignment Optics/ Exposure Source Platforms

To maximize printing performance and operator convenience, the ABM alignment system employs a laterally-moving platform for each of the alignment optics and lightsource system. The platform positions the lightsource and alignment optics above the mask alignment tooling module when aligning or exposing and move to their home positions for loading/unloading of wafers & substrates. This method of moving the lightsource and optics ensures that the mask alignment tooling remains undisturbed -virtually eliminating the possibility of any movement between the aligned mask and substrate.

1.5 Operator's Control Panels

There are two operator control panels located on the top console of the aligner.

1.5.1 Operator's Control Modules (electrical & pneumatic)

Left front is the Electrical Control Panel with power on/off, auto expose, manual expose, timer stop/reset & auto expose on/off. Right front is the Pneumatic Control Panel that has substrate, mask & contact vacuum, contact vacuum adjust, N2, N2 adjust, mask frame raise/lower, align/home, expose/home & mask, substrate, and contact vacuum gauges. On top of the control panel is a vacuum gauge and pressure gauge that display house input levels.

1.5.2 Operating Function Description

These items operate all key functions of the aligner except for the lamp housing power supply. Operation of any particular function is provided by either a push-button or a toggle valve.

Functions include:

Power	Turns timer power on
Auto Expose	Opens exposure shutter and starts timer
Manual Expose	Opens exposure shutter to measure light intensity and uniformity
Stop/Reset	Closes exposure shutter & resets timer
Auto Exposure on/off	On, exposure shutter opens/timer starts automatically when exposure source is over mask alignment module. Off, auto expose function must be activated to open shutter & start timer
Timer	Allows user to set exposure time from .1 seconds to 999.9 seconds, in increments of .1 second.
Contact Vacuum	Applies vacuum to contact substrate to mask
Contact	Regulates the level of contact vacuum
N2 Flow Meter	Allows flow of nitrogen between mask and substrate
Mask Frame	Raises/lowers mask frame
Mask Vacuum	Applies vacuum to clamp to mask
Substrate	Applies vacuum to hold substrate
Align/Home	Moves alignment optics to and from align position

Home/Expose	Moves exposure source to and from expose position
System Vacuum Gauge	Displays incoming vacuum
System Pressure Gauge	Displays incoming CDA pressure
Mask Vacuum Gauge	Displays vacuum securing mask
Substrate Vacuum Gauge	Displays vacuum securing substrate
Contact Vacuum Gauge	Displays contact vacuum between mask & substrate

1.6 Alignment Optics

There are numerous options available in the selection of alignment optics. Binocular microscopes, stereo zoom microscopes, single field & split field microscopes (with optional trinocular head & CCTV) and Dual CCD split field alignments systems. Additionally, the user can select illuminators from the simplest Nicholas style (single beam, side lighting), ring or coaxial illuminators. Darkfield/light field is also available.

1.7 Alignment Optics Mounting Hardware

Mounting includes precision X,Y slide stage with +/- 4" motion. Stage motion is excellent for low/high magnification applications, and includes pneumatic (air) X,Y position locks.

1.8 Exposure Lamp Power Supply/Controller

Standard aligner includes a 350 watt constant intensity controller. Available wattage/adjust range: 200W (130W low, 195W idle, 260W high), 350W (200W low, 300W idle, 425W high), 500W (375W low, 450W idle, 625W high), 1,000W (750 low, 950 idle, 1250 high), 2,000 (1700 low, 1900 idle, 2200 high).

1.9 UV/DUV Lightsource System

ABM offers high performance collimated (and non-collimated) Model 60 lightsource systems for Near UV, Mid UV and Deep UV output. Beam areas from 6.0" to 8.0" square are. A wide range of intensities can be produced depending on lamp wattage and beam size. Adjustable intensity range is typically 3:1. Quick release mirror mounting for UV or DUV output is standard.

2.0 SYSTEM OPERATION

2.1 Start-Up Procedures

In the event the system is in a full "shutdown" condition (i.e., system and lightsource power off), you must first bring the lightsource into operation. To start up the lightsource, complete the following procedures:

a. Turn the POWER switch on the front of the intensity controller to the ON position.
b. Press START to produce ignition of the mercury arc lamp.
c. Check to make sure that the cooling fans are operating.

NOTE: If the lightsource cooling fan is not operating, shutdown the system and make sure the 3-prong fan plug is secured in the receptacle in back of the intensity controlling power supply. The source should be stabilized in approximately ten minutes.

d. Set correct intensity for both channel 1 (negative resist) and channel 2 (positive resist).
e. Select proper channel for photoresist being exposed.

This is all that is required to bring lightsource into operation unless calibration or some other changes are desired.

2.2 General System Operation

a. Turn all pneumatic switches to "OFF" position
b. Turn on "POWER" switch to activate shutter timer module
c. Set timer to desired exposure tome
d. Move alignment optics and lightsource to "HOME" positions
e. Place mask in holder, then press "MASK ON" to vacuum clamp mask
f. Position substrate on chuck, switch "SUBSTRATE" to "ON"
g. Lower mask assembly, (if in up position)
h. Switch "ALIGN" button to bring alignment optics over tooling module
i. Turn Z control knob counter clockwise until the clutch begins to slip (Fixed Level Chuck)
j. Turn Z control knob counter clockwise while pressing the button located in the front of the module until the clutch begins to slip (Planarizing Chuck)
k. Release the button to lock the chuck

NOTE: Planarization button must be pressed at this time if using planarizing chucks

l. Set the separation gap by turning the Z control knob clockwise to the desired gap setting
m. Align mask to substrate and when satisfied, switch "CONTACT" to "ON" position
n. Switch "EXPOSE" System will bring exposure source over tooling module for exposure.

o. Switch "HOME/EXPOSE" to "HOME" to bring system to "LOAD/UNLOAD" position
p. Switch "CONTACT" to the "OFF" position
q. Switch "MASK RAISE" to lift mask assembly
r. Switch "SUBSRATE" to "OFF" position
s. Unload substrate
t. Repeat steps a through s for each substrate

2.3 High Resolution Printing

Utilize the system as described above, except in step m, after switching on "CONTACT", switch off "SUBSTRATE", then proceed as described.

The substrate will be forced upward against the mask, improving the intimate contact between them.

3.0 PERIODIC MAINTENANCE

3.1 Maintenance

The system (and subsystems) has been designed to minimize maintenance. There are however, several items which need regular maintenance to eliminate potential problems and wear on critical parts:

Alignment Tooling:	X,Y, and Z precision slides should be lubricated once a year. If a binding or sloppiness is observed the X,Y,Z mechanism should be properly adjusted and aligned by a factory representative. Microscope X,Y linear rails and other sliding mechanisms should be lubricated once every six months with normal usage, and monthly in heavy production environments.
Pneumatics:	No maintenance required.
Lightsource:	When replacing the lamp, always clean connections and oxide build-up inside heat sink. Always clean lamps with alcohol before installing.
Mirrors:	Should be cleaned every six months using (glass cleaner) with lens cloth or cotton balls. Rinse with clear water. Finally clean with alcohol or new lens cloth, then dry with filtered air.

Metal Reflector:	Should be carefully cleaned using lens cloth or cotton balls with alcohol. Clean several times with new materials to remove film and streaks.
Intensity Controllers:	No regular maintenance required.
Calibration:	Should be checked weekly and adjusted if necessary.
Alignment Optics:	Clean microscope objectives and eyepieces as required.

4.0 UNPACKING AND INSTALLATION PROCEDURE

The following set of instructions deal with the unpacking and installation of your ABM Mask Aligner.

4.1 Remove your aligner from the crate

a. Have the crate moved into or near the area that the aligner will be used.

NOTE: These machines have many precision parts, and any harsh movement out-side of the shipping crate should be minimized as it may cause damage and/or detune some factory-set mechanisms.

b. If it is not possible or practical to do, move the crate as close to the install position as possible before unpacking.
c. Remove all the other separate boxes included in the crate.
d. Unpack these boxes carefully and lay their contents about the table for identification.

NOTE: Handle all these boxes with care as most contain delicate instruments and subsystems which will be fitted onto your aligner..

e. Remove the aligner from the crate.

4.2 Plumbing Pneumatic Lines

Hook up your house vacuum and nitrogen lines to the system via the pneumatic manifold located at the rear of the machine on the lower left side.

a. Connect the CDA line to the left port (regulated).
b. Connect the vacuum line to the right port (unregulated).
c. Connect the nitrogen line to the center port (regulated).

NOTE: The mask aligner system requires a minimum of 25 inches of vacuum to operate, and the regulator for the nitrogen (or air) line on the system should be set to 9 PSI.

4.3 Lightsource and Power Supply Installation

a. Locate the lightsource cables that are hanging inside the system underneath the table top.
b. Remove the packing material from them and place to the back of the machine
c. Take the lightsource power supply (which was unpacked from the crate), and place it on the shelf of the table that your table top aligner will be placed on.
d. Plug in the cables from the lightsource into the power supply, making sure that the anode (+) and cathode (-) plugs are in the proper outlet and that the fan plug is firmly plugged in.
e. Push the system up next to the wall as all installation procedures that concern the rear of the system have been completed.
f. Once in place, remove all the remaining packing material from the system, making sure to remove the wrap from the bottom of the lightsource lens.

4.4 Lamp Installation

NOTE: Read Appendix 11, Lightsource System, of this manual before proceeding further. Once you have completed reading the Lightsource System section, you are ready to begin lamp installation.

a. Remove all thumbscrews from the lightsource panel that has the warning sticker displayed.
b. Remove the tape from the lead.
c. Remove the lightsource lamp (another item previously unpacked) from its box.

NOTE: Be very careful not to touch the glass part of the lamp as the oils and acids on your skin can damage the lamp and affect its performance.

d. (UV lamp) Holding the lamp at the anode (+) end (gold side toward the hand), place cathode (-) end of lamp up into the parabolic mirror and out the hole at the other end where it threads into a brass lamp mount.
e. Thread the lamp into the mount until it stops (do not force tight).
f. Remove the small nut on the exposed end of the lamp, and install the lamp heat sink (the aluminum extrude piece) over the end of the lamp.
g. Take the nickel lead wire and place the ring terminal around the stud of the lamp and secure with the lamp nut.
h. Mount and secure the lightsource side panel.

4.5 Hi-Magnification Motion System

a. Take the microscope and its mount and line up the two holes on the mount to the two on the motion bar of the microscope transit.
b. Mount the microscope "Y" in place with the two ¼-20 socket cap screws included, and tighten firmly.
c. Plug the lamp transformer into a wall outlet.
d. Plug the illuminator(s) into the transformer and attach the illuminator(s) to the microscope in the appropriate mounts.

The preliminary installation of your system has been completed.

RECOMMEDED SPARE PARTS FOR ABM MASK ALIGNER

ITEM	QTY	DESCRIPTION
1	1	Flow Control Valve (contact vacuum & N2)
2	1	3-Port Toggle Valve (contact/substrate vacuum & N2)
3	1	5-Port (ADI) Toggle Valve (align/expose)
4	1	5-Port (Pneumadyne) Toggle Valve (align/expose)
5	1	5- Port Push Valve (mask vacuum)
6	1	3-Port Push Valve (chuck lock on/off)
7	1	3-Port Valve (mask frame, to interlock align/expose)
8	1	2-Port Valve (console, to interlock align/expose & mask up)
9	1	24 Volt Switch Lamp (console electrical switches)
10	1	UV or DUV Lamp (specify type & wattage)
11	1	Lamp Heat Sink (specify lamp size)
12	1	51/4" Reflector W/Mount
13	1	8" Reflector W/Mount
14	1	4.5" x 6.0" x .125" UV Mirror
15	1	4.5" x 6.0" x .125" DUV Mirror (specify wavelength)
16	1	4800 Cooling Fan (200, 350 & 500 Watt)
17	1	4600 Cooling Fan (1,000 Watt)
18	1	Mask Frame (Stainless Steel Post Seal)
19	1	Vacuum Chuck Contact Seal
20	1	EKE 21v, 150 Watt Lamp (coaxial & ring illumination)
21	1	EKE 21v, 150 Watt Lamp (GOLD, for infrared alignment)
22	1	Zeiss, 6v / 15 Watt Lamp (coaxial illumination)

APPENDIX 1

Intensity Controlling Power Supply

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1. General Description

ABM Intensity-Controlling Power Supply systems are designed to produce significantly improved printing performance due to their ability to operate and precisely control the exposing source over a wide range of intensities. The capability allows the process engineer to develop an exposure matrix, and then select the optimum time/intensity relationship needed to produce the desired printing quality. The user inputs the desired intensity/time function, and the controller then delivers the selected parameters to an accuracy of better than ±2%. This accuracy is maintained throughout the life of the lamp.

This state-of-the-art intensity-controlling power supply is a solid state design with line and load regulation. When the desired intensity is set, the supply controls the average power and maintains proper operating temperature of the lamp.

ABM's power supplies are capable of operating all mercury vapor short arc lamps having negative pressure inert gas fill characteristics which allow a breakdown ionization voltage of 180 volts or less. The system provides direct optical feedback for precise intensity control or constant power control over its specified wattage range.

2. Specifications

Specifications for 2,000 Watt UV systems with constant power/constant intensity.

2.1 Mechanical (Power Supply Size)

UV 200 to 500 Watt:

Length	17.00 inches
Width	10.5 inches
Height	6.00 inches
Weight	Approx. 50 lbs

DUV 500 Watt / UV 1,000 Watt:

Length	19.00 inches
Width	13.5 inches
Height	7.00 inches
Weight	Approx. 50 lbs

DUV 1,000 Watt / UV 2,000 Watt:

Length	24.00 inches
Width	16.00 inches
Height	9.00 inches
Weight	Approx. 50 lbs

2.2 Electrical

Input Voltage	110-220 VAC
Input Frequency	50/60 HZ
Starting Voltage	2,000 to 30,000 VDC
Open Circuit Voltage	160-180 VDC
Power Range	1700 to 2200 Watts
Idle Power	1800 to 1900 Watts

2.3 Interfaces To UV Exposure System

Lamp Connectors	Anode, RED / Cathode, BLACK
Fan Connector	3-Prong (Male)
Sensor Connector	3-Prong (Female)
Interlock Remote Start	4-Prong (Male/Square)
AUX Interface	4-Prong (Male/Round) Not In Use
Earth Ground	Ground Nut

2.4 Operating Range (Power in Watts)

200 Watt	130-260W (idle @ 180 to 200)
350 Watt	200-425W (idle @ 275 to 325)
500 Watt (uv/duv)	375-625W (idle @ 450 to 500)
1,000 Watt (uv/duv)	750-1250W (idle @ 950-1250)
2000 Watt (uv/duv)	1700-2200W (idle @ 1800 to 1900)

2.5 Optical Sensors

<u>UV</u>

UV-365nm (A Channel)
UV-400nm (B Channel)

<u>DUV/UV</u>

DUV-220nm (A Channel)
UV-400nm (B Channel)

<u>DUV</u>

DUV-220nm (A Channel)
DUV-254nm (B Channel)

2.6 Typical Front Panel Layout

Power Switch	Turns power supply on or off
Start Switch	Momentary contact, provides breakdown voltage to ignite the lamp
Meter Select Switch (intensity or power) (watts).	Switch at right position; meter reads power Switch in left position; meter reads intensity units (mW/cm^2)
Meter Select Switch (voltage or current)	Switch in right position; meter reads lamp current (amps). Switch in left position; meter reads lamp voltage (volts).
Mode Select Switch Constant Intensity (C/I) Constant Power (C/P)	Selects systems operating mode. Switch in right position; system operates in constant power mode. Switch in left position; system operates in constant intensity mode.
Intensity Cal Pot	This ten-turn potentiometer calibrates the system's built-in intensity meter to user's external intensity meter.
Hour Timer	Analog Display, Supply/Lamp Hours

Intensity Set Pot	This ten-turn potentiometer sets the desired intensity when system operates in intensity controlling mode.
Power Set Pot	This ten-turn potentiometer sets the power level when system operates in constant power mode. Set "IDLE" power in constant intensity and power management modes.

NOTE: The dual channel systems have an additional switch for selecting channel A or channel B

3. Operating Information

3.1 AC Power Source

This power supply is intended to be operated from a single or three-phase, earth-referenced power source. The unit has a three or five-wire power cord with a three or five-terminal polarized plug for connection to the power source and safety-earth. The safety-earth terminal of the plug is directly connected to the power supply chassis. For shock protection, insert this plug only into the proper matching outlet with a safety-earth contact.

The power requirements of voltage, line frequency and the maximum wattage drawn, are listed in the information supplied with the equipment. The system is capable of operating at voltages from 110 VAC to 220 VAC and frequencies of 40 to 70 HZ. Each unit is wired internally for the power option specified on the purchase order.

3.2 Mercury Arc Lamp

This power supply can be operated where the ambient air is between 10°C and 35°C. The power supply is cooled by air being drawn in through the side panels. Adequate clearance must be provided on all sides to allow air flow through the holes in the power supply cabinet. Failure to observe this requirement may result in serious damage to the power supply.

3.3 Mercury Arc Lamp

This power supply is designed for use with virtually all mercury short arc vapor lamps of negative pressure inert gas fill. With normal temperature operating conditions, the lamp filled with inert gas at a negative pressure will achieve full power in approximately five minutes with voltage and current parameters specified by the lamp manufacturer.

When overcooled, the mercury in the lamp is not completely vaporized, and the lamp will not come up to full power and maximum intensity. If the voltage reading is not within a few volts of that specified, check to see that the cooling associated with the lamp-housing is according to specifications. Overcooling of the lamp will result in severely-reduced lamp life. (Lamp voltage will be below specification with an overcooled lamp)!

The following lamp criteria must be followed:

1. Always operate the lamp in a vertical position.

2. Always operate the lamp with the positive lead connected to the anode terminal.

3. The anode and cathode terminals of the lamp must always be isolated from ground and any conductive parts.

4. Use the proper lamps as specified by ABM.

3.4 Maintenance and Troubleshooting

Because of the unique design of the power supply's circuit and the special equipment required for a full diagnosis, only these selected tests should be carefully attempted by personnel trained in off-line maintenance of ABM power supply systems.

AC Power connection
Checking/Adjusting Line voltage and frequency adjustments
Power supply interface connections
Lamp condition
Full lamp cool-down (before restart attempt)
Power supply open circuit voltage
Power Supply starting current

4. Theory and Operation of the Intensity Controlling System

Constant Intensity Controllers are output power variable optical feedback controlled, power supplies for the mercury, xenon and xenon-mercury arc lamps used in contact, proximity, and projection mask alignment systems. Intensity controllers precisely maintain the lamps output as a user-selected exposure intensity. Controllers offer the most cost-effective method devised to optimize the printing performance of mask aligners. Direct optical feedback using sensors deliver the information needed for the controllers to compensate for lamp variations, and intensity degradation due to aging and input power changes. This significantly reduces downtime of the lamp due to extended life.

There are four (4) power conditions that should be fully understood by users of Intensity Controllers (1) the idle power (2) the maximum power available (3) the minimum power and (4) the exposing power level. Maximum and minimum power is preset at the factory. These settings are dependent on lamp rating, its enclosure and the application. The exposing intensity is set by the operator anywhere between the minimum and maximum power limits. Idle-power and exposing power are both user adjustable in ABM controllers. These levels and how they relate to intensity will be discussed in the manual.

The intensity controller is in reality a variable output power system which is commanded via optical feedback to adjust its output power to meet a preset intensity.

Power adjustment occurs only during an expose (or lamp test) cycle. At all other times the system remains at the idle power level.

If the user selects an intensity lower than the intensity at the "idle" power level, the system will drive downward (in power) until it reaches the power level that delivers the selected intensity.

Conversely, if a higher intensity is desired, the system will power up until the power level is reached which delivers the intensity selected.

Constant Intensity Controllers circumvents these problems by maintaining the lamp at an optimum power level (idle) between exposures. The lamp operates in the idle condition, thermally stable and unstressed, until the shutter opens to initiate operation. Only then does the system drive up or down in power to meet the pre-set intensity level that produces the pre-set exposure level. (This pre-set intensity level is established by the process engineer, who has previously generated an exposure matrix to determine the optimum intensity/time settings).

When the exposure cycle ends, the lamp returns to idle. This insures that lamps operated in high intensity applications are not powered to continuously, or operated at low intensity allowed to overcool. The result has greatly improved exposure repeatability, longer lamp life and better yields.

The intensity produced by any particular lamp system depends heavily upon the optical system in which it is used. This intensity output can be varied over the operating range within maximum and minimum power limits factory set in the Controller.

The intensity produced is monitored by sensors mounted so they receive radiation from the exposure beam. The sensors receive energy directly proportional to the actual intensity measured at the exposure plane. The narrow bank optical selected sensors convert the energy falling on them into an electrical signal which is sent to control circuits. The date is compared with the pre-set value,, and the lamp power (watts) is automatically adjusted to make the exposure intensity (mW/cm) equal the pre-set intensity level. The sensors are designed using photo-detectors coupled with computer designed absorption glass filters which tailor the spectral response to stimulate the exposure of the photoresist. It is essential that the sensor respond to the same spectral region as the material to be exposed if precise repeatable exposure is to be achieved. Most controllers come equipped with dual sensors having two filter/detector combinations each of which may track a different response curve. Typical sensor system employ the UV-365B and UV-400B spectrum to track most common negative and positive UV photoresists.

5. Simplified Description of Operation

ABM's line of mercury arc power supply and intensity controller systems are modular solid state designs with full transformer isolation. A capacitor and choke, plus sensing circuits provide filtering to keep output ripple less than 0.2% The starting circuit provides over voltage ignition which offers greater start reliability.

During the initial "on" condition, the lamp operates with very low resistance (impedance). As the lamp warms, the mercury vaporizes and pressure in the lamp envelope builds, increasing the lamps impedance stabilizing the current level. At this point, the regulation circuit takes over to maintain the lamp at the pre-set idle wattage.

The regulation circuit (in the idle mode) has a fixed reference point and is active when the shutter is closed. A second circuit overrides the first when the shutter is opened and sensor is activated by light energy. This override circuit drives power up or down until the lamp intensity (monitored by the sensor) meet the pre-set intensity value and restores balance to the circuit.

In order for the built-in panel meter to display a meaningful intensity reading in mW/cm^2 (intensity units), it must be calibrated against some external standard UV power meter having a spectral response that matches the response of the sensor package in the optical loop. The external UV power meter should be NIST traceable and read in mW/cm^2. The calibration potentiometers on the front panel (one for each control channel) are used to change the intensity at the exposure plane without regard to pre-set (reference) values. When both the external UV power meter reading and the front panel display reading are matched, the system is calibrated on that control channel. Each control channel requires individual calibration.

6. Optical Loop Operation

Silicon photo-detectors with absorption glass filters are mounted within the light path, receiving the energy in the selected spectral region. The sensor converts this energy into a proportional electrical analog signal (current) which is delivered to a current to a voltage amplifier (signal conditioner).

Calibration potentiometers are provided on the front panel for gain adjustment, one for each control channel. The output is compared to a reference signal from the intensity setting potentiometer (also located on the front panel).

When exposure begins, voltages from the sensor, amplifiers and the reference signal are evaluated by an analog multiplier. The previously balanced idle condition is interrupted and the system must drive up or down to rebalance itself. The sensor monitors intensity, and its data must be made to match the pre-set level to achieve circuit balance between power, intensity and pre-set level. When the shutter closes, the sensor signal is eliminated and the analog multiplier returns the system to a balanced idle condition again.

The system dynamics are limited by minimum and maximum lamp power wattage settings. In the event the optical loop cannot achieve a balanced condition at the maximum power limit, a signal is produced to activate an audible alarm, indicating that the pre-set intensity demand is beyond reach. This usually occurs because a lamp has lost output efficiency with age and must be replaced. It could also occur from an attempt to pre-set an intensity level beyond the operating range of the system (which would exceed the safe operating parameter of the lamp).

7. Intensity Controller Installation

The Controller requires about one inch of space on each side for ventilation air flow. The rear panel should not be obstructed, permitting both cable access and unrestricted exhaust.

Connect the red (+) anode and the black (-) cathode cables from exposure source to appropriate output connectors, which are clearly marked on the rear panel. Tighten couplings firmly, but not excessively. Observe polarity!
Plug the sensor connector into receptacle located at upper right of rear panel.

7.1 Calibration of intensity controlling power supply

Initial Front Panel Settings (ABM power supply)

POWER Switch	**Off Position**
INTENSITY/POWER Meter Select Switch	**WATTS Position**
CURRENT/VOLTS Meter Select Switch	**VOLTS Position**
C/I-C/P Select Switch	**C/P Position**
All Knobs (five total)	**Counter Clockwise**

1. Turn Main POWER on.

2. Depress START switch no more than 10 seconds continuously (until lamp starts). After five minutes of warm up, adjust power set to idle wattage. Lamp type: **200w** (set to 180-200w), **350w** (set to 275-325w), **500w** (set to 450-500w), **1,000w** (set to 950-1,000w), **2,000w** (set to 1800-1900w).

3. Open shutter on the lightsource system and using a calibrated intensity meter (ABM 100A, B, C or equivalent), measure light intensity in center of exposure beam (at expose level) with appropriate wavelength probe.

4. Set intensity/power meter to intensity position, adjust Cal knob until INTENSITY meter reading equals the intensity that was measured in step 3.

5. Set MODE select switch to C/I.

6. Adjust SET knob set to the desired exposure intensity. Lock knob.

7. If external intensity reading does not match power supply intensity set, rotate Cal knob to match. Lock knob.

This completes the setup procedure. The unit is now ready to operate. After initial setup is accomplished, it is not necessary to go through the setup procedure each time the system is turned on. Simply turn on the power supply and start lamp. The unit is ready to process parts in approximately five minutes.

8. Using the Intensity Controller

8.1 Intensity Checks

Intensity checks with a UV Power Meter should be performed regularly. (Frequency will be determined by experience developed during usage of your new Controller). Scheduled checks ensure that the Controller is functions properly. You will quickly discover that exposure intensity is maintained precisely at the pre-set value for the useful lifetime of the lamp. When making these intensity verifications, be sure the Controller is in the control mode, just as during production use and either C/I or C/P mode when making uniformity measurements.

The Controller's front panel meter serves as an on-line check after it has been initially calibrated. After confidence is gained in the system, this display's reading will probably suffice in lieu of frequent UV Power meter readings.

CAUTION: when performing maintenance checks be sure the system does not run for long periods of time at high or low power extremes. Put the system into "idle" (C/P).

NOTE: Experience has shown that when Intensity Controllers are initially installed, that operators cannot resist the temptation to tweak potentiometers needlessly. Such tweaking can cause variations in the process and will lead to very inconsistent system performance. This problem arises most frequently between personnel shift changes. If intensity checks between the external UV Power meter and the front panel display are continuously in disagreement, notify a factory representative. Altering adjustment on the lightsource without recalibrating the Controller will result in reduced performance. Additionally, if the exposure beam has a non-uniform pattern, contact an ABM representative.

8.2 How to Change Intensity

If you desire to change the exposing intensity, the procedure is very simple. The SET pot permits the user to vary the intensity anywhere within the operating range of the lamp, typically covering about a 2:1 intensity ratio.

Open the shutter, unlock the Set pots (outer ring), rotate the knob until the panel display reaches the desired exposure value. Be sure the INTENSITY/POWER meter's display is reading mW/cm^2. It is always wise to verify the new setting with an external UV power meter at the exposure plane.

If the maximum power alarm sounds when attempting to adjust a pre-set intensity level, it means the intensity desired is higher than can be delivered. A less demanding pre-set must be used. If the lamp is an older one, perhaps a new lamp will be able to obtain the demand without hitting the maximum power limit. Be aware, that if the pre-set intensity level is near to the maximum power limit, there is limited compensation available to make up for lamp degradation and it will not be long before the maximum power limit alarm sounds again.

8.3 Maximum Power alarm

the audible alarm sounds only when the lamp is out or when maximum power is applied to the lamp. If the alarm sounds during an exposure cycle, it is an indication of reaching the maximum power level. Then a decision must be made that either the lamp is to be replaced or the pre-set intensity level should be reduced. If usage is continued after the alarm sounds, the process will eventually start to degrade, demonstrating the effects due to underexposure.

Since the Controller can have up to two channels of control, the channel set using the higher intensity will be the first to activate the maximum power alarm. The other channel will continue to operate without setting off the alarm.

NOTE: Since mercury arc lamps degrade faster when repeatedly turned on and off than when operated continuously, ABM suggests that you do not turn the lamps off overnight; sometimes not even on weekends, as the idle mode is pre-set to achieve the longest stable life.

Considerable versatility is built into the Controller. It is very important for all attending personnel to be familiar with its operation and controls. When adjusting or monitoring performance, there must be no doubt about which intensity channel is in use, which wavelength each channel monitors, which value the front panel meter is set to display or if the system is in (C/P) or (C/I). Confusion about these functions can lead to operational problems.

8.4 Lamp Replacement & Recalibration

It is important that all lightsource adjustments for collimation, uniformity, etc. are done with the Controller in the C/P mode and before calibration of the system is attempted. If no changes have been made on source optics, recalibration is normally unnecessary.

To minimize lamp changes during production the exposing power (watts) should be monitored regularly. If the power level during an expose cycle is within 10-20 watts of the maximum level, lamp changes should be scheduled for the earliest convenient time.

WARNING: Do not attempt to change lamps without turning off controller.

8.4.1 Lamp Changing

Use procedure described in Lamp Housing Manual.

APPENDIX 11

MODEL 60 DUV/MUV/Near UV EXPOSURE SYSTEMS

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1. Safety Precautions:

Safety factors to be considered by users of Exposure Systems:

1.1 Effects of UV Radiation

Since these sources produce high levels of UV IR radiation, precautions must be taken to prevent looking into output beams or reflections of it, even for short periods. Damage to the eyes and possible blindness can result.

Prolonged exposure to diffused reflection from the output beam (even from illuminated surfaces near the beam) or exposure of even a few seconds to the direct output beam or to the lamp itself, can cause short-wave ultraviolet burns on the skin or outer layers of the eyes (these are similar to severe sunburns- initial symptoms feel like "sand" under the eyelids.)

CAUTION: WHEN OPERATING THE LIGHTSOURCE WITH A BRIGHT OR RELECTIVE SURFACE, WEAR GOGGLES OR SUNGLASSES. NEVER LOOK DIRECTLY AT LAMP OR INTO BEAM. NEVER OPERATE THE LAMP WITHOUT ALL ACCESS PANELS IN PLACE AND SECURE.

1.2 Lamp Explosion

a. When at operating temperature, the mercury arc lamps have an internal pressure at 35 to 50 atmospheres. Lamps are subject to possible explosion due to (1) aging of the quartz, (2) physical abuse, or (3) lamp temperature (over cooled/high exhaust), (over heated/low exhaust, bad cooling fan or missing lamp heat sink).

* **MINIMIZE TORQUE TO THE QUARTZ ENVELOPE DURING LAMP INSTALLATION & REMOVAL.**

b. A lamp exploding inside the housing can effect reflector performance, break main 45 degree mirror and occasionally damage some of the elements in the optical integrator assembly.

c. Fingerprints and other contaminants left on the lamp during replacement will cause deterioration of the quartz envelope and can lead to catastrophic lamp failure.

* **DO NOT TOUCH LAMP WITH BARE HANDS. CLEAN LAMP WITH EITHER (#1 METHANOL), (#2 ALCOHOL), (#3 ACETONE), UPON INSTALLATION.**

1.3 Ozone Hazards

Do not operate the system without proper room ventilation because lamps produce small levels of ozone, especially during warm up. If ozone generation is a problem, the use of ozone free lamps is recommended.

Call ABM for ozone free lamp information.

1.4 Electrical Shock

a. Before lamp replacement or working on the exposure system, disconnect input power and check the power supply voltmeter for zero voltage to be sure that the system is fully discharged. Or remove the lamp leads (anode/cathode) from the power supply.

b. Do not turn on power supply or ignite lamp with any exposure system access panels removed.

1.5 Cooling

DO NOT ATTEMPT TO ALTER THE SYSTEM'S COOLING WITHOUT FIRST CONSULTING ABM. Lightsource cooling fans have been designed to maintain lamps in a comfortable, thermally stable environment (approximately 200 degrees C @ lamp heat sink operating at rated wattage of lamp).

Modification of the cooling could lead to overcooled, unstable operation (low/wavering intensity) or overheating, which produces short lamp life and possible catastrophic failure.

2. Description of Standard UV Lightsource System (350nm-450nm)

This UV lightsource produces an intense, uniform, collimated beam of ultraviolet energy. Radiation from high-pressure mercury arc lamps is collected by a reflector and directed to a 45 degree mirror, optic integrator (fly's eye lens), then reflected toward the 2^{nd} 45 degree mirror and to the exposure area after passing through the collimating lens.

3. Description of Deep UV (200nm-280nm) & Mid UV (280nm-310nm) Lightsources

Deep UV (220-280nm) and Mid-UV (280-310nm) Lightsource Systems differ from the standard system in three (3) ways.

1. The optics are designed for high reflection and transmission at shorter wavelengths. The mirrors are tuned to the wavelength spectral regions desired. All transmitting optics (optical integrator and collimating lens) are made of high transmission (low absorption) quartz materials.

2. The lamp used can be either mercury (Hg), Xenon (Xe), Mercury-Xenon (Hg-He), or Mercury Xenon Plus (Hg-Xe). The selection depends on the wavelength and level of radiation desired. The (Hg) type lamps are anode (+) down while the Xe types are anode (+) up. In all cases, the gold band on the envelope should be down.

3. The electrical system is different for Hg and Xe type lamps. The anode (+) and cathode (-) sides are reversed with Hg and Hg-Xe lamps.

Different power supplies must be used as Hg lamps are higher voltage, lower current, while the Xe lamps operate at a significantly higher current. (Example: the 500W Hg lamp has 65-70 Volts @ 7.7-7.1 Amps while the 500W Xg lamp has 31-36 Volts @ 14-16 Amps).

4. Setup and Alignment

4.1 Lamp Installation

NOTE: Be sure lightsource power supply is turned off prior to lamp removal and installation.

Xenon-Mercury (Xe-Hg) arc lamps must be operated with cathode (-) down and anode (+) up (a gold band is down). Use the heat sink provided and install by rotating lamp into the heat sink. **Note: Some higher wattage (short arc mercury) UV lamps, 2,000 watts & higher require anode (+) up, cathode (-) down.**

Mercury (Hg) arc lamps must be operated with cathode (-) up and anode (+) down (gold band is down). Always mount proper heat sink on lamp before starting lamp.

1. Thoroughly clean lamp envelope with either (#1 Methanol), (#2 alcohol), (#3 acetone) with lint-free or lab wipes prior to installation.

> **CAUTION: FINGERPRINTS OR GREASE STAINS LEFT ON THE LAMP DURING OPERATION WILL CONTAMINATE THE QUARTZ ENVELOPE AND CAN CAUSE PREMATURE LAMP FAILURE OR LAMP EXPLOSION.**

2. Mount lamp in housing. Remove lamp access panel by removing thumbscrews. Install lamp in brass mount through opening in reflector. Install ignition wire to lamp base and secure with nut.

CAUTION: IF LAMP INSTALLATION IS REVERSED (anode/cathode), LAMP WILL NOT BE STABLE (voltage/current ratings will be out of specification) AND LAMP COULD EXPLODE.

3. Secure lamp access panel with thumb screws.

4.2 Electrical Installation (verification / initial system installation)

1. With the cables supplied, connect the positive (+) housing lead to the positive (+) terminal of the power supply output. Connect the negative (-) lamp housing lead to the negative (-) terminal on the power supply.

2. Connect other cables accordingly. 7-pin, male (to shutter timer or mask aligner timer) 3-pin, male (to lamp power supply, cooling fan power), 3-pin, female (feedback sensor, C/I operation).

3. Connect power supply line cord to proper voltage AC inlet.

4. Recheck all connections and connectors to be certain they are secure. Also check that both sides of power supply are in a position where the cooling air flow will not be restricted.

4.3 Alignment (lamp focusing), Required For All Installed Lamps

1. After the lamp has been operating long enough to stabilize (5 to 10 minutes), place a suitable ultraviolet sensitive sensor (such as the ABM Model 150 Digital Power Meter) in the center of light beam. **(Make sure power supply is operating in C/P mode only).**

2. Remove access panel to lamp focus assembly. Using the vertical adjustment (Z motion) wheel, raise (or lower) the lamp until the light sensor indicates maximum intensity.

3. Turn the other horizontal (X,Y) lamp adjustments (one at a time) in either direction until maximum intensity is achieved.

4. Move sensor from side-to-side, front-to-rear (within specified uniform beam size), to check uniformity. Adjust horizontal (X,Y) knobs until uniformity is achieved (+ / - 3 to 5%). Uniformity formula: difference between high & low intensity, divided by low intensity, divided by 2 x 100.

5. Repeat step 2 with vertical lamp adjustment for final output verification.

6. If a lower intensity is desired, the lamp can be lowered (turning Z wheel counter clockwise) without significantly affecting uniformity of light beam.

4.4 **Lamp Replacement**

1. Lamps used are typically rated by the manufacturer for 400-600 hours of operation.

   CAUTION: CATASTROPHIC FAILURES INCREASE WITH NUMBER OF LAMP STARTS AND EXCESSIVE INPUT POWER TO THE LAMP.

2. To replace a lamp, refer to Section 4 (Setup and Alignment) and follow all steps.

APPENDIX 111

Model 150
Digital Intensity Meter

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1. General Description

The had held Model 150 Digital Intensity Meter is designed to precisely and measure UV and Deep UV (DUV) radiation. The unit includes a dual-sensor probe containing industry accepted spectral regions (UV365 and UV400) which simulate the spectral responses of negative and positive resist. DUV sensors are also available.

2. Applications

Model 150 is used primarily for the measurement of intensity mW/cm and beam uniformity of UV/DUV output. Such lightsources are principally used in the manufacturing process of integrated circuits, thin film hybrids, and printed circuit boards.

3. Features

a. LCD Display
b. Interchangeable, calibrated spectral probes
c. Operates on 9-volt transistor battery with typical life greater than 150 hours
d. Intensity scales: $2W/cm^2$ ($2{,}000\ mW/cm^2$) or $200mW/cm^2$.

4. Specifications

NIST Traceability	Better than ±3%
Repeatability	Better than ±1%
Accuracy	Electrical ±1%; Linearity ±0.1%; Optical Calibration ±5% absolute; ±1% relative
Intensity Scales	Channel A: $20mW/cm^2$ and $200mW/cm^2$ Channel B: $20mW/cm^2$ and $200mW/cm^2$
Circuitry	Solid State CMOS integrated circuitry
Display	Liquid Crystal 3.5 digit for intensity values, Low battery
Controls	ON/OFF, CHANNEL SELECT, INTENSITY SCALE, HOLD DISPLAYED INTENSIY
Spectral Responses	Standard Probe (dual channel) Channel A=365nm, Channel B=400nm
Optional Probes	Available in Deep UV (220,248,254,260nm), Mid UV (280 and 310nm), UV (365, 400 & 436nm)
Power Requirements	One standard 9V transistor battery
Dimensions	6.0" L, 2.75" W, 1.1" D
Weight	11.5 ounces

5. Maintenance

The Model 150 requires no user maintenance other than battery changes. “Low Bat” will be displayed whenever a battery change is required.

ABM recommends yearly calibration checks to maintain NIS tractability.